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Windows Server 2008

Microsoft Visual Studio

Vanderbilt University Medical Center

Medical Center Develops Patient Screening Tool Using Enhanced Web Technologies

Overview

Country or Region: United States
Industry: Healthcare

Customer Profile

Vanderbilt University Medical Center (VUMC) is a leader in innovative patient care, research, and education. Based in Nashville, Tennessee, its hospitals and clinics treat over one million patients each year.

Business Situation

Sepsis is the tenth leading cause of death worldwide and accounts for 40 percent of total ICU costs. VUMC wanted to develop an integrated information system to enhance early detection and treatment.

Solution

Accent on Integration used the core Web technologies of Microsoft® Visual Studio® 2008, Windows Server® 2008, and Microsoft SQL Server® 2005 to develop the Patient Safety Screening Tool for Sepsis.

Benefits

- Rapid Web application development
- Integrated workflow design tools
- Centralized hosting environment
- Flexible, extensible customization
- Enhanced administration, management

Accent on Integration

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Severe sepsis is the tenth leading cause of death worldwide and costs hospitals over U.S.$16.7 billion each year. Vanderbilt University Medical Center (VUMC) decided to develop a technology-based patient screening tool to help its clinicians more effectively detect and manage sepsis. Physicians at VUMC collaborated with the healthcare application developers at Accent on Integration (AOI) to create a Web-based solution called the Patient Safety Screening Tool (PSST) for Sepsis. To optimize the solution, AOI used the enhanced Web technologies of Microsoft® Visual Studio® 2008, Windows Server® 2008, and Microsoft SQL Server® 2005, along with Microsoft Office SharePoint® Server 2007 and the 2007 Office system. AOI maximized the dynamic new capabilities of .NET Framework 3.5 and IIS 7.0 to create a flexible, extensible solution for VUMC.

Microsoft

"If we detect sepsis early enough and apply the right treatment protocols we can significantly improve the outcome for our patients. Early detection and appro-priate intervention are critical."

Michael Higgins, MD, Chair, Department of Anesthesiology, Executive Medical Director for Perioperative Services, Vanderbilt University Medical Center

Situation

Throughout its 133-year history, Vanderbilt University Medical Center (VUMC) has been committed to the use of knowledge-based tools that help its clinicians provide exceptional healthcare to patients. This commitment to innovation has earned VUMC a reputation for leadership in research, medical education, and patient care. Vanderbilt University Hospital was one of only two Tennessee hospitals selected by U.S. News and World Report for inclusion in its list of America's Best Hospitals, and 49 of the 76 physicians chosen by the magazine as America's Top Doctors in Tennessee practice at VUMC.

In 2006, over one million patients visited Vanderbilt Clinics, and more than 46,000 patients were admitted to the four Vanderbilt Hospitals. By providing quality care to such an extensive patient population, physicians and clinicians at VUMC have become increasingly familiar with the impact of sepsis. Sepsis is characterized by a systemic inflammatory response to infection which can progress to circulatory system dysfunction, multiple organ failure, and eventually death. Severe sepsis is common, with over 750,000 cases diagnosed in the United States each year. It is the tenth leading cause of death worldwide, killing approximately one person every minute (Angus, DC et al. *Critical Care Medicine*, 2001; 29:1303-1310).

"Sepsis is a complex disease process that results in a high degree of morbidity and mortality," says Michael Higgins, MD, Chair of the Department of Anesthesiology and Executive Medical Director for Perioperative Services at VUMC. "It's a disease that's widespread but difficult to detect and challenging to manage. We do know, however, that if we detect sepsis early enough and apply the right treatment protocols, we can significantly improve the outcome for our patients. Early detection and appropriate intervention are critical."

Not only is sepsis a leading cause of death, it also accounts for nearly 40 percent of all intensive care unit (ICU) costs. In 2001, hospital expenses for patients with severe sepsis totaled over U.S.$16.7 billion (Angus, DC et al. *Critical Care Medicine*, 2001; 29:1303-1310). The burden of these costs to providers could increase substantially due to an August 2007 ruling by the Center for Medicaid and Medicare Services (CMS) which limits payment to hospitals for certain preventable, hospital-acquired infections. Sepsis—along with other acquired infections like pneumonia, urinary tract infections, and methicillin-resistant staphylococcus aureus infections—is slated to be added to the list of conditions covered by this ruling in 2009.

