Business Intelligence Healthcare Model: Getting The Right Requirements For Malaysian Rural Citizens

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***Abstract*— Malaysian government is facing big challenges in providing healthcare services to its rural communities. To meet up with the challenges, a concept called business intelligence (BI) is employed for their informed decision-making that utilizes their enormous data. However, only a few of BI initiatives have their success stories as many are still struggling to justify the investments. Among the most reason of the failures were that BI requirements were overlooked, leading to poor BI deployments. Taking rural healthcare in Malaysia as a case study, the paper attempts to model BI requirements using goal-oriented approach. Rural healthcare BI requirements were modelled two-folds: (1) decision making requirements, cantered on stakeholders; and (2) BI data requirements, focused on organizational and decisional aspects. The model can guide BI developers on the process and data needed in rural healthcare strategic decision-making. Theoretically it provides new insights and facilitates the improvement of new healthcare knowledge.**

***Keywords*—** *Business intelligence; data warehouse; goal-oriented; requirement model; rural healthcare*

1. Introduction

The Malaysian healthcare is facing a lot of challenges as the rural dwellers are accessing to poor healthcare services [1]. The consumers of rural healthcare in Malaysia are mainly those whose purchasing powers are very limited and they are very much dependent of free public services provided by the government. They also have limited choice of accessing other healthcare providers such as private hospitals, which provide better products and services. Another prominent issue is the present number of healthcare professionals in the rural healthcare organizations. On average the rural folks possess less doctors and nurses as compared to their urban and wealthier friends [2], leaving them in sicker and poorer conditions.

Realizing these issues and to overcome these challenges, Malaysian government has since put in place many initiatives including implementing information systems. These systems that requires them to gather healthcare information such as patients, diagnosis, treatment and others, have been storing massive amount of information in databases throughout the country over the years. However, so far proper programs are still not in place to analyse these so called 'Big Data' owned by them. Owning massive amount of data, a forward-thinking healthcare organizations must realize that data and, thus, a concept known as business intelligence (BI) is at the centre of informed and precise decision-making that will improve their services [3]. To achieve the full benefits of BI in healthcare organizations, there must be a strategic approach to define decision-making requirements for BI. The proper modelling of data, analytics and decision-making process should be done for the people in organizations to take advantage of their data.

This paper identifies, analyses decision-making requirements for rural healthcare centre and finally, constructs a BI requirement model for rural healthcare centres in Malaysia.

2. Business Intelligence

BI has emerged as an important area of study for

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both practitioners and researchers, reflecting the magnitude and impact of data-related problems to be solved in contemporary business organizations including healthcare organizations [4]. Scholars from difference school of thoughts have their own definitions of BI, but generally it is an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance [5]. From technology point of view, BI is used for gathering, storing, analyzing, and providing access to data for better business decisions [6]. Some earlier scholars view BI as a process of turning data into information and then into knowledge that can be used for good decision-making [7, 8].

With competitive and complex business environment today, organizations, private or public are under tremendous pressure. They need to respond quickly to changing conditions and be innovative in order to stay competitive. It requires them to be agile and make frequent strategic, tactical, and operational decisions. Making such decision may require considerable amounts of timely and accurate knowledge. Processing these in the framework of the required decisions needs quick, frequent and some computerized support, which is traced to BI [9]. Making BI a success story is the real challenge to organizations, among the main factors that mentioned in the literature is that BI doesn't fulfill their decision-making requirements. Many BI systems failed to deliver the promised 'knowledge' needed by decision makers.

2.1 Business Intelligence Requirement Modelling

Requirement plays a very important aspect of BI implementation, where poor requirements management can lead to project failure. BI project managers need to acquire necessary skill in order to optimize the results and to minimize problem during BI requirements elicitations.

BI requirements analysis can be classified in two categories: (1) data-driven approaches - starting from analysis of data sources; user requirements impact on design by allowing the designers to select which chunks of data are relevant for decision making and by determining their structure according to the multidimensional model; and (2) requirement-driven - start from determining the information requirements of end users, and how to map these requirements onto the available data sources. Data-driven approaches simplify the design but, they give end-user requirements a secondary role. On the other hand, requirement-driven approaches start from determining the information requirements of end users which bring requirements to the foreground, but it requires larger efforts when designing as it needs a more structured method.

