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Techniques in the Design of Decision Support System for Health Service

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Abstract: **A decision support system (DSS) application is usually built to assist management in their decision making purposes and aid in discovering patterns in a historical data in a given context. Moreover, a DSS also have the capacity to assist in making prediction when combine with data analysis tools to develop the model. In turn, DSS assists management decision making by combining data, sophisticated analytical models and tools, and user-friendly interface into a single powerful system that support semi structured or unstructured decision making [8]. The main purpose of DSS is not to make a decision but to be assisted in decision-making. However, addressing organizational such as health service decision making problems require a broad systematic approach that includes data and requirement gathering, and modeling the data to best suit the service decision-making. Here, the concepts of observatory plays a critical role as it can strategical facilitate processes involved in the data and requirement elicitation. A DSS application help structure the organization well in this era of knowledge management and utilization of large data to find patterns and make predictions. The decision support system application implemented in this work engaged a special database known as data warehouse. This data model technique used thus a multidimensional modeling interface with data analysis tools such as query and reporting, and multidimensional analysis.**

Keywords: **observatory, multidimensional model, multidimensional data analysis.**

I. INTRODUCTION

Managing knowledge and making decisions in the health service organizations for effectiveness and planning for resources control on timely aid decision makers or administrators to transform data or information into actionable intelligence that can be interpreted to assist different functional actors' decision-making within the health service organization. However, administrators are needed to make certain that healthcare organizational tasks are carried out in the best way possible to achieve organizational goals and appropriate resources control including financial and human resources that are adequate to support the organization in order to deliver best service to patients. For example, in the healthcare organization, it is a policy for administrators to periodically analyze current trends and changes in healthcare data on a weekly, monthly or quarterly basis. The administrators then provide a report detailing the analysis to the sponsoring healthcare organization and this report becomes the basis for future decision making and planning for healthcare management. However, to address this challenge with DSS application, decisions related data such as patients' demographic and historic medical records make it possible to identify all individual patients seen by a healthcare provider and produce a profile of all services received by each patient and resources used in treating their ailment over any defined time period.

Moreover, health service DSS this research seek to develop addressed the problem of manual processing of data at the departments. A DSS is any form of structured repository of health service decision data or raw information that would be used to support healthcare decision-making, and hence to promote health development for efficiency and effectiveness in managing patient care, services delivery, and resources at the health service in order to react quickly on emergencies. DSS is extensively used in business, management, executive dashboards and other business performance software that allow

faster decision making, identification of negative trends, and better allocation of business resources. In turn, the decision making related data such as patients' demographic and historic medical records, services received at the facility, and resources used in treating patients enable observations, analyses and generate a representation of knowledge that can be used for information and process modeling at the service. However, the concepts of observatory and competitive intelligence were strategically used as synergy for processing health service DSS application at the backend of the system development and frontend visualization of system output. That is, at the backend, primary observatories missions were engaged for data collection and requirements elicitation while at the frontend, secondary observatory is ensued for observing the output display to retrieve or make changes to some aspects, summarize, and analysis the decision related data. The competitive intelligence concept in this context aids the process of making choices for alternative courses of action based upon factual and value premises that would help in driving the healthcare delivery to improve services.

II. RELATED WORK

In a recent time, information technology, and computer software in particular, have extended the scope of their activities to healthcare industry management, clinical and diagnoses, planning and administration. Literature reviewed has revealed that there is another popular heuristics approach is data mining techniques which identify pattern or rules about various quality problems. DSS is therefore built based on the data that are derived by data mining techniques and is effective in reducing cost incurred by the organization by preventing adverse events and improving quality practice [1]. It was realized during the reviewed that two critical factors for success with decision support system include a large, well-integrated data warehouse, and a well-defined understanding of the institution process within which data mining is to be applied (such as customer prospecting, retention, campaign management, and so on) [7]. There have been success stories of decision support system application in a wide range of companies and government institutions such as Pharmaceutical Companies, Credit Card Companies, Transportation Companies and large consumer package goods companies to improve the sales process to retailers [6]. Each of these examples has clear common ground and intended to solve a problem in a specific domain. They leverage the knowledge about customers implicit in a data warehouse to reduce costs and improve the value of customer relationships. There is another system that improves quality and delivery of healthcare services called Strategic Healthcare decision support services which is a synergy between knowledge management and data mining techniques [10].