Leland Lancaster, MD, Director of Commercial Development, Department of Anesthesiology, explains that the first step in detecting and treating sepsis is to standardize diagnostic indicators and treatment protocols. "Several critical care associative groups came together to evaluate the available information regarding sepsis and to determine the best ways to treat these patients—both early on in the progression of the disease and when the patients are already septic and in shock," Lancaster says. "They formed consensus statements about the common denominators that would point a physician or clinician to suspect sepsis, then recommended specific treatment processes." Aggressive treatment protocols, also known as bundles, have been shown to lower mortality rates by 30 percent for severely septic patients and by 50 percent for patients who are at risk but have not yet developed the disease (Rivers et al, *New England Journal of Medicine*; 2001; 345:1368-1377).

"The consensus statements and treatment bundles are a great starting point, but it's not

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enough," says Higgins. "Implementing them and making sure that everybody stays on track with them is the real challenge. This is where we see a huge opportunity for information technology to deliver a real solution."

Solution

For over 12 years, VUMC has used Microsoft® tools to develop in-house information management systems. "One of our strengths has been using Microsoft technologies to develop software that really provides value to our clinicians," says Lancaster. In 1995, the Department of Anesthesiology developed the Vigilant Perioperative Information Management System (VPIMS) to bring electronic charting and data analysis to surgical patient care. Another tool, Vigilance©, monitors patient and systems data in surgical settings and sends alerts and notifications to care providers. VUMC has recently made VPIMS and Vigilance© available to other hospitals as a commercial product through a third-party reseller, Acuitec.

"These tools are very helpful for getting patient information to the clinicians," explains Higgins, "but what we'd like to work towards is creating a tool to help us detect problems and effectively manage them. When Microsoft suggested we work together to create a patient surveillance tool that would screen for sepsis while also gathering information for the clinician—we saw this as the perfect win-win situation."

Defining the Infrastructure

VUMC turned to Microsoft and Accent on Integration (AOI), a Microsoft solutions partner, to help it define and develop the PSST solution for managing Sepsis. "We understood the importance of creating a screening tool specifically for sepsis," says Jeff McGeath, CTO, Accent on Integration, "but from a technology point of view, we saw the potential to create a foundational environment for additional disease state management tools. After deploying the PSST for Sepsis solution, we plan to reuse every bit of this infrastructure to create a PSST for other acquired diseases. It will simply be a matter of redefining the screening questions and plugging these new modules into the database. We designed the workflows and built the interface technology stack to make it easy for us to further customize this solution."

To support this flexibility, AOI decided to develop the PSST for Sepsis as a Web-based application. Developers used the enhanced Web technologies of the Windows Server® 2008 operating system, the Microsoft Visual Studio® Team System 2008 development tools, and Microsoft SQL Server® 2005 database software (with plans to upgrade to Microsoft SQL Server 2008 as quickly as possible once the product is available). The interface technology stack also included the Microsoft Office SharePoint® Server 2007 and the Microsoft Office InfoPath® 2007 information-gathering program.

The PSST implementation is also an example of an Office Business Application (OBA) solution built on top of Microsoft technologies using Office SharePoint Server 2007 and the 2007 Microsoft Office system.

Designing the Workflows

AOI used the workflow designer tool in Visual Studio Team System 2008 to map the workflows for the PSST for Sepsis solution. "In healthcare, workflows tend to be complex, multi-state, and non-linear," says McGeath. "We used the workflow designer tool in Visual Studio Team System 2008 because it made it so much easier for us to visualize and create workflow components. To be able to have workflows that call additional workflows, to do context switching back and forth between workflows, and to handle all the

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workflow-to-workflow communication with just one tool was huge for us."

AOI also used the Microsoft Silverlight™ browser plug-in development tool to create the main launch page and primary navigation home page for the solution. "We used Silverlight to develop a visual style for this application that's quite unique when compared to traditional Web applications," McGeath says. "We modeled it after the Windows Media Center navigation metaphor, so some of the menu and command navigations scroll vertically as well as horizontally. It's very dynamic."

Managing the Services

AOI relied heavily on Windows Server 2008 with Internet Information Services (IIS) 7.0 to develop the PSST for Sepsis solution. In IIS 7.0, the Windows Activation Service manages application pool configuration and worker processes instead of the World Wide Web Publishing Service. AOI used Windows Activation Service as a hosting environment in conjunction with the Windows Workflow Foundation and Windows Communication Foundation programming interfaces, both of which are part of the Microsoft .NET Framework 3.5 managed code programming model.

