Medical Equipment Tele- and Condition- Based Maintenance with Enhanced Remote Diagnostic Access (RDA) and Computer Vision

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ABSTRACT

The current medical equipment maintenance model is "on site and physical", rather than "remote and virtual". There is no comprehensive or standardized remote diagnostic access (RDA) capability for biomedical technicians to troubleshoot and resolve problems remotely and securely. Additionally, the current operations model is "reactive", rather than "proactive", in terms of early problem detection and prevention. The lack of visibility to the health of medical equipment and the need to be on site for problem resolution, coupled with frequent rotations and scarcity of medical equipment technicians, continue to cause considerable downtime of critical medical equipment densities and is detrimental to the health care support to our war fighters.

Complex medical equipment such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Computed Radiology (CR) scanners, along with ultrasonic and laboratory devices are critical to the patients' treatment regimen. Unscheduled delays and/or extensive downtime of the equipment severely hamper the physicians' ability to diagnose and treat a patient's injury or medical condition. Complexity often requires the local maintainer to rely on external support or SMEs, many times from the equipment's manufacturer, to assist in the diagnosis and repair. This "wait and see" method coupled with the lack of any pre-screening capability to identify troubled areas, worn parts, or signal "out of tolerance" modalities can cause additional delays.

While medical equipment manufacturers offer variations of managed-services to monitor and maintain medical equipment in service for commercial installations, these offerings often can only support individual manufacturers' own brand and model of medical equipment. Furthermore, their service architecture and the providers' infrastructures generally do not comply with the government's security protocols and regulations. As a result, virtually all the offerings do not have the authority to operate (ATO) within the government networks due to the lack of accreditations and compliance. Compounding the problem is the fact that manufacturers are reluctant to release proprietary hardware and software specifications, access protocols, application programming interfaces (API), or software development kit (SDK) to allow independent development, integration, and support for telemaintenance in medical equipment operations.

The subject of this paper is to summarize the research and development of a new RDA capability, and a proactive monitoring system as the foundation of the new medical equipment telemaintenance framework. The RDA helps transition the maintenance model from "physical" to "remote", while the monitoring system helps transition the operations model from "reactive" to "proactive". In essence, the monitoring system is enabling the condition-based maintenance (CBM+) practice by proactively seeking and detecting conditions on medical equipment that may trigger a maintenance work order on-demand. As such, it will also help transition the management model from a "time-based" to "condition-based" practice. The research outcome is a unified remote diagnostic access gateway, the Teleconsole, with an efficient methodology for provisioning secure remote access for medical equipment diagnostics. This unique RDA gateway provides all the necessary tools to enable proprietary and legacy medical equipment, including those without native RDA support, to become telemaintenance-ready. The new methodology provides technicians with the ability to remotely perform diagnostic tasks and resolve problems without any time and physical constraints. The research continues with the development of a methodology, based on the concept of computer vision (neural networks) working in conjunction with proven techniques such as macro automation, to train computer systems to perform monitoring tasks on behalf of the technician around the clock. This research is in progress.

1.0 INTRODUCTION

For many decades, telemaintenance and condition-based maintenance have been well established ‘best practices’ for the Information Technology (IT) operations. However, most recent independent surveys still suggest that these capabilities are virtually non-existent, or not an enterprise-wide capability, in equipment operations outside the realm of IT services, such as healthcare, utilities, communications, and other sectors.

Telemaintenance is accomplished by a remote diagnostic access (RDA) capability that enables a remote technician to perform diagnostic tasks on equipment without having to be onsite, or the ability for the local maintainer to collaborate with remote subject matter experts (SMEs) assisting in the troubleshooting and repair of the equipment.

Condition-based maintenance (CBM) is accomplished by real-time sensors deployed to monitor the health of the equipment. When an impending problem is detected, the condition serves as a trigger for the responsible technician to perform a specific maintenance task on the equipment.