A decision support system is an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions [8]. DSS application uses an interactive, flexible, adaptable computer-based information system specially developed for supporting the solution to a specific non-structured management problem. It uses data, provides an easy user-interface and can incorporate the decision maker's own insight, includes models and is developed through an interactive and iterative process. It supports all the phases of decision making and may include a knowledge component. For instance, DSS application in health service is seen to improve quality, safety and efficiency of the patient care which adversely reduce misuse of hospital resources and promote timely distribution of resources for better healthcare delivery.

There has been an expanded decision support system framework containing the model-driven DSS, data-driven DSS, communications-driven DSS, document-driven DSS and web-based DSS. Model-driven DSS emphasizes access to and manipulation of financial, optimization, and simulation models. A fifth category, known as knowledge-driven DSS has been added [16]. There has been management decision support system that assisted production and marketing managers for marketing and coordinating with other departments. A communication-driven DSS supports more than one person working on a shared task. Data-driven or Data-oriented DSS on the other hand emphasizes access to and manipulation of a series of internal organization data and sometimes external data. The document-driven DSS manages, retrieves and manipulates unstructured information in a variety of electronic formats. The knowledge-driven DSS can suggest or recommend actions to managers. DSS can be seen as person-computer system with specialized problem solving that consists of knowledge about a particular domain or understanding of problems within that domain, and solving some of these problems [8]. From Figure 1, it is clear that DSS belong to an environment with multidisciplinary foundations, including (but not exclusively) Database research, Artificial intelligence, Human-computer interaction, Simulation methods, Software engineering, and Telecommunications.

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Figure 1: History and Trends in DSS

In general, decision support systems are a class of computerized information systems or information intelligent systems, which have expert system features that support decision making activities. However, studies on DSS development conducted during the last 15 years have identified more than 30 different approaches to the design and construction of decision support methods and systems. Interestingly enough, none of these approaches predominate and the various DSS development processes usually remain very distinct and project-specific. This situation can be interpreted as a sign that the field of DSS development should soon enter in its bench mark stage for formalization.

III. METHODOLOGY IN DATA AND REQUIREMENTS ELICITATION FOR HEALTH SERVICE DSS

Health Service DSS Requirements Gathering:

The data warehouse development focuses on facilitating the analysis that will change the health service process to make it more effective. The data and requirements identified at this point in the development are used to build the data warehouse model and the DSS application. This in turn describes the main function and what end users want to analyze in the application.

The methods used in deriving healthcare business requirements are placed in the following categories: source-driven and user-driven requirements gathering through primary observatories missions.

Source-Driven Requirements Gathering:

Source-driven requirements gathering is a method based on defining the health service DSS requirements by using the source data in healthcare operational systems. This is done by analyzing source data or the actual physical record layouts and selecting data elements deemed to be of interest to DSS application. The result of the source-driven approach is to provide the user (or actors in the system) with what the developer has and this eliminates the user face of requirement. However, analyzing relationships in the source data identify health service areas on which to focus the data warehouse development for the DSS.

User-Driven Requirements Gathering:

User-driven requirements gathering is a method based on defining the health service DSS requirements by investigating the functions the users perform at the healthcare facility. This was done through a series of meetings and interviews with users to obtain what users actually want from the DSS application. In turn, the major merit to this approach is that the focus is on providing what is needed rather than what is available to end users. In this instance, two methods were combined to gather health service DSS requirements from the stakeholders and administrators of the health service. It was realized during the missions for source-driven and user-driven requirements gathering that user-driven approach has a smaller scope than the source-driven approach. However, the health service DSS requirements gathering for building the data warehouse and the DSS application began with source-driven approach, which breaks the project into subject areas and the user-driven approach was engaged to gather the requirements for each subject area. Moreover, these approaches were engaged through the primary observatories missions. The primary observatory mission is data acquisition processes that identify, extract, transform, and transport the various source data necessary for the operation of the data warehouse.

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Data acquisition is performed between several components of the warehouse including operational and external data sources to data warehouse. Furthermore, end-user requirements suitable for the DSS data warehouse modeling and the application can be further classified into two categories namely: process-oriented requirements that represent the major information processing elements, which end users are performing or would like to perform against the data warehouse being developed, and information-oriented requirements that represent the major information categories and data items that end users require for their DSS application data analysis activities.

