

## Decision Support System in Healthcare

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### Abstract

Decision Support System (DSS) is a system that helps user in a decision-making process. There are four main components that make up a DSS system, which are user, data, models, and knowledge. The increase in the number of clinical data that is needed to make a diagnosis started the usage of decision support system in healthcare. There are several issues in building a DSS system. One of the issues is the difficulty in deciding which data is needed for the system to generate or suggest a decision. Lack of data means the system cannot produce a right decision and data overload can cause confusion for the user and for the system itself. Due to the revolution in the computers, which has creating smaller and smaller processors, we might see more decision support system embedded in personal applications. Sooner or later, this trend might spread to healthcare field, where the usage of DSS in healthcare will expand from hospital based applications to personal health applications.

### I. Introduction

The revolution in computer industry leads us to a new era of information. It makes information became much widely available and faster to gather. This new phenomenon means the amount of info that needs to be analyzed is more than what we had twenty to thirty years ago. This also causes human to live in faster pace than before. Nowadays, you do not need to wait several days for a travel agent to give you the best hotel or airline price, since you will be able to get that information by yourself within minutes. These same effects also affect companies, where they have to deal with more information and have to react with that information almost instantly. These are the things that ignited the development of Decision Support System (DSS).

Decision Support System is a system that helps user in a decision-making process. Based on one or more goals that user has provided, and some data that the system has gathered, the system should be able to find the best possible solution and suggest that solution to the user. The system might also provide user with multiple

suggestions and analyze the effect of each suggestion in the future.

Decision Support System was originally built to assist operational level managers in doing their daily tasks, such as allocating the number of employees to assist specific task based on a goal and several limitations. This type of DSS is called decision support system based on linear programming. Over the years, decision support system became more widely used, not only for managers in operational level, but also for high level executives, which drove the system to become more complex, and influenced the development of different types of DSS, such as expert system, groups support system, and artificial neural network. Nowadays, frontline workers, such as firemen, soldiers, and doctors, also use DSS to help them to perform in their daily tasks.

There are four main components that make up a DSS system, which are user, data, models, and knowledge. Users communicate to DSS using a user interface subsystem. This subsystem is important since we want the user to have pleasant experience when they interact with the system. These days, most user interfaces are using graphical user interface (GUI) which should make them easy to operate. Similar to many other systems, a DSS need to have inputs in order to produce an output, and the inputs are usually come as form of data. Data can be gathered from DSS database itself, corporate warehouse, internet, or user input. All data is maintained and managed by database management system, which will manage the retrieval, inquiry, and update process to that database. To analyze a data, a model is needed for the system to process the data. Model is the simplified representation of real live, so the system does not need to apply the data to real life situation which usually more complex and harder to apply. Models usually reside under subsystem called model base management subsystem.

All three components in the previous paragraph are required in order to build a functional DSS. There is also another component that is used by some DSS, but is not available in all DSS, which is knowledge. Knowledge component is usually

available for intelligent based DSS, such as an expert system. The knowledge is located under knowledgebase management subsystem and sometimes it has connection with the database system or user interface, so user can update the knowledge if needed.

The increase in the number of clinical data that is needed to make a diagnosis started the usage of decision support system in healthcare. A decision support system in healthcare is needed to help a clinician in making faster and more reliable decision, since a DSS based application can handle more data, and analyze that data faster than human brain. In the end, people hopes that decision support systems can help healthcare practitioners in providing better care to patients.

Around 1980, people started to think about creating a machine that can be used in helping healthcare practitioners to perform their jobs, such as determining a patient's diagnosis. One of the first machines that was designed to do that is called DXplain, which was developed by Massachusetts General Hospital. This machine contains more than 2000 diagnoses and 4900 clinical findings (such as symptom, laboratory data, and condition). Doctors can enter all clinical findings and the correlations between the diagnoses and clinical findings will direct the system to come up with several possible diagnoses. This system uses complex algorithm and decision tree to produce possible diagnoses. People sometimes categorize this system as an expert system.

Healthcare also uses other type of intelligent DSS, such as Focal Point, an intelligent system that analyzes pap smears tests. Instead of using computational algorithm to generate the diagnoses, it uses artificial neural network (ANN) to produce a diagnosis based on the result of pap smears test. Using image recognition approach, the system examines pap smears result and identifies any abnormal cell in the slide. Before it is used, the system was set to do supervised learning, where it will try to read the result that pathologists have already diagnosed and adjust any associate weight in the system to produce desired outcome.

