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Review

On connectivity approach for a unified communications and integrated collaborations system in the health sector of developing countries: a case of Uganda

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Abstract

Access to information holds the key to the empowerment of everybody despite where they are living. This research is to be carried out in respect of the people living in developing countries. Considering their plight and complex geographical, demographic, social-economic conditions surrounding the areas they live. These conditions hinder access to information and of professionals providing services such as medical workers, which has led to high death rates and development stagnation. Research on Unified Communications and Integrated Collaborations (UCIC) system in the health sector of developing countries comes in to create a possible solution of bridging the digital canyon among the communities. The UCIC will deliver services in a seamless manner to assist health workers situated anywhere to be accessed easily and access information which will help in service delivery. The proposed UCIC provides the most immersive telepresence experience for one-to-one or many-to-many meetings. Extending to locations anywhere in the world, the transformative platform delivers Ultra-low operating costs through the use of general purpose networks and using special lenses and track systems. The aim is to identify the most suitable connectivity method for the deployment of the UCIC system in the health sector of developing countries. The right choice will enable the system to run effectively thus an efficient and effective workforce of the health sector will bring enhancement to the speed and quality of services offered by health workers. The capacities of UCIC will help health workers shorten decision cycles, accelerate service delivery and save lives by speeding access to information and by making it possible for all health workers and patients to collaborate everywhere.

Keywords: Connectivity, developing countries, unified communications and integrated collaborations.

List of abbreviation and acronyms

3GPP; Third Generation Partnership Project, AD RMS ; Active Directory Rights Management Services , ADSL; Asymmetric Digital Subscriber line, CATV; Cable Television, CDMA; Code Division Multiple Access, CDPD ; Cellular Digital Packet Data, DP/QPSK; Dual Polarization Quadrature Phase Shift Keying, DSLAM; Digital Subscriber Line Access Multiplexer, DSSS; Direct Sequence Spread Spectrum, DVB-RCS; Digital Video Broadcasting – Return Channel via Satellite, EDGE; Enhanced Data for Global Evolution, EGPRS; Enhanced General Packet Radio Services, EMI/RFI; Electromagnetic Interference/Radio Frequency Interference, ETSI; European Telecommunications Standards Institute, EV-DO; Evolution-Data Optimized, FTTH; Fiber-To-The Home, FQPSK; Feher-Patented Quadrature Phase-Shift Keying, GMSK; Gaussian Minimum Shift Keying, GPRS; General Packet Radio Services, GSM; Global System for Mobile Communications, HFC; Hybrid Fiber Coax, IEEE; Institute Electrical Electronic Engineers, IPBH; Internet Protocol Backhaul, IP and P2P; Internet Protocol Peer-to-Peer, ISP; Internet Service Protocol, LTE; Long-Term Evolution, NAP; Network Access Protection, OFDM; Orthogonal Frequency Division Multiplexing, PLC; Power Line Communications, PPM; Pulse Position Modulation, PSTN; Public Switched Telephone Network, QAM; Quadrature Amplitude Modulation, TDM; Time Division Multiplexing, TDMA; Time Division Multiple Access, UMTS/HSPA, Universal Mobile Telecommunications Services/ High-Speed Packet Access, UCIC; Unified Communications and Integrated Collaborations, VoIP; Voice over Internet Protocol, Wi-Fi; Wireless Fidelity, WiMAX; Worldwide Interoperability for Microwave Access.

INTRODUCTION

The health sector Information and Communications Technology (ICT) infrastructure has to become an enabler for the medical strategy of growth, excellence and good performance by providing premier information services and contributing as a valued service provider for its citizens. Establishing a foundational infrastructure sets a platform on which higher level services can operate. Central to this platform system is the establishment of a Global Directory and Authentication Service. With these core services in place, attention and effort can be focused on other services that enhance medical business processes like email, data collaboration systems, Network Access Protection (Vanover, 2008), Active Directory (AD) Rights Management Services (sloan, 2010) and System Central Management. Additionally, by simplifying and eliminating the duplicated effort of providing core platform services like network, directory and authentication (Lee, 2012), Information and Communications Technology will be able to provide high quality and efficient services to the health sector.

The health sector should be therefore able to deliver a robust infrastructure that caters for the following initiatives: Messaging – Email and Calendaring; Collaboration - Web Portal services (Pirkola, 2012), Intranet (Scarpati, 2009); Unified Communication – Instant Messaging, Conferencing, Presence; System Management and Security (Don Van et al., 2009); Change management – Training and Process. UCIC is the integration of real-time communication services such as instant messaging (chat) (Baglioni, 2012), presence information (Grigonis, 2000), telephony (including IP based telephony) (Anoshin, 2012), video conferencing (Barlett, 2011), data sharing (including web connected electronic whiteboards or Interactive white Boards) (Campbell, 2011), call control (Farla, 2007) and speech recognition (Denny, 2005) with non-real-time communication services such as unified messaging (integrated voicemail, e-mail, SMS and fax). UCIC is not a single product, but a set of products that provides a consistent unified user interface and user experience across multiple devices and media types (Parlas, 2011).

UCIC allows an individual to send a message on one medium and receive the same communication on another medium. For example, one can receive a voicemail message and choose to access it through e-mail or a cell phone. If the sender is online according to the presence information and currently accepts calls, the response can be sent immediately through text chat or video call. Otherwise, it may be sent as a non real-time message that can be accessed through a variety of media. TelePresence is a combination of cutting edge audio, video and network enterprise solutions, also hardware optimized environments and a software glue that holds the elements together to make the best high definition video presence available in industry today (Bhat et al., 2011).

