Cloud Customer Relationship Management (CRM) Ontology

مجموعة المفاهيم (انتولجي) في سحابة أدارة علاقة الزبائن

By

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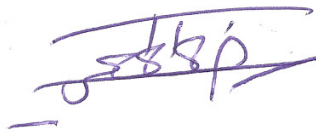
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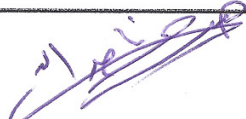# ACKNOWLEDGMENTS

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ABSTRACT

Cloud Computing has opened wide doors on many applications and services that are provided to the customers in order to reach their requirements. These applications (such as Customer Relationship Management) and services are provided by different providers. Those providers use different architectures for their Cloud systems which are considered not compatible. On the other hand, the providers have many ways to describe their services which considered as a big challenge that may face the customers. This thesis explores the possibility to automate an environment where the customers can find the appropriate services provider that meets their requirements.

Moreover, this thesis presents a well-detailed Ontology construction and refinement process in the domain of Cloud CRM. The Cloud CRM ontology has two major aspects: characteristics of the business functions and characteristics for the cloud provider (e.g., networks, servers, applications, services, and location).

This thesis also presents a description and performance evaluation of a new model which uses semantic matching to suggest appropriate provider of Cloud CRM to customers based on their requirements. The model consists of three main components: Online User Interface, Query Analyzer, and Cloud CRM ontology. The model consults the Cloud CRM ontology to suggest the appropriate Cloud CRM providers.

The performance of the model is evaluated by comparing the results of our approach using Semantic Matching, and the results of traditional Keyword Matching with the Human Experts results to a sample of query scenarios.

The experiments were conducted in order to check the efficiency of the proposed system. However, the results demonstrated that the model with Semantic Matching usage has a (88 %) success rate, and it enhanced the results by (30 %) than the traditional Keyword Matching.

Keywords: Cloud Computing, Ontology, Semantic Similarity, Semantic Matching, Cloud CRM.

ABSTRACT IN ARABIC (الخلاصة)

لقد فتحت الحوسبة السحابية الباب لتطبيقات عديدة تقدم للزبائن للوصول الى احتياجاتهم ومتطلباتهم، هذه التطبيقات (مثل ادارة علاقات الزبائن) والخدمات المزودة من قبل مزودين مختلفين. يستخدم هؤلاء المزودين بناءات مختلفة من انظمة السحابة الالكترونية التي تعتبر غير متكاملة. على صعيد اخر، لدى مزودي السحب الالكترونية طرق مختلفة لوصف خدماتهم التي تعتبر تحدي كبير يواجه الزبائن. يقوم هذا البحث باستكشاف امكانية اتمتة البيئة اينما استطاع الزبائن الوصول الى مزود الخدمات المناسب الذي يلبي متطلباتهم واحتياجاتهم.

إضافة لذلك، قدم هذا البحث فكرة بناء انتولوجي مفصل بشكل جيد تستخدم تحليل دلالات الألفاظ للوصول إلى احتياجات المستخدمين بطريقة تسهل عملية البحث عن افضل وانسب نظام سحابة محوسبة. حيث أن الانتولوجي تحتوي على جانبين أساسيين: خصائص وظائف العمل، و خصائص مزودي السحابة الالكترونية مثل (الشبكات، الخوادم، التطبيقات، الخدمات والموقع).

قدم هذا البحث ايضا وصف و تقييم لأداء النموذج الجديد الذي يستخدم مطابقة الدلالات ليقترح انسب مزود سحابة لزبائن سحابة نظام إدارة علاقات الزبائن بناءا على متطلباتهم. يتكون النموذج المقترح من ثلاث مكونات رئيسية: واجهة مستخدم عبر الانترنت، محلل للاستعلام، وانتولوجي خاصة بسحابة نظام إدارة علاقات الزبائن. إضافة لذلك، يقوم النموذج بإرشاد الانتولوجي لاقتراح أفضل وانسب مزود سحابة نظام إدارة علاقات الزبائن .

تم تقييم اداء الانموذج عن طريق مقارنة نتائج الطريقة المقترحة مع نتائج الطريقة التقليدية المبنية على خبرة الإنسان في مطابقة التشابه.

تم اجراء التجارب من اجل فحص كفاءة النظام المقترح و اشارت التجارب الخاصة باداء المقارنة ان نسبة نجاح النظام المقترح هي 88% وتفوقت على الطريقة التقليدية بنسبة 30%.

