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# A Virtual Platform for Electronic Health Record (EHR) Education for Nursing Students: Moving from In-House Solutions to the Cloud

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**Abstract.** There is a need to develop cost effective ways to bring hands-on education about essential information technologies, such as electronic health record (EHR) systems to nursing students, nursing faculty and practitioners. This is especially the case as worldwide there is an increased deployment of these systems and they are transforming the practice of healthcare. However, due to technical, financial and knowledge limitations, many nursing schools and programs do not have an adequate way to bring such technology into their classes and curricula. In this paper we describe an approach to developing Web-based EHR education that allows students from any Web-accessible location to access and work with real EHR systems remotely over the Internet for learning purposes. In this paper we describe our work in moving this approach to a cloud-based solution to allow access to EHRs for educational purposes from any location with Web access and to do so in a way that is both educationally sound and cost effective.

**Keywords:** electronic health records, nursing education, medical education, health informatics education, cloud computing

## Introduction

Currently, there is a need to provide nursing students and nurses entering the work world with knowledge and skills about electronic health records (EHRs). This is required as nurses need to understand both the positive benefits of using this technology as well as the issues and limitations of this important technology. Presently, there is also a need to develop cost-effective and reliable ways of allowing students to have hands-on exposure with a range of different types of EHRs and related technology in order to prepare them for their interactions with this technology in health care environments. Over the past several years, researchers at the School of Health Information Science at the University of Victoria have developed an approach to introducing a range of students to EHRs and other related technologies, which we have explored with a number of collaborators and published about in the health informatics literature [1,2]. Our initial work involved development of a Web portal that allowed

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students (e.g. medical, nursing and health informatics students) the ability to remotely access and interact with different types of EHRs over the Internet. The initial project involved the development of a portal which was hosted on a server physically located at the University of Victoria [3]. The portal housed systems including Open Vista, Open MRS and several personal health record systems. In a series of trials, the portal was integrated into the education of students. The first trial involved having fourth year medical students access the portal in order to interact with their “patient of the week” during problem-based learning (i.e. to access the patient information, prescribe medications and review the data associated with a particular patient case – i.e. the case of “Tom’s backpain”). From this work it was found that by allowing virtual access to example EHRs, education about using health information technology could be integrated with education about diagnosis and treatment. In a second set of trials, the portal was used to allow nursing students taking a fourth year course on nursing trends to access and learn about EHRs at their own pace and from whatever location they wanted to (only requiring access to the WWW). In addition, a number of trials were done of health information science students using the portal to enhance their training and hands-on experience with different health information technologies [1].

In this paper we describe our current work in transitioning virtual EHR educational systems to a cloud-based solution. Using the approach that will be described, virtualization is taken a step further – i.e. the local in-house servers used to host the educational EHR software are being replaced by hosting of the applications (e.g. EHRs, PHRs, and decision support tools) in the “cloud”, which forms the focus of this paper. From our prior experience, despite the advantages of the hosting of EHRs on a local server at the University of Victoria, a number of issues were encountered, including the cost and difficulty in maintaining both the hardware and software needed to run the portal and the EHR software it contained.

In the past few years, there has been a move to building, developing and maintaining scalable and reliable architectures using what is known as cloud computing [4]. This move represents a departure from developing and maintaining applications locally on servers that may require local expertise in their operation and maintenance. Given the nature of efforts to give nursing and health professional schools access to a range of EHRs, it has been found that commercial solutions may not be effective (such EHRs are likely to be deployed only at local sites in-house, or accessed from implementations in hospitals affiliated with nursing schools) and if purchased for educational purposes can be expensive and difficult to set up and maintain locally. On the other hand, if the same solutions can be hosted in the cloud there are a number of possible advantages. The strengths and weaknesses of this approach for hosting educational EHRs will be explored in this paper, along with our work in analyzing the requirements for a virtual Web-based educational EHR portal using cloud computing as the underlying architecture.

## **1. Advantages of the Cloud for EHR Educational Computing**

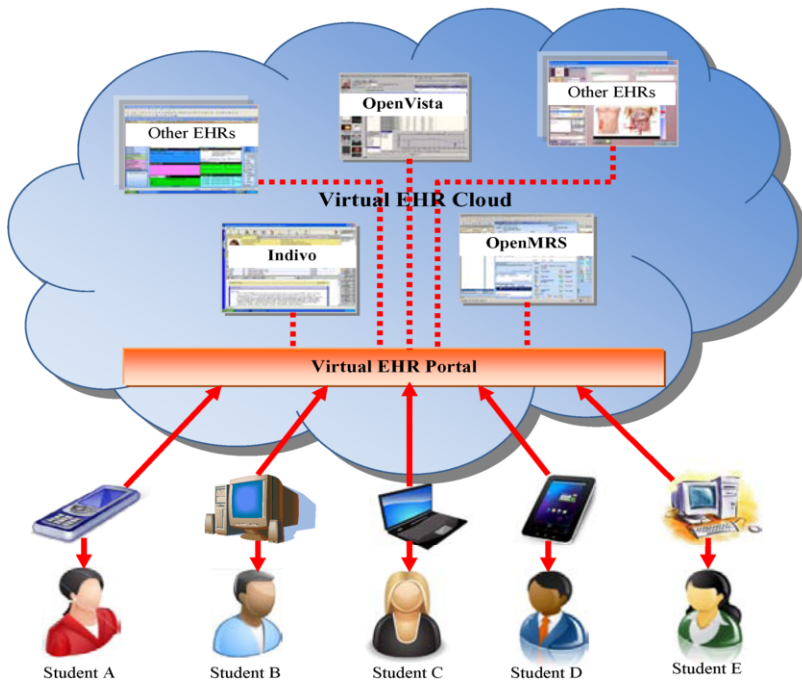
The main principles that define cloud computing are the following: (1) the pooling of shared computing resources that leverages cost of set up by all users who subscribe, (2) optimization of computer resources through virtualization and improved hardware utilization (i.e. you only pay for what you use), (3) flexible scaling up or down as needed, and (4) automatic creation or deletion of virtual machines that can run different