UCIC is a very new, unique, innovated technology that creates in presence, high definition, virtual meeting possible. It is known that predominantly it is about productivity, getting people in front of others and in a very virtual environment, but creating that in presence experience is key (Teleris, 2011). Futhermore, TelePresence is about improved responsiveness for health workers to be able to respond to patients, to be in presence of patients, also for subject matters to get in front of the patients very promptly, so TelePresence enables that to happen. The aim of this research work is to develop an environment with seamless flow of information in the health sector by using UCIC system, thus enabling prompt medical services delivery in the health sector which will reduce the death rate in the developing countries

The Health sector Information Technology optimization should begin with infrastructural and foundational elements such as Directory, Identity and Authentication services. The services will lay the foundation for an evolution towards a high-value IT service structure, followed by such services as Microsoft Unified Collaboration including Messaging and Unified communications, firewalls, endpoint (Forefront) security, Microsoft office applications, Active Directory Rights Management Services (AD RMS), Network Access Protection (NAP), Management infrastructure, legacy clean-up and optimization, and then on to a state of other expanded well-tuned services where as the user is in middle as shown in figure 1. One of the most important aspects in the success of the UCIC is the connectivity deployed, and this aspect is discussed in detail in the following sections.

ICT Connectivity Technologies Present In Uganda

Cable Technology

A network needs media to connect its nodes together. The physical medium is where the cables are used for data to flow. There are several media types often used in networking. The main connectivity types are described in the following paragraphs.

Dial-up

In dial-up access, a voice-band modem at a subscriber site communicates with the corresponding modem at her Internet Service Provider (ISP) site over the Public Switched Telephone Network (PSTN) during an Internet connection as shown in figure 2. The maximum data rate for both standards give downstream is 56 kbps.

Figure 1. Conceptual Diagram of UCIC Places User in the Middle

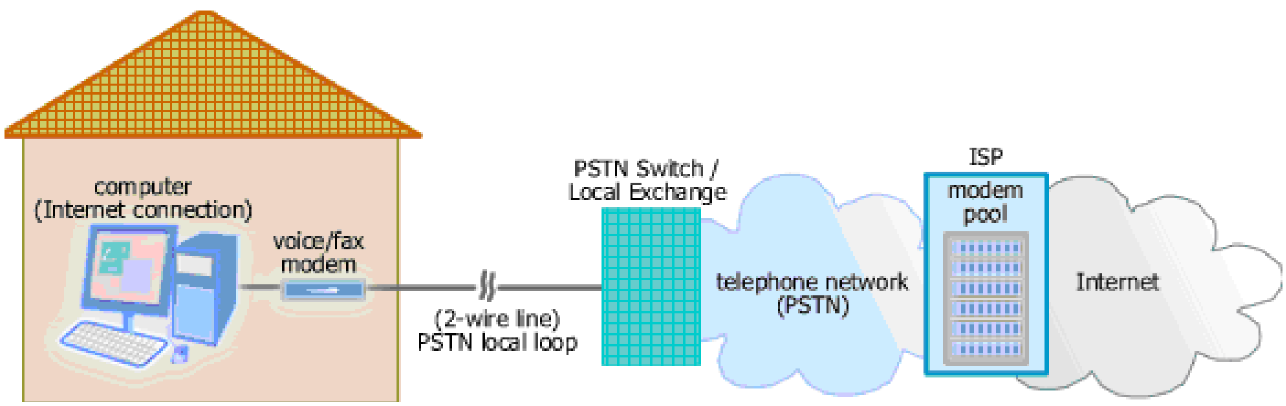

Figure 2. Dial-up Internet (Winder, 2000)

Upstream data rate of V.90 is 33 kbps, while V.92 can reach 33 - 48 kbps (Winder, 2000; Home networking, 2006).

Cable Modem

Internet access using cable modem, data (Internet) signal is delivered through Hybrid Fiber Coax (HFC) infrastructure which consists of fiber optic cables from a cable TV operator site or head end down to a neighborhood hub and a coaxial cable from the hub to each subscriber house. At a subscriber house, a coax splitter is used to split the drop coaxial cable into several coaxial cables typically one is allocated for Internet connection and the rest for Cable TV (CATV) delivery as shown in figure 3. The maximum shared data rate is 38 Mbps downstream and 30 Mbps upstream.

Asymmetric Digital Subscriber Line (ADSL)

ADSL is a popular DSL technology that provides asymmetric downstream and upstream data over a telephone line by spreading data to higher frequencies above voice frequencies. To have ADSL service, an ADSL modem must be installed at a subscriber home and an ADSL operator in Digital Subscriber Line Access Multiplexer (DSLAM) rack as shown in figure 4. ADSL maximum downstream data rate is 8 mbps (full rate) or 1.5Mbps Giga. Lite (G. Lite) and upstream data rate is 1 Mbps (full rate) or 512 kbps G. lite.

Fiber-To-The-Home (FTTH)

Fiber optic cable has long been used in backbone network that is the network that interconnects telephone

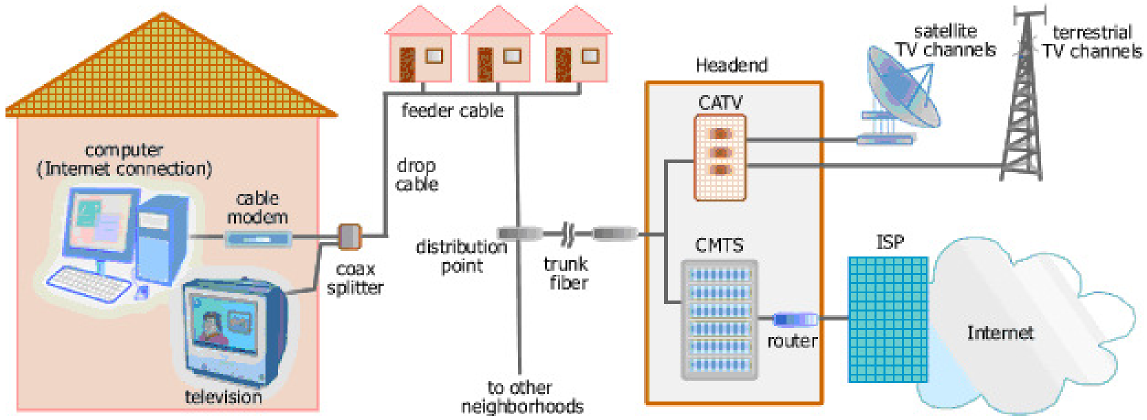

Figure 3. Internet access over cable TV network (Winder, 2000)

