

## Medical Portals: Web-Based Access to Medical Information

Michael Shepherd  
Fac. of Computer Science  
Dalhousie University  
Halifax, NS  
Canada B3H 1W5  
shepherd@cs.dal.ca

David Zitner  
Faculty of Medicine  
Dalhousie University  
Halifax, NS  
Canada B3H 1W5  
david.zitner@dal.ca

Carolyn Watters  
Fac. of Computer Science  
Dalhousie University  
Halifax, NS  
Canada B3H 1W5  
watters@cs.dal.ca

### Abstract

*Public portals, such as Web search engines, have been available for a number of years and corporate portals that facilitate access to enterprise information within a company, normally through the Web, have been available for the last few years. Such portals are made up of "channels" of information and the purpose of these portals is to provide an interface that presents an organized view of the data to which the user has access, i.e., a straight forward means of access to this data. Both public and corporate portals provide access to potentially vast amounts of complex, distributed information through a Web browser. The infrastructures are based on Web technologies and the common interface is the Web browser.*

*Medical information is vast, complex and distributed. Similar to corporate and public portals, medical portals can provide the medical community with access to medical information through the Web browser. Appropriate portals and channels within those portals can be defined to provide access from the desk of the physician, the hospital administrator, the insurer or the consumer of health services. This paper discusses medical portals that can provide such Web-based access to medical information and describes a three-tier Web architecture to support such access.*

### 1. Introduction

**portal** (noun). 1. A doorway, entrance, or gate; especially, one that is large and imposing. 2. Any entrance or means of entrance: a portal of knowledge. [7]

Public portals to information on the Web have been available for a number of years. Examples of such public

portals include the large search engines such as Yahoo! and Alta Vista. These portals permit searching by query and by browsing hierarchical classifications of the Web-based information. Each subtree or branch of the hierarchical classification rooted at the portal represents a major subject area such as education, health or entertainment. These subtrees within portals are called "channels" of information.

Corporate portals, also called enterprise information portals, have developed over the last few years. A corporate portal permits enterprise information to be made available across the company, normally through the Web. Not all the information in a portal is available to everyone in the company. A corporate portal is analogous to a database view, i.e., the information channels within the portal are analogous to database attributes and portals may be defined for specific individuals. These information channels permit access to information on the Web, and this Web-based information may be in a Web markup language such as HTML (Hypertext Markup Language) or XML (eXtensible Markup Language), in databases, in spreadsheets, or in word processing documents. The information may also be generated dynamically by processes run at the time of access.

Both public and corporate portals provide access to a vast amount of complex, distributed information through a Web browser. The infrastructures are based on Web technologies and the common interface is the Web browser. In a similar fashion, medical portals can provide the medical community and patients access to medical information through the Web browser. Appropriate portals and channels within those portals can be defined to provide access to the physician, the hospital administrator, the resident, nurse, the insurer or the consumer of health services.

This paper describes a three-layer Web architecture to support such medical portals. Section 2 provides a brief discussion of medical information systems. Section 3 presents the three layer architecture.

## 2. Medical information systems

Tom Noseworthy has suggested that health care is, "... back in the dinosaur age compared to the information management and technology in many other industries." [9] A patient sees a doctor who assesses health (and may or may not record it). At the time of an initial encounter the clinician collects information about patient health and today, most often, records the information on paper. Prior information about health status or lab information is often difficult to obtain, and the new information, when hand written on a piece of paper may also be unavailable for subsequent use at other locations.

The general problem we are trying to solve is how to accelerate the appropriate use of information technology to provide useful support for access to medical information for clinical care, research, teaching, health services administration and patient care. In an ideal information world a patient would have access to decision support tools to be informed about the need for a medical visit. At the time of the visit the clinician would obtain information about the patient from various sources. Some of the information is fixed, some variable [21]. In order to provide such information, information tools are needed and these tools are likely to be electronic, portable, fast, easy to use, connected to both a large valid database of medical knowledge and to the patient record, and will be a servant of patients as well as doctors [15].

Over the last few years, there has been a shift from administrative health systems concerned primarily with billing procedures to clinical information systems [2] that provide support for providers of health care. Such clinical information systems may build on an electronic patient medical record as a way to unify the data, even though that data may come from many sources and be of many different types. However, vendors at the May, 1999, TEPR Conference (Towards an Electronic Patient Record) indicated that while the use of administrative systems is almost universal for billing, less than five percent of physicians are using an electronic patient record. See [1] for a list of electronic medical record projects.