The research and development initiative is to establish a new medical equipment telemaintenance framework consists of two key objectives: the RDA capability to enable secure remote access for equipment diagnostics, and the Proactive Monitoring capability to enable early problem detection by leveraging the new RDA capability. Considering the RDA capability as “paving the roads” on which diagnostic activities and equipment statistical information can be transported, then the Proactive Monitoring capability can be viewed as “problem sensors” for early problem detections. Being able to detect impending equipment problems before they occur is the beginning of a transformation from the current time-based maintenance methodology to a condition-based maintenance (CBM+) operations model. All of these are fundamental building blocks of the telemaintenance platform; furthermore, they align with the requirements and objectives of the Hospital of the Future (HOF) initiatives as well.

2.0 RDA AND CBM IMPLEMENTATION CHALLENGES

In the IT world, console access has been standardized with the RS-232 protocol. Whether a DB25 (outdated), DB9 or RJ45 console port is on the device, the same software and methodology is used to access network devices or servers.

2.1 Proprietary Software and Communications Protocols (Standardization)

It isn’t the same for medical equipment. Each piece of equipment may have a different communication interface, as well as different software required to perform the maintenance. Original equipment manufacturers (OEMs) use proprietary software for the console access, placing dependencies on the manufacturers to provide management and diagnosis capabilities. This is good for their bottom-line as they provide managed services offerings, often times for different makes and models within their own product lines.

2.2 Non-disclosure by OEM (Interoperability)

Adding to this vendor “lock-in” is the fact that they are reluctant to release proprietary hardware and software specifications, access protocols, application programming interfaces (API), or software development kits (SDK) to allow independent development, integration, and support for telemaintenance. Without the ability to integrate or consolidate these individual and diverse management points, from various OEMs, the enterprise does not have a standardized and centralized management platform on which complex data-mining can be performed and analyzed.

2.3 IT and Biomed Operational Gaps (Alignment / Convergence)

Some of the more complex medical equipment are partially available via remote access, due to the fact that they have two management points. The first is a 'computer' part that runs a specialized OS, such as Microsoft XP Embedded, along with custom software used by the technician to operate the equipment. The second is a 'mechanical' part that is controlled by circuit boards and is accessible by the technician via the serial console and running proprietary diagnostic software. To implement full RDA for medical equipment, the IT organization assisting the efforts often does not understand the dual management points. If the IT engineers recommend some in-band access solutions, such as virtual network computing (VNC), remote desktop protocol (RDP), or virtual private network (VPN), then the solution negates the management point on the medical equipment that can only be accessed via out-of-band console. Conversely, if the suggested solution is serial console access, then the equipment cannot be accessed via in-band services as mentioned above, or other out-of-band console such as those using USB and KVM interfaces. As such, IT organizations' recommended solutions, based on products designed for IT operations, generally do not meet the requirements of biomed telemaintenance, such as form factor, in-band versus out-of-band access, serial console versus USB console, and text-based console versus graphical console (KVM products).

2.4 The Lack of CBM Capability

Monitoring of IT components is well established and an operational best practice to provide visibility to the health of IT resources. It also provides the predictability of when a problem will occur so that the administrators can proactively diagnose and resolve the problem before they can impact the overall operations. Proactive monitoring in IT uses standard protocols and tools adhering to those protocols over the 'in-band' network. Unfortunately, that same methodology is not applicable to medical technology operations. First, OEMs don't adhere to standards and continue to use proprietary management tools to maintain vendor lock-in. Second, device access for management and maintenance is 'out-of-band' through the console port and typical IT monitoring tools are not capable of utilizing that access method. With a properly implemented RDA capability in support of telemaintenance, it can also serve as the necessary transport for the implementation of the CBM capability.

All of the factors above contribute to the challenges organizations face to maintain a fully functioning and efficient health care facility. Some of the shortcomings of this on-site approach include,

1. **It is slow**. Because the technician or manufacturer support personnel need to go on-site for maintenance, the travel time needs to be accounted for. In addition, personal schedules can impact time to repair as organizations are reliant on a subset of individuals to perform the maintenance.