كلمات البحث: الحوسبة السحابية، علم الوجود، التشابه الدلالي، مطابقة الدلالي، سحابة أدارة علاقة الزبائن.

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LIST OF ABBRIVATIONS

CaaS	Communication as a Service
CPDS	Cloud Provider Discovery System
CRM	Customer Relationship Management
CSS	Customer Support System
DaaS	Data as a Service
DOLCE	Descriptive Ontology for Linguistic and Cognitive Engineering
e-business	Electronic Business
e-CRM	Electronic Customer Relationship Management
Ed	Error Decreases
H	Human Percentage
Haas	Hardware as a Service
hso	Hirst and St-Onge
IaaS	Infrastructure as a Service
IT	Information Technology
jcn	Jiang and Conrath
KAON	Karlsruhe Ontology
Lch	Leacock and Chodorow
LCS	Least Common Subsume
lin	Lin
LSI	Latent Semantic Index
O-CREAM	Ontology for Customer RElAtionship Management
OntoGen	Ontology Generator
OWL	Ontology Web Language
PaaS	Platform as a Service
PC	Personal Computer
Ps	Provider Percentage.
res	Resnik
SaaS	Software as a Service
SACoSS	Semantic Agent based System for Cloud Service Suggestion
SLA	Service Level Agreements
WSDL	Web Services Description Language
wup	Wu & Palmer

1 CHAPTER ONE: INTRODUCTION

1.1 Preface

Cloud computing had been developed in recent years which make a significant mark in information technology and internet technology particularly in web applications (Wang L. et al., 2008) (SunY. L. et al., 2012). Cloud computing concept depends on requesting services online which represented as an applications or programs and delivered those services over the internet and the hardware and systems software in the data centers provide those services (Armbrust M. et al., 2010). However, using cloud computing technology may reduce the use of PC's or wastes capacity of Hard Disk. By this way, cloud customer hasn't to install programs or applications on the PC, just customer can request the services from service providers on cloud computing via web applications built on the PC (Liljefors, 2011). The services on cloud computing are programs and applications which can be implemented on PC's as an applications. These services include Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Database as a Service (DaaS), Communication as a Service (CaaS) and Hardware as a Service (HaaS) (Youseff L. et al., 2008) (Katzan H., 2011). People in cloud computing architecture are cloud services providers (Amazon, Google, etc.) and cloud services customers (Balaji B. S. et al., 2012). In order to automate an environment whereby the customers can reached to the appropriate services that meet their requirements, an ontology based semantic (the study of meanings of concepts, terms or words) matching are needed for precise discovering and provisioning computing resources across various cloud computing providers. Ontology defined by Gruber as: "A formal, explicit specification of a

shared conceptualization" (Gruber T. R., 1993). An ontology based on semantic to view the data (Jean-Mary Y. R. et al., 2009). Generally ontology provides set of concepts and their interrelationships in a specific domain to facilitate understanding and automatic processing of text (Zhang J. et al., 2012). It defines and supports a common vocabulary for researchers who need to share information in a domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them. However, ontology has importance in cloud computing for many reasons:

1. Share common understanding of the structure of information among people or software agents.

2. Enable reusing of domain knowledge.

3. Make domain assumptions explicit.

4. Separate domain knowledge from the operational knowledge and to analyze domain knowledge.

There are many steps to construct ontology methodology. These steps are used by developers to manage their ontology and support services for users. The procedure of constructing ontology contains: determining the domain and scope of the ontology, considering reusing existing ontologies, enumerate important terms in the ontology, define the classes and the class hierarchy, and define the properties of classes—slots (Fernández-López M., 1999) (Bermejo J., 2007). Developers have to be careful when they design and construct ontology according to the requirements of the desired objective. On the other hand, users are responsible for correct selections when they choose their services. To achieve good services using cloud computing and get customers loyalty of using cloud