Health Service Process-Oriented Requirements for DSS:

The process-oriented requirements represent the major information processing elements that end users are performing or would like to perform against the DSS data warehouse being developed for the health service. Moreover, the end users (or analyst) in the DSS have a profound effect on the way the data warehouse is developed and on how the DSS application using the data warehouse is developed. Figure 2 demonstrates the various categories of the end user requirements for the health service DSS data warehouse and application.

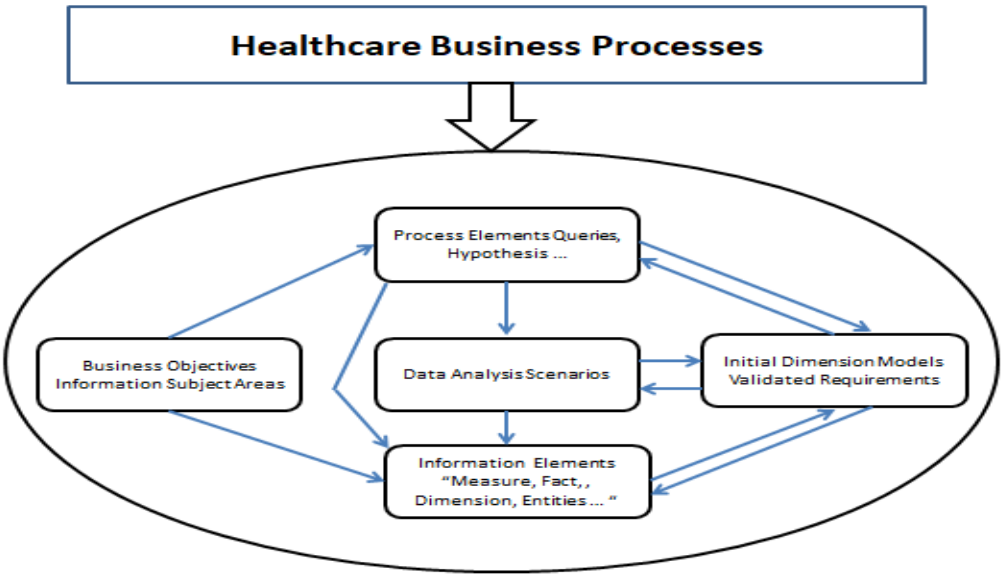

Figure 2: Categories of End-User Requirements for Health Service DSS

The requirements captured for the DSS belong to either or both of these categories (see Figure 2). However, the type of requirements that will be available and degree of precision with which the requirements will be stated or can be stated depends on two factors: the type of information analysis problem being considered for the health service DSS data warehouse implementation, and the ability of end users to express their information needs and the scenarios, and strategies they use in their information analysis activities at the service.

Healthcare Business Objectives:

Healthcare business objective is high-level expression of information analysis objectives, expressed in business terms. Moreover, more business objectives were specified for the health service DSS data warehouse implementation such as, for example, the health service DSS data warehouse has to support the analysis of healthcare cost, services patient received, patient medical records, patient recovery from certain illness to help reduce cost burdens that associated with the treatment, and resources used in treating patients at the hospital. A combined healthcare business objectives were used in the data warehouse implementation as indicators of the scope of this work. They were also used to identify information subject areas involved in the health service DSS research work and as a means to identify measures of the healthcare business processes the end-user is analyzing. For example, in specific relation to health service DSS research work, the apparent information subject areas are patients' medical care and healthcare delivery, patients' demographic and medical records, and services received at the healthcare facility in relation to resources management and logistics used in treating patients at the hospital. The objectives indicate that the measures used in the healthcare information analysis process are "healthcare cost", "resources management in the healthcare facility", "patient recovery from certain ailment (patient medical care)" and "profile of services received at the healthcare facility" among others.

Healthcare Business Queries:

Healthcare business queries represent the queries, hypotheses and analytical questions that end users issue and try to resolve in the course of their information analysis activities. However, healthcare business queries are expressed in business terms just like business objectives and usually not precisely formulated and not expressed in terms of SQL.

Examples of some frequently encountered categories of healthcare business queries are:

- Existence checking queries such as "Has a given patient recovered after receiving a number of services for a time period".
- Item comparison queries such as "How effective is a medicine compared with number of them on patient recovery".
- Trend analysis queries such as "What is the historical recovery of patient for being diagnosis and treated with combination of medicines over the last 6 months?"
- Queries to analysis clusters such as "Rank the best medicine tried on patients over the last 8 months". Or "Rank patients recovery rate on number of ailments over the last 8 months"
- Statistical analysis queries such as "calculate the average recovery time on patients for taking a certain medicine per geographical area" or "The average quantity of logistic purchased for a particular department over a period" or "The total number of patients who seek healthcare on quarterly and the total revenue to the hospital". This also includes obtaining numerical summaries such as mean, standard deviation, medium, and maximum and minimum values among many others.