2. **It is costly**. Travel costs are quickly becoming a large expense in organizations. Because all work needs to be on-site, those travel expenses can quickly grow to be a financial constraint. But, it is also costly in another form – that of human health and lives. People rely on this equipment on a daily basis for emergency medical service and chronic care management, which can cost people their health, or even lives, if the equipment is down or not functioning properly.

3. **It is reactionary**. Due to the on-site nature of maintenance, it typically ends up being done in a break-fix manner. This contributes both to the cost and time necessary to make the maintenance repairs. Patient safety is directly affected by this. It has been recognized by the World Health Organization that 1 in 10 patients around the world are impacted by health care errors. It is unknown how many of those errors are as a result of out-of-maintenance or malfunctioning medical equipment.

3.0 PREVIOUS RDA IMPLEMENTATION ATTEMPTS

An earlier attempt was made to implement RDA capability for medical equipment using teleconferencing tools that worked effectively for telemaintenance of aircrafts and vehicles. This type of system is generally made up of a video camera, an audio device (microphone, speaker, or handset), a computer with pre-installed diagnostic software, a communication device for network connectivity (wired, WIFI, satellite link, etc.), and an optional battery for mobility. The system utilizes video for remote over-the-shoulder viewing during troubleshooting hardware failures, and the audio gears allow the local maintainer to communicate with the remote SMEs. When the system was used in medical equipment telemaintenance, the RDA capability provided by the system was found to be inadequate. Some of the limitations are:

1. In general, medical equipment troubleshooting requires proprietary diagnostic software supplied by the equipment manufacturer and they must run on the local maintainer's laptop. The software also requires a physical serial cable connecting from the laptop to the medical equipment's console port (a DB9 port is common although newer equipment comes with a USB port instead). Since the software is very specific to the brand, model, and firmware versions of the medical equipment being diagnosed, the local maintainer must use the software that matches the hardware component to ensure compatibility. This means, if the teleconference system is used for medical equipment telemaintenance, the computer found in the system must have all the diagnostic software pre-installed, including different version of the same software. Even if it is possible to pre-load all the diagnostic software from all the manufacturers into all the teleconference systems' computer, it is impossible to keep the versions of all software up-to-date on these systems.

2. The teleconference system is usually equipped with one serial port to support wired console access. This means the local maintainer cannot diagnose several equipments simultaneously, or he cannot efficiently troubleshoot on complex equipment with multiple console ports, such as the MRI.

3. The teleconference system is designed for on-demand applications. That is, a local maintainer would connect this device to the medical equipment at the time of need – when the equipment needs repair. This method is not a long-term solution given one of the medical telemaintenance's objectives is the proactive monitoring capability, which would require the teleconference system to have a persistent connection to all the medical equipment being monitored.

Another previous attempt to establish RDA for medical telemaintenance was the use of conventional remote access solution designed for telecommuters or teleworkers in the Information Technology (IT) world, such as a virtual private network (VPN) and other secure access gateways. This type of solution enables a remote user to connect to a computer at the office, or allows an IT support personnel to remotely access the user's computer to troubleshoot a software issue. When the solution was tested for medical equipment telemaintenance, it was also proven inadequate. The limitations are:

1. Telecommuter systems (hardware, software, or both) are in-band or network-based access solution.

They work effectively when the remote computer and its operating system are healthy. This type of solutions generally does not provision access for out-of-band methods, such as serial console, universal serial bus (USB) console, or keyboard video mouse (KVM) consoles. For medical equipment diagnosis or calibrations, out-of-band access method is required. As such, out-of-band access devices must be added to the in-band access solution. The resulting RDA solution becomes very bulky and difficult to manage, as explained below.