types of operating systems and applications. The main advantages of cloud computing include greater flexibility and agility in deploying applications. In the area of hosting educational EHRs, a major advantage is that nursing, medical and other health professional schools may not have faculty and staff available with the expertise to set up and run local server-based systems. In addition, few of these schools or departments either own or have access to the type of servers required to set up virtual training in EHRs. In addition, the use of an educational EHR portal will not be continuous but tends to be sporadic. However, as more courses and potential end users and students begin to use the applications on such platforms, there may be a need to scale up. With cloud computing an important concept is that of dynamic scaling – the ability to be “elastic” and dynamically change how much resource is consumed depending on how much is needed (i.e. as demand grows and shrinks). Basically, cloud computing services are offered by a third party, thereby relieving educational programs from having to maintain their own hardware and software to run educational EHRs and simplifying the set up and maintenance of hardware and software required (i.e. this does not have to be done by the educational school or department, freeing up time and resources to focus on teaching issues). In addition, the approach allows for considerable economy of scale, with the initial and recurring costs offset by the ability for EHR applications in the cloud to be accessed by many schools, departments and organizations (i.e. across a region, nationally and internationally). Furthermore, the approach is particularly attractive for making such advanced technology available remotely to schools and departments of nursing internationally where the cost to set up and maintain local servers is either too high or would be impossible (i.e. in developing countries). The literature on cloud computing further distinguishes among three types of cloud delivery models: (1) Software as a Service (SaaS), where the cloud computing provider manages the applications (i.e. hardware, software, operating systems) which are accessible to the end users over the cloud (2) Platform as a Service (PaaS) where clients can deploy and manage their applications on their own on the cloud, and (3) Infrastructure as a Service (IaaS) where the cloud infrastructure is what is made available by the cloud computing provider [5].

There have been a number of reported downsides to using cloud computing and one of these in the area of hosting EHRs has been concerns about issues of privacy and confidentiality of hosting real medical, health and patient data. While these issues are still unsolved for many sensitive healthcare applications (e.g. the issue of storage and retrieval of real healthcare data that is stored “somewhere out there in the cloud”), in the area of providing educational EHRs this is not a concern, as the “patient data” stored and used remotely for education purposes typically consist only “dummy” or “hypothetical” patient data (used for educational purposes only and not real patient data). This is an important point as one of the greatest concerns about hosting health care applications on the cloud has been that of privacy of patient information, however using the cloud approach described in this paper this involves only hosting of educational materials (e.g. using “fake” or “artificial” patient data) and therefore this is not an issue.

## **2. Requirements for a Cloud-based Educational EHR Portal**

In the past year we have worked on developing the requirements for a cloud-based educational EHR. This has included considerations about: (1) initial cost for deploying



**Figure 1.** The cloud computing based virtual EHR e-Learning environment

EHRs over the cloud (2) recurring costs for hosting over the cloud (3) performance requirements (4) licensing and related requirements for hosting on the cloud. Regarding issues related to licensing, for the applications that we are currently moving to the cloud (i.e. open source EHRs) this is not an issue, with open source or free EHR applications, but needs to be considered and negotiated in hosting training versions of any commercial software. In addition, software that allows for the creation of new patient cases and dummy training modules needs to be considered. The overall model for the cloud-based approach to educational EHRs is shown in Figure 1. As can be seen from the Figure, the virtual EHR portal service, the applications that it accesses (shown are several EHRs) and artificial patient data used to run educational simulations with end users (e.g. nursing students) are all to be housed in the Virtual EHR Cloud. End users access the virtual EHR portal to gain access to a variety of different systems and explore their features and functions using artificial patient data. In the Figure we can see students and faculty can access any EHR that has been hosted on the virtual EHR cloud from a variety of devices. In addition, course instructors can interact with and post cases and assignments over the virtual EHR cloud from the same computing environments as well.

