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Dr. Pastore's academic and corporate positions and involvements are too numerous to review here. At Pace, he has served as the Dean of the Lubin School of Business as well as Provost of the University. At Boston College he served as Executive Vice President. At Columbia University he has been a Visiting Scholar. At Siena College in Loudonville, New York, he served as a Trustee for over ten years. Among the companies for which Dr. Pastore has consulted are IBM, SwissRe, Verizon, AT&T, British Telecom, i3 Mobile, Cube Computers, and Virtual Reality, Inc.

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Wireless Technologies in Pre-Hospital Communications: An Analysis for Northern Westchester Hospital

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Abstract: *This report summarizes the findings of our preliminary study into emergency pre-hospital care communication systems conducted for Northern Westchester Hospital. Many hospital emergency departments are exploring new communication and information technologies that will assist them in providing higher quality of care by improving the speed of flow, the consistency, and the accuracy of information shared among all the parties involved in an emergency response team. This report describes some currently available or on-the-horizon communication and information technologies that may be appropriate for use in the emergency services field, discusses three communication systems currently being used by other hospitals, and provides three alternative approaches to obtaining the type of emergency communication system that will best fit the needs of Northern Westchester Hospital's emergency department. The particular solution to be chosen should ultimately depend on the time frame allotted for the project, the funds budgeted, and the number and skills of the staff members responsible for implementing the system.*

0. Introduction

Trauma is the fourth leading cause of death in the United States, killing more people each year than AIDS, cancer or heart disease. In fact, two Americans die because of trauma every 10 minutes.[1] The outcome of a trauma call is often determined by timely access to communication and reliable information, particularly within the "golden hour," the hour immediately after injury when resuscitation and stabilization are considered the most beneficial to patients.[2] While the use of radios and cellular phones has been a tremendous help to ensure the success of emergency personnel in coordinating their efforts during such emergencies, each of these technologies presents some significant problems. Issues of confidentiality and shared bandwidth among multiple agencies arise when radio technology is utilized. With wireless cellular phones, problems include unreliable or unavailable cellular coverage in certain service areas and limitations of voice communications in diagnosing and treating certain medical emergencies. These issues are challenges facing almost all emergency service agencies around the world today.

Our primary concern here is the emergency department at the Northern Westchester Hospital, a suburban community hospital in Mount Kisco, New York. During an emergency, many individuals and departments are involved in the pre-hospital care of the patient and the

management of the emergency scene. They include dispatch, police and fire first responders, volunteer EMT ambulance crews, paramedics, and the staff at the hospital. The above-mentioned problems with the use of radios and cellular phones have limited their ability to timely communicate with one another and to share reliable and current information. In their attempt to address these problems, the emergency department at Northern Westchester Hospital is interested in exploring new communication and information technologies that will assist them in providing higher quality of care by improving the speed of flow, the consistency, and the accuracy of information shared among all the parties involved in an emergency response team. The purpose of this report is to assist Northern Westchester Hospital in this endeavor.

There are three main sections in this report on the investigation of emergency pre-hospital care communication systems. The first section is a discussion of some currently available or on-the-horizon communication and information technologies that may be appropriate for use in the emergency services field. This section will also include a discussion of the advantages and disadvantages of all these technologies. The second provides information about three communication systems currently being used by other hospitals. Lastly, utilizing the information presented in the previous two sections, recommendations are provided concerning the type of emergency communication system that might best fit the needs of Northern Westchester Hospital's emergency department.

1. Wireless Computing and Communication Technology: A World of Possibilities

Wireless communication and computing are poised to take off the way dot-coms did a few years ago. For emergency services, the possibilities that wireless technology and its applications promise will mean more accurate and timely information exchange so that needless morbidity and mortality can be prevented. There will be ambulances that can access a route optimization system and get real-time updates on road conditions to make sure the rescue team reaches the patient and gets the patient to the hospital as quickly as possible. Vitals and other pertinent medical information collected at the emergency scene can be sent ahead to the emergency room prior to the arrival of the patient. A physician in the emergency room can receive live images of the patient's injuries so that the necessary preparations for treatment can be made while the patient is en route to the hospital. All these scenarios may have once sounded like excerpts from science fiction novels but now, thanks to products like the ones discussed below, they can and have become reality.

