

# Solutions for Deploying Multi-Architecture EHRs on a Single EHR Educational Portal

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**Abstract.** In this paper technical issues are discussed related to the development and implementation of a remotely accessible portal that allows users to interact with a range of electronic health records (EHRs). The Portal (known as the UVic EHR Educational Portal) was designed to allow for the hosting of a range of types of EHRs, ranging from thick client systems to web-browser-based systems. The portal has been successfully deployed to allow simultaneous access by hundreds of users (i.e., health professional students) in order to work with representative EHRs for educational purposes. The overall architecture is described and issues related to the challenges in allowing for the hosting of systems of diverse designs.

**Keywords.** electronic health records, health professional education, health informatics, computer architectures, web architectures, health informatics

## 1. Introduction

Every region and country in the world uses differing types of health information systems (HISs). For example, electronic health records (EHRs) vary in the complexity of their design, their features, functions and architectures (e.g., thick client EHRs, web-based EHRs). EHRs have also been implemented using differing approaches (e.g., big bang, incremental deployment). EHRs have also met with differing levels and types of health professional appropriation [1]. In our previous work [2] we described a technical and architectural framework that was used to provide access to differing EHR systems over the Internet using a single portal [2] – which we called the University of Victoria (UVic) EHR Educational Portal (the “Portal” for short). In Canada the implementation of frameworks for provision of EHR/EMR technologies to healthcare professionals is underway [3–5], though these programs are still relatively in their infancy, with little or no interoperability between systems, a main driver for these frameworks to provide for the sharing of health data across providers, institutions and jurisdictions.

We suggested that the deployment and availability of HISs through such a portal could help educators to integrate EHRs into both the undergraduate and graduate healthcare curriculums of health professionals [1, 2]. In this paper we will discuss a solution for providing students access to many differing types of EHR systems using a portal and a variety of remote access clients (e.g., thick client, web-based), and we will demonstrate how such EHR hosting approaches can be used to provide nursing, medical and health informatics students with opportunities to use differing EHRs within a classroom (i.e., university educational) setting. The EHRs we implemented on

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the Portal had differing systems designs, operating systems and accessibility requirements. The overall aim of this paper is to document how we provided access to a combination of thick and web-based EHRs utilizing a remote access technology framework by means of a single hosted portal.

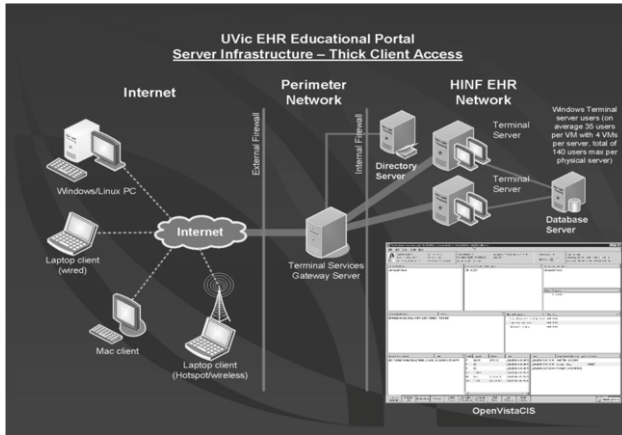
## 2. Method

Below we will discuss the approach we have taken to implementing different types of HIS on our Portal.

### 2.1. Example of Implementing a Thick-Client Health Information System

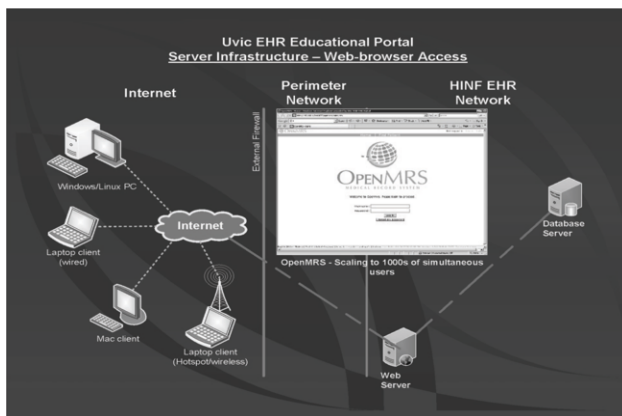
We initially implemented an EHR on the Portal that is a traditional, desktop-based client-server application. Such applications are typically found in physicians' offices or hospitals (and are referred to as thick clients as they have a significant client, or user side with more elaborate user interfaces). This system was selected and placed on the Portal for remote access (i.e., as an ASP-based solution) since it is representative of the types of systems that would be found in a typical physician's office. Traditional thick clients typically integrate third-party applications or external modules so that reports can be processed, mail can be merged, and data can be analyzed (e.g., using Crystal Reports, Microsoft Word, SPSS). This feature of traditional thick client applications (e.g., extensibility) adds value for the user.

In order to place a thick client on the portal and provide 150 or more simultaneous users (e.g., health professional students) with a robust, interactive and simultaneous user experience, Microsoft Windows Terminal Services was installed [2] and the remote desktop environment was sensibly restricted to only install and run certain applications. As we implemented a virtual machine environment [2], we had to ensure that robustness and stability were paramount in our provision of services to end-users. It was identified in testing that a thick client application had its limitations in the sense of how many simultaneous users could be logged into a single server, and so load balancing between several servers was implemented. In order to lower utilization of memory and bandwidth, the database component of the thick client application was installed onto a separate server (client-server approach), effectively increasing the speed at which users access, retrieve, input and analyze data. The purpose of separating components out (as is normal in most client/server applications) is to maximize the number of remote users that could login and load applications on a single server virtual machine (VM), and by separating out the database server we ensure that this would not be a limiting factor to the user's experience. The environment the student connects to is based on Microsoft Windows Terminal Services, that has certain limitations on how many users can effectively remotely connect and be given a desktop session which means, in our calculation, a maximum of 35 users per virtual machine was capable and allowed us to provision 5 virtual machines to fulfill our 150-user access requirement. This model is typically found in larger healthcare organizations and is effective for scaling systems for increasing numbers of simultaneous users.