Information systems scholars have come up with techniques for modelling that help analyze and understand requirements for systems such as Context Diagram, Entity Relationship Diagrams and Sequence Diagram. But most of these modelling techniques only cater for operational type of information systems, whereas BI is a strategic information system that has different needs in terms of data as well as processes.

2.1.1 Requirement Modeling with Goal-oriented Approach

In the field of DW design, [10] proposed Agent-Goal-Decision-Information (AGDI) model to support the early and late requirements for development of DWs from the stakeholders' perspective. This model also supports three interrelated modelling activities, namely, organization modelling, decision modelling and information modelling. [11] proposed a comprehensive method in order to determine information requirements of DW users and match these requirements with the available data sources. The activity model represents the core component of a comprehensive methodology for information requirements analysis for DW systems.

Requirement analysis is split in two which is early and late requirement analysis in designing phase [12]. [13] stated that during the first phase, domain stakeholder and model will be identified as social actors, and in late requirement analysis, the conceptual model will be designed consisting of new actor and a number of dependencies with other actors. [14] presented the comparison between different approaches to analysis the goal-oriented requirement models, to understand the ways in which procedural design choices affect results.

The sufficient requirements to support the decision making process are required to manage the DW changes correctly. This will help the information provided will meet the business goals.

However, the requirements for DW are difficult to decide from the goal of the decision maker or organization since the current DW modelling does not consider the goal concept in the model [15]. All the pre-requisites must be squared up, identified and analyzed within early and late requirement analysis by using suitable modelling.

Requirement analysis is split in two which is early and late requirement analysis in designing phase [16]. [16] stated that during the first phase, domain stakeholder and model will be identified as social actors, and in late requirement analysis, the conceptual model will be designed consisting of new actor and a number of dependencies with other actors, meanwhile in architectural and detail design phases focus on the DW detailed design specification in the implementation phase.

In the perspective of goal-oriented approach, [12] presented the comparison between different approaches to analysis the goal-oriented requirement models; to understand the ways in which procedural design choices affect results. They were advocated goal-oriented to capture and link technical requirements to derive high-level or details user requirements using elicited goals, capture and compare alternative potential implementations. Several applications of goal-oriented techniques in different modeling frameworks, techniques, or methodology include KAOS, GBRAM, NFR, i*, Tropos, GRL, and AGORA.

[18] proposed a GORE approach for modeling, organizational goals that the DW supports and relating them to the information required and to use the i* modeling framework and the model driven architecture (MDA) in order to describe (i) how to model goals and information requirements for DWs, and (ii) how to derive a conceptual multidimensional model that provides the required information to support the decision making process. Computation independent model (CIM) is specified by using the i* modeling framework in order to model goals and information requirements for a DW and then the conceptual multidimensional model of a DW is derived from the CIM into the platform independent model, PIM.

2.1.2 Tropos Methodology

Tropos is an agent-oriented software engineering methodology. In DW design, Tropos can be uses as goal-oriented approach to requirement analysis in two perspectives of modelling which is organizational modelling and decisional modelling and GRAnD. Giorgini, Rizzi and Garzetti proposed a few step in goal analysis as shown in Figure 1. GRAnD methodology encompasses these two modelling. Tropos support from early phases of requirements analysis to detailed design that focused on the understanding of the environment where the DW must operate, and communication between analyst and stakeholder in decision-making process.

There are four phases in Tropos methodology consist of early requirements, late requirements, architectural design, and detailed design. Early requirement concerned about the intentions of stakeholder that underlie in DW design, problem in decision-making process on organizational setting, exploring system solution and alternatives, and it must be done before UML modelling.

Early requirement analysis proposes two main diagrams which is the actor diagram and the goal diagram in goal analysis. Tropos has adopts Eric Yu's i* model which offer actors (agent, roles or position), goals, and actor dependencies in the early requirement modelling. Late requirement analysis defined the requirement specifications including functional and non-functional requirements for the DW design. Meanwhile, architectural design defined the interconnected through data, control and dependencies, and detailed design defined the behaviour of each component.