Wireless Broadband

Wireless Broadband[3] is a broadband feed delivered to your home or workplace over a ground-based antenna system or via satellite signal. It is a dedicated high-speed Internet connection that is sent through the atmosphere. It operates in the 2.4GHz radio band and can be up to 100 times faster than dialup. Businesses can use broadband networks for videoconferencing, for example, and to let employees telecommute. In addition, links can be

established in even the remotest parts of the country. Today, there are two major wireless broadband technologies: fixed wireless and satellite.

Fixed wireless derives its name from the fact that its signals are delivered from stationary, or "fixed," antennas and towers to antennas mounted on buildings, homes and other structures. The systems use microwave radio frequencies to deliver Internet-access speeds of up to 1.5 megabits per second (mbps) compared to the 56 kilobits per second (kbps) that a dial-up modem offer. The two types of wireless broadband are: MMDS (Multichannel Multipoint Distribution Systems), which used to be called "wireless cable." It also delivers TV service to about 1 million U.S. households and LMDS (Local Multipoint Distribution Systems), which primarily serves the business community in most major U.S. markets. Fixed wireless can be purchased through such companies as WorldCom, Sprint, WinStar, NextLink and Teligent. Sprint Broadband Direct charges $99 for equipment and $39.95 a month for residential service. NextLink, WinStar, Advanced Radio Telecom Corp. and Teligent, which serve mostly businesses, typically charge about $300 for equipment and installation. Monthly charges run from $89.95 to $699 depending on the service's speed.

The second type of wireless broadband is satellite-delivered broadband. It allows a user to call satellite-delivered service Internet access from outer space. Satellites beam their signals to an antenna the size of a large pizza pan mounted on the side or roof of your household or business. That dish is connected to your computer by two cables and a special card -- a link that can download information at the rate of 400 kbps. Services are delivered by three major sources. Direct Broadcast Satellite (DBS) services, Geostationary Earth Orbit (GEO) satellite systems: Lockheed Martin's AstroLink service and iSky Inc., among others, will launch high-speed broadband services primarily to businesses in the next two years, and Low Earth Orbit (LEO) satellite systems: Skybridge and Teledesic provide "broadband-in-the-sky" services. The software, antenna, cables and other items for DirecTv's DirecPC service will cost about $300 to $550, depending on who installs them and monthly service costs $29.99. Hardware for EchoStar's broadband access service costs from $99 to $250 and monthly service starts at $21.95.

As wireless broadband technology advances and more service providers enter the market, wireless broadband systems will become more powerful and less expensive. In the next few years, the use of laser beams in "infrared broadband" service can deliver Internet-access speeds two or three times faster than today's speediest connections. In the meantime, users must be content and live with the following drawbacks of wireless broadband:

- LMDS service can slow down in a heavy rainstorm or blizzard.
- MMDS and LMDS service can be affected if trees, hills and other geographic features get in a signal's way.
- An MMDS system signal sometimes has trouble penetrating a building's thicker walls.
- With satellite-delivered broadband, the antenna must be able to face the satellite delivering your signals.

Wireless LAN (WLAN)

A wireless LAN (WLAN)[4] is a local area network (LAN) without wires. WLANs have been around for more than a decade, but are just beginning to gain momentum because of falling costs and improved standards. WLANs transfer data through the air using radio frequencies instead of cables. They can reach a radius of 500 feet indoors and 1000 feet outdoors, but antennas, transmitters and other access devices can be used to widen that area. WLANs require a wired access point that plugs all the wireless devices into the wired network.