### 3. Comparative Analysis of Costs

Based on our experiences and from our analyses of the costs involved in moving from an in-house solution to a cloud-based solution (i.e. moving away from an approach involving servers needing to be set up locally), the initial hardware and set-up cost for

**Table 1.** Costs of an in-house server solution versus a cloud-based solution for creating a virtual EHR Educational portal

Costs	In-House Server Solution	Cloud-Based Solution
<b>1. Hardware and Set-up Costs</b>		
Server Hardware	\$60,000	\$0
Consulting Costs (for initial set up)	\$40,000	\$5,500
<b>Sub-total</b>	<b>\$100,000</b>	<b>\$5,500</b>
<b>2. On-going Costs (per year)</b>		
System Admin/Consulting Costs	\$40,000	\$1,500
Hardware Upgrades	\$4,000	\$0
Off-site hosting costs	\$0	\$1,000
Licensing and maintenance	\$2,000	\$2,000
<b>Sub-total</b>	<b>\$46,000</b>	<b>\$4,500</b>

both the in-house and cloud solution for hosting educational EHRs can be itemized and compared (see Table 1).

Based on estimates of cost from our real experiences in setting up an in-house server solution versus creation of a cloud-based solution, it can be seen in Table 1 that the costs are considerably different. For example, when considering hardware and set-up costs, the server hardware that was required to run the in-house server version of the virtual EHR portal was in the order of \$60,000 (USD). Furthermore, that solution required part-time consulting costs in the order of \$40,000 for the initial set-up, making the one-time hardware and set-up costs in the order of \$100,000 USD. In contrast, by hosting on the cloud, the costs for buying a local server are removed (as the cloud replaces the in-house server) and the consulting costs are only for setting up applications on the cloud (as opposed to also setting up all the underlying server software in the in-house server solution). The result is a cost reduction for the cloud-based solution of more than ten-fold.

Regarding on-going yearly costs for running the virtual EHR portal, Table 1 indicates a ten-fold reduction in moving to the cloud-based solution. While licensing costs remain the same, costs related to hardware upgrades are removed, and the costs for employing a system administrator for the server system are also removed. Instead, there are now monthly charges for hosting the applications in the cloud, but even given this, the total yearly cost is reduced considerably by moving to a cloud-based solution. However, it should be noted that when using cloud-based solutions from external vendors, emergency plans for any service interruptions should be considered (which is also the case for running the applications using a local in-house solution).

#### 4. Plans for Testing and Evaluating the Cloud Computing Approach

We are currently in the process of moving from the in-house server approach described above to the cloud-based solution described. The costs being incurred are validating the estimated costs that were initially developed and given in right hand column of Table 1. In addition, it is expected that performance parameters related to access time and capability for multiple simultaneous users accessing the EHR applications will be improved using the cloud approach. We are currently in the planning phases for conducting a performance evaluation and case study evaluation of the move to the cloud. This will involve simulation and stress testing of the cloud-based solution to compare to data already collected from deployment of the in-house server solution.

#### 5. Discussion and Conclusions

Given the worldwide need to give healthcare students, faculty and professionals access to EHRs for learning and educational purposes development of cost-effective and technically feasible approaches to doing so will become increasingly important. In this paper we have described our work and plan in moving from an existing in-house server based solution to providing students with EHRs to a cloud-based solution that will ultimately replace it. Our work to date has indicated that this is not only technically feasible, but also will substantially reduce costs and likely lead to increased performance. The emergence of cloud computing has promised to revolutionize many business and professional domains [5,6]. In healthcare there have been a number of barriers to applying this kind of solution to applications holding live patient data. Although these issues are likely to be overcome in the near future, they are not problematic in the case of hosting educational EHR applications that do not contain or access live patient data. In addition, given the complexity of setting up either local servers for hosting such systems, or requiring limited access to locally available hospital systems, the approach described in this paper will allow for ubiquitous worldwide access to a range of EHR systems. In particular, a number of open-source EHR systems are amenable to being deployed over the cloud, and this represents a logical extension of our prior work in this area [1,2].

In terms of types of end users of the cloud-based solution described in this paper, it should be noted that the EHR applications in the cloud can be accessed not only by students, but also by faculty instructors and can also be accessed by practicing health professionals (e.g. nurses) for continuing education about EHR and related technologies. With applications we have deployed remotely this way, it has been found that different user interfaces may need to be developed. For example, using customized or open source EHRs for teaching has involved developing electronic templates and user interfaces for instructors to “seed” virtual electronic health records for students with illustrative (but “fake”) patient case data. Development of these types of interfaces is ongoing in our research group and is an important aspect in developing access for participants having different roles and duties (e.g. use of the platform for education by students, use by faculty and instructors and access by technical staff for maintenance and updating of applications stored in the cloud).

In conclusion, to address the need for allowing nursing and other health professional students hands-on access to advanced information technologies, such as the EHR, cloud computing solutions appear to offer considerable promise. We are

currently undertaking the process of moving towards this type of architecture and will be undertaking future work in evaluating the effectiveness and feasibility of this approach for educational purposes to leverage the technical effort required, while at the same time reducing costs and increasing accessibility by students to advanced healthcare information technologies.

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