A Decision Support Technology Clearinghouse

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ABSTRACT

The Decision Support Technology (DST) Clearinghouse is an on-line database of current information concerning medical decision-making technologies. It makes DST knowledge easily accessible to users and potential users of the technologies. The system will minimize costly duplicated research efforts by informing developers of parallel technologies. Additionally, areas in medicine where this type of development has been lacking will become apparent. Perhaps the area where the Clearinghouse could have the greatest impact on medicine is in evaluation.

INTRODUCTION

The necessity for using computers to manage and report the ever-increasing amount of medical data and number of technological advancements has been well documented [1,2,3,4]. One of the most interesting aspects of this use is in Decision Support Technologies. Decision Support Technologies (DSTs) may be defined as a general class of technologies that can interact with an information database to solve specific clinical and/or administrative problems. DSTs include technologies that may range from printed algorithms to computerized expert systems. Evan's Infection Control project [5,6], developed at LDS Hospital in Salt Lake City, Utah is a good example of a DST which fits these criteria. In this paper we will describe a mechanism for collecting, categorizing and disseminating information regarding DSTs in medicine.

The first real effort toward cataloging and eventually evaluating DSTs occurred in September 1985 at the National Invitational Conference for Decision Support Technologies. This gathering included leading DST developers, hospital administrators and a select, representative group of potential DST users. Sponsored by the Veterans Administration Health Services Research and Development (HSR&D) Service, the conference was held in Salt Lake City, Utah. A prototype DST Clearinghouse was demonstrated. Conference participants were asked to evaluate the need, potential benefits and problems with a DST Clearinghouse. They supported the idea of an Clearinghouse and the most useful parameters to be used in a database design were formulated. The Clearinghouse would keep tabs on what was happening in the field of DST development and evaluate mature technologies for clinical use. The Clearinghouse would eventually be expanded to include other important domains such as computer-aided instruction.

As an initial effort to find potential DSTs for inclusion into the Clearinghouse, the Salt Lake City HSR&D staff read and screened over 9,000 DST-related articles. These citations were classified into categories relevant to their usefulness in describing or evaluating a DST. Citations rated as "most useful" numbered 2,537. Of these, 1,143 were actually placed in computer files. From the file of "most useful" documents, 274 distinct DSTs were identified and the DST Clearinghouse was born. Fifty-one parameters were selected to describe and categorize each DST. Information concerning literature references describing and/or evaluating the technologies along with information useful for contacting DST experts were also included in the database.

NEED

For the individual researching Decision Support Technologies, current information on DSTs is very difficult and time-consuming to obtain because it is scattered among journal articles and isolated developers. Additionally, many parallel decision support systems have evolved because researchers were not aware of existing similar technologies. DSTs are usually developed in areas of interest to researchers. This leaves some areas of medicine without mature DSTs. The DST Clearinghouse would quickly pinpoint areas needing decision support systems and give a wider range of medicine their benefits. A study of information management in medicine, conducted by the Massachusetts Medical Society on health providers and administrators, found that 81% of study participants found the amount of literature too great to keep up with new technologies and innovations in health care [7]. When queried further, study participants indicated direct contact with experts was the preferred method for solving their information problems.

This lack of desire to dive into medical journals and other paper-based resources was echoed at the September 1985 DST National Invitational Conference. In addition, Conference participants identified their need for a database to monitor research efforts in the field of decision support technologies. Developers are often frustrated when they find out years of effort are only a duplicate of a project already under way by another developer. The DST Clearinghouse is a way for developers to get information on a DST previously developed or currently in the works. This aspect of the Clearinghouse would save a great deal of duplicated efforts and may actually spawn increased interaction and resource sharing among developers.

The VA Medical Center in Salt Lake City, Utah has used the DST Clearinghouse for researching several DSTs. Currently being implemented into the medical center's Admitting Office/Emergency Care Unit are DSTs for lab and X-ray ordering, arterial blood gas interpretation, real-time pulmonary function monitoring and drug-drug interactions. These clinically proven DSTs were discovered and identified through the DST Clearinghouse. Without the help of the Clearinghouse, finding these DSTs and determining their "fit" into the VAMC Salt Lake City's scheme of health care would have taken much longer. This is clearly a case where the usefulness of the DST Clearinghouse has been demonstrated.