A new standard put out by the Institute of Electrical and Electronics Engineers (IEEE) called 802.11b or Wi-Fi is making WLAN use faster and easier. 802.11b transfers data at speeds of up to 11Mbps (million bits per second) in the 2.4 gigahertz radio band (a license is not required for this band). 802.11b is an open standard, unlicensed wireless spectrum, which means the use of the underlying technology and radio waves is free. There are numerous types of devices out on the market that are configured for 802.11b connectivity. These devices include, laptops and a variety of handheld devices. 802.11b cards can range from $150 to $275. The biggest issue with WLAN is security. A small research group at the University of California at Berkeley recently put out a report stating that they found flaws in the 802.11b standard. Their report states that they were able to intercept and break encrypted transmissions over the wireless network.[5] However, with some additional security on top of what is provided by the hardware, all concerns about security and 802.11b wireless networking should be dispelled. Some examples of such added security measures include, a "real" Virtual Private Network (VPN) solution that runs in software (between your machine and a gateway or firewall on the other side of the 802.11b base station) and protocols that include their own encryption security (such as accessing e-mail via SSL-secured web pages). Another problem with WLAN is that the air band can become overcrowded if too many users in the same area have WLANs.

The use of WLANs is already penetrating the healthcare and emergency services sectors. Hospitals such as St. Bernard Hospital and Health Center in Chicago and Miller-Dwan Medical Center in Duluth, Minn. have switched to 802.11b LANs in emergency rooms. WLANs have made it possible for administrators, doctors, and nurses to collect patient information using notebook computers and to transmit the data to patient-management systems.[6] In the area of emergency services, WLANs are being deployed by agencies like the Federal Emergency Management Agency (FEMA). FEMA assists agencies actively dealing with rescue and recovery such as fire and police departments and the U.S.Army Corps of Engineers, gathering information and staging additional support as situations arise. FEMA uses a fleet of 802.11b wireless laptops with MAC (Media Access Control) addresses, instead of standard encryption, to prevent unauthorized access to the DFO's wireless data.

Electronic Medical Records (EMR)

There are enormous pressures on the healthcare industry to embrace information technology, specifically, electronic medical records. One reason is that the managed care environment compels hospitals and physicians to reduce their costs and increase their efficiency. A second reason is that the Federal government has established a goal of reducing medical errors, currently the 8th leading cause of death in the U.S., by 50% in the next five years.[7] Electronic medical records, if designed to integrate every point of service in the healthcare delivery system, can potentially address both these issues.

EMRs come in various forms: wireless, desktop, and Internet-based. Wireless systems have the advantage of both small size and portability. A wireless computer is at hand whenever a doctor needs it. Downsides, however, include expense - approximately $4000 per unit - and the risk of damage or theft. Desktop EMR systems obviously require larger, multiple pieces of equipment than wireless ones. They also should be installed in every exam room and workstation. Price, however, is an important differential, especially for large hospitals or group practices purchasing many units. The newest trend has been the migration of EMRs to the Internet. The Application Service Provider (ASP) model, as it's called, enables practices to "rent" EMR software from vendors. Physicians can download the software from the vendor's Web site and run it on their own systems, or they can use a browser to interact with it. Data are stored at an off-site location rather than on a file server in the physician's office. Many of these Internet-based EMRs allow patients access to their personal medical records, which raises security and confidentiality concerns, but also presents the opportunity for patients to participate more fully in the decision-making and treatment planning processes.[8]

Some significant changes in EMR product design include the availability of biometric identifiers and a broader range of data entry methods. Biometric identifiers use physical characteristics unique to a particular individual, such as a fingerprint or retinal pattern, to identify users. This technology might eventually make password protection obsolete. Data entry methods have also evolved; more vendors now offer light pens, touch screens and voice recognition as alternatives to the keyboard and mouse.

The range of prices on EMR systems varied greatly depending on the configuration and type of practice. Some EMR products are priced per user license. Others charge more for the first license and discount subsequent licenses depending on the number of users. Some vendors bundle the costs of the hardware and software. Some low-priced EMR products are available, but their functionality is limited. These types of EMRs may be ideal starter systems, but it will be costly to add bells and whistles later. On the other hand, an expensive full-featured system may not be economical if only 5 to 10 percent of its functionality will be used. The most commonly reported pricing structure for ASP systems was a start-up fee plus a monthly subscription rate. Some ASP systems also charge transaction fees.[9]