Figure 1 shows the Tropos notation that used in DW design. An actor is represented as stakeholder. In healthcare domain, there are Ministry, Hospital and Clinic. An actor related by dependencies to the other actor to achieve the goal in actor diagram. Actor diagram is a model to show how the actor depending in other actor to respect the goal of organization. Meanwhile, rationale diagram is used to represent the model goals and sub-goals of actors.

There are a few new concepts required in DW context by using Tropos which are facts, attributes, dimensions, and measures. Facts is a set of events that happen when the goal is achieved, attribute is a value provided when facts is recorded to achieve

the goals, dimensions is a facts property to fulfil the analysis goal and measures is a numerical property of a facts related to the decision making.

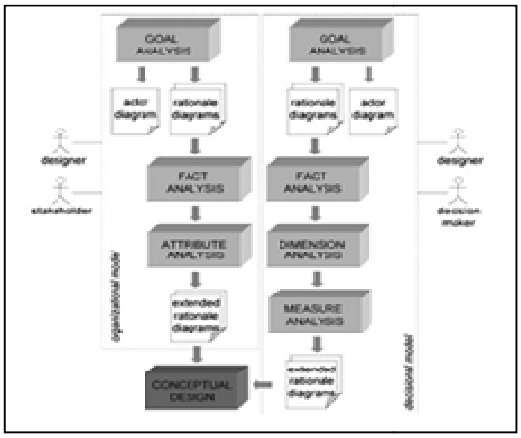

Figure 1. Notation for actor and rationale diagram

Figure-2 shows the notation that used in BI design. An actor is represented as stakeholder. In healthcare domain, there are Ministry, Hospital and Clinic. An actor related by dependencies to the other actor to achieve the goal in actor diagram. Meanwhile, rationale diagram is used to represent the model goals and sub-goals of actors. There are a few new concepts required in DW context by using Tropos which are facts, attributes, dimensions, and measures. Facts is a set of events that happen when the goal is achieved, attribute is a value provided when facts is recorded to achieve the goals, dimensions is a facts property to fulfill the analysis goal and measures is a numerical property of a facts related to the decision making [23].

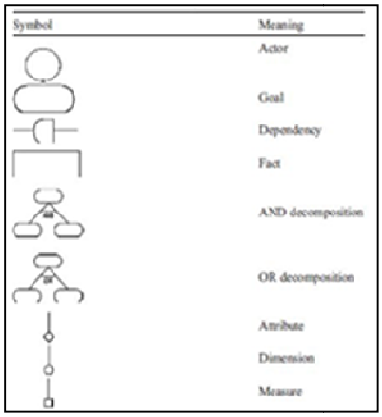

Figure 2. Notation for actor and rationale diagram

In the result sections, the phases are described in detail with reference to real case study, the Malaysian Rural Healthcare Centres. The system used in hospital and clinic is not integrated to each other. This causes the management of information and decision-making between medical practitioner and staffs have a difficult time to organize and utilize these volumes of patient's data effectively and efficiently. This indicates it is a necessity to implementing the BI concept in this institution's health care as a solution to integrate the system in order to collect and distribute the healthcare data.

3.0 Healthcare Organizations

The global healthcare environment has widely divergent perspectives on the use of data and information for decision-making. The ability to collect and analyze data garnered from the point of patient care has been impressive. Healthcare delivery, however, has often been plagued by underfunded, less advanced methods of collecting and analyzing data. Most providers continue to use (EHR) systems and strive to integrate systems that combine both clinical and administrative data.

Through this transition, healthcare provider organizations can take advantage of this data and explore analytics as a competitive tool as a method to help provide better care, improved outcomes and safer, more effective decision making. Taken together, systems and data cannot solve all of the problems that face healthcare system alone. This requires an eye toward setting the strategy based on sound fundamentals along with policy decisions that govern the operations of healthcare environment. Hence, exploring and understanding the healthcare requirements from business intelligence are vital in order to achieve the goals.

