

A Web-Based Correctional Telemedicine System with Distributed Expertise

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Abstract

Due to increasingly tougher and mandatory sentencing laws, the U.S. has experienced a sharp increase in the prison population during the last decade. Correctional facilities face unique challenges in providing health care to a population that has a history of physical, mental and psychological abuse. Telemedicine is an innovative way to bring health care to prisons in a safe and cost-effective manner. The steady proliferation of the Internet, its versatility and low cost are ushering in new possibilities for providing telemedicine through such a cyberspace medium. This paper discusses the workflows involved in correctional health care environments and develops an object-oriented architecture for a Web-centric telemedicine system. The prototype uses relational tables to represent expert knowledge and ActiveX programming for initiating and coordinating the consultation sessions over the Internet. The prototype has the ability to deal with single physician consultations as well as with distributed multiple experts in more complex diagnostic sessions.

1. Introduction

The progress of technology over the last three decades has touched many aspects of human life, from assisting with the simplest of tasks at the individual level, to modern complex organizations, and to the most complicated of national defense efforts. Among the multitude of computer applications, none has contributed more directly to improving the quality of our daily lives than health care systems. In the past, many of these systems were limited to patient billing, insurance, prescription and medical history databases (Snyder, 1997). Further, these applications have largely been localized to either a single hospital or a chain of hospitals

in a confined geographic area. Recent advances in telecommunications and Internet, however, has now made it possible to break geographical barriers and allow physicians deliver health care to patients on an any time and any place basis (Mason, 1998). This has led to a new branch of computer applications called telemedicine systems.

Today, telemedicine allows patients in remote areas to receive consultation rapidly by specialists who are often located in urban areas (Lugg, 1998). Care may be provided at local health centers instead of having to transport patients to large referral hospitals. Often patients can receive early and more accurate diagnoses through consultation with experts and the treatment interventions may be easier, safer and cheaper. Families don't have to undertake the financial burden of paying for gasoline, food, lodging, and time lost from work to take the patient to a distant referral center for an outpatient consultation or hospitalization. The telemedicine system also decreases duplication of laboratory and radiology studies, which frequently takes place when a patient is referred to another medical facility. Hence, insurers, social agencies, and the patient's family save costs (Armstrong, 1998). Telemedicine also permits greater access to health related information for patients and families to learn more about health problems, treatment options, and prevention strategies. Another benefit is telementoring - the continuing medical education and training the field professionals spontaneously receive through teleconsulting with experts (Franczyk, 1998). Finally, telemedicine has the potential to tie distant practitioners more closely to experts and colleagues in other areas and bring new discoveries and treatments into practice faster than ever.

In the past, telemedicine has mainly been limited to telephone consultations. Physicians, nurses and other personnel talk with each other, patients and families providing information and offering reassurance without the expense of an office visit for the patient. Many health insurance organizations have established telephone advisement programs to reduce unnecessary office visits. The fax and e-mail have recently enhanced the available alternatives to share medical data among consulting physicians (Stoloff, 1998). There are also sensors available that can transmit information such as pulse, breathing and blood pressure collected directly from the patient. The most sophisticated telemedicine systems involve interactive videos. These systems require extensive investments towards the design, implementation and maintenance of telecommunications infra structure. In addition to laying long distance fiber optic networks and setting up satellite links, these facilities are furnished with specialized equipment and software at all interfacing locations where human experts interact (Binius, 1999). However, the widespread growth of the Internet is beginning to give us an alternative. Many patients today have Internet connections already set up in their homes. The versatility of the Internet in terms of being able to carry multimedia such as voice, video and data combined with its low operating cost features makes it an attractive medium for telemedicine consultations. Advances in data compression, security, cross platform software and development of modeling techniques in designing distributed networks also hold the Internet as a promising new tool for future telemedicine applications.

2. Telemedicine and Correctional Setting

An important development in telemedicine during the last decade has been its appeal among state and federal correctional institutions. Correctional facilities have unique characteristics that make them well suited for telemed applications. The prison population in the United States has risen exponentially over the past two decades due to tougher laws and mandatory sentencing and currently stands at more than 1.5 million (Thorburn, 1995; Vitucci, 1999). This growth has resulted in higher health care costs. Health care providers practicing within the walls of prisons are faced with the challenge of caring for patients who had long abused their health with drugs, unsafe lifestyle and poor nutrition. Many suffer from chronic physical and mental illnesses as well. Diseases such as Hepatitis and Aids, along with heart conditions and cancer among the older prisoners are increasingly placing pressure on prison administrators to find innovative ways to provide health care in a cost-effective manner (Spaulding, *et al.*, 1999). Telemedicine reduces the cost of bringing medical specialists to the correctional facility. Treating inmates through distance consultation