computing via customer relationship management (CRM) service we have to get strong CRM strategy using Internet encapsulated by cloud computing applications. The concept of CRM depends on develop company's interactions with customers in current time and in the future. However, CRM is used by many companies' particularly online companies in order to enhance the dealing with their customers to desire good revenue. Our research uses CRM model and approach connected with ontology that supports semantic analysis in searching in Internet. Besides that, CRM is the most popular category of business application in the cloud computing. It needs less privacy, security, and tolerates downtime. In contrast with other applications whose existence depends on data protection of customers, trade secrets, classified information, or proprietary information, such as health insurance (Hofmann P. and Woods D., 2010). Our research uses cloud CRM in different way in order to enhance searching on web sites about customer's subjects. However, there are several ontologies in the traditional CRM. This ontology's are suitable for supporting interoperability and communications both within a same company and in more open environment. This motivates this research to construct ontology for cloud CRM consider cloud services (SaaS) to provide the same benefit for cloud CRM. The CRM cloud ontology has two major aspects: characteristics of the business functions and characteristics for the cloud provider (e.g., networks, servers, applications, services, and location), Non cloud CRM ontology specifies the concepts (and relations) characterizing business events (e.g., sales, offers, etc.), and the relationships which the enterprises are involved in, as well as those concepts (and relations) relevant to the knowledge that an enterprise has on (or derives from). All these things are required for business functions, thus for CRM ontology. In addition to these characteristics we need for cloud CRM

ontology characteristics for the cloud provider features and capabilities (Tahamtan A. et al., 2012). These two aspects together facilitate discovering the appropriate CRM cloud provider that satisfies customer requirements. The availability of traditional CRM and cloud CRM also motivate this research to construct ontology in this domain.

1.2   The Problem Statement

Cloud computing is defined as an architecture that provides computing services via the Internet from different locations and these services provided by different providers. Those providers propose different architectures for their cloud systems and usually these are not compatible. In addition providers have different ways to describe and invoke their services. Moreover these providers offer new different services to follow customer's needs. However it's very hard to find a single provider which provided all services needed by customers. The challenge here is how the customers can define the best cloud that meets their requirements. This will lead to several problems to be identified as following:

1. How can we construct cloud CRM ontology for a provider?

2. How can we construct integrated cloud CRM ontology to many providers?

3. How can we identify a discovery mechanism searching different cloud CRM systems providers and provide a detailed description about its services to customer?

1.3   Research Questions

This research represents a new approach in combining between CRM and cloud computing in one web application that business companies can benefit from this technology. Thus, this research will answer the following questions:

1. How can we construct the domain (i.e. CRM) ontology, either from scratch, or by reusing other ontologies which are already available in the literature?

2. How can the ontology capture and represent the aspects (concepts and relationships) which are explicitly representing the studied domain?

3. How can the ontology be used in the domain of CRM cloud?

4. How can we evaluate the ontology and ensure its quality for its content, performance and accuracy on tasks for which the ontology is designed and used?

5. How much can we generalize the finding of this study to other domains?

1.4 Research Objective

This research will contribute in deploying ontological concepts to enhance cloud computing. The main objective of this research is to construct cloud CRM ontology and use it for semantic matching. The main aim of this ontology is to match between cloud providers and customer requirements. This matching will be semantic, not the traditional keywords matching. Ontology provides precise matching and more relevant to customer requirements. Ontology discovers the proper cloud services provider by providing more information to the query.

The research also contributes in defining the framework that supporting business process. It also will provide insight knowledge about the applicability of ontology in supporting real cloud.

1.5 Significance of the Research

In general, the CRM applications have been widely used in the organizations for its importance in terms of managing businesses; for this purpose, the use of cloud computing

was strongly recommended by technicians, researchers, managers, etc. to be applied and integrated with the CRM applications. Moreover, the integrity of CRM with cloud technology makes users more satisfied. Importance of this research is coming from supporting CRM service using web applications. However, the research aims to construct ontology to support CRM approach using web application. This ontology helps users in searching for their subjects via CRM using web application. However, this research enables user to get correct research according to the desired subject.

On the other hand, this research merges between CRM concept and cloud computing technology. Besides that, the research has another importance because it uses semantic analysis techniques in order to enhance the research in Internet based on CRM approaches. In other words, based on using semantic analysis approach in the research engines, smart results will be attained.

1.6   Research Motivation

Cloud computing is developed more and more daily by adding new different services that serve many users at the same time. The services that supplied by cloud computing are concerned by business companies to develop their core business competencies. Cloud computing provide effective and affordable IT tools helping organizations to investing in new infrastructure, training new personnel, or licensing new software without spending lots of money on in-house resources and technical equipment. Thus, cloud computing is very economical, popular and powerful (Sahni S. and Walia R., 2012).