Nowadays, making diagnoses is not the only reason why people use DSS in healthcare. In this field, intelligent machine is also used for decision-making, quality assurance, acute care, long-term care, laboratory and administrative

procedure. According to Coirea, Enrico (2003), laboratory is one of the most successful areas which intelligent machines are applied. They interpret the results so people will understand what those lab results mean. SmartCare, by Dräger Medical GmbH, is a sample of intelligent machine that is used for acute care. It manages mechanical ventilation in Intensive Care Units based on the current patient conditions such as breathing frequency, tidal volume and end tidal CO<sub>2</sub>. The system then will generate the correct mechanical ventilation needed for the patient based on those conditions. Another sample is a DSS application that use intelligent machine for drug design, such as AMBER, Assisted Model Building and Energy Refinement, which uses a set of molecular mechanical force fields. This field has been greatly advanced after the emergence of human genome.

## **II. Diversity of Decision Support System**

There are several types of decision support system based on the system's capabilities. The first type of DSS, which is already obsolete, is called Transaction Processing System (TPS). This system only saves raw data without any editing, and there is not much that you can do with the data inside the system. The next type is linear programming DSS, which can help operational level manager in deciding resource allocation based on data, model, and constraint that is provided by the user. These two types of DSS are ones of the earliest DSS.

As the requirement from the users for a decision support system became more complex, other types of DSS were born. The need to have a system that can retain knowledge of an expert led to the development of DSS type called expert system. In this system, a subsystem called interference engine is used by the system to create a suggestion to user based on facts and knowledge that the system has. This type of DSS is considered the first type of intelligent system.

A more complex intelligent system, which is also another type of DSS, is artificial neural network (ANN). ANN is a computational paradigm that imitates the way human nervous system works. This paradigm is needed in order to make a machine that is able to solve a problem as general, so there is no need to create an extensive algorithmic solution for each problem. With this

model, people hope that someday we will be able to create a machine that is smart enough to handle and adapt any changes to the environment. ANN is also called “learning machine”, which means that the system performance improves over time. There are many more DSS types out there that I will not describe here.

Some of those DSS types that I mentioned above are used in healthcare. System for nursing acuity, which schedules nurses based on nurse availability, needs, specialty, and other constraints, usually uses linear programming type DSS. This system enables nurse coordinator to give the best possible combination of nurses to work for a period of time.

Another type of DSS that is used in healthcare is an expert system. As we have learnt from previous chapter, DSS in healthcare was originally built to help healthcare practitioner in diagnosing a patient. Most of the systems that do that task are considered expert systems. In an expert system, a subsystem called interference engine suggest patient diagnoses based on fact (clinical data) and knowledge (medical knowledge) that are stored in the system. Expert system is not only used for generating a diagnosis, it is also used to provide clinician with automated patient work flow, provide drug recommendation, and prevent adverse reaction of administer drug.

People usually use DSS with artificial neural network to handle less structured problem, such as image recognition or behavior pattern. One of the samples is the one that I mentioned earlier, which is Focal Point. This system generates a patient diagnosis based on analysis of the image result of a pap smears test. A human who is an expert in reading the pap smears result “teaches” the system on how to identify abnormal cell in the image during several trials and run periods. The drawback in using “teaching” method is the system performance will depend on the correctness of the desired output during learning, as what was told in Wired Magazine: “If FocalPoint kept learning ‘in the wild’, its performance would vary depend on the skill of the lab tech who was teaching it”<sup>1</sup>. Another example of a healthcare system that uses this type of DSS is Entropy Maximization Network,

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<sup>1</sup> Wired Magazine, It’s Alive article

which is used for predicting metastases in breast cancer patients.<sup>2</sup>

Today, the most widely used type of DSS in healthcare is probably information portal. In this type of DSS, user (in this case a clinician) can see all important information that is needed to help them make a decision in one place. This type of DSS is used by many clinical data repository systems, such as Microsoft Azyxxi (Amalga) or Cerner CDR (Clinical Data Repository).

### III. Issues and Problems

One of the big challenges in building a DSS is the difficulty in deciding which data is needed for the system to generate or suggest a decision. Lack of data means the system cannot produce a right decision and data overload can cause confusion for the user and for the system itself. Other than deciding what data is needed, the other issue in building a DSS system is how to create the right model in the DSS that should mimic the system’s process flow in the real life.

To make sure the system only request and process the right amount of data, we need to incorporate a person who knows the detail of a particular process (such as how to interpret magnetic resonance angiography) when we are designing and building a DSS. He or she needs to work closely with the developers and closely examine the prototype that developers will assemble. This examination should enable this person to give developers feedback if there is any missing data or unnecessary data in the system. That person will also help developers in creating the correct model which should show the real life representation for the specific process flow.

Once we have successfully built the DSS, we might encounter another roadblock during the implementation phase which usually is the result of lack of user training such as when clinicians are not ready to handle the new protocol that they need to execute. Also the need for clinicians to manually reenter the data from one ancillary system to their DSS application is another issue that clinicians will face when using the DSS. This task, if not carefully executed, might cause

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<sup>2</sup> Introduction of Neural Network in Healthcare

a data input error, thus causing the system to generate a suggestion based on incorrect data. In another front, patients think that DSS decreases the time clinicians spend on direct patient care<sup>3</sup>.