According to the Computer-based Patient Record Institute (CPRI), "A computer-based patient record (CPR) is electronically maintained information about an individual's lifetime health status and health care. CPRs are not merely automated forms of today's paper-based medical records, but encompass the entire scope of health information in all media forms. Thus CPRs include medical history, current medications, laboratory test results, x-ray images, etc. ... They are not massive databases, but independent computer systems at individual care sites with minimum connectivity requirements ... CPR systems provide availability to complete and accurate patient data, clinical reminders and alerts, decision

support, and links to bodies of related data and knowledge bases." [5]

Early clinical systems attempted to provide the functionality envisioned by the CPRI, but were hampered by incompatible standards and a lack of interconnectivity [6]. With the development of the World Wide Web, almost every large system vendor is now offering a Web-based clinical system [10]. Most of these new systems are based, at least in part, on XML, the eXtensible Markup Language, defined by the World Wide Web Consortium [20]. In moving to the Web, these clinical information systems become more available to a wider variety of users than ever before. In particular, consumers of health care are demanding easy access to relevant health information [12].

Although doctors can be slow adapters of new information technology [2, 16], the availability of any data, at any time, from any place, changes the dynamics. Access of any data implies access to multiple types of data including medical images, lab reports, prescribing profiles, hand-written patient histories, hospital bed usage, etc. Access at any time implies that the systems are available 24 hours a day, 7 days a week, e.g., medical images are available through the Web even though the office itself is closed. Access from any place implies access from the physician's desktop, from the home computer, or from a hand-held computer over wireless communications while doing rounds or on the Maui golf courses.

Such access raises issues of privacy and security as the information should be accessed only by authorized and the integrity of the data must be maintained. While architectures have been developed for clinical information systems [4], these are issues that are common to other fields, such as electronic commerce, that are using similar Web technologies.

Another important feature of these systems must be transparency of use. We propose that the concept of medical portals makes it easier for users to access the data and systems, based on having a consistent Web-based interface that may be tailored to group or personal needs, without the need to invest in large, centralized data repositories.

### 3. Medical portals

Many systems, such as InfoClique [3], provide portal-like access across an intranet, rather than on the Web itself. InfoClique is an intranet-based system that defines views by user type; health system administrator, clinical care co-ordinator, intranet staff, physician, physician office staff, and clergy. Each of these views provides access through a Web browser to information and processes defined for that group of users. However, the system architecture of the InfoClique system is quite different than that of medical portals. In the InfoClique system, all data from the various systems are downloaded several times a day to either SQL servers or text files on one of two computers and these computers provide the intranet access for the users.

Using the Web as the backbone, the proposed medical medical portal system does not require downloads to centralized servers. Rather, each contributing system is a repository of Web-accessible data. The data remains on the particular system that first captured that data and makes it available to Web applications. Thus, new databases can be made available to the user without downloading that data to a centralized server.

A three-tier architecture is not uncommon for such access to multiple heterogeneous databases and is used in systems such as the W3-EMRS [17, 18]. Figure 1 represents the architecture of the portal system in a non-standard manner. Rather than having three distinct layers in the figure, all components of the architecture are connected by the Internet, which is represented by the large, dark circle. All three tiers are built on the Internet using Internet and Web technologies. The first tier consists of the access devices of the users. These are represented by the portal blocks in this figure. In most cases, these will be desktop computers running standard Web browsers, but with the interfaces configured for the appropriate portal. Each user would have access through a portal that would provide access to the required data. The hand held devices would connect to the Internet through a standard wireless communications systems.

The third tier consists of the data repositories and applications at the appropriate servers to which the user requires access. These are represented by the data base icon, graph icon, x-ray image icon and the icon for the Internet Grateful Med search engine [11].

The second or middle tier is represented by the box in the middle of the Internet circle. This tier is the glue that makes this possible and consists of a proxy Web server and a suite of programs and databases. Data communications between the first and third tiers flow through and are controlled by this middle tier. It provides security and access to the data and applications in the third tier. When a patient record is requested, that information

may be distributed across many Web sites. The middle tier will identify the distributed parts of this virtual record and integrate them via a hypertext link structure, displayable in a Web browser at the first tier. In this system, once the second tier delivers the link to the first tier, the first tier can access the bottom or third tier directly without necessarily going through the middle tier again. This hypertext structure differs from the W3-EMRS architecture [17] in that each tier-three server in the W3-EMRS architecture converts the required data to the Health Level 7 (HL7) message format and sends these messages to the middle tier. This middle tier, called the Agglutinator, integrates the data and converts the result into an HTML page and sends this page to the client in the first tier.