It is essential to have an intelligent mechanism, which can understand and analysis customers' query semantically. There are several search engines (Google, Yahoo, Baidu,

etc.) to get information which is adopting keywords matching mechanism. Keywords' matching is insufficient due to the retrieval of a large amount of irrelevant information, which has shortness in understanding customers' query intentions. Ontology allows semantic analysis of customers' queries and a heuristic search, the expected information can be retrieved more precisely and completely that's satisfying customers' intentions (Dai W. et al., 2011). Finding the "best" cloud is a real challenge. This research contributes in using ontological techniques to find the best cloud that meets customer's requirements in the domain of CRM.

Because of importance of CRM for business companies (to improve their behavior and to get customer loyalty for their services) we have to develop new system based on connection between cloud computing and CRM. However, end users' confidence with business companies that are considered cloud computing is related to confidence with cloud computing applications. Thus, it is important to construct CRM systems within cloud computing services.

1.7   Methodology

Methodology concerns one four main points which aim to use semantic analysis to meet the providers services' and customers requirements' in a way that facilitate the process of finding the best cloud system. These points are:

1. Construct cloud CRM ontology: The proposed ontology depends on providers' documents and collecting data about cloud CRM systems. Then, KAON, OntoGen, and WordNet tool are used for performing extraction for concepts and relationships related to cloud CRM system.

2. Conduct Cloud Provider Discovery System (CPDS): The proposed system consults cloud CRM ontology to suggest the most appropriate cloud CRM provider to customer.

3. Evaluate the result: This will do by measure how much a resulted cloud CRM provider suggested by CPDS is close from consumer' requirements.

1.8   Dissertation Outline

The remaining part of this dissertation is organized as follows: chapter 2 contains the literature review which highlight on previous researches and studies that are related to the subject of cloud computing in general, ontology and semantic matching, and using CRM with cloud computing technique. On other side, chapter 3 contains proposed work that suggests ideas to solve the problem of research. Chapter 4, 5 contains briefly presenting and discussion of results of the research, chapter 6 contains recommendations and conclusion of the entire project and these recommendations are important to future works particularly if these researches related to ontology technology.

1.9   Summary

This chapter has given a general idea and background to the research. It has defined and justified the research context, as well as outlined the rest of the project. This chapter indicated the reason of connecting cloud CRM model in ontology of search. Moreover, this chapter outlines the research problem as well as diagnosis the problem elements individually. Also, this chapter shows the motivation of the research which gives attention to the research problem. As well as, the objectives of the research that must be achieved

are also mentioned in this chapter. This research has significance as any other research so we debate the research significant in this chapter.

2   CHAPTER TWO: LITRETURE REVIEW & RELATED WORKS

2.1   Preface

This chapter provides a background and literature review on the five main concepts covered by this research, namely, cloud computing, ontology, customer relationship management (CRM) ontology, semantic matching, and WorldNet similarity measures. It is divided into three sections. Section 2.2 discusses the necessary background information that is needed to better understand topics embedded in the thesis. The most important related studies in the field of ontology and semantic matching are discussed in Section 2.3. Finally, Section 2.4 presents a range of tools that are used for construcing domain ontology.

2.2   Literature Review

This section analysis of existing researches which are relevant to our topic and presents some background reading required to give context to our work.

2.2.1   Cloud Computing

Many researches and studies highlighted the cloud computing technology. However, (Wang et al., 2008) tries to study the concept of cloud computing from many aspects such as: definitions, benefits and enabled technologies. This paper gives review and introduction about cloud computing services. Moreover, authors highlighted the types of cloud

computing services: HaaS, SaaS, DaaS. The paper also indicated that cloud computing distinguish itself from other like paradigm in several aspects: user-centric interfaces, autonomous system, etc.

(Dillon et al., 2010) also highlighted many definitions of cloud computing and criticized these definitions. Also, authors have studied the challenges that face improvements of cloud computing besides to cloud computing issues. They have discussed the relationship between computing paradigms. They highlighted the relationships between service-oriented computing and grid computing. On other hand, authors studied the harmony of cloud computing and the solutions of cloud computing technologies. To indicate the important of system safety, authors discussed the role of security on data in cloud computing and how can security increase the efficiency of the cloud computing models and infrastructures.