Perhaps the greatest benefit of the DST Clearinghouse will come in transferring DSTs to patient need areas. It will give hospital administrators, rural clinicians and urban practitioners a reliable and objective source of computerized expert systems which match their specialized needs. For example, imagine a hospital which needs a method to flag possible drug-drug interactions before the drugs are given to the patient. If the pharmacist were to query the DST Clearinghouse, he would most likely get a list of several DSTs fitting his criteria. And if he specifies hardware requirements, it is very possible there will be a drug alert DST already in existence that will be easy and timely to implement. The DST Clearinghouse will save this hospital a great deal of time and effort in finding a system to meet their needs. It will reduce undue patient suffering and possibly save lives.

IMPLEMENTATION

After the 1985 conference, design and implementation of the DST Clearinghouse began in earnest. Several students from the University of Utah were hired to research, retrieve, read, filter, categorize and file DST articles. A graduate student from computer science was hired to begin designing and building the database. The Department of Health Services Research and Development at the VAMC in Salt Lake City, Utah became the center of Clearinghouse development. Under the direction of Williamson, Director of HSR&D and Warner, Chairman of the Department of Medical Informatics at the University of Utah, the project grew and evolved into a fully-functional information retrieval service.

The amount of work done in the literature review process cannot be overstated. Each article was read by two staff members. A worksheet evaluating the article and related DST was completed for each reading. Expert names and other relevant datum were extracted from the articles. Documents were categorized according to the amount of descriptive or evaluative information they contained. Copies of each article were then filed for future reference. Information entered into the completed database was taken directly from the worksheets done on each article.

In order to give the system user friendliness, Warner and Williamson decided to implement the DST Clearinghouse on Apple's Macintosh computer. The Macintosh's interface is perhaps the most user friendly and easy to learn of all microcomputers. And with ongoing technological advancements and additional processing power, it was anticipated that the Macintosh could handle what would surely become a very large database.

Omnis 3, a relational database package marketed by Blyth Software, was chosen as the software to use. Omnis 3 is one the best relational database in the Macintosh market. A relational database works on the concept that information should only be entered once. Information usually entered into a database several times is kept in a separate file and "related" to the file(s) it would normally appear in. For example, in the DST Clearinghouse separate files exist for the DST itself, experts who have developed the technologies, contacts made to these experts, citations describing or evaluating DSTs and a medical content file describing the medical specialty or subject matter covered by the DST's decision making process (figure 1). This setup was chosen because one expert often develops more than one DST. Likewise, one DST may be described by more than article. Each DST, expert, medical content and article is entered into the Macintosh computer only once. Relationships between the files are maintained by "links". For example, a leading

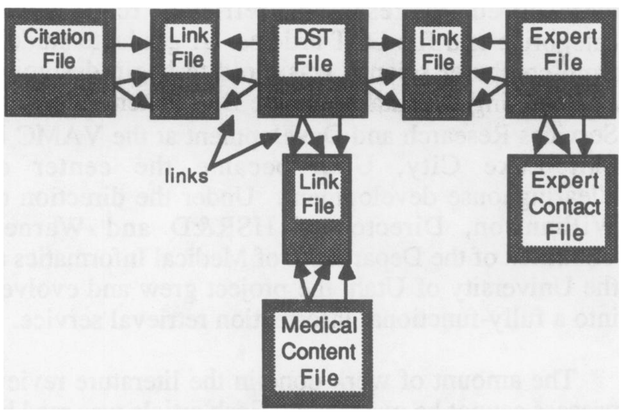

Figure 1. Diagram of files and their relationships within the DST Clearinghouse database. Note the link files allowing links and searches to go from one DST to many Experts or many Experts to one DST.

DST researcher/developer might be "linked" to several different DSTs. A search on that expert's name will retrieve all related DSTs. Information about the expert (name, institution, address, phone number, etc.) is entered only once. As additional DSTs developed by this expert are entered into the database, only the relationships (links) to the expert's file are created. This method saves disk space and file size and ultimately leads to faster and more efficient information retrieval. The same process is repeated for relating DSTS to multiple articles and medical contents. Linking can be reversed for the occasions where more than one expert, article or medical content exists for a DST. In the case of the contact file, one expert can be "linked" or related to several contacts made to that expert. The contact file is important for administrators of the database. It not only manages and documents the expert contact process, but it flags experts every six months for recontact. This scheme helps keep the database up to date.