helps to avoid the high costs of maximum security-transportation and security-supervision of the patient at the hospital. The transportation and supervision costs are high because at least two guards and a state vehicle are required for security reasons. It is estimated that the average prisoner transportation cost is over \$700 for one off-grounds appointment (Swanson, *et al.*, 1993). When helicopter transportation is involved the cost rises to \$5000. In addition, correctional programs also are expected to ensure public safety by preventing potential escapes during transportation to and from the hospitals. Furthermore, incorrect diagnosis and treatment also have legal and monetary consequences (Gilbert, 1999). In some situations when inmates require medical attention, it can be difficult to decide whether to treat the patient inhouse or send to the emergency room for off-grounds hospital care. For example, if an inmate becomes unconscious briefly during a prison fight but maintains normal vital signs, and no other obvious sign of injury, it may be a difficult task to decide whether to send the patient to the hospital or treat the patient within the prison infirmary. Where inmates have died due to incorrect medical diagnoses under state care, multimillion dollars lawsuits from families are not uncommon. Telemedicine offers an effective solution in the diagnosis and treatment of the prison population in these situations.

It can be seen from the discussion so far that telemedicine involves a complex interplay among patients, local health personnel, remote expert physicians, and delivery technologies in space and time. Modeling health exams, diagnostic workflows, expert consultation and negotiation sessions, incorporating medical policies/procedures and patient data into the decision processes are complex but yet are the required fundamental blocks in conceiving and implementing any telemedicine system. The purpose of this paper is to address these issues with emphasis on the correctional settings. The paper is organized as follows. Section 3 covers the literature review of telemedicine with some of the early systems both in standard as well as prison environments. Section 4 discusses the workflows in typical telemedicine sessions and develops a process model. The object model for a prototype telemedicine system consisting of the suggested objects, attributes, relationships and methods are illustrated in Section 5 along with examples of how the distributed expertise of the various consultants can be represented on the Web. In Section 6, the prototype implementation itself is explained using a sample scenario. Finally, we conclude with a discussion of future challenges in telemedicine.

3. Literature Review

3.1 Telemedicine Systems in Standard Environments

Telemedicine has been in existence for almost 40 years (Grigsby and Sanders, 1998). The first known telemedicine project involved the transmission of neurological records across the campus of the University of Nebraska in 1959 (Benschoter, 1971). Five years later, the same university established a link with a state mental hospital 112 miles away. The Nebraska program and many of the other early telemedicine applications arose out of concerns about the limited access of remote populations to a variety of health services. Since that time, many state and federal agencies as well as private insurers, health maintenance organizations (HMOs), software companies, and medical device manufacturers have created their own telemedicine initiatives. Although the total amount of money spent on telemedicine research and development is unknown, a recent report by the U.S. General Accounting Office (GAO) places telemedicine investments by nine federal departments and independent agencies at \$646 million for fiscal years 1994-1996. According to the report, the Department of Defense (DOD) is by far the biggest investor, allotting \$262 million to telemedicine initiatives (Mun, *et al.*, 1998). The departments of Veterans Affairs, Health & Human Services, and Commerce follow, with each investing approximately \$100 million. Like the military, the health care system operated by the Department of Veterans Affairs (VA) has characteristics that are attractive to those evaluating telemedicine. In addition, the VA has, over several years, developed a fairly comprehensive and flexible patient information system that can integrate text, test results, and images (Dayhoff, 1996).

In May 1996, telemedicine was used during an expedition to Mt. Everest. To ensure the safety of these climbers, who were 29,000 feet above sea level and experiencing a harsh environment, a team of remote physicians monitored them and reported back on their progress. From the base camp clinic, video and data were transmitted via the INMARSAT Indian Ocean satellite to a land station in Malaysia. Calls were routed from Malaysia over the SATCOM Global ISDN network to Santa Paula, California where they were picked up by the AT&T ISDN network. Video and data received from the medical teams and the Everest site was placed directly on the Web site. Without the telemedicine network, the climbers could not have been successfully monitored from remote locations. (Larkin, 1999).