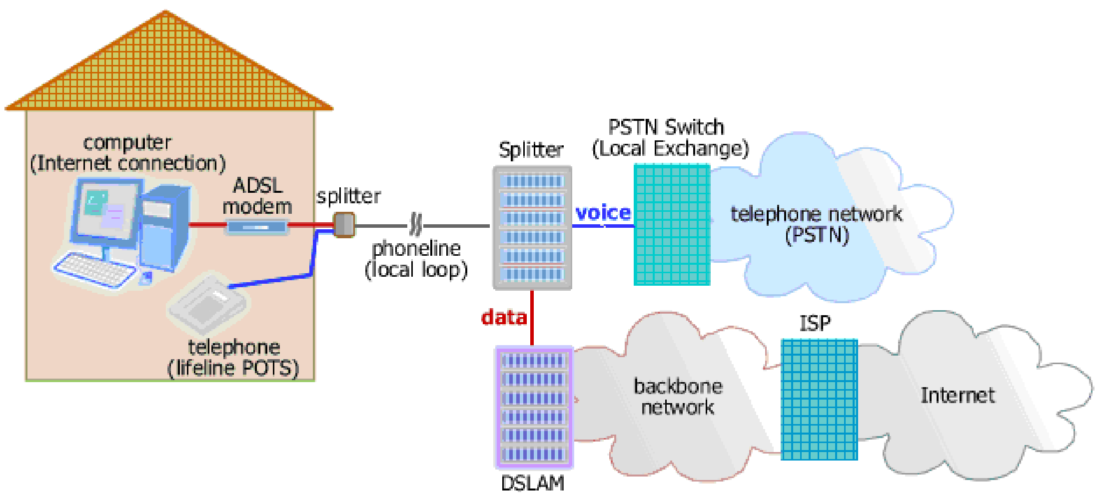

Figure 4.ADSL Network (Winder, 2000)

switches and data centers. Fiber optic cable is selected due to the advantages it has over other transmission media and many developing countries have adopted it as there national backbone network. It carries information as optical pulses (not electrical signals as in twisted pair or coax) therefore it is immune to interference (EMI and RFI), crosstalk, and noise. It can deliver information over longer distance than copper or coax. It has abundant bandwidth for carrying information, limited only by the equipment that lights the fiber. An FTTH operator or service provider delivers multiple types of services from the Central Office (CO) or Point of Presence (PoP) via a fiber optic strand to a subscriber home as shown in figure 5.

Internet Access over Power-line

Power line communication (PLC) is a technology that makes possible the transmission of voice, video and data over standard power distribution lines that is medium and low voltage cables (power line) as shown in figure 6. PLC enables data transmission at speed of up to 200 Mbps; this transforms the power line into real broadband network capable of providing any kind of services offered by telecommunication provider. PLC uses high frequency carriers for data transportation which covers a range between 1MHz to 34MHz. PLC uses Orthogonal Frequency Division multiplexing (OFDM) coding for data transmission. This modulation is the safest against interference taking place in power networks and provides the highest level of spectral performance and efficiency.

Wireless Technology

Wireless technology seems the most appropriate to be deployed in the health sector of developing countries considering the conditions that surround the areas such as difficult geographical terrains, sparse population, cost

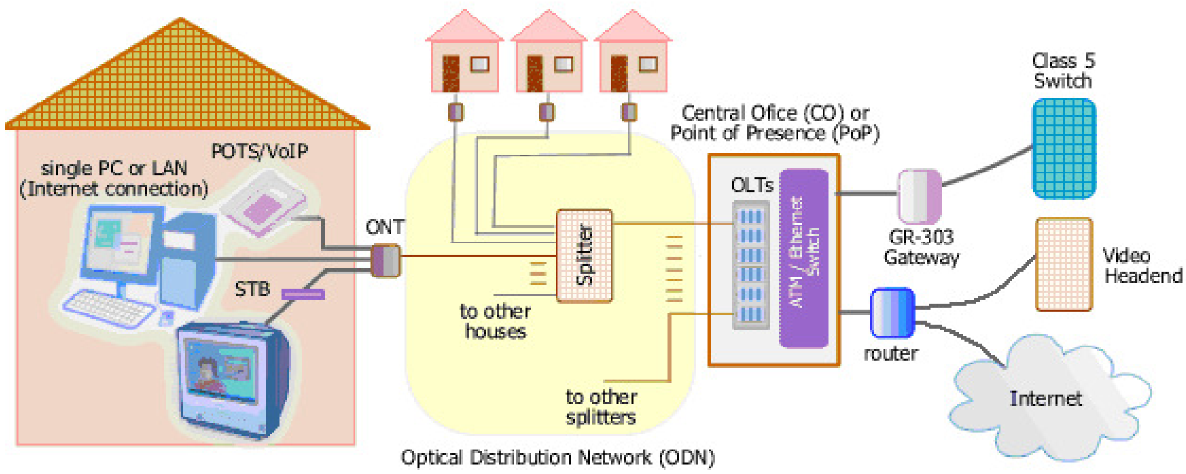

Figure 5.FTTH Network (Home networking, 2006)