The following are just some of the EMR systems currently on the market. ChartWare[10], EpicCare[11] and Health Probe[12] are conventional EMR systems rated highly for their general design attributes, functionality for health care providers, functionality for patients, and the EMR system market, functional requirements and costs. Based on these same criteria, NextGen[13] and topsChart[14] also come highly recommended as top-rated ASP models.[15] Another product to watch for is the Open Healthcare Group's XChart Project.[16] Its goal is to create an electronic medical record that is easier than paper records. XChart is an XML-based open source implementation that makes it portable across operating systems and languages. Additionally, XML can be transformed into many presentation formats including HTML for rendering within browsers and WML for wireless devices. Finally, there are also some EMR products on the market specifically geared towards emergency services such as VitalWorks[17] and HealthMatics EMR.[18]

SafetyPAD™

SafetyPAD[19] is a comprehensive flexible, Windows 9x, NT, 2000 computerized pre-hospital information management system that allows agencies to collect, reference, share, assimilate, and distribute call and patient emergency medical information. It is comprised of two unique systems: SafetyPADmobile and SafetyPADbase. SafetyPADmobile helps guide medics through documenting and assessing various stages of a patient encounter through an easy-to-use pen and voice-enabled interface. For added freedom and mobility, a flexible, rugged, wearable, device is available to work with the $1300 SafetyPADmobile. The ViA II Wearable is a fully functional 1.2 pounds Pentium-class computer that can be worn like a belt. It comes with 32 or 64 MB DRAM, 2.1 GB mass storage device, peripheral device options such as audio headsets and head-mounted display, and optional modular add-ons like wireless LAN and GPS or Differential GPS cards. Additionally, medics have the option of managing information hands-free by utilizing the voice entry and prompting feature. The second component of SafetyPAD is the SafetyPADbase, which is an open architecture and configurable design system. It can be used to collect, distribute, analyze, and manage information. SafetyPAD is designed with an emphasis on flexibility; flexibility to customize the system to fit specific needs, flexibility to interface with a variety of systems, and the flexibility to upgrade to more advanced technologies and enhanced capabilities.

SONICblue ProGear

National Semiconductor originally trademarked the name "WebPAD" in 1998 when they developed the first prototype of a tablet-shaped Internet access device. Today, the same term may be used to refer to Internet Appliances, Thin Clients, Windows CE Tablets, regular pen tablets or even some of the upcoming Tablet PCs powered by a special version of Windows XP. One such product is called the ProGear[20], a $1500 11 x 9 inch Tablet PC that is just under one inch thick and weighs a little over three pounds. While the device is not ultra-rugged, its magnesium housing and screen lid makes it completely rigid and affords it protection. It was designed primarily as a vertical market device for applications in medicine, education, travel, entertainment, etc. The ProGear is a full-function computer that runs either on Microsoft Windows 98SE or Mobile Linux. It has a relatively fast processor (Transmeta TM3200, 400MHz), a 5.6GB hard disk, a battery life of about 2-6 hours (depending on the type of battery used), and an internal 802.11b socket for wireless connectivity. The screen can be manipulated either with a stylus or with a finger in conjunction with an onscreen keyboard, which comes in three settings: tiny, large, and ergonomically arranged. Though its 1024 x 768 XGA resolution on a 10.4-inch screen makes icons and text quite small, all images are razor sharp. Onboard connectivity is limited to one USB port, a power jack, a microphone jack, an IR port, and an audio-out jack.

Products like the ProGear can be portable, yet powerful tools to emergency rescue workers when used with emerging technologies like broadband and wireless local area networks (LANs). The use of such devices has the potential to improve efficiency, seamlessly collect, manage, distribute information, and even cut costs.

Cambridge Consultant SEE Camera

The United Kingdom's Cambridge Consultants have developed a rechargeable digital camcorder called the SEE camera.[21] The device can record up to 100 still pictures or 30 minutes of video on one battery charge. Once the images or video has been recorded, they can be sent wirelessly to a server's hard drive. Additionally, the unit has a touch screen with a stylus for marking on the images. A disadvantage of this device is that it runs on a UMTS (Universal Mobile Telecommunication System) 3G Network; hard to find here in the United States. However, the developers state that SEE can be made to work with Bluetooth or other wireless network standards. Another disadvantage is that SEE is a concept device and is currently not for sale. While Cambridge Consultants have no plans currently to market the product, it does hint that others can license and build it.