In the context of cloud computing concept (Verma et al., 2011) discussed a sight into cloud computing technology. They have discussed the cloud computing concept and its services in different aspects. Besides that, the authors highlighted the role of cloud computing in development of IT industry. They claimed that cloud computing provides architecture for creating market-oriented clouds by leveraging technologies such as virtual machines. Furthermore, authors discussed the cloud computing types and they have indicated each type and what services that provided by each one.

On the other hand, (Sahni & Walia, 2012) tries to test the feasibility of cloud computing concepts in the domain of large-scale computers. Authors claim that the next generation of cloud computing infrastructure will support companies with tremendous values whatever the size of company. Also, authors claim that cloud computing is good new abstraction to

process large systems which is reliable and scalable systems. Besides that, they claim that cloud computing services can be developed according to the needs from users and companies.

(Nemecek & Vanková, 2012) highlighted on the fast development of economy in the range between 2007 and 2010, and what is the impact of cloud computing on development of economy. The author claimed that this study indicates whether the companies purchase complete solutions of CRM for their using or whether they use CRM as a service from cloud computing service providers. They claimed that the main objective of implementing CRM is to guide companies to increase their quality of relationship and communication with their customers. Also, they described several types of cloud computing and they have indicated the concept of CRM and relationship between CRM and services of cloud computing. Besides that, they have debated the using of CRM and cloud computing in the selected companies.

2.2.2 Ontology

In the topic of ontology (Corcho et al., 2003) studied comparisons between selected methodologies of ontologies to indicate the different between them. This paper tries to compare the main methodologies according tools, languages for building and relationships. Authors claim that ontology methodology has become mature enough. However, authors concluded that there is no correspondence between ontology building methodologies and tools and because the lack of methodological support in many methodologies developer cannot apply them in the construction task of methodology. Moreover, they have concluded that many tools focus on few activities of the lifecycle of ontology. Most ontology's share in building tools so they cannot interoperate which can overcome obvious

problems. Also, authors concluded that ontology may not be implemented manually compared with available ontology tools. Finally, authors believe that markup languages of ontology are still in development which may cause difficulties when managing them.

(Noy & McGuinness, 2009) presented a guide that helps the developer to build ontology. First, the authors defined the concept of ontology. After that, they present guide that has instructions about the ways to build ontology. And about the reason of building ontology, the authors claimed that ontology represents a common vocabulary about the searches of the users. Also, developers build the ontology to share common understanding of the structure of information among people or software agents. Besides that, authors suggest that the other reason of building ontology is to enable users and customer to reuse the knowledge and analyze domain knowledge.

(Lin et al., 2009) presented a method that aims to construct an ontology which describes customer information with an easy understood structure. Authors claimed that the suggested method composed of three phases

Phase 1: starts specify the ontology based on the experiences of the customers

Phase 2: then enhancing ontology via the browsing of the customers new ideas.

Phase 3: ends with the verification of ontology consistency.

Also, authors claimed that the method is applied in an exemplified application for travel arrangement. The paper concluded that the authors could construct ontology in CSS (Customer Support System) to describe customer information in suitable way. On the other hand, authors concluded that customers in CSS can get improved supports on participating

in various communities and ensuring matches of their requests with enterprise services where they make final selections.

On the other hand, (Kayed et al., 2011) highlighted that ontology develops the searching about information on web because it creates relationships between the approaches and objects, also ontologism provide semantic analysis among them. They claimed that components of any software are the essential part in the cycle of software development. In this paper, authors have built an ontology that provides the software components and then using them to solve some of semantic problems. Authors depended on many documents based on. Net and Java collected from different resources. However, authors conclude that develop strong ontology needs "good resources" and appropriateness between ontology's aims to measure the strength and "goodness" of ontology or the resources. The main objective of the paper is to build domain ontology's for the components of software and define a new appropriateness measure to check the resources quality. Because the domain of .Net and java are well known the author depend them on their research.

(Zhang et al., 2012) studied the challenges that may face ontology's in cloud computing when there different data from different resources that cause difficulties in dealing with them from different resources. So, this paper suggests building a novel solution in order to perform learning ontology. However, this solution includes a service-oriented ontology interaction framework, a service-oriented ontology learning strategy. It shows that it advances ontology learning to a higher level of performance and portability with a number of experiments in demo system. These frameworks and methods considerably support the development of core-serviced theory in cloud computing. In addition, the framework had been built in our laboratory since last year. Some frame has been built and some function

can be available such as ontology conception extraction, experts artificial maintaining and so on. In addition, the system was tested in complex product design processes and we got some considerable results.