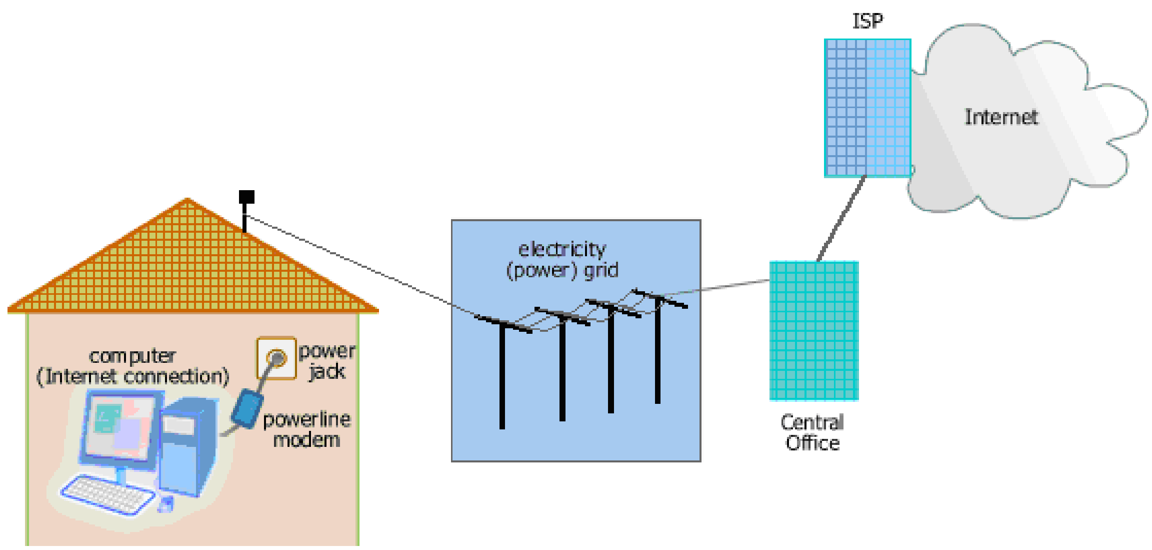

Figure 6. Broadband over Power-line (Home networking, 2006)

involved etc. Wireless technology enables communication with standard protocols, but without network cabling, examples are: WiMAX, Wi-Fi, Zigbee, GPRS, Bluetooth, via Satellite, GSM, LTE, EV-DO etc. The appropriate wireless communication system can be done by mixing more than one of the mentioned technologies in one network, where there are both mobile and fixed stations.

Bluetooth

Bluetooth is wireless technology, using radio as its physical medium that operates in the Industrial, Scientific and Medical (ISM) band, using 79 designated 1-MHz channels (or 23 channels in some countries) between 2.402 and 2.480 GHz, with data rate of 721 kbps and range between 10 – 100 meters. Bluetooth is used as a cable replacement technology to connect computer or mobile phone with peripherals for data and image transfer, synchronization, and voice application, Bluetooth is also used to create wireless personal area network as shown in figure 7.

Zigbee

Zigbee is a wireless data communication standard that is targeted for home automation, remote control, sensor system, interactive toy, and device monitoring. Zigbee is characterized by very low power consumption, low data rate, and long range. Zigbee operates in three

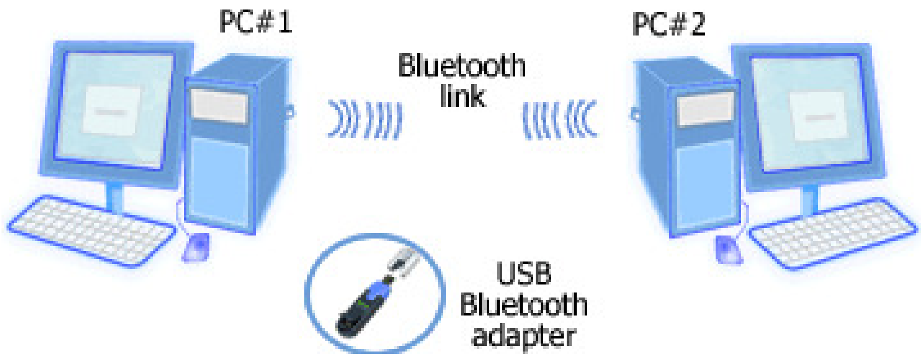

Figure 7. Bluetooth direct connection (Golmie, 2005)

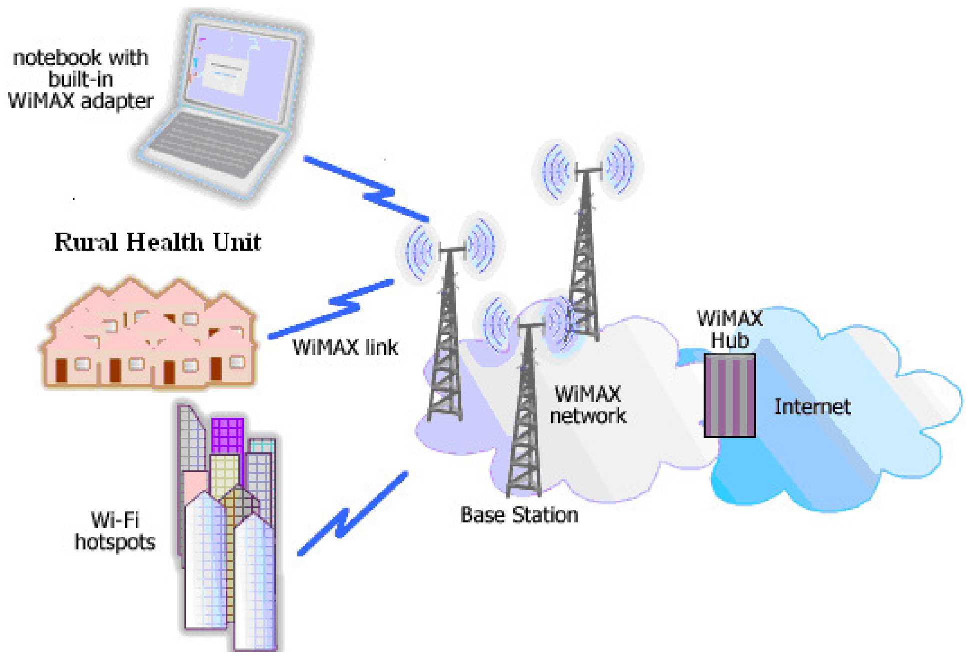

Figure 8. WiMAX Provides Broadband and Internet Connection Wirelessly (Wimax, 2006)

frequencies bands, namely 16 channels at 2.4GHz, 10 channels at 902 to 928 MHz, and one channel at 868 to 870MHz, the maximum data rate for each band is 250 kbps, 40 kbps, and 20 kbps respectively (Golmie, 2005; Roese, 2006).