Through a Web browser, a user accesses their portal which can be protected through appropriate password protocols. The portal software is the user's gateway to the required data and applications in the third tier. Individual resources at the third tier can also be password protected. Access to JDBC (Java Database Connectivity) and ODBC (Open Database Connectivity) compliant databases in the third tier can be made directly over the Web through the use of appropriate device drivers in the second tier. For non-Web compliant databases and resources, appropriate messaging protocols can be used between the second and third tiers to retrieve this data. There are many messaging standards including the HL7 protocol standards for the electronic interchange of clinical, financial and administrative information among independent health care oriented computer systems. However, at this time, many people are turning to XML for describing messages among such applications [14]. In fact, even HL7 now has an SGML/XML SIG [8] (SGML stands for Standard Generalized Markup Language).

The hand-held device portal functions in an identical fashion to the other portals. Due to the restricted screen size of the target device and the limited bandwidth of the wireless communications network, the middle tier will have to specially format the data for display on the device and balance the data flow. Therefore, development of information mark-up standards must continue.

#### 3.1. Portal interaction

The distributed nature and workings of such a medical portal system should be transparent to the user. From the user's perspective there is no middle tier. There are three types of interaction between the first tier and the third tier, through the middle tier. These are pull, push and update.

**3.1.1. Pull.** Pull is the standard Web technology for viewing a Web document or information in a Web-accessible database. The user clicks on a link or types in a

URL and the target page is downloaded from the targeted Web server to the client browser and displayed for the user. In the medical portal, the user would download a patient record by requesting or pulling that information from the server. The request to pull goes to the middle tier which finds the information at the appropriate third-tier servers and returns that information to the user.

**3.1.2. Push.** Push occurs when a Web server pushes information to the client browser, even though there has been no specific request for that information on the part of the user. Push technology has been tested successfully for a real-time patient monitoring system [19]. There are three types of push; continuous, periodic and triggered.

A continuous push is the equivalent of monitoring a device that is sending out continuous information. An example might be the monitoring of a patient's heart rate over a period of time. A periodic push is when the server sends information to the client browser at regular intervals. An example might be a server that pushes stock market quotations every five minutes. A triggered push is when information is sent from the server to the client on the occurrence of a particular event, i.e., the event triggers the push. An example of a triggered push would be the notification that a lab report is now available.

**3.1.3. Update.** A third and increasingly important portal interaction is the update of information at the server. The user must be able to update or add patient (or other) information or add new beliefs or knowledge at the client and this update must be made to data held by the appropriate third-tier server. The update from the user goes to the middle tier which then handles the update at the third tier. Examples might include the entry of new observations during a physical examination, admission to a hospital, payment of a bill, new guidelines for care, etc.

Updates of pulled information are somewhat different than updates of pushed information. The update of pulled information might take place at the server but will not be visible to the user until the next pull (or download) of that information.

The update of pushed information will be seen on the next push of that information from the server to the client. If it is a triggered or continuous push, the client will receive that information immediately. If, however, the push is periodic, the client will have to wait on the average of half the length of the period before the server pushes the updated information back to the client.

### 3.2. Design considerations

The different types of portal interactions have direct impact on the design of these portals. Directly affected are the handling of cache updates and security.

**3.2.1. Cache updates.** Most Web browsers cache or store the most recently viewed Web pages at the client to reduce network load and to decrease response time at the client. When a client requests a page (pull), the browser first looks in the cache and, if the page is present, simply displays that page rather than go across the network to the server to pull the page again.

Obviously, this has problems for all volatile data that might be updated. Pushed data contains new or updated information for the user and will not be present in any document or information cached by the user [13]. Similarly, the user may pull data from a server and the information at that server may be subsequently updated by another user or process. In this instance, the user will not have access to the updated data even if the user does another pull as the browser will return the information resident in the cache, which is now out of date.