This device may be a useful tool to connect emergency personnel at the emergency scene with those located at the hospital. When used in conjunction with radios and/or cellular phones, SEE can augment the communication process by providing real-time images/video of a patient's injuries and his/her condition to hospital staff as well as provide a form of visual communication between physicians at hospitals emergency workers at the scene.

Joint Combat Information Terminal

Scientists at the US Naval Research Laboratory have developed the first piece of communications hardware that can simultaneously receive and transmit voice, data, and video signals. The Joint Combat Information Terminal[22] can interact with wireless systems past, present, and future using eight channels that cover the spectrum from 2 to 512 megahertz. Received signal are converted to digital data that n be retransmitted on any other frequency. Civilian applications are projected to appear within two years in such areas like emergency dispatching and crisis management.

2. A Look at Other Pre-Hospital Systems

Today, mobile devices and wireless technologies similar to those mentioned above are already being incorporated into existing ambulance-hospital communications technologies. Emergency service agencies around the United States and in Europe are implementing systems that use the most up-to-date communications technology available to ensure best care possible. Descriptions of three such systems will follow: Sweden's IS Swede Information System, Virginia's Integrated ITS Public Safety System, and San Antonio's LifeLink System.

Sweden's IS Swede Information System

To ensure that paramedics obtain real-time information and efficient communications when saving lives, the Swedish National Board of Health and Welfare initiated a project called IS Swede.[23] CB radios and wide-area cellular phones were not providing the prompt, reliable interaction required by the hospitals and emergency staff. With the collaborative efforts of Hogia, Symbol Technologies, and Hewlett Packard, the new IS Swede information system connects central and hospital-based networks in real-time with the ambulance fleet using

database management, GPS tracking, wide-area networking (WAN), wireless local area network (WLAN), and mobile computing.

Using web interfaces, various emergency agencies can have access to central servers and hospital database networks. These servers and databases store information on citizen's medical history, disaster planning, and hospital facility material and human resources. Anyone from hospital staff, healthcare officials, ambulance services, and even the Sweden central emergency broadcast system (SOS Alarm) can easily get access to this valuable information.

Communication, both voice and data, between the ambulance staff and the hospital is handled by a server (Hogia's UCD-97E vehicle computer) in conjunction with a wide area Mobitex network enabled radio and Symbol's SPT 1740 pen computer, respectively. The Mobitex network enabled radio is equipped with GPS (Global Positioning System) tracking technology so that the hospital will know the exact location of the ambulance. The SPT 1740 is a rugged, Palm-based 802.11 wireless, barcode –embedded pen computer that paramedics can use to collect medical information at the emergency scene. By recording critical information by way of barcodes, the risk of communication and medication errors is greatly reduced. Using Symbol's Spectrum 24 access point, the ambulance becomes a roaming wireless LAN that will allow medical information collected on the pen computers to be simultaneously transmitted to the hospital via the 80 MHz Mobitex System (a system that enables two-way data communications with the central database network) and the Hewlett Packard Jomada 820.

So far, 50 ambulances, seven hospitals, two SOS Alarm systems, and Sweden's National Board of Health and Welfare are wireless-enabled. The application of wireless technologies has improved communications between paramedics and hospitals and provided instant access to critical patient information. All of which has allowed emergency workers to work more efficiently and effectively.

Virginia's Integrated ITS Public Safety System (IITSS)

Serving as a cutting-edge model for crash response systems for the 21st century, the Shenendoah Valley of Virginia implemented a system called the Integrated ITS Public Safety System (IITSS)[24]. Aided by ComCARE (Communications for Coordinated Assistance and Response to Emergencies) Alliance, a non-profit Washington, DC-based coalition that facilitates the deployment of wireless technologies for emergency services, IITSS integrates data and information flows between participating emergency response agencies. The system collects data from automated crash notification systems, law enforcement, wireless carriers, 9-1-1 systems, and other sources, and then combines, organizes, and routes specific information to emergency providers and other entities supporting the response efforts. Because the system was designed as an open architecture, open infrastructure, and scalable system, IITSS can supplement and fully integrate with existing systems, is open to an unlimited number of applications, and can even supply information to outside applications such as traffic management and traveler alerts.