2. Conventional IT-centric access solutions are generally not designed for medical operations environment, such as the ER, mobile hospitals, and etc. First, the hardware form factor is designed for mounting on a rack. For medical equipment telemaintenance, the form factor should be miniaturized so that the access device can be embedded inside and become an integral part of the medical equipment.

3. Commercial off the shelf (COTS) products for out-of-band access are available, such as those serial-over-LAN devices designed for Supervisory Control And Data Acquisition (SCADA) applications, and KVM-over-LAN for headless server applications. This method of bundling different brands of out-of-band devices, with each one being a stand-alone or point solution, to create the RDA capability for medical equipment telemaintenance is not ideal because it is impossible to integrate all these COTS products into a single management point.

4.0 RDA RESEARCH AND DEVELOPMENT

In order to understand the issues pertaining to implementing RDA for medical equipment telemaintenance, the next few sections summarize various subjects that are relevant to the research approach and prototype strategy to be discussed later in the report:

4.1 In-band and Out-of-band RDA for Medical Equipment

In-band access is a “network-based” access method, which allows a technician to access the medical equipment via the network. This implies that the Operating System (OS) and the access application servers running on the OS in the medical equipment, such as the Virtual Network Console (VNC) server, File Transfer Protocol (FTP) server, Secure Shell (SSH) server, etc., must be fully functional.

Whenever the medical equipment is having a problem at the OS or firmware level (hardware), the network services supporting remote access often become unavailable; and consequently, the equipment can not be reached via the network. This is because the network driver and the associated services are not running when the OS is not operational.

Out-of-Band is a “non-network” access method, which allows the technician to access the medical equipment using a physical connection between the user and the console found on the equipment. The console port can be one of three types: serial (DB9, DB25), USB, and KVM. Universally, the purpose of the console port is to allow administrative access for configuration, troubleshooting, or calibration when the equipment is either not accessible via its network interface; or in some cases, certain administrative tasks can only be performed via the console. The term “console access” is analogous to an out-of-band access.

4.2 Understanding Console Access for IT Operations

In IT operations, network and server administrators typically use in-band access to perform routine maintenance tasks while the device is fully functional. However, for configuration changes or when the device is non-functional due to component failures, they must rely on the out-of-band or console access to configure and troubleshoot the problem.

A network technician generally uses a serial console access method for their remote diagnostic access. One thing to note is that the serial console access in the IT world has been standardized such that the software used to connect to a serial console on one brand of network router is the same for accessing the console on another brand; furthermore, the same software can be used to connect to the serial console on different brands of server. Specifically, the common protocols are Telnet and SSH for "terminal emulation access", the actual implementations are known as reversed-Telnet and reversed-SSH, respectively.

Another standard in IT operations for serial console access is the use of a serial console server, a device that accepts the user's commands via the network protocols and then relays the messages to the console on the device via a serial communication protocol. With this device, along with the standardized access protocols, remote diagnostic access capability for IT operations, even for out-of-band access, have been achieved and is a common practice.

A new type of serial console, based on the USB standard, appeared in recent years. The USB console access method is completely different from the serial console and it is still uncommon even for IT practices. The remote diagnostic access for IT equipment, based on the USB console access method, is almost non-existent.

A server administrator generally uses a network-enabled KVM console access method to remotely maintain servers. The KVM console is simply a device that takes the analog video output signals from the VGA port on the server and converts it to digital signals so that they can be transmitted over the network. The KVM console allows the administrator to take control of the server hardware (with the ability to control the mouse and keyboard while viewing the monitor output) as if he / she is physically in front of the server. The KVM access method used in IT operations is well established and can support virtually all hardware and OS platforms.

4.3 The Development of a RDA Gateway

As part of the research, commercial off-the-shelf (COTS) IT products were acquired to implement all access methods for all the medical equipment in the lab. At the conclusion of this experiment, a preliminary solution was established and it was able to provide RDA to all the equipment, even those with no native or built-in RDA functions. The solution consists of a large collection of hardware and software products from various vendors. While this solution can provide the full RDA capability for the medical equipment, it was deemed too expensive, complex, and bulky to be feasible for medical applications.