This update problem can be solved by simply not caching any data, but at a cost in performance. A more appropriate solution is to investigate cache coherency solutions as implemented for distributed databases and operating systems.

**3.2.2. Automatic link association.** When databases are updated in this scenario, the data is not centralized. Rather, the data is maintained in Web-accessible databases in the third tier. Therefore, appropriate links must be generated automatically among the various parts of a patient's virtual record. This entails either that the third-tier Web server notify the middle tier so that these links can be generated or that sophisticated dynamic link algorithms be present in the middle tier.

## 4. Example medical portals

In this section, we present three sample portals by way of showing the potential of medical portals. Note that in the three sample portals, the portals are divided into frames. Each frame represents an information channel within that portal and may have very different characteristics, as will be explained below. Also note that some of the frames have a toolkit icon. This indicates that the information in those frames can be updated by the owner of the portal. In fact, the portal itself can be customized by the individual user.

### 4.1. CEO portal

Figure 2 is an example of a portal for a CEO of a hospital. The Information Sources and Decision Support channels or frames are examples of typical pull technology. Each underlined label is a link to other information on the Web that can be viewed. Note that the

Decision Support subsystems allow updates by the CEO. These updates may be in the form of notes or database data.

The Observations channel hosts access to server applications. Each link in this frame is a link to an appropriate application.

The information channel in the lower right corner showing the histogram is an example of triggered push technology. Each time any of the inpatients, outpatients or emergency waiting numbers is updated, this triggers a push to this portal to update the appropriate row in the histogram. This could also be implemented as a periodic push with the appropriate numbers pushed from the server every few minutes.

The calendar channel in the middle of the lower part of the screen is an example of update technology with a triggered push. This information comes from both a scheduling and a messaging service. The information can be updated by the CEO, i.e., the CEO can delete messages, add entries, and annotate existing entries. This updated information is sent back to the server to update the appropriate database. Once updated, this triggers a push of the updated calendar back to the browser so that the user views the updated information. The push could, of course, go many different clients simultaneously. For example, this push could also go to the admissions department.

## 4.2. Physician's portal

Figure 3 is an example of a physician portal. Note that the Decision Support channel is set up differently and contains different choices than the Decision Support channel of the hospital administrator in Figure 2.

The Personal Collection and Decision Support information channels are pull technology. In this instance, the physician is on rounds and has chosen to view the patient record of Jane Doe. The basic record information is shown and can be updated in the lower middle frame and this again is an example of update followed by a triggered push from the server. The Images channel is coordinated automatically as part of the patient record by the middle tier so that images (including live video if desired) are available for viewing.

The Lab Tests channel provides a list of ordered lab reports concerning Jane Doe is displayed. When the report is ready, it is put on the Web and a triggered push alerts the Web browser. If the report is ready, it is so indicated and the name of the report now becomes a link to the actual report itself. In this example, the physician can view the endocrinology lab report on screen simply by clicking on the Endocrinology link. Previous such reports, as part of the patient history, can be viewed in a similar manner. The Hematology Report has been ordered but is

not yet ready. Note that this channel can be updated by the doctor. This means that new tests can be ordered through this channel. This would be an update followed by a triggered push to update the lists of tests ordered.

In Figure 4, the physician has chosen to view Jane Doe's x-ray. Multiple size x-ray images may be available and viewed at the browser.

## 5. Summary

Advantages of the Web as backbone for medical portals are that access can be available for any data, at any time, from any place. The data does not have to be centralized. Rather, information *about* the data is centralized in the middle tier.

A Web-based medical portal would be available at any time and from any place from any computer, even remotely from wireless devices. The interface characteristics for wireless (and other) devices can be built into the middle tier so that appropriate amounts of information are transmitted to the client devices and this information is appropriately marked up for display on that device. In addition, the user interface is now the ubiquitous Web browser and is easily customized for any group or individual. The authors have now prototyped such a wireless medical portal using a hand-held computer and cellular communications.

We believe that access to appropriate portals, for each segment of the industry will increase acceptance for other purposes. Each component of a health information system might not, by itself, be usable or used if not integrated within an overall health information system architecture. Of course, some portions of a health information system could be valuable in their own right.

To paraphrase Smith [15], medical portals provide the physician with information that is electronic, portable, fast, easy to use, connected to both a large valid database of medical knowledge and to the patient record, and will be a servant of patients as well as doctors.