This data delivery network is comprised of the following components: an Emergency Provider Access Directory (EPAD), an Intelligent Message Broker (IMB), several web-based Geographic Information Systems (GIS) displays, a computer aided dispatch system (CAD), and public-safety answering points (PSAPs). The EPAD is a set of linked directories containing contact information for EMS and other emergency responders to help identify the proper agencies needed to respond to a particular emergency. Using the IMB as a switch, information about the emergency event is routed to all the responding parties and the data is displayed on

web-based GIS maps (provided by AcuoERS and Gannett Fleming) in addition to critical crash data (including real-time video), other information about the driver and incident (provided by the telematics service providers such as OnStar and ATX Technologies or a medical database system), and weather and traffic conditions in the area. The same data that is sent to a web-based GIS display is also sent to a Computer Aided Dispatch (CAD) system that is capable of receiving the standardized XML data (provided by Centurion Solutions). The CAD system is not only able to receive an incident notification, but also can be used to dispatch resources to the scene. Furthermore, this data can be sent to emergency management applications, such as NetCompliance's First Responder Communications System (FRCS), which can provide additional information to emergency responders about hazardous materials stored in facilities nearby an emergency scene. All this occurs in a matter of seconds because countless steps have been eliminated from the process.

Also instrumental in the success of this pilot program is the use of Palm handhelds and other PDA devices. The hand held devices are a low-cost and efficient way for emergency providers to collect, to organize, and to disseminate information. The use and dependence on paperwork is reduced because information can be sent wirelessly, infrared synched, and downloaded to disk or hard drive.

The events of September 11, 2001 have increased the federal government's interest in programs like Virginia's Integrated ITS Public Safety System. While Shenandoah Valley is one of several initial sites chosen to implement an integrated system, there are upcoming initiatives to make this a national model that will one-day link the entire country in this manner.

San Antonio's LifeLink System

Through a project called LifeLink[25], San Antonio, TX is experimenting with a combination of wireless and fiber-optic links to give emergency room doctors at a hospital a look at a patient in an Emergency Medical Services (EMS) ambulance. Previously, the ER team was dependent on a paramedic to describe a patient's condition and symptoms en route to the hospital, but LifeLink has changed all this. LifeLink, is part of TransGuide, a partnership among the city of San Antonio, the metropolitan transit authority, the Texas Department of Transportation (TxDOT) and several San Antonio research organizations. Begun in 1993 and formally opened in July 1995, TransGuide was selected a year later as one of four sites for the federal DOT's Intelligent Transportation Systems (ITS) Model Deployment Initiative (MDI). Seattle, Phoenix and New York are the other sites. The goal of TransGuide, as with other ITS programs across the country, is to use advanced technology to better manage traffic flow and to provide better response to accidents and other emergencies.

The LifeLink System provides a distributed mobile LAN to create a communication link between San Antonio Fire Department ambulances and local area hospitals. The system utilizes a standard Ethernet LAN protocol that enables the use of Simple Network Management Protocol (SNMP) techniques for network management of configurable system devices such as TOC Ethernet switching equipment and roadside Wireless Ethernet Bridge (WEB) radios. This allows the ambulance crew to conduct real-time videoconferencing with physicians at the hospital and the ambulance crew to use portable medical data instruments to send vital statistics to terminal equipment located in the hospital.

At a cost of $25,000 per ambulance, a LifeLink ambulance is outfitted with a rugged computer configured with applicable videoconferencing hardware and software, a video camera, and WEB radio (2.4 GHz computer-controlled wireless spread-spectrum radio).[26] The system is basically a one-button operation for the and is built in a modular fashion so that if one of the components fails, it can be pulled out and replaced rather than repairs having to be made aboard the ambulance. The videoconferencing hardware and software application enables bi-directional transfer of video, audio, and data and provides for CIF resolution (352 x 240), outputs an image scaleable to full screen, offers a local view output, and operates within the LifeLink System available radio bandwidth. If the video signal breaks up for any reason, a failsafe ensures that the ER physician will be left with the last good digital frame received on the hospital video screen until communications are restored. A separate data channel is provided as an RS-232 link operating at 38.4kbps for transmission of optional vital statistics data. The WEB radios communicate en route to the hospital via a system of 59 receiving antennas placed at TransGuide fiber hubs alongside the San Antonio freeway system. The roadside fiber-optic network costs $25,000 each.[27] The communications are sent from the hubs over fiber-optic lines to the TransGuide Operations Center. From there, the transmissions are carried via a T-1 phone line to the hospital. The reverse path handles hospital-to-ambulance communications.