The parameters used to describe and categorize the DSTs, as well as a short definition for each, is presented below:

Parameter:	**Definition:**
Decision Type	
Screening:	Testing large numbers of people to determine the presence of some disease, or risk factors.
Interpretation:	Recognizing a pattern in data to make a decision from a single source (e.g.: ECG or Blood Gas data).
Diagnosis:	Classifying a patient's illness into a disease category, using data from more than one source.
Prognosis:	Predicting the course of a patient's illness.
Therapy:	Deciding about treatment of a patient.
Prevention:	Identifying a potentially dangerous intended action in time to prevent such action (e.g.: adverse drug reaction).
Knowledge Representation	
Flowcharts:	Written or hard-coded algorithm constructed so that the binary branching sequence is predetermined by the program.
Bayesian:	Uses Bayes' theorem (conditional probabilities) in software logic.
Probability & Utility:	Sometimes referred to as decision analysis. This assigns numerical values to weigh outcomes. The probabilities are determined using Bayes' Theorem.
If... Then ... Rules:	Uses if...then... logic to determine the decision pathway, but the execution sequence of logic is not predetermined by the program. Many AI or Expert Systems use if.. then .. production rules.
Empirical Scores:	Rather than attempt a yes/no decision, numerical weighting is used to reflect pseudo-probabilities, and the importance of elements in the decision structure.
Discriminate Functions:	Use of a discriminate function to make a decision.
Other:	Any schema not covered by the above.
Software Implementation:	Written in LISP, FORTRAN, C, PASCAL, etc.
High Level Language for Programming:	A high level, user-friendly language is used to alter the program.
Data Source	
Terminal:	Manual input from a keyboard terminal.
Another Computer:	Direct, non-manual input from another computer
Instrument:	Input from some type of electronic instrument (ECG, radiograph, SMAC, etc.).
Database	
Linked to Patient Database?:	Is a patient database used as a source of data for the DST, and are the decisions stored in a patient database?
Linked to Hospital Information System?:	Can the DST collect and share information electronically from a hospital information system?
Decision Destination	
Terminal User:	Is the decision displayed to the user at a terminal?
Report:	Are the results printed in the form of a report?
Alert Facility:	A decision requiring immediate action causes a warning to be printed or sounded in time to affect actions taken.

Electronic Mail:	Are reports/ information directed to the appropriate party via electronic mail?
To a Control Device:	Is the decision used as a control in a closed loop?
Modem:	Is the DST accessible via modem?
Decision Explanation:	Does the DST explain how it arrived at a conclusion, if requested?
Data Driven Decision Making:	Is the decision process initiated automatically, by data?

Knowledge Base

Editor:	Can the knowledge base be manipulated by an edit function?
Modular:	Can one module of the knowledge base be changed without requiring a change in other modules?
Program Independent:	Can the knowledge base be changed without requiring a change in the program?
Natural Language:	Can the knowledge base be changed by a non-programmer?

Developmental Status

Project Active:	Is some group currently continuing development on the project?
Described in Literature:	Description available from published source.

Operational Status

Demonstrated in Lab:	The DST has operated in Lab setting.
Operational in Lab:	The DST is currently running in a test environment.
Demonstrated in Clinic:	The DST has operated in a clinical setting.
Operational in Clinic:	Now used routinely in a clinical environment.
Commercially Available:	Is it available through a commercial vendor?

Share Knowledge Base

Academically:	Share with another developer/colleague.
Non-academically:	Share with any interested party.

Evaluation

Developing Group:	Has the developing group published any article that you would consider an evaluation of the DST?
Outside Group:	Has an outside group published any article that you would consider an evaluation of the DST?

One of the most notable features of the Clearinghouse database is the medical contents file. It is anticipated that this file will be the "front-end" for most searches. Investigators interested in DSTs related to a specific need or subject will want to find technologies which make decisions related to those needs. An example usage of the Medical Contents front-end search would be a clinician interested in DSTs concerning pneumonia.

In order to verify and update the DST information gathered in the initial screening processes, attempts were made at contacting each expert/developer. In addition to phone calls, each expert was mailed a cover letter, list of parameters and a breakdown of their DST(s) as had been interpreted via literature searches or informal contact. They were asked to respond with corrections and updated information. They were also queried for additional literature references and any other information they thought pertinent. In this manner, each expert was able to provide some control over Clearinghouse information concerning their respective DSTs.

Numerous search possibilities exist with this type of database. DSTs can be reported individually or in groups. A search may find all DSTs linked to a particular expert, literature citation or clinical subject (or vice versa). The search could also be conducted by any combination of the 51 descriptive parameters. An example might be a developer who is interested in all DSTs that: aid in diagnosis, use empirical scores in the knowledge base, are written in Pascal (he knows Pascal), are data driven and are available commercially. Additional scenarios will be described later.

The database can be accessed by telephone or mail inquiry. In the future it will be queried by electronic mail, direct hookup via modem, the Veterans Administration Information System computer network based in Washington, D.C. and as part of a nationwide, high-speed fiber-optic academic network.