Worldwide Interoperability for Microwave Access (WiMAX)

WiMAX is used as a current standard for Wireless data transmission technology, which is optimized to deliver high bursty data rates to mobile subscribers, and to support real-time multimedia and Voice over Internet Protocol (VoIP) applications. The topology of the WiMAX architecture is shown in figure 8. WiMAX allows higher data rates over longer distances, efficient use of bandwidth, and avoids interference almost to a minimum. With high performance in both distance and throughput, WiMAX supports traffic scheduling, dynamic bandwidth allocation and QoS per service flow, which guarantees every type of traffic will be handled with its associated bandwidth, latency, jitter, and priority requirements. Therefore, WiMAX can deliver toll quality VoIP while maintaining best effort traffic such as e-mail and web browsing at the same time.

Wireless Fidelity (Wi-Fi)

Wireless Fidelity (Wi-Fi) refers to wireless Local Area Network (LAN) that conforms to the IEEE 802.11b

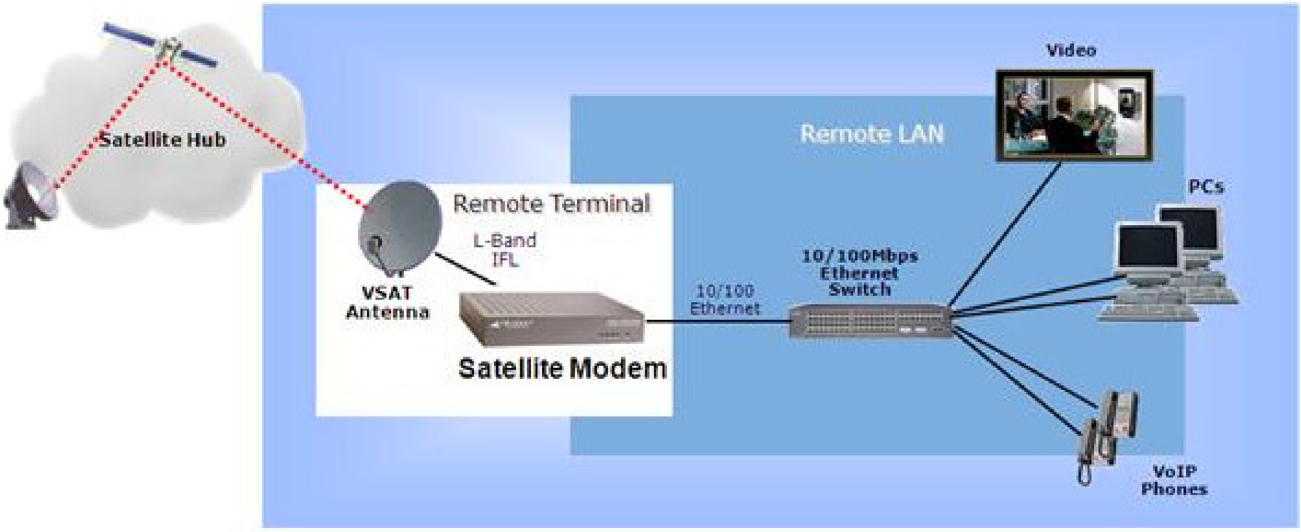

Figure 9. Communications Satellite (Home networking, 2006)

standards. It is also a general name referring to all 802.11 LAN standards, including 802.11g and 802.11a that provide secure and reliable wireless connectivity. A Wi-Fi network can be used to connect computers to the internet, and to wired networks which use 802.3 or internet. Wi-Fi networks operate in the unlicensed 2.4 and 5 GHZ radio bands, with an 11 Mps (802.11b) or 54Mbps 802.11a data rate.

Communication Satellite

A communications satellite is an artificial satellite stationed in space for the purposes of telecommunications. Modern communications satellites use geosynchronous orbits, molniya orbits or low polar earth orbits. Satellite communication technology is being used to connect to the internet via broadband data connections as shown in figure 9. This is very useful for users who are located in very remote areas, and cannot access a wire line broadband or dialup connection (Whalen, 2006).

Global System for mobile Communications, originally Groupe Spécial Mobile (GSM) GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones. The GSM standard was developed as a replacement for first generation (1G) analog cellular networks, and originally described a digital, circuit switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit switched transport, then packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS).

General Packet Radio Service (GPRS)

General packet radio service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM). GPRS was originally standardized by European Telecommunications Standards Institute (ETSI) in response to the earlier CDPD and i-mode packet-switched cellular technologies. It is now maintained by the 3rd Generation Partnership Project (3GPP) (Sloan, 2010). GPRS usage is typically charged based on volume of data transferred, contrasting with circuit switched data, which is usually billed per minute of connection time. GPRS data may be sold either as part of a bundle (e.g., up to 5 GB per month for a fixed fee) or on a pay-as-you-use basis. Usage above the bundle cap is either charged per megabyte or disallowed.