The LifeLink System has been an instrumental tool for San Antonio in severe emergency cases where physician input is essential to the success of the emergency call. "We are certainly not using it yet on a daily basis," said Alex Mcleod, an EMS captain with the San Antonio fire department. "But most EMS people seem to like the system, and the potential is certainly there to use it more often. "It's such a natural fit for us," Mcleod said. "After all, that's our job in any accident: to function as the physician's eyes, ears and hands."[28] Only increased use and a much longer period for evaluation will tell how useful LifeLink will be, and one of the most important opinions will be that of the EMS community.

3. Possible Solutions for Northern Westchester Hospital

The emergency communication systems described earlier provide some ideas for potential solutions to Northern Westchester Hospital's challenge to improve their pre-hospital communication system. Three possible solutions will be presented, ordered from the most to the least preferred based on four criteria: the amount of time, money, skill, and manpower required to deploy the solution. The solutions all attempt to devise a system that provides reliable voice and data pre-hospital communications within a working budget of $250,000. Optional features include vehicle tracking and an electronic medical record system.[29] The three possibilities are the purchase of a total commercial-off-the-shelf (COTS) system, a combination build/buy solution, and a vendor customized system.

Solution 1:

The first possible solution is to purchase proprietary wireless computing products specifically designed for use by emergency services personnel. One such product is called SIREN[30], a software product developed by Medusa Medical Technologies Inc. SIREN meets the paramedic's need for a rugged, portable, interactive communication tool that is medically

intuitive in terms of work flow. It provides patient-specific graphical clinical protocols and reference to a pharmaceutical database that defines and guides the data collection process. It also provides real-time wireless data communication between the paramedics and the physician at the hospital. Finally, it is easy to use and has a highly efficient touch-screen technology, which automates data gathering and reporting so errors are reduced. SIREN also provides value to physicians and administrators because of its data management capabilities. The product allows for complete and comprehensive documentation of each patient encounter and all this data is easily shared wirelessly via a secure intranet, mobile computers, and printed reports through a variety of communication vehicles. SIREN's open architecture and user-definable work flow provides unlimited capabilities for customizing information collection, display, and storage.

There are other products similar to SIREN on the market. The SafetyPAD system, as mentioned earlier, includes SafetyPADmobile, SafetyPADbase, and a wearable, device called the ViA II Wearable. Another product is Symbol Technology's NetVision® Data Phone,[31] which is a $1350 wireless device that does almost everything. It combines voice communication, text messaging, voice intercom, data capture, bar code scanning, an embedded thin client, and an IEEE 802.11-compliant radio card to offer ultimate mobile computing communications in a single, lightweight device. Integrated with Symbol's award-winning Spectrum24 wireless local area network (WLAN), the NetVision Data Phone provides scalable, dynamic in-building connectivity. It is based on wireless IP-based packet-switched technology, known as Voice-over-IP, and provides high-quality service supported by the ITU H.323 standard.

Solution 2:

The second solution is a combination build/buy decision. The "build" aspect of the solution involves building a WLAN, an intranet, and integrating various store-bought elements into the final solution. The store-bought elements of the WLAN and other computing devices will encompass the "buy" portion of the solution. Implementation of this solution may be accomplished by student teams enrolled in Pace University's Software Engineering course.

The WLAN can be built in the following manner. The first step is to install a wireless access point containing a wireless transmitter and receiver, which will enable multiple computers to access the Internet using a single connection and a single IP address. Compaq for example offers two types of access points: the Compaq WL410 ($489) and the Compaq WL510 ($899). The number of access points will depend upon the geographical area the WLAN will need to cover. The second step will involve connecting computers to the access points and to prepare them for wireless access. Third, a broadband connection must be set up to provide access to the World Wide Web and email. Finally, the phone/thin client handheld devices need to be connected to the Internet over the broadband connection. In order to web-enable the handheld devices, a wireless adapter and software must be installed. Additionally, an IEEE 802.11-compliant radio card must also be installed to provide voice communications between the ambulance crew and hospital staff.