Information technology has the ability to deliver medical portals. What is needed is the political will to roll out these portals and to complete the policy discussions around privacy, confidentiality, security and access.

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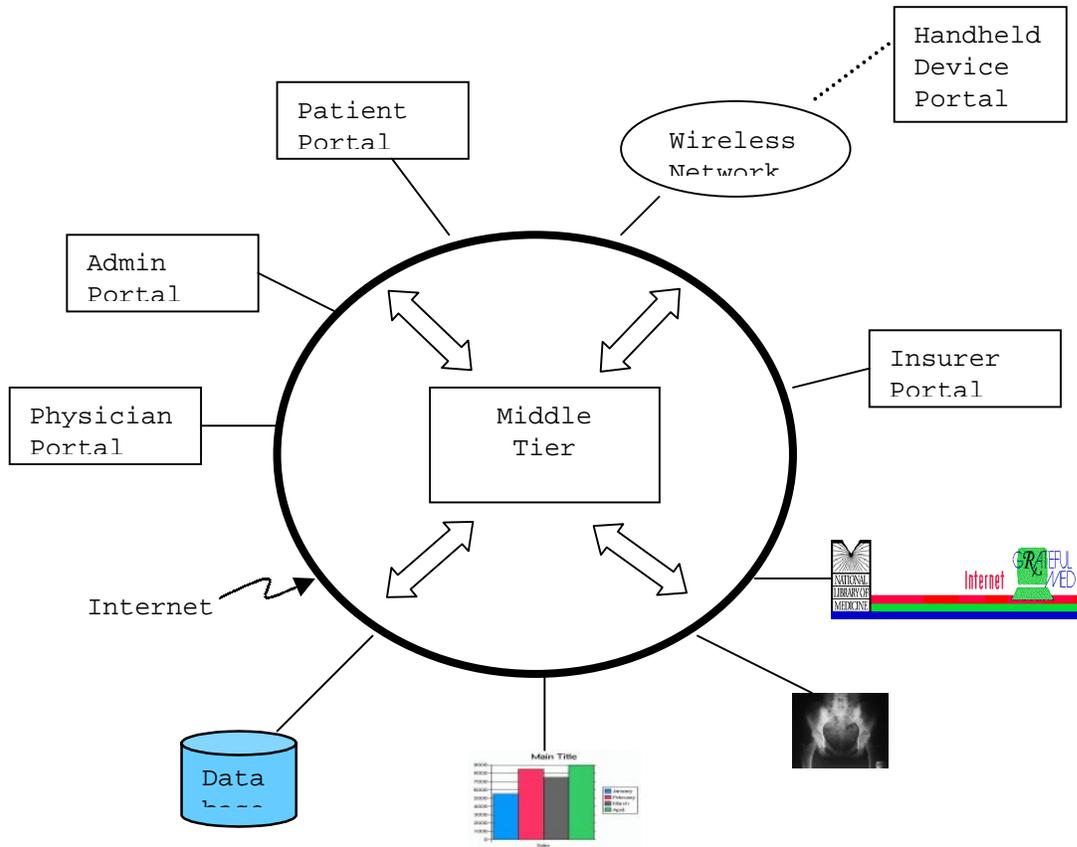