2.2.3   CRM Ontology

(Damme et al., 2007) presented visual approach that enables users to take a significant place in the ontology process. Also, in this approach users can add their information into their parts in the ontology which makes users to share in the process of development of the ontology. However, authors use domain CRM ontology to overcome the problems of the weak results of search about any concept. Besides that, authors suggested an integrated approach called "Employonomy approach" that helps employees to tag their contents to a flat apace taxonomy. Authors recommended that concept definitions and its relationships must be extended. Finally, authors concluded that this type of approach can be applied in other company systems and departments. Also, the authors claimed that semantics are very important for retrieving the desired data with high quality, connecting systems and improving the communication process between departments.

(Magro & Goy, 2010) presented an approach based on ontology called O-CREAM CRM that depends on two DOLCE modules. The proposed project relies on the belief that all actors involved in CRM could benefit from an ontological investigation of this field, aimed at providing a core set of formally described concepts and relations, useful both for describing CRM processes and for specifying the functionality of CRM applications. In particular, a well-formed CRM ontology would support communication and interoperability both in intra-organization and in interorganization CRM processes. The paper discusses in details the axiomatization for the sale and customer relationship

concepts, as well as for the corresponding business knowledge items (i.e., sale and customer records). It concludes by sketching a possible concrete exploitation of O-CREAM.

2.2.4 Semantic Matching

In this topic, (Li et al., 2003) highlighted that the similarity between words and concepts had become difficult problem that face many applications and artificial intelligence. This paper, tries to predict the determination of semantic similarity by a number of information resources that contain semantic information from lexical taxonomy. They also indicated how information sources could be used effectively by using variety of strategies for using various possible information resources. However, authors argued that all first-hand information sources need to be processed in similarity measure. Besides that, authors claimed that humans can compare word similarity with a finite interval between similar and non-similar.

(Fazzinga et al, 2011) expected that adding semantics to web data will make huge change in web information technology which is the next step in development of information technology. However, they have prepared a paper that discussed building new approach based on novel methods in order to semantic web search. On the other hand, semantic web search allows for semantic processing that applied on semantic queries and evaluating complex web structure. Authors have added ontological structure and semantics to web pages that allows for attaching a meaning to web search queries and web pages. Also, semantic search allows for formulating and processing ontology based on complex search queries. They claimed that, they have obtained a general or vertical semantic of web search interface. They have addressed the web into an ontological knowledge base. Furthermore,

they have built a formal model behind their approach and developed an implementation for this model on desktop search. To approve their solution model they have made some of tests based on semantic web search for movie database. After making split operation on the text each word is stored in specific location in special array, and each element in array will be processed individually. System takes each element in the array and compares it with system lexicon by comparing words with dictionaries according to the type of word: verb, adverb, noun…etc.

2.2.5   WordNet & Similarity Measures

(Pedersen T. et al., 2004) indicates wup (Wu & Palmer) is one of the three Wordnet similarity measures which are based on path lengths between concepts. The two remaining measures are *lch* (Leacock & Chodorow) and *path*. Each measure finds the relatedness between concepts and calculates the value of this relatedness. Wup finds the path length to the root node from the least common subsume (LCS) of the two concepts, which is the most specific concept they share as an ancestor. The value of relatedness is scaled by the sum of the path lengths from the individual concepts to the root.

(Miller et al., 2006) proposed an introduction to Word Net. They highlighted on the difficulty differences between WordNet and standard dictionary is that WordNet divide word into five elements: nouns, verbs, adjectives, adverbs and function words, and in fact the WordNet contains only four elements: nouns, verbs, adjectives and adverbs. Also, authors have indicated the lexical matrix and explained the principle of this matrix and how it can be used in semantic analysis to find matches between concepts.

(Budanitsky & Hirs, 2006) proposed paper aims to evaluate similarity measurements based on WordNet. However, the authors have evaluated five measurements lexical semantics

distance. The authors mentioned that most of their work was limited to the narrower notion of similarity measures. These relationships include not just hyponymy and the no hyponymy relationships in WordNet such as meronymy but also *associative* and *ad hoc* relationships. As the authors mentioned, these can include just about any kind of functional relation or frequent association in the world.