GPRS is the best-effort service, implying variable throughput and latency that depend on the number of other users sharing the service concurrently as shown in figure 10, as opposed to circuit switching, where a certain quality of service (QoS) is guaranteed during the connection. In 2G systems, GPRS provides data rates of 56–114 kbit/second. 2G cellular technology combined with GPRS is sometimes described as 2.5G, that is, a technology between the second (2G) and third (3G) generations of mobile telephony. It provides moderate-speed data transfer, by using unused time division multiple access (TDMA) channels in, for example, the GSM system. GPRS is integrated into GSM Release 97

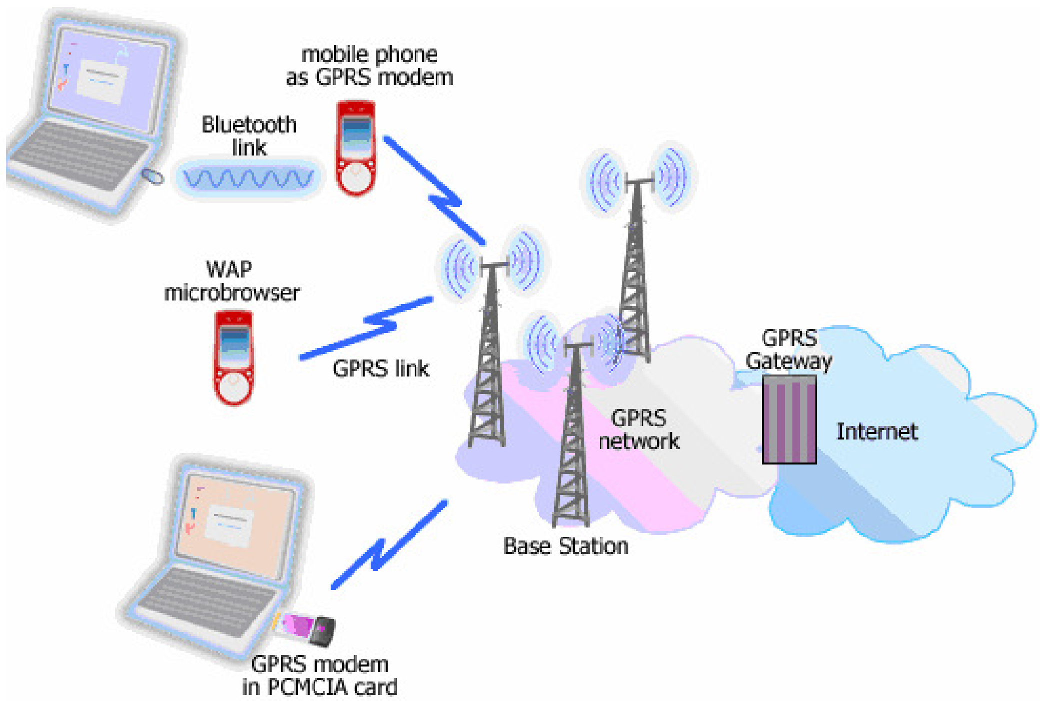

Figure 10. Internet Access over GPRS (3GPP, 2012)

and newer releases.

Long-Term Evolution (LTE)

LTE, an initialism of long-term evolution, marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements (LTE, 2012). A further goal was the redesign and simplification of the network architecture to an IP-based system with significantly reduced transfer latency compared to the 3G architecture. The LTE wireless interface is incompatible with 2G and 3G networks, so that it must be operated on a separate wireless spectrum.

Evolution-Data Optimized (EV-DO)

Evolution-Data Optimized (EV-DO) is a telecommunications standard for the wireless transmission of data through radio signals, typically for broadband Internet access. It uses multiplexing techniques including code division multiple access (CDMA) as well as time division multiplexing (TDM) to maximize both individual users' throughput and the overall system throughput. It has been adopted by many mobile phone service providers around the world – particularly those previously employing CDMA networks. It is also used on the Globalstar satellite phone network (Cyrus, 2006)

EV-DO was designed as an evolution of the CDMA2000 (IS-2000) standard that would support high data rates and could be deployed alongside a wireless carrier's voice services. An EV-DO channel has a bandwidth of 1.25 MHz, the same bandwidth size that IS-95A (IS-95) and IS-2000 (1xRTT) use. The channel structure, on the other hand as shown in figure 11, is very different. Additionally, the back-end network is entirely packet-based, and thus is not constrained by the restrictions typically present on a circuit switched network. The EV-DO feature of CDMA2000 networks provides access to mobile devices with forward link air interface speeds of up to 2.4 Mbit/s with Rel. 0 and up to 3.1 Mbit/s with Rev. A. The reverse link rate for Rel. 0 can operate up to, 153kbit/s, while Rev. A can operate at up to 1.8 Mbit/s. It was designed to be operated end-to-end as an IP based network, and so it can support any application which can operate on such a network and bit rate constraints.

Benefits of UCIC to the Health Sector of Developing Countries

The benefits of Unified Communications and Integrated collaboration in the health sector are not rip-and-replace

