A Web Implementation: The Good and The Not-So-Good

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E-commerce, e-mail, e-greeting, e-this, and e-thateverywhere you turn there is a new "e" word for an internet or Web application. We, at the Cleveland Clinic Foundation, have been "e-nlightened" and will discuss in this report the implementation of a web-based radiology information system (RIS) in our radiology division or "e-radiology" division. The application, IDXRad Version 10.0 from IDX Corp, Burlington, VT, is in use at the Cleveland Clinic Foundation and has both intranet (for use in Radiology) and internet (referring physician viewing) modules. We will concentrate on the features of using a web browser for the application's front-end, including easy prototyping for screen review, easier mock-ups of demonstrations by vendors and developers, and easier training as more people become web-addicted. Project communication can be facilitated with an internal project web page, and use of the web browser can accommodate quicker turnaround of software upgrades as the software code is centrally located. Compared with other technologies, including client/server, there is a smaller roll out cost when using a standard web browser. However, the new technology requires a change and changes are never implemented without challenges. A seasoned technologist using a legacy system can enter data quicker using function keys than using a graphical user interface and pointing and clicking through a series of pop-up windows. Also, effective use of a web browser depends on intuitive design for it to be easily implemented and accepted by the user. Some software packages will not work on both of the popular web browsers and then are tailored to specific release levels. As computer-based patient records become a standard, patient confidentiality must be enforced. The technical design and application security features that support the web-based software package will be discussed. Also web technologies have their own implementation issues.

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THE CLEVELAND CLINIC Foundation has a large radiology practice performing 600,000 examinations per year in four different hospitals. Each hospital has its own medical record number. The radiology department also provides services to free-standing imaging centers and outpatient clinics. The web-based radiology information system

(RIS) will service all of these sites. Presently, the web-based RIS services one hospital and is used throughout the system to provide integration between our picture archiving and communication system (PACS) and other systems, including the hospital information systems (HIS).

SYSTEM DESIGN

The web-based design allows partitioning of the application into client and server portions.¹ All client processing is done as scripts for web pages. The only software needed on the client is a web browser. Unfortunately, web browsers are not all alike. This causes developers to write to specific browsers and decreases the universality of the application. Our application requires Internet Explorer and does not run on Netscape or other web browsers.

The server portion consists of a web server, a database, business logic, interface engine, web image distribution, and printing and faxing functions. The fact that the application was developed for the web and as an n-tier application allows partitioning of these components. This allows for these components to be run on a single system or several different systems. The ability to have multiple servers allows you to scale the system from very small to very large. Unfortunately, it also increases the complexity of managing the system and its hardware. All components of the system must be functioning to have the application function. Also if the components are distributed across several different physical servers all servers must be operating and managed for the system to operate.

The n-tier system design allows for increased redundancy at the server level. Instead of the application running on one system, each component can be running redundantly on several systems.² Each major system component has a separate server cluster for redundancy.

Also, the physical location and network location of the servers can be distributed. For example web-based imaging servers can be placed in several different hospitals, with each server serving that hospital to increase performance and decrease wide area network bandwidth requirements.

Web-based applications can be run on many different kinds of client hardware including per-

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sonal computers (PCs), Unix systems, and Macintosh systems. They can also be run on thin clients and handheld systems. This diversity at the client side allows many choices of client hardware platforms. It also allows the RIS to be run on the acquisition device itself thereby decreasing significantly the number of hardware devices technologists need. Unfortunately, all device manufacturers are not all allowing us to run the web application on the acquisition device even though the hardware natively supports the web browser.

Client hardware choice is nice, but it also has its own problems. Given choice, people have a problem of all choosing the same type of client hardware platform. This can lead to the problem of having to support many different client hardware configurations and manufacturers. We choose to support only two platform types (PC and Unix) as these were the major client platforms currently in use in our department.

The use of web technology can simplify client side application integration. We have integrated a diagnostic workstation with the web application to provide full access to the RIS from the diagnostic workstation. Unfortunately, this type of integration has not been standardized. There is a developing standard under Health Level 7 (HL7) called Visual Integration that is beginning to standardize this type of integration.

IMPLEMENTATION

We have currently implemented the full web RIS at one hospital performing about 100,000 examinations per year and across our system for modality and PACS integration. Users have transitioned from a terminal-based system to a web-based system. Client hardware placement has been

facilitated by the use of low-cost and small PCs. Also, touch screens have been used in several locations to facilitate quick RIS interaction. This has been especially useful at digital modalities such as digital radiology.

Implementation of web-based systems requires new skill sets for informatics personnel. Technical personnel need training in management of web servers, use of web browser for printing, and security issues related to web-based protocols. There is also a need for network engineers familiar with transmission control protocol/internet protocol (TCP/IP) and configuring these networks.

Remote connectivity using the web allows many different methods of access, including dial-up, internet, and intranet. Connection speeds for web implementations are higher than for terminal implementations because of the richer functionality supported and the use of graphics to enhance the user interface.

The ability for anyone with a supported web browser to use the application increases the ability if its use in remote locations. However, security procedures and secure access methods become increasingly important.³ It also becomes necessary to provide additional security infrastructure such as digital certificates to provide secure access over the internet.

CONCLUSION

Web-based applications provide advantages over terminal and traditional client server applications including wider availability, easier client management and more user friendly applications. However, there are issues related to web implementation that need to be addressed, including security, bandwidth requirements, and personnel training.

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