3.1 Malaysian Rural Healthcare

There are a lot of issues in rural healthcare spanning from managing medical professionals to clinical related problems. The successful implementation of rural healthcare in Malaysia requires competence and professional benchmark which embedded being-patient in the values and behavior. The rural healthcare staffs in Malaysia have witnessed upgrading in knowledge and skills to sustain the right value and attitudes. One of the contemporary issues bordering Malaysian rural healthcare is the number of health workers and

their distribution. The fact that the number has been increasing over the year, the effect is yet to be felt in catering for the rural dwellers while their demands are yet to be met. The issue of distribution of experience and skilful healthcare professionals in Malaysian rural areas can be tackled by applying BI as a measure. Despite the great strides made in socio-economic development, there are still remains pockets of disadvantaged communities such as aborigines in the remote rural areas. The disadvantaged and marginalized groups in the rural areas need to be alleviated in achieving successful rural healthcare services in Malaysia.

Nevertheless requirement analysis for business intelligence healthcare systems, in this case rural healthcare, has not been given much attention so far. BI requirement analysis is often neglected due to (1) the projects are long-term ones, in which most requirements cannot be stated from the beginning; and (2) requirements are poorly shared across organizations, unstable in time, and refer to information that must be derived from data sources [27]. Several surveys indicate that a significant percentage of BI projects fail to meet business objectives or are outright failures. One of the reasons for this is that requirement analysis is typically overlooked in real projects, leading to failure to meet the objectives of decision makers.

4.0 Methodology

This study employed a qualitative approach, where interview and documents sampling methods were used to collect relevant healthcare data needed for modeling process. The semi-structured interviews with 15 healthcare staffs including 8 medical doctors, 5 nurses and 2 administration staffs from 5 rural healthcare centers in Kedah and Perlis were administered. Relevant documents were also sampled to get in-depth views on healthcare data, processes and decision making activities. These interviews were analyzed by content analysis method and the results were used to model business intelligence requirements. Goal-oriented requirements analysis and design (GRAnD) were then adopted to model the requirements and the modeling results are discussed in detail in the following sections.

5.0 Result – Modeling Of Business Intelligence Malaysian Rural Healthcare

Based on content analysis result on interview data and document sampling, 2 types of modeling were performed. Based on GRAnD method, BI healthcare were modeled according to (1) organization in order to get stakeholders point of view and (2) decisional to get their goal and decision-making activities.

5.1 Rural Healthcare Organization Modeling

Organizational modeling represents the main data in the organization and comprise most relevant attribute to data sources. Organizational modeling consists of three types of analyses which is goal analysis, facts analysis, and attributes analysis and produced list of facts and attributes.

5.1.2 Goal analysis

The first step in goal analysis is represents the intentions of relevant stakeholder for the organization and their dependencies in actor diagram. Follow by analysis to decomposing the high level goal into sub-goal as shown in Figure-3. The analysis is conducted by interviewing the stakeholders. Figure-3 shows the actor diagram for Malaysian Health Care. It is start with the high level of goal from actor Ministry of Health (MOH). The goal of MOH depended on the State of Health Department and District of Health Office to be achieved. Then, proceed to decomposing the goal into sub-goals that needs to be achieving by State of Health Department and District of Health Office as an actor. Three different types of templates are provided, which are Main Actor (Actor, Objectives), Sub-actor (Sub-actor, Type, Goals) and Dependencies (Depender, Dependee, Goal).

Figure-4 shows an actor diagram for Rural Health Care. This diagram shows a partial actor diagram for Malaysian Health Care case study. The Hospital depends on Clinic to achieve the goal provide Public Health and the Patient to achieve the goal manage In-Patient. Meanwhile, the actor Clinic depends on Patient to achieve goal manage Out-Patient.