It was decided that a new RDA device must be custom built to provide all the RDA functions without the high cost, bulk, and complexity. The result is the development of a device known as the Teleconsole. The Teleconsole is a unique hardware appliance that has quantified all possible RDA methods and integrated them into a single device – one with a comprehensive set of ports, embedded software, security, and wired and wireless capabilities that can universally transform medical device with no built-in remote diagnostic capability into one that is fully telemaintenance-ready.

Teleconsole provides technicians with the ability to remotely perform diagnostic tasks and resolve problems without any time and physical constraints. With such a new RDA capability, a local maintainer can collaborate with subject matter experts (SMEs) via the "over the shoulder" view of the medical device; or a remote technician can "reach in" via secure access to calibrate machine components, retrieve error logs, or upgrade configuration files – all of which can be achieved through an extensive set of RDA functions that are agnostic to the brand, make, and model of the failing medical equipment.

IT support personnel are accustomed to having the ability to access all equipment remotely, including the console ports necessary for 'out-of-band' access. The latter piece has been solved in the IT world through the use of a serial console server – a device which accepts communications over the network and transfers them to the standardized RS-232 protocol and out the physical console port connected to the network device or server. By combining standard in-band access with the functionality of a serial console server, it provides alignment with the typical access methods that IT is familiar with.

Equipped with 6 DB9 serial ports and 4 USB ports – as well as network interfaces, the Teleconsole can provide in-band and out-of-band access methods in a single platform to both management points on even the most complex medical equipment. The in-band allows remote access to devices with an integrated 'computer' component, while the out-of-band access is used for the 'mechanical' component of the medical equipment.

OEM supplied diagnostic software has been developed to communicate directly with the console port on the medical equipment. The Teleconsole allows the software to think it is doing so even though the technician's laptop is not connected to any medical equipment. To accomplish this, a few steps are needed. First, a virtual communications port needs to be created on the technician's computer so the application thinks that it is speaking directly with the device via the COM port and a physical cable. Next, a piece of software running on the same computer needs to accept the traffic from the virtual COM and transmit it over the network to the serial console server physically connected to the medical equipment. Lastly, the serial console server transfers the communication directly to the console port on the medical equipment using the raw serial protocol. The same process using a virtual port and software transmitting communication over the network to the console server is also applicable for USB access.

5.0 PROACTIVE MONITORING RESEARCH AND DEVELOPMENT

In order to understand the issues pertaining to the proactive monitoring of medical equipment, it is necessary to understand the different characteristics of managing and supporting IT devices versus medical equipment.

5.1 Proactive Monitoring of IT Resources

Proactive monitoring of IT infrastructure components, such as networks, servers, applications, databases, and etc. has been well established. The monitoring and trending of IT component utilization, performance, and availability are critical and essential operational best practices. The visibility to the health of the IT resources provides the predictability of when a problem will occur so that the administrators can proactively diagnose and resolve the problem before they can impact the overall operations. It would be impossible for any mission critical IT infrastructure to exist and functioning optimally without the proactive monitoring and problem detection capability.

Proactive monitoring is easy to implement for IT operations because there is an abundant of products, as well as standards, API, and SDK that allow a monitoring tool to be able to communicate with the managed devices for data collection, statistic gathering, and etc. For the most part, hardware and software vendors in the IT world are very willing to cooperate by either adhering to pre-defined management standards; or they release proprietary specifications so their hardware and software can be managed by 3rd-party tools. If a vendor is unwilling to release such information, then enterprise customers will simply refuse to use their products.