It was mentioned in the earlier section that some of the new telemedicine systems involve the use of video. These systems let specialists examine patients by looking at computer video images from remote hospitals. They

are being increasingly used in emergency rooms. This is because it is not cost-effective to have a trauma specialist present 24 hours a day. Patients can still get proper care at the hospital because they have a link with a trauma expert. The local physician receives assistance from a trauma doctor who watches, listens and offers advice from afar via an interactive video link. To use the telemedicine system, the physician speaks into a wireless, remote headset while the video is rolling and assesses patients while the whole event is broadcast live to an emergency department doctor, who can direct cameras in the far-away examining room and zoom in on the patient's injury. This entire scenario enables the physician to have an expert consultation and guidance right in the room. Any patient having straightforward problems such as flu symptoms, sinus infections, and allergic reactions can be treated without transfer to a full-service hospital. Symptoms that generally prompt transfer in adults are serious chest pain, abdominal pain, and infections and high fever and serious illness in children. The telemedicine approach is not to burden the primary care providers in rural communities; it is intended to act more like a back up to community doctors.

3.2 Telemedicine Systems in Prison Settings

Health care clinics within a correctional facility are often designed with limited goals in mind and are not equipped to function as full-service hospitals. In general, many of the inmates are not physically in need of emergency care but suffer from past neglect, chronic illness and other psychological deficiencies (Spaulding, *et al.*, 1999). Thus, clinical care in correctional settings is not resource, equipment and personnel intensive. Often there is only 24-hour nursing care with one field physician who works during the day at the facility and who remains on call the rest of the time. Emergency requiring hospitalization is rare, but such situations do arise. Riots, fights, heart attacks, illnesses among the old inmates often are the most common cause. If severity of injury is borderline between sending a person to hospital and retaining at the facility, telemedicine systems can be of great help. It can ensure expert consultation and best of care for the inmate without the accompanying escape-risk and cost of transportation (Raines, *et al.*, 1998).

Two early telemedicine systems implemented in correctional facilities settings and considered largest in volume of consultations handled are the Texas Tech University Health Sciences Center (TTUHSC) and the University of Texas Medical Branch (UTMB). Both were born of actions by the Texas legislature in 1993 and are responsible for providing health care for the inmates of the Texas Department of Criminal Justice. This legislation in effect created a health maintenance organization

(Tinstman and McCaughan, 1995). It is making significant differences in the delivery of inmate health care, giving providers a new avenue to provide care, as well as breaking the isolation and stigma associated with practicing medicine within a prison (Rendleman, 1999). TTUHSC is responsible for the inmate health care in the western half of Texas, where the inmate population has reached more than 30,000. TTUHSC created the department of Correctional Health Care to facilitate the delivery of inmate health care. Telemedicine is conducted on a weekly basis with the Texas Department of Criminal Justice at the Clements Unit in Amarillo, the Robertson Unit in Abilene, the Allred Unit in Wichita Falls, and the Laughan Unit in Fort Stockton, Texas. Amarillo, the pilot site for the telemedicine project, is home to the Clements Unit, housing 3300 male inmates, and the neighboring women's unit, housing additional 1300 female inmates. The National Commission on Correctional Health Care since February 1993 has accredited the Clements Unit. The infirmary includes a 17-bed inpatient facility, emergency room, and multiple clinical settings throughout the unit (Armstrong, 1998).

The Ohio Department of Rehabilitation and Corrections (ODRC) implemented a telemedicine pilot project in 1995 (Brunicardi, 1998). The project brought together the southern Ohio correctional facility in Lucasville, the corrections medical center in Columbus, and the Ohio State university medical center also located in Columbus. With the two-way interactive video, physicians in one location established audio and video links with inmates hundreds of miles away. The ODRC experienced considerable savings for telemedicine usage. Another telemedicine project in correctional environment connects Powhatan Correctional Center (PCC) of the Virginia Department of Corrections and the Medical College of Virginia Commonwealth University (McCue, et al., 1997). The project saved 25% of expenses through savings in transportation and medical costs. Non-dollar benefits included implementing more consistent and timely treatment of inmates and reducing security risk.

There are other correctional telemedicine systems as well that are currently in use. A telemedicine system connects the Waupaun prison and the University of Wisconsin Medical School which are fifty miles apart. The system has already saved by cutting in half the number of trips between the prison and the hospital (Appleby, 1995). Similarly, there are nine prisons in Iowa that have access to medical facilities through telemedicine (Zollo, 1999).

In summary, with rising prison health care costs and shrinking state budgets, correctional facilities have to devise innovative ways to provide health care. Of the

several methods being explored, telemedicine stands out prominently. Rabinowitz (1997) estimates that over the last five years, telemedicine systems have saved the prison health costs by over \$125 million. Currently, many institutions are using audio, video and teleconferencing links that have been specially installed for telemed consultations. As the Internet and the related technologies mature, there is an opportunity to investigate how it can be adapted to correctional care. This offers a potential to bring down the costs of communications even lower. By modeling the workflows and diagnostic processes and capturing physician expertise, this paper investigates how a Web-centric telemed system can be designed and implemented.