#### **IV. Suggested Improvement and Prediction of the Future**

Decision Support System has been slowly invading many areas in our life. Just imagine that you are on a trip to visit your uncle in another city; the airport where you depart from might use airport information systems to manage airport operation, such as assigning gates, scheduling planes, and directing baggage. The plane that you are using will have intelligent module in the flight controller application to help pilot operate the plane. Once you arrive, the car that you are riding might contain fuel injection that uses DSS with a learning algorithm.

Due to the revolution in the computers, which has creating smaller and smaller processors, we might see more decision support system embedded in personal applications. Nowadays, we already see a washing machine that was built using artificial neural network. According to Dr Rodney Brooks, the director of MIT's artificial intelligence laboratory, by 2050, our lives will be populated with all kinds of intelligent robots. Several years from now there might be an application that will automatically execute trades on our stock based on the condition of the market. In the near future, people might start using an intelligent refrigerator that will automatically alert us for any depleted grocery items, or even better, create the grocery list and contact the grocery store automatically to have the store send us the replenishment.

Most of DSS based healthcare systems have proven that they can increase the quality of care by generating a more precise diagnosis and better care management. According to study by Kensaku Kawamoto, et al, 48 of the 71 DSS based healthcare systems significantly improved clinical practice, and 75 % of intervention succeeded when decision support was provided to clinical automatically<sup>4</sup>. Healthcare DSS also have proven that they can help clinician in performing diagnoses or reading a result, which will enable clinician to do other important tasks.

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<sup>3</sup> Making Health Care Safer, chapter 53

<sup>4</sup> Information in Practice

DSS based healthcare system is also used to help monitoring possible adverse drug events for patients using patient clinical data and system knowledgebase and this application is known to reduce the number of patient risk factors for adverse drug events. All of those DSS based healthcare applications have proven to increase the quality of care by generating a more precise diagnosis and better care management. They also have been proven to reduce the number of possible malpractice, which in turn will reduce the number of medical liability lawsuit. One of the samples is MedStar Health, a health system comprises of eight hospitals serving Washington DC and Baltimore area, which saves about \$3 million yearly from its liability claims after employing an expert system in their obstetric department. Those success stories of DSS implementation will prompt more and more healthcare organizations to use a DSS based healthcare system in their operations. In ten years or less those systems will be used by more hospitals and widely available in most departments in each hospital.

Even though there are many benefits of employing a DSS based healthcare system, the system itself is not welcomed by some people. The absence of human interaction during patient visit is usually the main reason why patients do not like the idea of interaction with a DSS machine. Hospitals or clinics need to proactively inform their patients about the benefit of using DSS, which in turn should make patients more willing to accept interaction with a DSS machine. More human-like robot might be able to ease this type of rejection. In Touch Health, a California based robotic technology company; created a human like robot that helps clinician gather the condition of the patient. The robot has the LCD screen, which displays the face of patient's personal physician and makes the patient more acceptable to interact with the robot<sup>5</sup>.

In the future, the trend to embed DSS to personal device might spread to healthcare field. To make DSS based healthcare system more useful, software vendor need to start thinking to build a personal diagnostic device that can be placed at any house. That device, which contains intelligent system such as expert system or ANN, will have equipment that can be used to get the clinical data from user's body, such as body

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<sup>5</sup> Robot Doctor Gets Thumbs-up from Patients

temperature, heartbeat, and blood rate. If a person does not feel well, he/she can attach that device to his/her body, and the device will be able to acquire important clinical data from user's body.

Currently MedStar Health is piloting a similar project with a device called HealthBuddy. The device will collect the heart rate, blood pressure and temperature from a patient and then sends this information to physician office using modem. If one of the vital sign is outside the normal range, the system will alert physician, and the physician will decide what need to be done for the patient, such as prescribing different drugs, revising the drugs' dosage, or requesting the patient to come by to the office for further examination.

In the future, the device itself might be able to generate possible diagnoses and suggest any treatment using the clinical data and knowledge base that the device has. The device will also automatically update the patient's medical record, and contact doctor's office if the device thinks the person needs to get assistance from a healthcare practitioner. The device might also be able to contact emergency response team if the person is in critical condition. This vision will probably help reduce the cost of healthcare and in the same time, improving healthcare conditions. With this breakthrough, healthcare practitioner can focus their task to diagnose more complex symptoms or treat more serious illnesses.

## **Conclusion**

Implementation of DSS in healthcare has been proven to be one of solution for reducing unnecessary treatments, wrong diagnoses, and poor care management, thus reducing the cost of healthcare. Employing healthcare based intelligent systems have also been proven to systematically increase the quality of patient care. Similar system can also be used to assist

healthcare practitioner in delivering care to patient.

The future of DSS based applications in healthcare might shift from hospital applications to personal health applications. This shift will enable people to manage their own health with the help of DSS based healthcare application. Healthcare practitioner will be available for support, and might only be involved in serious and complex illness.



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