The WLAN is necessary for the mobile ambulance to access an intranet site to Northern Westchester Hospital's Emergency Department and to various other Internet sites using their handheld devices. The intranet site should be secure behind a firewall and entry is password-protected. The intranet site will contain links to work flow interfaces for clinical assessments and medical information collection. All the critical patient data collected can then be transmitted wirelessly to the hospital staff and be saved in a back-end database. Other resources provided on the intranet site could be emergency protocols including helpful images or diagrams and maps of

Westchester County. This site will also include links to external Internet sites such as online pharmaceutical databases, online mapping services, and possibly patient registries for various medical conditions.

Other aspects of the solution such as GPS tracking, EMR, and videoconferencing can also be purchased and added to the final system depending on how much money is available. GPS tracking can be provided by various devices and services. Spycompany.com, for example offers GPS-Web™ Vehicle Location System for $1899 and GPS-Web™ Vehicle Tracking Service System for a monthly cost of $15. An ASP electronic medical record system may be the best choice, as this would mean convenient and easy access to patient medical information as long as there is Internet access. Videoconferencing could be provided by products such as the Tandberg 1000.[32] With a price range of $4400 to $6500, the Tandberg 1000 is a small, portable, self-contained unit that can operate in a wireless LAN environment using a PC card (PMCIA).

Solution 3:

The third possible solution is to purchase comprehensive services from a vendor who can customize and design an integrated communication system that meets the specific needs of the Northern Westchester Hospital Emergency Department. Even though prices for such services were unavailable at the time the report was written, they have been included as possible solutions because their cost may fall within the $250,000 budget or be customized to fit the $250,000 budget.

One such vendor is Science Applications International Corporation (SAIC).[33] SAIC can be employed to design and implement an architecture that supports the objectives of the emergency department at Northern Westchester Hospital. SAIC offers comprehensive systems integration services, application development and interface support, network and infrastructure solutions, and consulting services for health care clients. The Maryland Institute for Emergency Medical Services Systems (MIEMSS) selected SAIC to design and develop their Emergency Medical Resources Center/Systems Communications Center (EMRC/SYSCOM) and to integrate their state-of-the-art information systems. SAIC designed the new facility and infrastructure and provided new software applications for helicopter flight following, voice teleconference system operation and control, and mobile radio voter system and operation management.

Conclusion

For emergency response workers, real-time information and efficient communications are crucial to saving lives in emergencies. Many emergency departments are ensuring this by integrating wireless mobile computing and communication technologies into its ambulances to guarantee prompt interaction between emergency workers and hospitals. In the case of Northern Westchester Hospital, wireless technology is the direction that the emergency department should head towards particularly in light of the problems that CB radios and cellular phones present. Wireless technology will eliminate the problem of unreliable and unavailable coverage. The particular solution to be chosen by Northern Westchester Hospital should ultimately depend on the time frame allotted for the project, the funds budgeted, and the number and skills of the staff members responsible for implementing the system.

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For interested readers:

The following are comments on the preceding manuscript from a review by a telecommunications system design expert.

Interesting paper. I was unaware of some of the systems that have been deployed and this paper gave a good summary. Two elements are a bit troublesome, but their significance depends on the level of the course.

Firstly, existing cellular and emergency services radio systems are deemed inadequate due to fundamental radio frequency propagation issues (that are not identified as such.) The reality is that any solution that is "wireless" needs to address these issues. It is curious that the proposed wireless solutions are assumed to work and are assumed to be cheap. The reality is that a wide area wireless network is expensive and has the same performance issues as cellular networks (that are dismissed as inadequate).

The second issue is the lack of network security analysis. Connecting this kind of data to the Internet is very troublesome from a security perspective, as is the use of wireless LAN technology. The security issues alone would make a nice masters thesis.

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