5.2 Proactive Monitoring of Medical Equipment

Medical technology operations currently do not have a well defined management strategy across the board. It is still relatively primitive. The main reason is that medical technology operations are, for the most part, autonomous. And each silo of medical technology operations places heavy dependency on the equipment's manufacturer to provide the management as part of the maintenance contract. This practice is slow to change because the manufacturers do not want to, as they can capitalize on services revenue; and customers do not know how to, because there is no off-the-shelf product on the market as an alternative to the manufacturers' offerings.

The obvious reason for the lack of 3rd-party monitoring tools for medical equipment is due to the proprietary hardware and software interfaces. Even worse is the incompatibility of the proprietary protocols between equipment from the same manufacturer. As long as the manufacturers are not willing to release their specifications, and they continue to use proprietary protocols in their hardware and software interfaces, there will be no standardization.

The not-so-obvious reason is the fact that some complex medical equipment, such as the CT scanner, may have two management points: 1) the "computer" part that runs a specialized OS, such as the Microsoft XP Embedded, along with custom software used by the clinician to operate the equipment. For simplicity, we call this the "in-band" management of the medical equipment. And 2) the "mechanical" part that is controlled by circuit boards and is accessible by technician via the serial console and running proprietary diagnostic software. Again for simplicity, we call this the "out-of-band" management of the medical equipment.

5.2.1 The In-band Management

The in-band management point is actual a standard computer housed in a custom case and thus can easily be managed by existing IT-centric monitoring tools. This is because the OS is Windows based and the services running on this computer is network based. As such, as long as the computer is fully operational, any monitoring tools can be used to check its CPU, memory, disks, processes, and custom applications.

5.2.2 The Out-of-band Management

The out-of-band management point is only accessible via the serial console on the medical equipment. Furthermore, the statistics and the operational state of the equipment, in most cases, can only be obtained using the proprietary software that runs on the technician's computer. The technicians generally use the software to configure and calibrate the mechanical parts of the medical equipment.

With two separate management points, the statistics gathered can be deceiving if only the in-band component is being monitored via off-the-shelf IT monitoring tools. This is because while the "computer" portion may be healthy with no apparent sign of trouble, the mechanical part may be severely mis-calibrated, requires oiling, or is experiencing high temperature that may be damaging to the equipment, if left neglected, or may produce erroneous patient test results.

5.3 Proactive Monitoring System Development

The objective of the research is to evaluate off-the-shelf technology that can be leveraged in developing a new monitoring platform that can be programmed to emulate medical equipment technicians that systematically, automatically, and proactively accesses the medical equipment to monitor their operating state. This system can be scheduled to perform checks when the medical equipment is not in use or when the technician is not available on site to perform maintenance over an extended period of time.

In order to solve a problem with infinite diversity, due to the proprietary hardware and software interfaces on medical equipment, and with no access to any specifications, protocols, API, or SDK from the equipment manufacturers, the strategy is to identify the commonality and predictability that exists in medical technology. There is one: the human element is a consistent and reliable criterion that medical equipment manufacturers must take into consideration when they engineered their products. Namely, it is the software user interface, designed for human interaction with the medical equipment, as the basis for our project design focus.

The process of simulating a trained technician, that is connected to the serial console of the medical equipment and is navigating the proprietary software to perform specific maintenance tasks, can be broken down into three key steps: navigation, observation, and action.

Navigation represents the sequence of key presses and mouse clicks over an application UI visible on the technician's computer screen. Each of his activities is an input and the screen change (rendering of a new page), object change (a button is depressed after his click), character painting (echo of his typed text), etc. are outputs.

Observation represents his viewing of the presentation on the screen. If the software is not waiting on a backend process to complete (ie: no hour-glass on the screen), then this is "idle" time. Otherwise, it is "wait" time.

Action represents his activities after the idle time starts. If the activity is key presses or mouse click in the application, then he is back to the Navigation step. If his activity is outside the application, he may be performing a remediation for a problem he saw during the Observation step. While auto-remediation capability can be added to this project at a later time, it is outside the current scope of the "monitoring" objective.