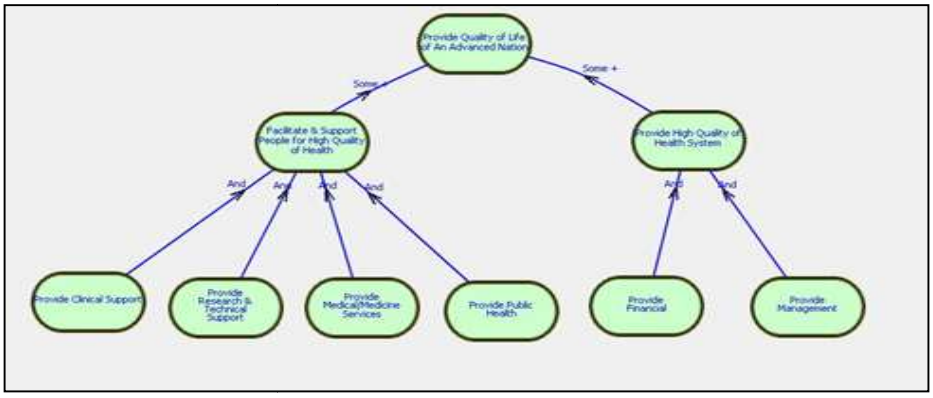

Figure 3. An Actor Diagram for Malaysian Health Care

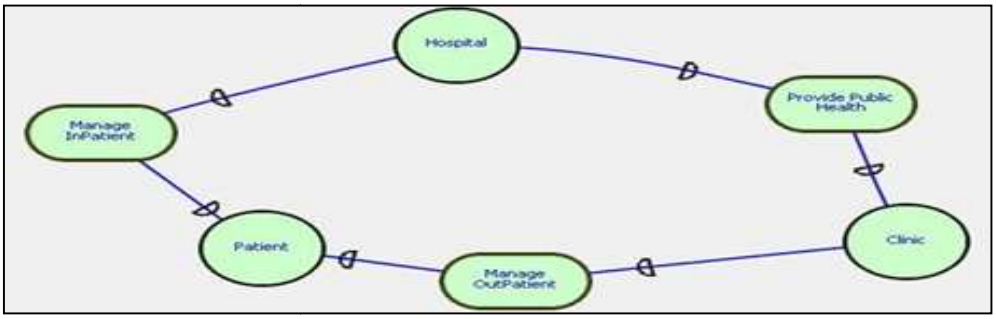

Figure 4. Actor Diagram for Rural Health Care

5.1.2 Attribute analysis

All the attributes that are given a value is identified when facts are recorded. Starting from previous diagram, the entire related attribute for the sub-goals is explored. The attributes are simply data that associated to the goals. The information is collected by using table (Attribute, Goal, and Fact).

Figure-5 shows the extended rationale diagram for OPD Services of Rural Health Care in organizational modeling for Medical Practitioner and Out-Patient actor. The fact OPD Services is associated to the main goal provide OPD Services. Then, by analyzing the sub-goals of the goal provide OPD Services, introduced the a few attributes that is associated to each sub-goals.

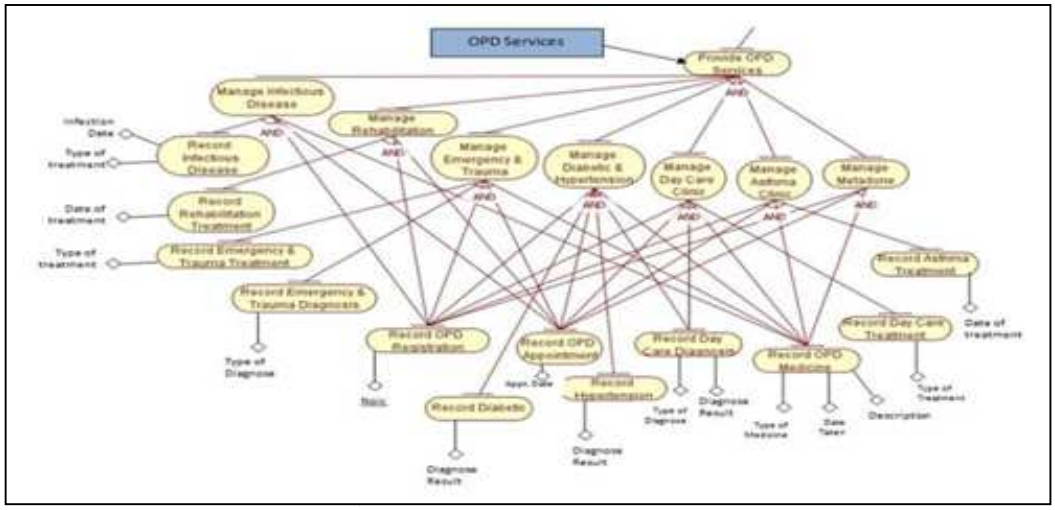

Figure 5. Extended Rationale Diagram for OPD Rural Health Care (Organizational Modeling)