According to (Yong et al., 2009) who studied the similarity on the ontology of cloud computing by building a prototype model to test their hypothesis. However, this paper used domain ontology to extend the original keywords that are entered by users and then calculating the similarity. The results of the experiments indicated that their model is feasible and strong. Authors concluded that similarity measure between concepts aims to make machines clever in order to understand the concepts based on Artificial Intelligence. On the other hand, this paper used algorithms of similarity comparisons to abstract the levels of ontology and concepts. Also, authors combined the semantic distance in ontology with OWL semantic features. Authors claimed that users can get flexible similarity expression of various parameters by adjusting the value of these parameters.

(Snasel et al., 2010) studied the WordNet ontology and semantic analysis mechanism in order to retrieve data from Internet to the user PC. The authors say that although of the big advantage of semantic there still several problems that need to be solved. When retrieving information it is important to consider the dimensions of the desired document. The authors suggest method for retrieving information called LSI (Latent Semantic Index) which is numerical method that discovers latent semantics. In this paper authors present a basic method for mapping LSI concepts. The results of the test of proposed method show that the method was strong enough in semantic retrieving data.

(Kwak & Yong, 2010) proposed building an ontology based on Word Set matching where Word set method aims to find similarity between words. However, they have indicated the concept of Word Set which includes hypernym, hyponym, holonym, and meronym sets in Word Net. The similarity of Super Word set is calculated by the rate of words of concept name and synset's words inclusion in the Super Word Set. Also, authors claimed that in order to measure the Super Word Set similarity by extracting the matched concepts. Unlike previous ontology matching tools that utilize only WordNet's synonym sets, the proposed method employs semantic relationships set of WordNet - i.e., *Super Word Set* including collectively WordNet's hypernyms, hyponyms, holonyms, and meronyms is used for ontology matching.

2.3   Related Work

(Han T. & Sim K. M., 2010) built an agent-based discovery system that consults ontology when retrieving information about Cloud services. They used an ontology represents the relations among Cloud services and classify these services as Software service, Hardware as a service, Infrastructure as a service. The importance of the project is that it is the first attempt in building an agent-based discovery system that consults ontology when retrieving information about Cloud services. The study has another importance in which the study contributes with building of the Cloud service discovery system. Also, the project aims to construct the Cloud ontology.

(Dastjerdi et al., 2010) proposed an advertisement approach for IaaS providers and they have suggested applying architecture using ontology-based discovery to help user for finding the best suited IaaS providers. In addition using this architecture to provide QoS aware deployment of appliances on Cloud service IaaS providers. This paper presents a

way to indicate how to describe the monitoring services, deployed, and then how they have to be executed to enforce accurate penalties by eliminating service level agreement failure cascading effects on violation detection.

(Kang & Sim, 2011) presented a four-stage, agent-based Cloud service discovery protocol. Utilizing an ontology description, in which each resource is described semantically and relatively to other resources, we develop a multi-agent system that cooperates efficiently by introducing a flexible ontology-based matching. To increase the utility and success rate of matching customers' requests to resources, we use a database to store and keep track of historical data for making intelligent recommendation based on attribute value prediction. The results that have been got from the test show that when the broker agents the system use cloud ontology and a connection procedure with a recommendation stage achieved better performance in finding the appropriate cloud services than when broker agents 1) use only the connection procedure but not the cloud ontology and 2) do not use both the connection procedure and the cloud ontology.

(Balaji B. S. et al., 2012) proposed Semantic Agent based System for Cloud Service Suggestion (SACoSS) using cloud service ontology, which uses the Service Level Agreements (SLA) and WSDL document of cloud services to extract the knowledge about the cloud service and answers the cloud service customer with appropriate cloud services as. Authors mentioned that the evaluation of their system indicated that the system provides better results and achieves higher accuracy in prediction process. The authors claimed that their system contains seven semantic agents and a cloud service ontology repository. Also, the procedure work of SACoSS divided into two aspects: cloud service ontology updating and cloud service suggestion generation.