We are currently developing the monitoring capability based on the navigation and observation steps. This means the system can act as the technician in traversing the UI and reviewing the results.

5.3.1 Developing Navigation Capability with Macro-based Automation

One existing technology that is commonly used by IT administrator is the macro-based automation tools. This type of tools is designed to record and replay a user's activity, within an application running in a graphical desktop environment, such as Windows, to automate repetitive tasks without programming. Out-of-the-box, this type of tool is not efficient because a recorded segment can't be easily modified. For example, if there are 10 steps to perform task A and there are 11 steps to perform task B (the first 10 steps are identical as task A), the user has to create a new macro from scratch, recording the first 10 steps before doing the 11th. However, it is possible to enhance an existing macro tool to overcome this limitation by manipulating the recorded segment in a macro.

With customizations and enhancements done to an off-the-shelf macro tool, we will be able to train a computer (once), by recording the activities of a trained technician performing a set of maintenance checks;

we can then subsequently edit and tag certain segments to create macro sets for navigating to various areas within the proprietary diagnostic software. When each macro is replayed at scheduled intervals, the result is simulating the navigation of the technician for performing a specific maintenance check on the medical equipment. This is the "navigation" capability of the monitoring system.

5.3.2 Developing Observation Capability with Computer Vision

One existing methodology, known as screen scraping, is a technique in which a program is designed to extract data from the "display" output of a second program, whereby the second program does not have to be running on the same computer. The significance of this type of data extraction, which is different from parsing data between applications, is that screen scraping collects data that is in the final presentation state of the data designed for human viewing. This method is popular for application developers to interface with a legacy or 3rd-party software without having access to the protocols, data structure, or API.

Utilizing screen scraping technique, we can implement a method of "observation" for our monitoring system. In the previous navigation step, a macro represents the sequence of activities performed by the trained technician to go from the start of the UI to a destination where he then "observes" the data output on the screen. The screen that the technician is viewing has been captured as an image. The screen scraping step is essentially an image manipulation process, based on neural networks programming, designed to quickly obscuring the majority of the graphical area and identify all the "useful" areas based on various algorithms. Useful areas are defined as tab labels, button states, fixed fields (grayed out), editable text fields (fields that are changeable), and etc. Mimicking a human, this process can accurately identify all "useful" areas because there is a finite set of object that can appear in an application UI.

Once the screen image has been fully "marked" or "dissected", the screen scraping process continues to the next stage: data recognition. This process is known as Optical Character Recognition (OCR). OCR technology has existed for many years and one common use is extracting contact information from business cards. OCR is not effective when it is used on handwriting, printed characters that use non-standard fonts, or large image area (such as translating a faxed document into editable content). In the case of processing application UI screen images, focusing only on the marked "text" areas, the speed can be extremely fast and can achieve 100% accuracy because of the small area to scan and the fonts in application UI are very common, respectively.

When the OCR process completes, the extracted data is mapped to a predefined structure in the database based on the macro used; and subsequently, an XML file can be generated for exporting the data to be further processed by an external program. For the monitoring process, the XML file can be a formatted and forward to a syslog server, a snmp collector, or to an enterprise monitoring system.

6.0 CONCLUSION

Since last 2008, the research and development efforts for medical equipment RDA and CBM+ enablement have created the framework for the telemaintenance and condition-based maintenance transformations. This framework can be expanded overtime to include and adopt other IT best practices in operations processes, security measures, and resource manageability.

The Teleconsole provides a centralized and standardized RDA method in a single platform to access virtually any device regardless of the complexity, brand, make or model. The RDA function paves the way for the

Condition-based maintenance, which allows for proactive maintenance and management of the equipment – leading to true telemaintenance. The new telemaintenance solution will improve the availability and resiliency of the medical equipment, reduce costs associated with unscheduled repairs, and validate equipment performance measures, which in turn provides the physicians with the ability to deliver quality health care to their patients.

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