4. Modeling Telemedicine Workflow

At its most basic level, in the telemedicine context, workflow is the automation of medical examination, consulting, diagnosis and treatment processes. Workflow applications decompose processes into a number of steps called tasks. In addition to speeding up execution of tasks wherever possible in parallel, understanding workflow enables tracking the status of tasks in progress. Any workflow model should provide a comprehensive workflow diagram similar to Figure 1 for describing the various paths through which a decision process may flow. This provides an infrastructure for programmers who later would be coding the system. An incomplete or an incorrect model could lead to expensive alterations to the program later. If undetected, it might have serious consequences during an actual medical emergency.

The workflow model divides the telemedicine process into three phases. These are: i) Examination, ii) Diagnosis and iii) Recommendation/Treatment Plan. These are described below.

Examination

The problem-solving process begins with data collection from the patient user who has a health problem that needs to be solved. Typically, when a patient arrives as an emergency case to the clinic, the patient is first evaluated to determine if he/she needs to be sent to a hospital on an emergency basis. Subjective data such as patient's description of symptoms and feelings as well as objective data like vital sign measurements are collected. Some of the symptoms/criteria that are used in evaluating such emergency includes: if the patient heart rate is below 40 or above 60, if the patient is suffering from fever with body temperature more than 104° F, uncontrollable bleeding and others as shown in the Figure 1. If the patient meets one or more of these criteria, then the

security is notified and the emergency number 911 is called. It is standard practice for two custodial officers to accompany the patient to the hospital to prevent prisoner escapes during the transportation and stay at the hospital. The resident doctor is also notified of the actions for the

follow up diagnostic processes. If the patient, however, does not face a life-threatening emergency, then the next step is to perform a complete diagnosis workflow in-house itself.