**Figure 1.** Thick client access

In Figure 1 the thick client solution is demonstrated which depicts the local (user's side) and the remote side (the Portal). The user's side of the equation can be any of Windows/Linux/Mac operating systems using an application from Microsoft called the Remote Desktop Connection software for Windows/Mac or rdesktop for Linux, which is used to access remote Windows terminal servers. The Windows servers are contained within the Portal as shown in the far right side of Figure 1 (shown is a screen of the OpenVistaCIS system). In order to scale to 150 or more simultaneous users it was necessary, due to technological limitations, to deploy multiple terminal/remote desktop servers. The design of the environment, which is based on virtual machine architecture [2] allows for the maximization of server potential by providing for multiple instances of terminal servers per physical machine (upwards of 150 simultaneous users across 5 virtual machines, in this paper's example). In this way a single server can be used across multiple disciplines, and with more physical servers designed in this way (e.g., with virtual machines) it can scale to thousands of users [2].



**Figure 2.** Web-browser access

2.2. Example of Implementing a Thin-Client Health Information System

As can be seen in Figure 2, a web-browser-based solution can scale up to hundreds of users per virtual machine, thereby effectually increasing the number of users and lowering your total cost of ownership as fewer physical servers and software licensing would be required. To provide students with representative web-browser-based health information systems, we have deployed several EHR applications in addition to OpenVistaCIS, namely OpenEMR, OpenMRS, and OscarMcMaster. This is an important deployment for the Portal as the current trend in the commercial EHR space is moving towards developing health information systems for access via a web browser (Internet Explorer, Firefox, etc.) as a thin client solution (i.e., designed to have a minimized client component in order to be more easily accessible over the WWW at low bandwidths). It is important, we feel, for students to be exposed to web-based and thick-client systems to be able to compare and contrast the differences between the two (advantages and disadvantages). This can help healthcare professionals in future selection and procurement of health information systems to best meet their needs (and is the education provided to students via the Portal as in [1]).

2.3. Integrating Approaches: The Overall EHR Educational Portal Architecture

The Portal was designed to support both thick client and web-browser-based EHR applications as shown in Figure 3. The overall architecture which students would access to remotely login to the Portal is shown in Figure 3, and as mentioned above there are a number of EHRs that could be a part of such a technology architecture.

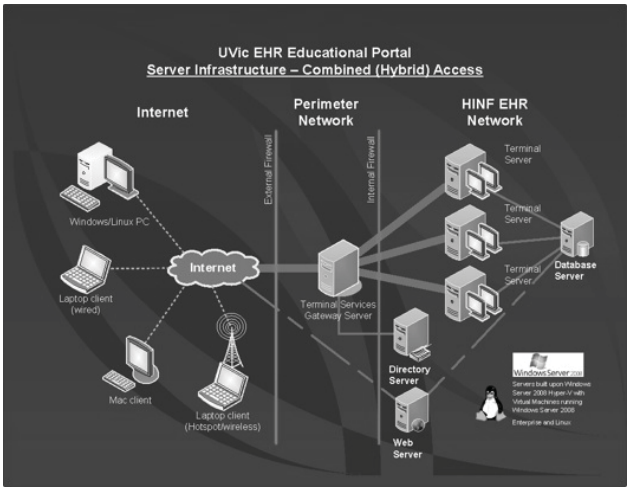


Figure 3. Combined (hybrid) access

In Figure 3 we have developed a combined view of both the thick client and web-browser-based client architectures. This approach (integrating the two) is increasing in popularity in the implementation of HIS applications, as it allows for the benefits of both thick and web-browser clients to be realized in the workflow of the healthcare professional. As can be seen in Figure 3, the architectures from Figure 1 and Figure 2 are essentially combined in a single solution. The Portal embodies this hybrid

technological approach in order to allow for practical hosting of a wide range of current and future EHR technologies whether they are thick or web-browser-based. From an educational point of view this allows health professional students realistic and wide exposure to health information technologies they should and will need to know about.

### 3. Conclusions

The benefits of the UVic EHR Educational Portal arise from a number of factors: 1) the reduction in the number of physical servers due to the implementation of virtual machines, 2) the introduction of remote access to applications which means that students can remotely access the servers 24x7x365, 3) the ability to support training facilities in multiple locations without the limitations of distance, 4) the ability to scale to support more student users by provisioning additional virtual machines, 5) providing access to EHR open source software applications (discussions are currently underway with commercial vendors to donate their software) means that students can experiment with systems and try out new systems, without the major barrier of software licensing costs, and, 6) it provides a platform and model that can be used to test EHR frameworks and solutions for both research and for testing implementations for real-world scenarios (integrated health networks (IHNs), clinics, hospitals and single practitioner offices). In our recent implementation our approach was used to support education of nursing students about EHRs, where 150 nursing students accessed OpenVistaCIS using the portal in order to gain exposure to current EHR technology. This was integrated into class discussion of issues related to adoption of EHR in healthcare, including issues related to design as well as privacy and security concerns [1, 2]. Finally, in addition to providing a model, the technology infrastructure as demonstrated in this paper provides for a scalable architectural solution that can be widely integrated into medical, nursing, and healthcare informatics education frameworks. Evaluation of our solution (in terms of maximum number of users, database server load, as well as usability measures) will be presented in a future paper.

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