Figure 1. Three-tier architecture

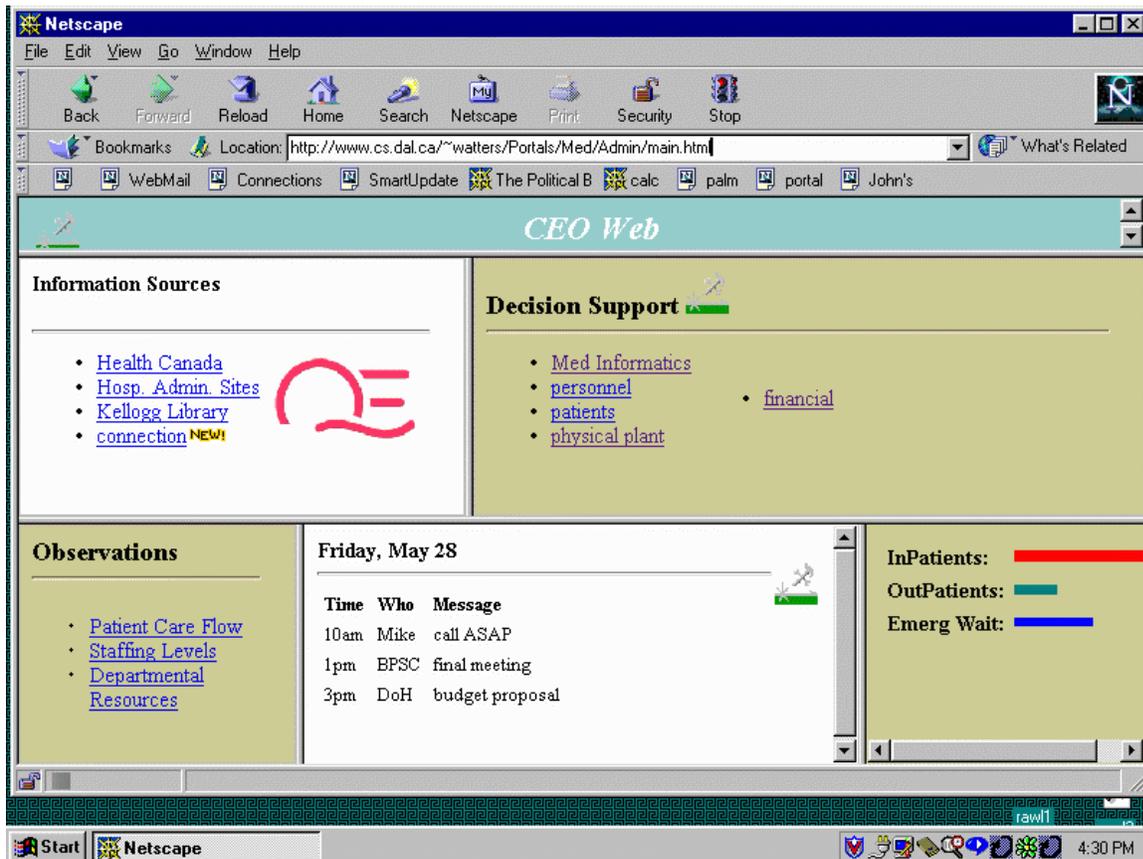


Figure 2. Example of a hospital administrators portal.