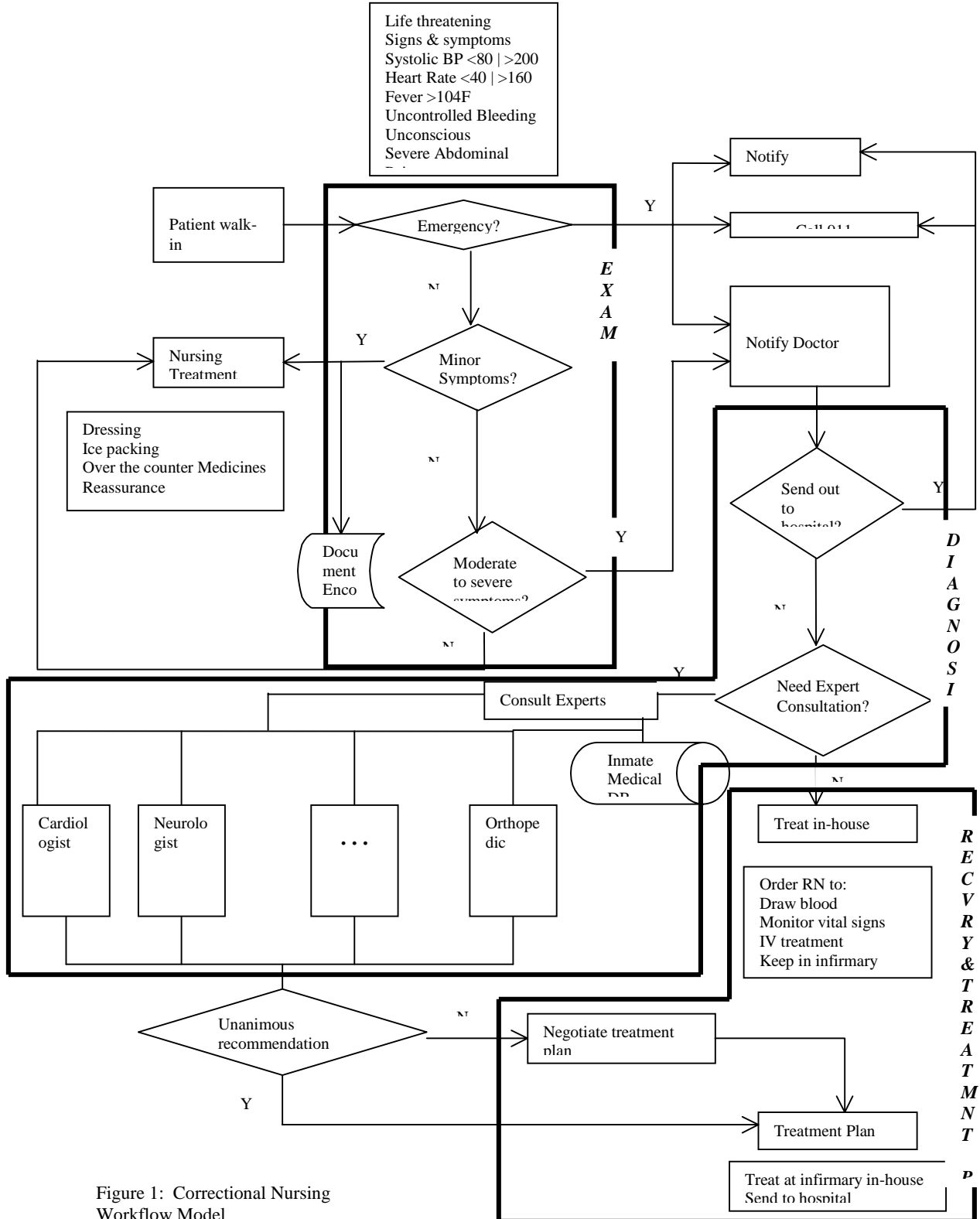


Figure 1: Correctional Nursing Workflow Model

Diagnosis

Diagnosis is the process of identifying the cause of the illness or injury. In simple cases it is often possible for the in-house nurse to make a diagnosis without a physician's help. In case of minor symptoms, such as minor cuts, bruises and mild fever, the diagnosis phase is fairly straightforward. In such situations, the physician is not contacted but the nurse treats the patient and releases him/her to the prison officers. The medical encounter is filed for record purposes.

When the symptoms range from moderate to severe, the resident doctor is notified. If the doctor's diagnosis indicates a life threatening situation, s/he might notify the security and order the patient's transportation to a hospital. On the other hand, if the symptoms are not severe enough, the doctor might decide to admit the patient to the prison infirmary. If the doctor is unsure of the diagnosis, she/he might want to make a consultation with outside experts via telemedicine. The doctor provides these experts with the medical information regarding the patient. The medical database is also made available to the experts if they want to access it to find out more information.

Recommendation/Treatment Plan

In a simple scenario, the nurse her/himself will be able to make an appropriate treatment without having to contact the physician. Example nursing treatments of this category would include: dressing the wound, ice packing, giving over the counter medicines and reassuring the patient.

In situations where the patient symptoms are more severe, the physician may follow two possible leads in arriving at a recommendation. In the first alternative, the physician may conclude that he/she has conclusively diagnosed the malady and is certain about the treatment method that would be adopted. If, however, the physician is unsure about the treatment strategy, he/she may decide to consult other experts in the field using the telemedicine approach for advice. Once the experts have formed an opinion and recommended a solution, the next step is to determine if the recommendations from various experts are unanimous or compatible with one another. In case the recommendations are consistent, a treatment plan is made out. If they are not, then the experts negotiate a consensual treatment plan that is then carried out by the prison physician. The treatment plan might prescribe the treatment to be administered in-house or the patient might be sent to a hospital.

5. Object Modeling for a Web-based Correctional Telemedicine System

This section describes strategies for transforming the workflow model described earlier into an object-oriented architecture that is implementable on the Internet. Several objects have been represented for completeness. Some sample ones shown in Figure 2 are: frmSmptms (request object), MedHistory (data object), MetaDiagnos (data object), Dr_A (data object), Dr_B (data object), and frmRcmnd (response object). The data objects can reside as part of a single or multiple databases located any node in the Internet. Their attributes and cardinal relationships are shown in Figure 2.

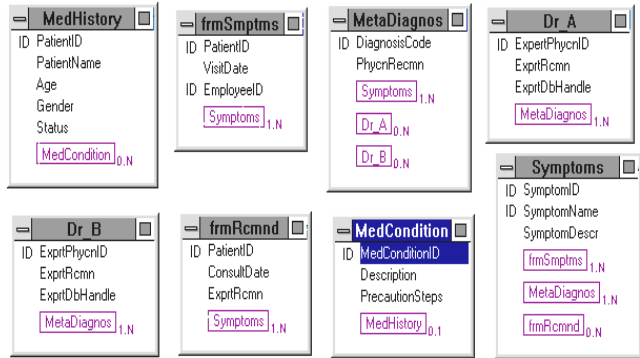


Figure 2 Objects in Correctional Telemedicine

The above objects have methods associated with them that can be invoked when appropriate event conditions arise during a diagnosis session. For example, the frmSmptms form has a procedure that can check the validity of user input values to the form that is invoked when the Submit button is pressed (see Figure 8 in the next section). It has also a Request method which allows the form to bundle all the property values submitted by a user and forward them to the Internet server. The MetaDiagnosis has Connection methods to set up a new connection to a database on any of the node on the Internet and run Structure Query Language (SQL) queries through the use of ODBC drivers. All results are obtained through the Response method. Figure 3 summarizes the web-based architecture for the correctional telemedicine system in more detail.