Data Analysis Scenarios:

Data analysis scenarios are a good way of adding substance to the set of health service DSS requirements being captured and analyzed. Essentially, two types of data analysis scenarios that are of interest to health service DSS data warehouse modeling and the application are:

- The query workflow scenarios that represent sequence of healthcare business queries, which end users' perform as part of their information analysis activities. The query workflow scenarios significantly helped create a better understanding of the information analysis process for the DSS application.
- The knowledge inference strategies, which represent end-user requirements, acknowledge the fact that activities performed by end users in the health service DSS data warehouse have expert system characteristics. As with query workflow scenarios, these strategies provide more understanding of the activities performed by end users in terms of expressing how they get to an answer or find a solution for their problems in delivering health services duties. For example, the simplest forms of knowledge inference strategies in this research work are those that show how users roll up and drill down along records or dimension hierarchies for retrieving task-relevant datasets or information.

Information-Oriented Requirements for DSS:

The information-oriented requirements capture an initial perception of the kinds of health service information end users use in their information analysis activities. The information-oriented requirements categories those that are of interest for the requirements analysis and the health service DSS data warehouse modeling process, and this include the following step.

Information Subject Areas:

The information subject areas are high-level categories of healthcare business information. This are used to build the high-level enterprise data model such as the health service DSS data warehouse model. The information subject areas indicate the scope of the DSS data warehouse model and the application for the health service. They also contribute to the requirement analyst's ability to relate the DSS data warehouse model with other parts of the healthcare database or mart already developed. The information subject areas define the problem domain or context within which the health service DSS application is built. Again, it clearly defines the scope of the operational data (that is files and other source-driven data) for the data warehouse model in this work. For example, some of the information subject areas that are of interest in this work include: healthcare delivery, resources purchase and control, and services received when seeking medical care (that is patients' activities within the hospital).

Dimension Data Models:

The multidimensional modeling primarily uses techniques that produce flattened dimensional model such as star schema models. This part gives brief description of the multidimensional data model that is based on the key concepts of cube, dimension and hierarchy. The cube is the concept that describes the whole of the data, which are presented along labelled edges of that cube (i.e., dimensions). The hierarchies define the way in which dimensions are grouped. This dimensional modeling approach results in a data warehouse design that is consistent with the paths by which end users or actors in the health service DSS data warehouse wish to enter and navigate. In this case, cubes, dimensions, measures, hierarchies, levels and cells constitute the basic online analytical processing structures [13]. However, putting all these together defines the logical structure of an online analytical processing (or multidimensional) database. The measures (i.e., attributes) are data that one wishes to analyze while dimensions (i.e., entities) define the organization of these measures. Moreover, data are stored and managed in the data warehouse, which presents multidimensional views of data to a variety of frontend tools such as query tools, report writer, analysis tools, and data mining tools [11]. However, a high-level conceptual model (also known as the subject-area data model) of the solution for each of the healthcare business questions is created. The conceptual model serves as the blueprint or documentation for the data requirements of the health service DSS data warehouse.

Health Service DSS Requirements Analysis:

The health service DSS requirements analysis was done at the same time as the initial data model in order to facilitate smooth transition from healthcare business source data and requirements to the data model. The requirements analysis techniques that are used to build an initial dimensional data model (or the DSS data warehouse model and the application) represent the end-user requirements captured during data and requirements elicitation (see Figure 1). The health service requirements analysis produces a schematic representation of a data model that information analysts can interpret directly. The results of health service requirements analysis are the primary input for the DSS data warehouse modeling once they have passed the requirements validation phase. The scope of work for health service requirements analysis for the data warehouse model in the DSS application is summarized and discussed as follows:

- Determine candidate measures (attributes), facts (central table ‘or entity’), and dimensions (other tables ‘or entities’) including the dimension hierarchies (how entities are grouped). A query-oriented approach is used here, so measures are determine first (e.g., analysis of the healthcare business queries), and then dimensions associated with measures, followed by facts. This approach flows naturally when the requirements analyst picks up the end-user queries as the first source. Measures are usually associated with several dimensions in the relational model.
- Determine granularities. This step formally states the lowest level of detail (i.e. the granularities) used for recording the measure in the dimensional model. The granularity of a measure is determined by the combination of recording the details of its entire dimension. It was realized that determining the right granularities of measures in the data warehouse model is extreme importance because it basically determines the depth at which end users will be able to perform information analysis using the data warehouse.
- Building the initial dimensional model. The above two steps serves as input for the initial dimensional model leading to the final data model for the DSS application. That is, the above based elements (i.e. measures, dimensions and dimension hierarchies and facts.) have to be identified and arranged in the model.
- Establishing health service business directory for the elements in the DSS data warehouse model. This step of the initial dimensional model is the establishment of health service business directory (i.e., metadata) for documentation, which includes definitions of elements in the dimensional model.

IV. DSS ARCHITECTURE

A DSS is an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions. Decision Support System is a general term for any computer application that enhances a person or group’s ability to make decisions. Again, decision support systems refer to an academic field of research that involves designing and studying decision support systems in their context of use. Three fundamental components of DSS: the

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database management system (DBMS), the model management system (MBMS), and the dialog generation and management system (DGMS) [18]. The three fundamental components of the DSS are further classified as follows:

- the Data Management Component stores information (which can be further subdivided into that derived from an organization's traditional data repositories, from external sources such as the Internet, or from the personal insights and experiences of individual users);
- the Model Management Component handles representations of events, facts, or situations (using various kinds of models, two examples being optimization models and goal-seeking models); and
- the User Interface Management Component is of course the component that allows a user to interact with the system. The interface aids in model building and interaction with the model, thus describes how user enters problem and receives answers.

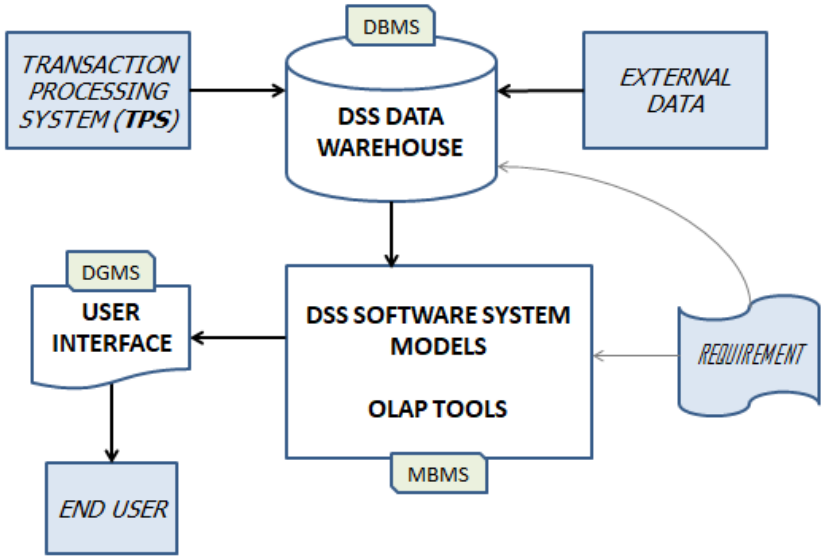

Figure 3: The DSS Architecture

A DSS architecture have the above three components and play a prominent role in their structure. Interaction among them is illustrated in Figure 3. The structure entails transaction processing system for transfer of health service organization transaction data into the data warehouse. The DSS data warehouse contains current data from application and groups (i.e., external data). The user interacts with the DSS through the user interface management component (thus how user enters problem and receives answers). The user interface management component (i.e., DGMS) communicates with the data management component (i.e., DBMS) and model management component (i.e., MBMS), which screen the user and the user interface from the physical details of the model base and database implementation.

V. CONCLUSION

The aim of the healthcare business requirements analysis for health service DSS data warehouse is to analyze the information gathered as described and these activities is further summarized as follows: to determine the data requirements of the data warehouse in terms of healthcare primitive objects (as entities), classify and describe the information about these healthcare objects (as entities or attributes), identify and classify the relationships among the healthcare objects (associations between entities), determine the types of healthcare operation (queries) that will be executed on the data warehouse and the interactions between the data and the healthcare operations, and finally, identify the rules governing the integrity of the data (constraints). A decision support system presented in this paper is an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions in a given domain. Moreover, the perceived benefits that a well design and constructed DSS would offer the health service organization includes decision quality, improved communication, cost reduction, increase productivity, time savings, and improved customer and employee satisfaction.

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