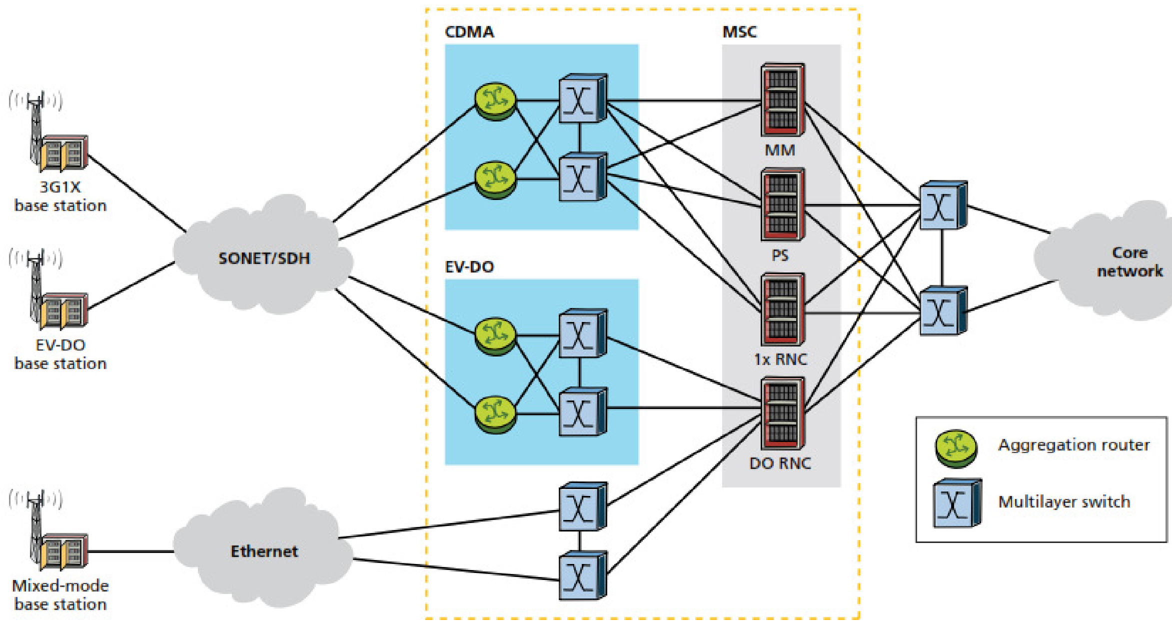

Figure 11. Present mode of operation: Many disparate network elements needed for IPBH for CDMA and EV-DO (Cyrus, 2006)

solution. But Keep the phone system, fax and software applications you already have and use UCIC to bring them all together. Then deliver voice, SMS and email to a single inbox on a mobile, laptop or PC. It is possible see where everyone in the health sector or referral network is at any time, find out when they are free and how best to contact them (Boyle, 2006).

Video conference with patients and colleagues and gain access to specialist advice without inconvenience of travel, monitor and treat patients in their homes - one can create a virtual ward where patients can be treated and monitored at home, locate and contact staff more easily, communicate best practice faster. UCIC provides a single, integrated location where staff can share resources, search for experts and information, collaborate on documents, maintain task lists, implement workflows and share patient information, Train without travel and timeframe - Using Polycom Round Table device, healthcare professionals can attend virtual training sessions, stay on top communication. With just one inbox for email, voicemail and fax messages, clinicians can receive messages in the ward or between locations and communicating via cloud. With a flexible UCIC cloud computing platform, healthcare sector can get the communication solutions they need without investing up front in expensive infrastructure (Boyle, 2006).

Healthcare workers rely on a constant flow of information in order to manage their patients effectively. In the health sector, this information is delivered physically by someone having to carry the files or may have been delivered to each ward through a single computer station, which is cumbersome, time-consuming, and takes valuable time away from monitoring and caring for patients.

Real time access to patient charts, laboratory results, and medical histories can be made available through wireless devices at the bedside. There are also benefits in reducing paperwork and needless human traffic. Less time is required inputting notes and more time available to spend with patients. There are benefits relating to decision support and computer-assisted medicine. The need for mobile “evidence-carts,” consisting of evidence-based medicine and medical reference material at the point-of-care has been described (Boyle, 2006; Olufemi, 2006) adverse drug events are primarily caused by physician error and many of these errors result from problems with point-of-care drug knowledge.

Connecting patients to monitors and monitors to local area networks requires a large number of cables. This wiring is generally inconvenient and particularly troublesome if a patient needs to be mobile or a patient is stationary but the layout of equipment (operating table, anaesthesia equipment and monitors) is rearranged. There are pressures within healthcare to minimize error rates, conduct diagnoses on the bases of real-time patient data, improve efficiency and reduce costs. Implementing wireless technologies is a solution to these pressures.

Specific healthcare areas that can benefit from real-time wireless access to data include admissions, laboratories, medical records, radiology, nursing and bedside care, emergency services, and home health care. Benefits to clinicians include documentation of a

Table 1. Comparison between connectivity technologies

Connectivity Technology	Data Rates	Application	Network	Typical range	Frequency ranges	Modulation	Key attributes
Dial-up	33-56 Kbps	Personal area/internet	IP and P2P				Flexible
Cable Modem	30-38Mbps	Internet	IP and P2P		24MHz		Flexible
ADSL	512Kbps-1Mbps	Internet	IP and P2P		80MHz		Flexible
Fiber to the Home	200Mbps	Broadband Internet	IP and P2P		1-34MHz	DP/QPSK	Low attenuation/ High throughput coverage
Powerline Communication	2.7Mbps	Broadband Internet	IP and P2P		24-500MHz	PPM/ OFDM	Throughput coverage
Bluetooth	2-6Mbps	Personal area	IP and P2P	5-20M	2.4-5GHz	TDM	Less cost
Zigbee	20-250Kbps	Personal area	IP and P2P	50M	900MHz-2.4GHz		Less cost
WiMAX	75Mbps	Broadband internet	IP	50KM	2-11GHz	QAM	Throughput coverage
Wi-Fi	54-108Mbps	Wireless LAN Internet	IP and P2P	100M	2.4GHz	DSSS	Wider bandwidth flexibility
Satellite	500Mbps-1Gbps	Broadband Internet	IP	22,236KM	Ku Band	FQPSK/ QAM	Throughput coverage
GPRS	56-114Kbps	Broadband Internet	IP	Mobile	900-1900MHz	EDGE	Flexibility
GSM	400Kbps-1Mbps	Broadband Internet	IP	Mobile	900-1800MHz	GMSK	Flexibility
LTE	75.4-299.6Mbps	Broadband Internet	IP	Mobile	2600MHz	QPSK/ 16QAM/64/QAM	Flexibility
EV-DO	2.4-3.1Mbps	Broadband Internet	IP	Mobile	800-1900MHZ	CDMA/EVDO	Flexibility

patient encounter that is prompt, complete and legible, not having to spend additional time at the end of a shift entering scribbled notes, and access to reference databases and evidence-based practice guidelines (decision-support) (Boyles, 2006) (Table 1).