There were several reasons why such architecture was used. First, the suggested objects can be represented using relational structures which are well suited to capture the expert rules of individual doctors. In standard expert systems rules are represented in the format, "IF <conditions> THEN <conclusion>". For example, "If <sneeze=yes and eyes=teary> Then <diagnosis=allergy>" is a production rule. In the telemedicine system, we propose that the relational record

is the logical equivalent of the production rule by adopting a relation of the format R (Condition1, Condition2, ..., ConditionN, Conclusion). Thus, the earlier rule can be represented by an instance of the record type viz., R ("sneeze=yes", "eyes=teary", "diagnosis=allergy"). By using the relational records, it can be seen that the entire knowledge base of an expert can be stored into the table. In our system a relational table is used for each expert /consulting doctor. These tables in our prototype are called as Dr_A and Dr_B. We have also a table called MetaDiagnos which contains information on which experts are appropriate for consultation depending different combinations of potential symptoms.

The second reason for the proposed architecture is that it is consistent with the Active X objects and ODBC technologies currently available for developing Internet applications. Active Server Paging (ASP) comes with several built in methods for dealing with the server, application, session and other objects. Further, in ASP programming model, there is a wide range of functionality that is accessible to the programmer. ASP allows us to track the state of a user, dynamically generate HTML, output, and take data from forms to be inserted into a database. All of this functionality makes ASP well suited for distributed processing over the Internet that the telemedicine system demands.

6. Prototype Implementation

Based on the workflow and object models described in earlier sections, a prototype has been implemented using Microsoft Personal Web Server and Access database files. Its operation is described below using (i) a sample admission and (ii) a consultation scenario.

6.1 Sample Admission: Input of Patient MedHistory

When a prisoner is brought into the correctional facility for the first time, a complete medical history and physical exam of the patient is recorded in the database. This helps in future medical decisions. The medical history includes any serious medical condition that the patient is suffering from e.g. heart disease, diabetes, allergies and the like. This ensures that he/she is not administered any medication that would be harmful in a subsequent medical encounter.

The information is inserted into the table using a web page form (Figure 3). Once the information has been filled by the health professional and the Submit button is pressed, the web form executes the corresponding ASP

page. This results in setting up the database connection and inserting the information into the table (Figure 4).

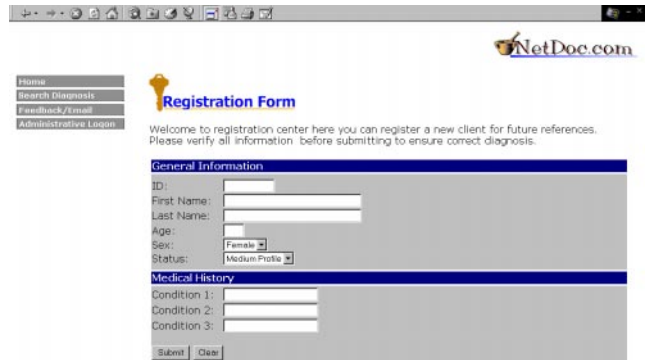


Figure 3 Registration form for taking medical history of a new inmate

```

Set Conn = Server.CreateObject("ADODB.Connection")
Conn.Open("dsn=TempAsp")
sql="insert into Master
(ID,FName,LName,Age,Sex,Status,Cond1,Cond2,Cond3)"
sql=sql + "values (" + Id + "," + FName + "," + LName +
"," + Age + "," + Sex + "," + Status + "," + Cond1 + ","
+ Cond2 + "," + Cond3 + ")"
Conn.Execute(sql)
Conn.close
Set Conn = nothing
    
```