5.2 Rural Healthcare Decisional Modeling

Decisional modelling consists of four types of analyses which is goal analysis, facts analysis, dimension analysis and measures analysis to support the decision making and produced list of facts, dimensions and measures. Decisional modelling is focused on how the DW supports the decisional process of the organization, and the requirements of the DW from the perspectives of the decision maker. The previous diagram from organizational modelling is used to support the identification of the facts that to be associated with the decision maker goals.

5.2.1 Goal analysis

In this analysis phase, goal analysis starts with analyzing the actor diagram for the decision maker. Decision maker are identified and initial dependencies between them were established. The goals are the decomposed to produce rationale diagrams.

5.2.2 Fact analysis

A rationale diagram from organizational modeling is used to identify the facts and as-associating it to goals of decision makers. Basically, the facts for rationale diagram are imported from rationale diagram in organizational modeling.

5.2.3 Dimension analysis

In dimension analysis, each facts is related to the dimensions that decision maker consider to achieved the decisional goals. Dimensions are identified by analyzing the goals and facts from rationale diagram of decision maker.

5.2.4 Measure analysis

Finally, a set of measures is associated to each of facts from previous diagram. A measure is a numerical property of facts that relevant to decision making process.

Figure 6. Rationale Diagram for Medical Practitioner Decision Maker: OPD Services from Decisional Perspective

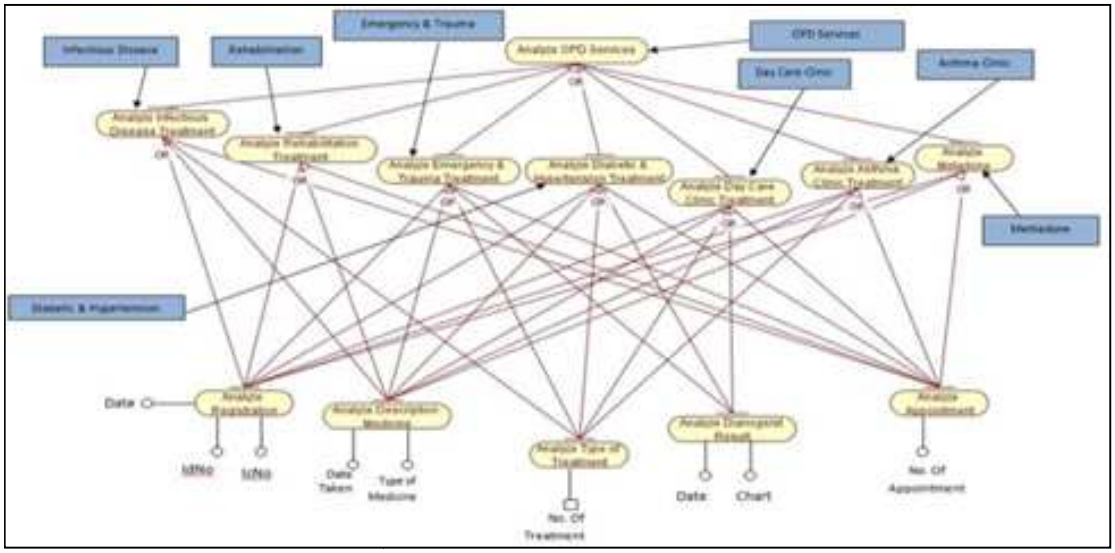

Figure 6 shows extended rationale diagram for medical practitioner as decision maker in OPD Services from decisional perspective. The analyst associates fact OPD Services, identified during organizational modeling to goal analyzes OPD Services. Then, dimensions such as date, ID No and Ic No are connected to the goals associated to the fact and one measure is identified for goal analyzes type of treatment.

