



A cloud based health insurance plan recommendation system: A user centered approach



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HIGHLIGHTS

- We present a cloud based health insurance plan recommendation system.
- We propose a standard ontological representation for all the health insurance plans.
- An algorithm to determine the similarities between the user requirements and plans is presented.
- We propose a ranking technique based on the Multi-attribute Utility Theory (MAUT).

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ABSTRACT

The recent concept of “Health Insurance Marketplace” introduced to facilitate the purchase of health insurance by comparing different insurance plans in terms of price, coverage benefits, and quality designates a key role to the health insurance providers. Currently, the web based tools available to search for health insurance plans are deficient in offering personalized recommendations based on the coverage benefits and cost. Therefore, anticipating the users’ needs we propose a cloud based framework that offers personalized recommendations about the health insurance plans. We use the Multi-attribute Utility Theory (MAUT) to help users compare different health insurance plans based on coverage and cost criteria, such as: (a) premium, (b) co-pay, (c) deductibles, (d) co-insurance, and (e) maximum benefit offered by a plan. To overcome the issues arising possibly due to the heterogeneous data formats and different plan representations across the providers, we present a standardized representation for the health insurance plans. The plan information of each of the providers is retrieved using the Data as a Service (DaaS). The framework is implemented as Software as a Service (SaaS) to offer customized recommendations by applying a ranking technique for the identified plans according to the user specified criteria.

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1. Introduction

The ever increasing use of information and communication technologies has brought exponential growth in the volumes of digital data over the Internet. Consequently, the data within the systems has started flooding at the rates that were never observed previously [1]. Moreover, besides huge data volumes, the trends of multi-source data origination and management that are formidable in nature have engendered the concept of “Big Data”

[2]. Furthermore, traditional data management tools are limited to handle such huge data volumes [1]. Therefore, the big data necessitates the use of new and efficient techniques and technologies to manage the data with multiple dimensions. Just like the big data prospects in e-commerce and other scientific and technological domains, the healthcare community is also witnessing huge healthcare content being instigated from various points of care and Web-based health communities [3,4]. Miller [1] categorizes the major sources of health related big data into: (a) payer-provider big data consisting of electronic health records, insurance records, pharmacy prescriptions, patient feedback, and responses, and (b) genomics-driven big data comprising of genotyping and sequencing data. From the payers’ perspective, the data matrix may consist of hundreds of thousands of elements having various characteristics, such as demographics and medical treatment histories [1].

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Consequently, the electronic medical information from dispersed locations, such as clinics, hospitals, medical labs, financial organizations, and health insurance organizations has been integrated and the phenomenon has emerged e-health [5]. However, the exchange and integration of electronic medical information managed by several healthcare providers is costly and difficult to administer that necessitates the use of cloud computing services in the e-health domain [6]. The cloud computing paradigm exhibits tremendous potential to enhance the collaboration among various healthcare domains and to deal with the challenges, such as scalability, agility, cost effectiveness, and round the clock availability of health related information [7].

The typical entities of a cloud based e-health system are: (a) healthcare providers, such as hospitals, clinics, pharmacies, laboratories, and (b) health insurance providers [8]. All of the aforementioned entities of the cloud based e-health systems are tightly integrated with each other to offer the convenient and on demand access over the electronic health data. For example, the related electronic health records originated at hospitals and clinics are made accessible to pharmacies and insurance companies for drug prescriptions and insurance claims processing, respectively. Currently, the role of insurance providers in the contemporary health cloud systems is only as a claim processing entity. However, with the inception of the Patient Protection and Affordable Care Act (PPACA) commonly known as the Affordable Care Act, the health insurance providers may emerge as the major entity of the cloud based e-health systems. The PPACA introduces the concepts of “Insurance Marketplace and Health Insurance Exchanges” to facilitate the individuals and small businesses to search the suitable health insurance plans [9,10]. More formally, the health insurance exchange as defined by the US Department of Health and Human Services helps the consumers and small businesses to buy insurance plans by permitting easy comparisons of available plans based on the price, coverage benefits, and quality [10]. Currently, there exist various other Web based tools that are meant to search health insurance plans. However, such tools are deficient in providing recommendations about the health insurance plans in accordance with the multifaceted user requirements. The apparent reason for the incompetence of the existing tools is their unawareness about the diversified coverage requirements of the users. Moreover, the tools do not allow consumers to specify their coverage needs and instead only acquire a few parameters, such as gender, age, and tobacco use as input. Consequently, the users are returned with long lists of health insurance plans from different insurance providers irrespective of the fact that such recommendations may not satisfy the requirements of the users. Moreover, filtering such huge data to find the desired information is an arduous task. Therefore, this is the high time for the development of health insurance plan recommendation systems with the capability to offer recommendations according to the diverse user coverage needs and financial constraints. Obviously, such a task can be accomplished by comparing the customer needs with the various health insurance plans to determine the most feasible plans.