"We used Windows Workflow Foundation and Windows Communication Foundation quite extensively to develop this solution so we needed a dynamic tool to help us manage the multiple services that we were running," explains McGeath. "Traditionally, developers had to use the HTTP protocol to host a service in IIS, but with Windows Server 2008 we can use Windows Activation Service to host our Windows Communication Foundation services. We're no longer bound to just HTTP protocol so we can run our services over TCP/IP and other protocols that are much quicker than HTTP. We also have centralized management for all of our services in IIS 7.0, which means we can do single-point deployment and we don't have to spend time coding services that IIS 7.0 gives us right out of the box."

Integrating the Solution

VUMC and Actuitec recently migrated the existing VPIMS solution from Microsoft Office Access™ database software and the Microsoft Visual Basic® development system to SQL Server 2005 and Microsoft Visual Basic .NET. AOI used this foundational architecture to support the integration of the PSST for Sepsis solution and the VPIMS tool. Using SQL Server 2005 and Windows Communication Foundation, developers designed the PSST for Sepsis solution to communicate with VPIMS and pull patient information directly from bedside monitoring equipment and other clinical systems. This information is displayed on an easily accessible SharePoint site and is available to care providers throughout the hospital. With Office SharePoint Server 2007, this data is also dynamically populated directly through InfoPath Forms Services and deployed to a server running Microsoft Office Forms Server 2007, reducing the amount of time clinicians spend performing manual assessments and capturing data.

In addition to gathering information, the system performs a real-time assessment of patient vital statistics every five minutes. As soon as a condition is met that indicates a patient is developing sepsis, a variance alert is automatically created and transmitted to care providers so that they can immediately begin early and aggressive treatment protocols.

Deploying the Pilot

VUMC chose a Dell PowerEdge 2950 III server computer with a Quad-Core Intel Xeon processor to run the applications and SQL Server 2005 database. "For the pilot deployment we used one application server to host all of the workflow components as

well as the Windows Communication Foundation classes and services," says Jason Whiteside, Vice President, Accent on Integration. "We'll potentially use three separate servers for the production deployment—one for the database server, one for the application server, and one for the Web server."

Nimesh Patel, Director of Perioperative Informatics for VUMC, adds, "Through our partnership with AOI and the work we're doing on the PSST project, we have been able to see some of the unique benefits that come from using the latest Microsoft Web development technologies, including Windows Server 2008, Visual Studio 2008, as well as SQL Server 2008."

John Barwise, MD, Medical Director, Neuroscience Intensive Care Unit, VUMC, and Physician Lead for the PSST solution, recommended the Neuroscience Intensive Care Unit (NICU) as the pilot location. The NICU is a 22-bed unit specializing in the care of critically ill adults, a patient demographic with a high risk of developing severe sepsis.

"In critical illness, it's very important to monitor all of a patient's vital signs continuously so that we can keep them as healthy as possible while they recover from their primary injury," says Barwise. "Just looking at an individual a few times a day isn't going to be nearly as effective as monitoring them continuously, and we felt that the IT solution we're developing might be excellent for this purpose."

During the initial phase of the testing, the VUMC team will work with Microsoft and AOI to capture as much patient screening information as possible. After the initial test, the pilot will continue in the form of a research study—over the course of a year, the VUMC team will capture, qualify, and quantify information obtained by using the PSST for Sepsis. As a result of being studied in this formal research environment within Vanderbilt, the return on investment for the PSST for Sepsis solution will be based on actual, non-subjective data. "Documented research is very important to the credibility of the PSST for Sepsis solution," says Lancaster. "As physicians, we want to see peer reviewed data around evidence-based medicine."

Benefits

VUMC and AOI used Microsoft technologies to create an integrated, easy-to-use, customizable patient surveillance tool. AOI maximized the dynamic new capabilities of IIS 7.0, .NET Framework 3.5, and Visual Studio workflow design tools to increase the speed and ease of application development, to simplify application management, to more easily conceptualize and design complex workflows, and to create a modular, extensible solution.

Rapid Application Development

Using the workflow designer tools in Visual Studio Team System 2008, AOI was able to more easily conceptualize and design workflow components. "Healthcare workflows are definitely not the traditional expense report approval workflow," says McGeath. "There are a lot of non-linear steps and multiple states that need to be visualized and orchestrated. Being able to draw those out using the workflow designer tools in Visual Studio Team System 2008 was a huge benefit for us. We would have needed to do a vast amount of hard-core manual coding to even approach something that is as flexible as we have now."