Proposed connectivity architecture of UCIC

The best choice of the right telecommunication technology will determine the success of the implementation of the UCIC system. The deployment and exploitation of this system will not only depend on the telecommunication infrastructure, but also on other factors like electrical power, existing telephone and TV infrastructure, environmental conditions and databases. For the proposed system, the technologies and methods that have been highlighted to be used are Satellite, WiMAX, Wi-Fi, LTE and EV-DO considering their advantages to the location where these health sector facilities are. Health sector facility LAN's can be interconnected to form a Wide area Network (WAN) that links all the health sector to facilitate information sharing through the globe.

A combination of technologies and protocols allows the computer on the internet to communicate. In the advent of coverage beyond the WiMAX network, the communication will be possible through the satellite due to its capability to communicate at long distances in remote areas and WI-FI for terminals that have Wi-Fi adaptors while the mobile devices can be connected via WiMAX, LTE or EV-DO. WIMAX can serve as backhaul for Wi-Fi hotspots. Satellite was not the first choice because of the presence of glitches and longer latency while conveying the signals. This is because it is positioned far away from the earth and the wireless (microwave link) passes through several atmospheric layers. The overall proposed topology is as shown in Figure 12.

CONCLUSIONS

This paper presented a novel, wide-area telemedicine platform, laying emphasis on patient monitoring and homecare services. The topology of the proposed

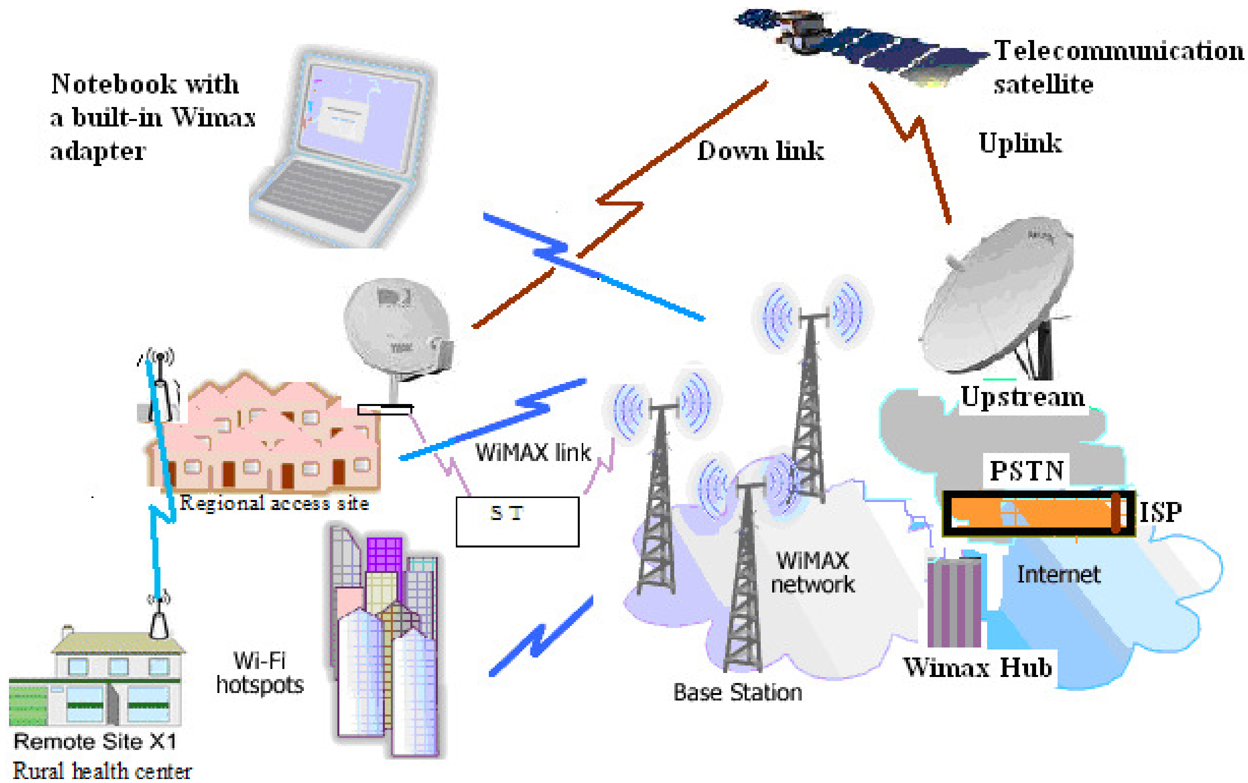

Figure 12. The Proposed Hybrid Topology

platform is hierarchical, involving an access network based on the fiber optic technology for backbone, WiMAX technology and network based on the DVB-RCS satellite communications technology for the lastmile. The monitored patients can be practically anywhere, even in geographically dispersed and isolated areas, where normally there is no terrestrial communications infrastructure capable of supporting similar services. For the deployment UCIC the hybrid connectivity topology is adequate. Unified Communications and Integrated Collaborations system can help to leverage the requirements of the health sector by reducing communication complexity, integrating disparate applications, and tying communications services directly to specific activity process to reduce human latency. UCIC creates a healthcare environment with highly regulated; data and information resources which meet strict requirements for privacy and protection.

UCIC offers noticeable and measurable benefits for health sector establishments looking to improve operational effectiveness. Through the deployment of UCIC, health sector organizations can advance customer services, maximize resource effectiveness, meet compliance requirements, and create new income opportunities. Therefore, the health sector organizations should develop explicit business cases for the use of UCIC technologies within their particular environment, paying close attention to situations that reduce latency, leading to tangible gain from speedy and comfortable interactions.

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