In this regard, we focus on the aspect that has not been addressed by the researchers in the near past. We argue that the existing cloud based e-health services should be extended to offer knowledge based recommendations about health insurance plans. Previously, a lot of research has been carried out on the recommendation systems to offer personalized recommendations about products, services, and locations. However, there is no recommendation service that offers recommendations about health insurance plans based on the multifaceted requirements of the users and consumers. Keeping in view the efficacy of deploying the recommendation system for health insurance plans in the context of the PPACA, we leverage the use of cloud computing to offer recommendation services according to the user elicited requirements. Under the perspective of the PPACA, more and more

users will be looking for health plans being offered under the insurance marketplace as well as by the private insurance providers in coming years. In addition, the health insurance providers are also expected to offer more plans considering the growth and diversity in the user coverage and cost requirements. As a result, the volumes of health data across the providers will intensely increase. Consequently, the demand for expensive Information Technology (IT) infrastructure will increase. Therefore, the cloud computing services seem quite practical to manage the huge data volumes and to cut the costs [7]. The reason is that the requirements to purchase expensive infrastructure, such as the high performance computing machines and storage are eliminated when all the processing tasks are delegated to the cloud services providers. The cloud computing paradigm enables the scalability or resizable compute capacity through the virtual machines [11,12]. The services offered by the cloud computing are offered through a network while ensuring the Quality of Service (QoS) and are inexpensive and on-demand [13]. The cloud users are charged for the use of hardware and software resources [14–16].

We propose a cloud based requirements driven recommendation framework for health insurance plans according to the tailored requirements of users. The rationale behind offering customized insurance plans is to effectively deal with the immense diversity of the health insurance coverage requirements among different categories of users. For example, a user that belongs to a geographical area where certain diseases are more common as compared to other regions may be more interested to have coverage for those diseases. Likewise, individuals who interact with chemicals during their work hours are vulnerable to different diseases, such as skin problems and cancer. Consequently, such individuals might be interested in insurance plans that offer coverage for the aforesaid problems.

We propose a user centered approach that offers a rich requirement gathering interface to elicit user requirements for decision making and insurance plan recommendation. The user centered aspect of the proposed approach permits the users to specify requirements in terms of cost and coverage. As a result, the users are enabled to compare various health insurance plans based on the fulfillment of the criteria laid down by the users themselves. We employed an ontology based methodology to overcome the issues of data heterogeneity across various health insurance providers. Each of the health insurance providers maintains a repository of health insurance plans ontologies in an autonomous way with the facility to add, remove, or update the ontology repositories. Considering the large numbers of insurance plans by different providers with heterogeneous data sources, we employ the concept of Data as a Service (DaaS) [17]. The DaaS is an approach that is used to retrieve plans data from different providers for subsequent comparisons with the user requirements. In the proposed framework, the users' requirements are captured and transformed into the user ontology. The plan ontologies maintained by each of the providers are retrieved based on the elicited user requirements using the DaaS. The ontologies retrieved are matched with the user requirements and a similarity score is calculated. For true characterization of the effectiveness of the framework, we employ a ranking technique based on the Multi-attribute Utility Theory (MAUT). The MAUT is an important analytical technique that aids in decision analysis by capturing the decision makers' preferences based on multiple independent objectives [18,19]. The proposed health insurance plan recommendation system permits the users to specify the preferred criteria or attributes, such as cost and coverage requirements over which the recommendation decisions should be based. The preferred attributes are assigned weights based on their relative importance to the other attributes. We used the Rank Order Centroid Method (ROC) and the ratio method to test the effectiveness of the plan ranking process. The experimental results depict that the ROC method is more feasible in ranking the results as compared to the ratio method of weight assignment.

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