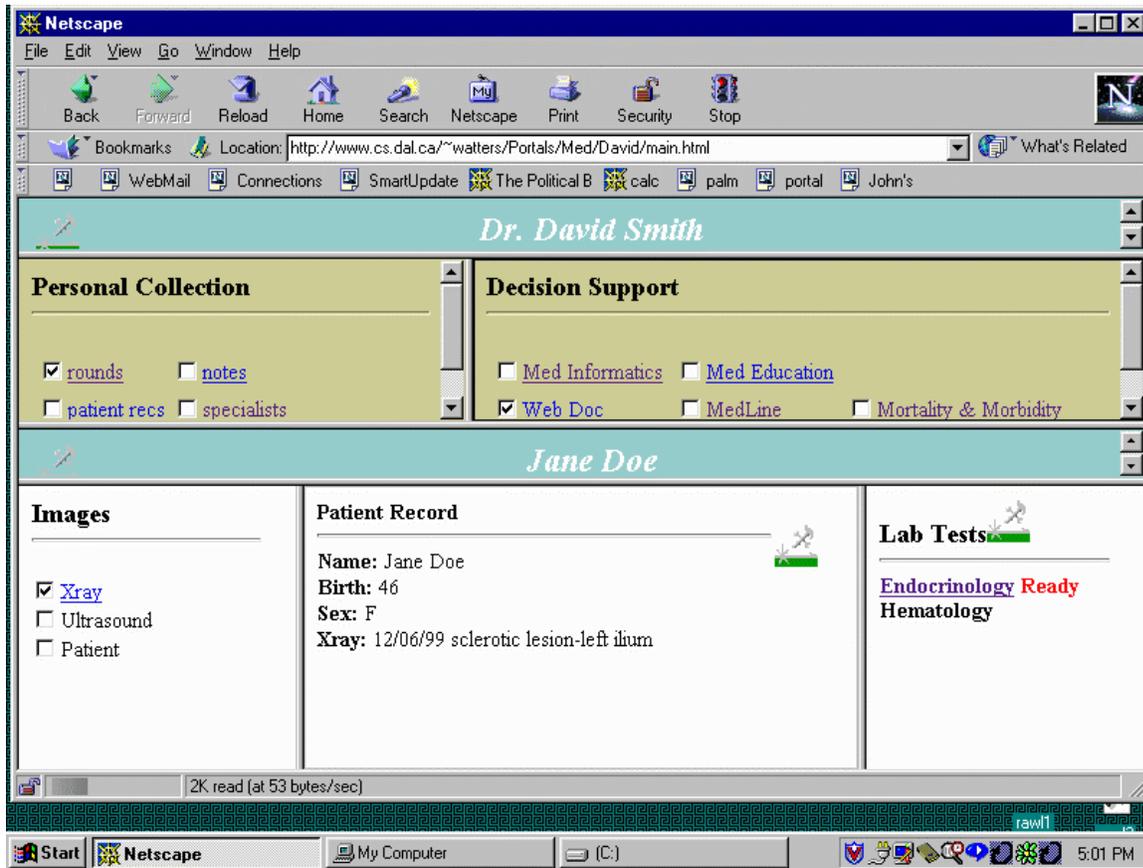


Figure 3. Example physician's portal.

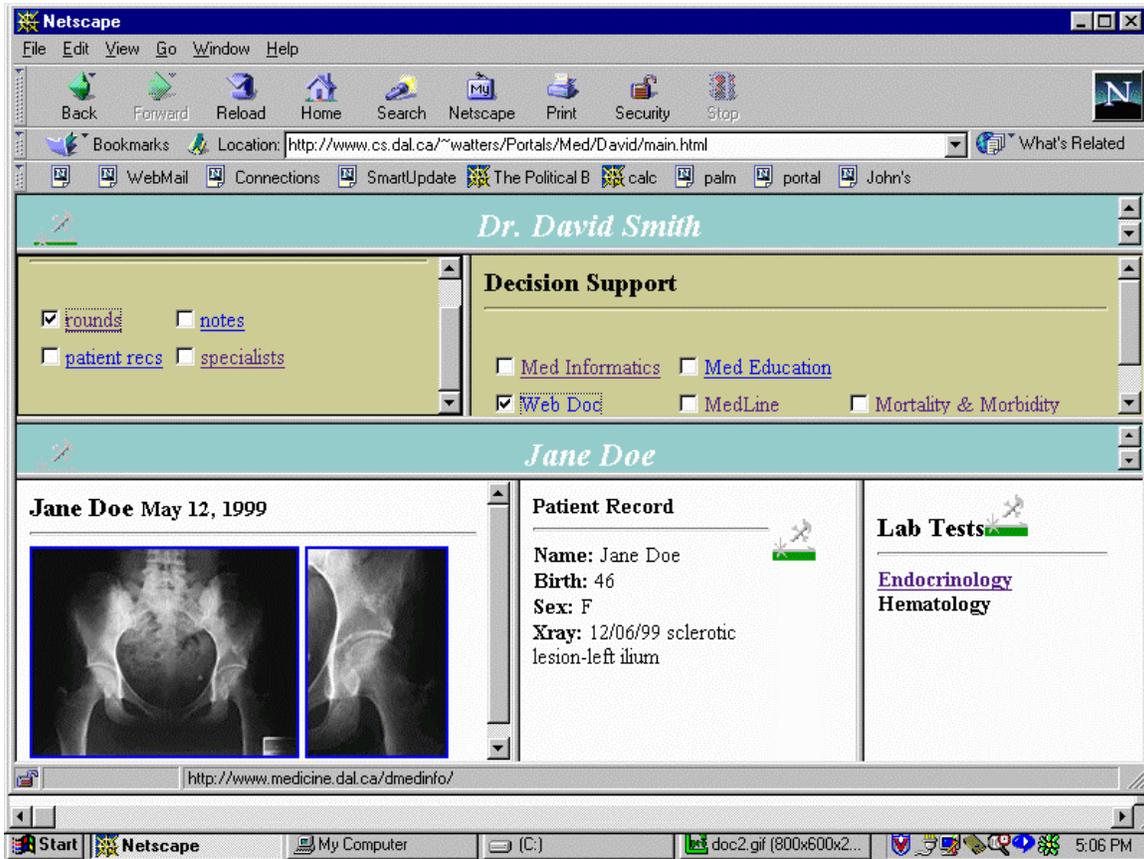


Figure 4. Example physician's portal with x-ray.