Figure 4 Creating connection object and SQL for inserting record

6.2 Consultation Scenario

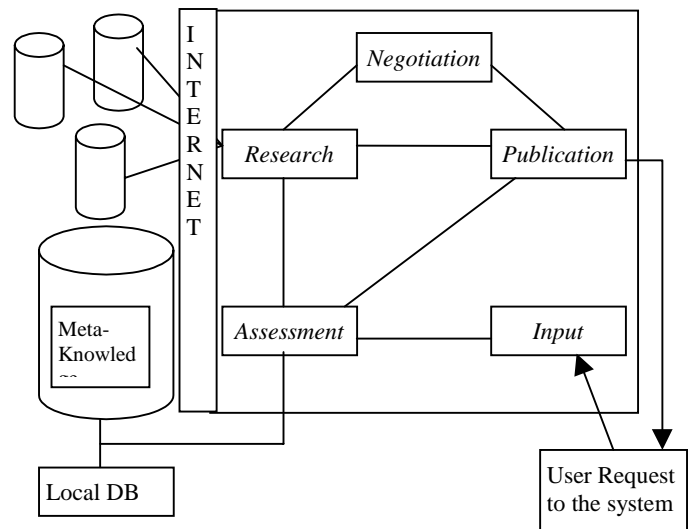


Figure 5 Steps in the telemedicine consultation

Each telemedicine consultation session is divided by the prototype system into five sequential processes: input, assessment, research, negotiation and publication (Figure 5). Tasks in each of these processes are discussed separately.

Input

Whenever a situation arises that requires medical intervention, the patient is brought into the infirmary within the correctional facility. The advice nurse performs an examination on the patient. This is when our telemedicine system comes into play. The nurse inputs the symptoms that the patient is suffering from. Similar to the patient medical history, this input is done on a web form (Figure 6). The prototype as implemented at this time can accept only three symptoms. In practice, this is sufficient. The possible symptoms have been coded into the form as list boxes. Not only does this make the data entry easier for the nurse evaluator, but also ensures uniformity in the input data string when the same symptom has to be entered in different sessions. This is important because during assessment phase, the system must be able to match symptom description string that was input to this form with the symptom string stored in the knowledge base.

For the purpose of illustration of the input phase, let us assume the nurse has input for an imaginary patient three symptoms consisting of nose bleeding, light-headedness and bruised face as shown in the figure and pressed the submit button. The control is then passed on to the Assessment module.

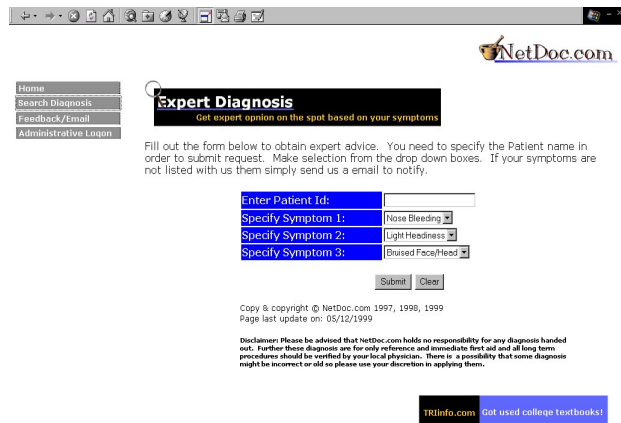


Figure 6 Input form used for diagnosis

While accepting inputs, the form object the system does a validation check to insure the integrity of the data being entered. When the patient ID is being entered, the system

makes sure that the field is not left blank. Also, the system does not allow the user to input characters that are not valid ID field characters. Users will receive error messages if incorrect data are entered into the form.

Assessment

Assessment is the second step in the consultation scenario. Once the symptoms have been entered on an ASP page, then the Visual Basic server-side scripts connect to the MetaDiagnos table in the database and retrieves diagnosis for the particular problem along with the recommendation. Using the same illustrative scenario mentioned in the Input phase earlier, the system searches in the MetaDiagnos relational table for the record with the three symptoms of nose bleed, light-headedness and bruised face. Once the matching record is located, the corresponding value in the Diag attribute for this record determines the diagnosis for these symptoms and makes the recommendation to use ice packs.

The system also uses the MedHistory table and takes patient’s medical history into consideration before giving a recommendation. For this, the value of the symptoms gathered from the input are formulated into a SQL statement and executed to identify recommendations of local and/or distributed expert nodes on the Internet. The system also shows the email links to the other experts in the query results so that if need be the experts may be contacted for further consultation.

Research

One of the greatest advantages of using a web-based telemedicine system is that we are not confined to a local database. We can contact other databases over the Internet and by passing out parameter values, we can get recommendations from other experts as well. Thus, when the situation is more complicated than the local database can handle, we contact other expert’s databases and get the recommendation from them by passing patient symptoms to these databases.