To increase development speed, AOI used the new Language-Integrated Query (LINQ) features in the .NET Framework 3.5 to extend query capabilities into the SQL database programming language. "We used LINQ to do a lot of our SQL interaction," says McGeath. Developers can use LINQ to handle

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data more productively by applying a consistent programmatic approach and to perform native queries without the use of specialized languages.

Simplified Hosting, Management, and Deployment

Using Windows Activation Service to host the Windows Communication Foundation services, AOI simplified server management by having one centralized hosting environment. "We were faced with having to manage these services ourselves, to create service management modules and develop our own security layers on top of that. Plus we had no real way to audit the performance of our services," says McGeath. "With IIS 7.0 we have one centralized hosting environment so we can do single-point deployment and manage the services much more effectively. This is something we simply couldn't do before."

After the pilot deployment of the PSST for Sepsis solution, AOI plans to use the Windows PowerShell™ command line interface and scripting language to accelerate automation. "In the future we're absolutely going to do automatic deployment using IIS 7.0 and Windows PowerShell," McGeath adds.

Modular, Customizable Infrastructure

Microsoft architects and AOI developers designed the PSST for Sepsis to be a modular solution so that the infrastructure could be easily reconfigured to screen for and manage other types of acquired diseases. Architects adhered to Microsoft best practices by creating a multitier architecture with separate presentation, application, and data tiers so that any of the three layers could be easily modified to meet the requirements of additional disease management modules.

AOI also used the Microsoft Visual Studio Tools for Office to create both application-level and document-level managed-code customizations behind the 2007 Office system applications, specifically Office InfoPath 2007. Developers also used Visual Studio Tools for Office to build and debug SharePoint workflow projects and to create applications that provide easy access to the VPIMS tool used by VUMC. Web Parts built for Office SharePoint Server are also easily reusable in other applications.

Developers also created the solution as a Web-based application to further enhance its flexibility. "Using the enhanced integration between Microsoft Office SharePoint Server 2007 and SQL Server 2005 we have zero footprint on client machines at VUMC," says McGeath. "We're using SQL Server 2005 as the application server to host all of our workflow components and Windows Communication Foundation services, and we're using Office SharePoint Server 2007 to deliver InfoPath Forms Services over Office Forms Server 2007. This means we're able to deliver our solution as a SharePoint Web site with the added functionality of Office InfoPath 2007 without having to install InfoPath clients on all of the hospital's machines."

VUMC deployed the pilot of PSST for Sepsis as a Web-based software solution, but the architecture will also support a software-plus-services model. In the future, hospitals can choose a traditional software solution by physically installing the software onsite; or they can choose a software-plus-services strategy that weaves together the best of software and Internet services. Hospitals will have the added flexibility of installing a subpart of the software onsite and then running the actual business intelligence, as well as the configuration of forms and services, through off-site data centers.

Easy Access to Data

From an end-user perspective, the PSST for Sepsis solution is simply a SharePoint site

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that is easy to access and simple to navigate. AOI designed the solution to integrate seamlessly with the existing VPIMS tool so that real-time patient data is available to clinicians with the click of a mouse.

VUMC expects to reduce the amount of time it takes its clinicians to perform patient screening assessments and to fill out screening forms because the PSST for Sepsis solution automatically populates screening data into patient screening forms. It also anticipates that the PSST for Sepsis solution will help its physicians and clinicians to significantly reduce the occurrence and severity of sepsis in at-risk patients through early detection alerts and management of treatment bundles.

Saving Time Saves Lives

"For sepsis patients, minutes can mean the difference between life and death," says Barwise. "The integration of the PSST for Sepsis solution with our existing infrastructure plays an important role in helping physicians be proactive in treating the disease. The faster we get the information, the sooner we can intercede.

"I believe this system could have valuable applications for settings beyond the critical care units," Barwise continues. "For example, if the PSST for Sepsis solution were placed near any hospital bed, early detection of sepsis and early treatment of sepsis would probably prevent these patients from needing to go to the ICU at all. This would shorten their length of stay and absolutely save lives."

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Software and Services

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  - Microsoft .NET Framework 3.5
  - Windows Communication Foundation
  - Windows Workflow Foundation

Hardware

- Dell PowerEdge 2950 III server computer, with a Quad-Core Intel Xeon processor

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