The organizational model produced by requirement analysis represents the main data that comprises the most relevant attributes that are part of the source database. On the other hand, the decisional model describes the decision maker's needs, which summarizing the role played by an actor associates to the facts, dimensions and measures.

The requirements derived from organizational and decisional modeling are matched with the

schema of source database to generate the conceptual schema for Malaysian Rural Healthcare. There are three phases involved which are requirement mapping, hierarchy construction and refinement based on GRAnD. Facts, Dimensions, and measures from ex-tended rationale diagrams are mapped onto the source schema. Every dimension associated to a goal related and successfully mapped to decisional model to the source is included in the conceptual schema.

Figure 7 shows the conceptual schema for rural healthcare BI. The model shows that the dimensions are associated and mapped to facts from decisional model to source schema with many-to-one relationship. Every measure associated mapped to a goal related to facts from decisional model to the source schema and provide many-to-one relationship.

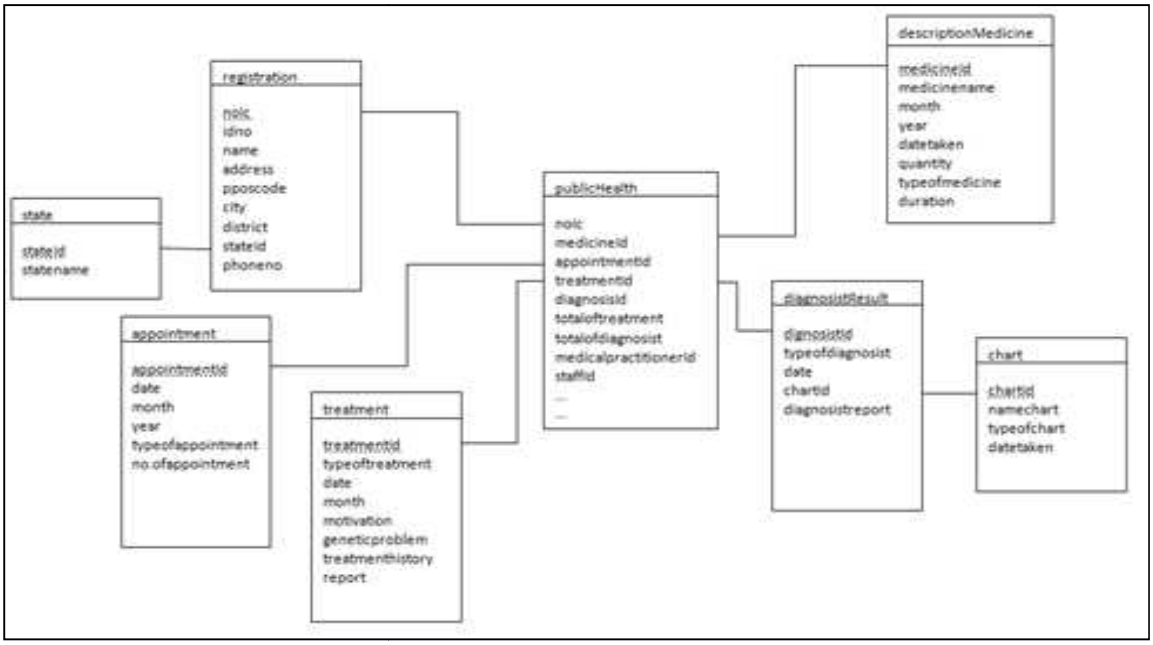

Figure 7. Conceptual Schema for Malaysian Rural Healthcare

6.0 CONCLUSION

This paper proposes a modeling of business intelligence requirements for Malaysian rural healthcare. A goal-oriented methodology for requirement analysis in BI is explored. The goal-oriented modeling is proposed to capture the requirements of BI from stakeholders' perspective, which are organizational modeling and decisional modeling. The approach captured and analyzed the early requirements for the Malaysian healthcare focused on rural health centers by using Tropos Methodology. The adoption of GRAnD in this modeling approach can help the designer to reduce the risk of project failure and at the same time, makes the design of BI simpler. The modeling results proved that GRAnD can be used as a language as well as method to derive data warehouse conceptual schema.

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