The methodology for identifying the experts’ recommendations is same as the one employed in the Assessment phase. In addition to the symptoms, diagnosis and recommendation attributes, the MetaDiagnos table has also attributes with names of expert databases that can be further contacted for consultation wherever appropriate. The system uses these expert database names as 'links' to make ActiveX Data Object (ADO) connections. Each expert database has a Diagnosis-Recommendation table which have heuristics stored as described in Section 5. This allows the user to receive independent diagnosis and recommendations from

multiple experts distributed over the Internet for the same set of symptoms online.

Negotiation

We can have situations where we contact more than one expert's databases to get the recommendation. In such cases, we can be faced with results where expert recommendations do not agree with each other. In this case, we need to negotiate among the experts and come up with a consensus on the diagnosis and treatment plan. Currently work is being done in choosing the appropriate theoretical framework and related algorithms towards their implementation into the prototype.

Publication

Finally, all the recommendations are published on the Internet browser interface for the user to see and take appropriate medical action. Following is an example system response (Figure 7). It can be seen from the sample response, that the local node recommendation from the MetaDiagnos table for the symptoms of nose bleeding, red eyes and back pain is heat stroke. However, the response screen also recommends the user to consult two other experts, viz., Dr_A and Dr_B. Since these are displayed as hyperlinks, all the user has to do to receive these expert consultations is to click on these hyperlinks.

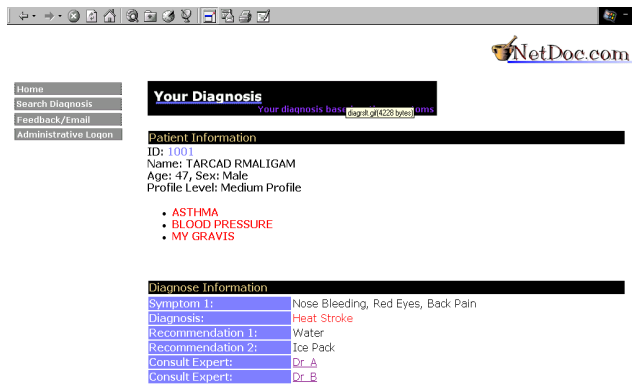


Figure 7 Web page showing results of diagnosis

User Authorization

One other area that our system has capabilities is the security aspect of the telemedicine system. The personal medical information has always considered private from the legal point of view. This is especially important to the prison system where the population has a disproportionately large number of ailments such as Hepatitis, Aids and other mental illnesses. When data is made available on the Internet, the potential for hacking is

even higher and the system developers should implement foolproof firewalls.

In our prototype, only authorized users can enter the system. This is done by having the input page dynamically created when the user name and a valid password has been read by the system and verified in the Login table. Thus, since the information does not even exist in a format that could be read and is only created after the verification of the user input information, the prototype provides a great measure of security for the database. The following screen shot shows the user authorization form.



Figure 8 Web page showing the administrator's screen

7. Summary and Future Challenges

The workflow and object models discussed in this paper should provide a developer with sufficient knowledge to design a Web-centric telemedicine system. Our experience with the prototype shows the concept of implementing a telemedicine on the Internet as technically feasible and the use of ActiveX technology quite powerful. Enhancements of the prototype are currently under way to incorporate additional expert database nodes and increase the rules represented in the system. The interface is being expanded to incorporate audio and video. Another important aspect of the system being augmented is the power of its negotiation module. Finally, software agents will be added so that the system can search proactively and provide preventive advice to patients and physicians before health problems become out of hand. Prisoners may not have to be hospitalized if accurate and expert diagnosis can catch and treat the problem quickly. Telemedicine technology has the potential to change the face of health care for the better and reducing the cost of health care services for the correctional facilities everywhere.

Telemedicine, like most other advanced information and communications technologies, depends on complex technical and human infrastructures that operate both within discrete institutions and across organizational and geographic boundaries. The harsh realities of the current health-care environment sometimes hinder the innovative strides being made by the visionaries in the field of telemedicine. Those responsible for creating information and telecommunications systems and programs face a bewildering and constantly changing array of hardware and software options, many of which are not tailored to health care uses. Different telemedicine applications may involve different combinations of technologies and because each Telemedicine program reflects different organizational objectives, the infrastructure on which they depend will vary from place to place. Despite these and many other challenges to overcome, the future of telemedicine looks very promising. The last ten years have seen a steady increase in the number of telemedicine projects throughout the U.S. and internationally. As the benefits of telemedicine systems become more manifest, more funding becomes available, and as the technology costs continue to decline, the use of telemedicine systems is bound to become a normal part of our daily lives.

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