USERS

Projected users of the DST Clearinghouse range from students to developers to hospital administrators. Consider the following scenarios:

❋ A researcher contemplates developing a system to help physicians make decisions about chest pain. Uncertain if a similar DST is already in existence, he calls the DST Clearinghouse to find that 43 have been developed. Seventeen are being used clinically. Several developers have indicated a willingness to their share knowledge base. Three chest pain DSTs have been developed with the researcher's approach but won't do as much in a certain area as he'd like. He contacts one of the developers who sends him a pulmonary knowledge base via modem and wishes him good luck in his effort. The information supplied by the DST database saved this researcher years of effort and money.

❋ A physician in Boston wants a quick way to determine if a patient has had a myocardial infarction. He contacts the Clearinghouse to find that 21 DSTs have been developed to test for previous M.I.s. Seven are being used clinically. Of these, two are in Boston, one in New York. He contacts the experts on these systems to determine which one best fits his needs. As it turns out, the DSTs in Boston and New York are inadequate. He recontacts the DST Clearinghouse for additional information on the remaining clinically used Myocardial Infarction DSTs. He finds one in Kansas which meets all of his requirements.

❋ A physician assistant in a rural clinic needs to make a decision on a urinary tract infection. If he knew of a decision support technology on this subject, and had it in his clinic, he could make the decision and treat the patient much sooner. The DST would save on costly phone calls and reduce patient discomfort. The DST Clearinghouse could direct such rural clinics to this and other medical decision support technologies.

❋ A San Diego hospital has a computer to manage the hospital pharmacy. An administrator has heard of other pharmacies that not only do inventory control and billing, but alert the pharmacist to patient drug allergies and possible drug-drug reactions. She knows such systems exist but doesn't know where. She contacts the DST Clearinghouse where she is informed of a commercially available system that will interface well with the present hospital computer.

EVALUATION

Perhaps the biggest problem today is that 90% of all DSTs are not evaluated or clinically tested [3]. Good DST evaluation studies, such as the one conducted by White [8] at LDS Hospital are rare. White conducted a double-blind study on the accuracy and significance of a DST to flag possible digoxin intoxication. His findings revealed a 22% increase in physician actions where the DST was in use.

The future of the DST Clearinghouse lies in not only classifying DSTs but in fostering efforts to evaluate and test them as well. It would be impossible for the DST Clearinghouse center to test all Decision Support Technologies, yet it could serve as a connecting point for developers and potential test sites. There is definitely a need for objective quality assurance in Decision Support Technologies. In addition to acting as a connecting point for developers and test sites, the DST Clearinghouse center could develop an environment or standard protocol for testing the technologies. One aspect of this standardization is that testing should not be done solely by the developer [3]. Agencies like the Food And Drug Administration are also looking into the need to evaluate Decision Support Technologies.

FUTURE/CONCLUSION

The DST Clearinghouse represents a major step forward in facilitating cooperation among consumers, medical scientists and computer program developers. Consumers, especially clinicians, are very interested in obtaining accurate and easily available information on these technologies. Promotions and exaggerated claims by vendors of these systems have sometimes led to costly and unfortunate investments. And, after years of intense effort, DST developers are eager to have others know about their systems. Furthermore, areas in medicine where this type of development has been lacking will become apparent. A promising recent development has been the willingness of a few researchers to share information on their lifetime of work in DSTs. It is hoped that development of the DST Clearinghouse will encourage additional cooperation among researchers and enhance the concept of integrating medical knowledge. The Uniform Medical Language System (UMLS), a congressionally-based project under the direction of the National Library of Medicine, is also working to bring about an integration of diverse DST resources.

Integrating the DST Clearinghouse into a system for evaluating DSTs will enable developers to more readily find hospitals or clinics willing to test their system. It will also give the FDA some feedback on the quality and types of computerized decision making systems currently available. But perhaps the group which will benefit the most from an evaluation-based DST Clearinghouse is patients. The DST Clearinghouse will increase awareness and therefore growth of good, clinically proven DSTs. These can be implemented in areas where they will assist medical practitioners to deliver expert, state-of-the-art health care.

In conclusion, the DST Evaluation Clearinghouse is more than just a database of expert systems. It provides a description of decision support technologies, serves a node between different developers of these technologies and provides specific reports based upon descriptive parameters. In the future it will provide objective evaluations as well as a set of standards for clinically testing decision support technologies and expert systems. With renewed support, the DST Clearinghouse will substantially advance the growth of decision support technologies, reduce duplicated research efforts and promote improved health care nationwide.

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