(Kaushik A. & Chana I., 2012) presented an ontology based on flexible cloud framework that can respond to the semantic queries created using Manchester Ontology Web Language (OWL) Syntax. The framework provides solution for the increasing complexity of cloud by showing that how Cloud development in ontology is efficient and fulfills the future requirements. However, the study concluded that all the previous studies focus on reducing the overhead, service response time and improving performance. Also, authors claimed that with proper load balancing, resource consumption will be kept to a minimum which will further reduce energy consumption and carbon emission rate which is a dire need of cloud computing. Existing load balancing techniques that have been discussed mainly focus on reducing associated overhead, service response time and improving performance.

(Tahamtan A. et al., 2012) introduced a unified cloud and business service ontology with querying facilities. It's unifying the cloud ontology with the business function ontology and by providing a mapping between business functions and cloud services. This ontology was based on discovery of cloud providers and it had two major aspects: required business functions/processes and characteristics of the cloud provider. Their ontology tried to represent a suitable framework that fulfills all the requirements of customers and companies. The authors concluded that any ontology must provide all the requirements of its objective. The framework is based on building cloud based on question as basic research. Also, the authors claimed that their framework provide flexibility and exchangeability by the cloud computing paradigm. In addition to that, the authors claimed that the framework works as repository of services as well as providing services.

(Rajan & Lakshmi, 2012) proposed incorporation of semantic matching methodology in semantic web for improving the efficiency and accuracy of the discovery mechanism. The current researches that aim to develop Internet need dynamic retrieval and invocation methods. Also, authors claimed that better search capabilities are also rapidly emerging. But performance of keyword-based search engines cannot be termed efficient. In order to handle such problems, the Semantic technology can be incorporated using ontology and an efficient matchmaking methodology. Retrieval of relevant information can be done automatically, efficiently and accurately, thereby, reducing knowledge overhead and hence, manual data analysis. The number of searches and the time of search can also be vastly reduced. The current search is implemented using Vaccine Ontology in the Healthcare domain. This can be extended to the entire Healthcare domain. Also, other domains can acquire the capabilities of the Web service discovery by using the same methodology, by using other Ontology.

(Sun et al., 2012) proposed ontology provide an application-centric, multi-layer ontological mechanism for specifying cloud requirements which can then be used for searching for suitable resources in a multi- provider cloud environment. This ontology provides a semantic mechanism for capturing application needs in a language familiar from users' application domains. The ontology uses semantic analysis approaches in searching about any subject. However, this mechanism facilitates using framework of searching by users. The proposed ontology depends on building semantic matching that performs the matched words between desired subjects.

2.4 Software Used in the Work

KAON: (Gabel et al., 2004) indicated that KAON is an open source ontology management infrastructure, and it is divided into KAON1 and KAON2. KAON comes from (Karlsruhe Ontology) which is developed by university of Karlsruhe. It included a number of comprehensive modules allowing easy ontology creation, management, and maintenance of ontologies. It supported the functionality of ontology learning from texts. Also, KAON provides an API for programming management, providing access to ontologies using stand-alone server, moreover, it's provided inference engine in order to solve the conjunctive queries.

OntoGen: (Fortuna et al., 2011) indicated the nature of OntoGen 2.0 system which is used for data-driven and semi-automatic ontology. However, authors claimed that semi-automatic system is an interactive tool that presents several helpful aids to the user during the ontology construction process. They also claimed that this system can suggest concepts, relations and their names automatically. And about data-driven the authors claimed that, many of the aids that represented to the users by the system are provided by the users themselves. The system application has many windows and the main window contains three main areas: ontology visualization and document management part and the concept tree showing all the concepts from ontology and on the bottom left side is the area where the user can check details and manage properties of the selected concept and get suggestions for its sub-concepts.

WordNet: (Morato et al., 2004) specified Wordnet as one of the manually compiled electronic dictionaries, which is no restricted to specific domain and covers most English nouns, adjectives, verbs and adverbs. The basis of this tool is to build a lexical-conceptual

model and database, consisting of both lexical units and the relations between such units, structured into a relational semantic network. Each unites/concept in Wordnet was assigned to certain terms related by prepositional logic. However, nouns and verbs are organized in hierarchies using Hypernym relationships. The following figure shows more details about Wordnet work. Hierarchies are organized using base types, and the primitive nouns and verbs will be resulted. However, in the objectives case the process is different and is more difficult because objectives may contain more than one meaning.

Computer, PC, laptop

→ Electronics, Electrical Devices

   ==> Integrated Circuits

      ==>Input/output data transferring, Network adapters

         ==>Electricity, digital devices

           ==>Electronics, Digitals, technology,…
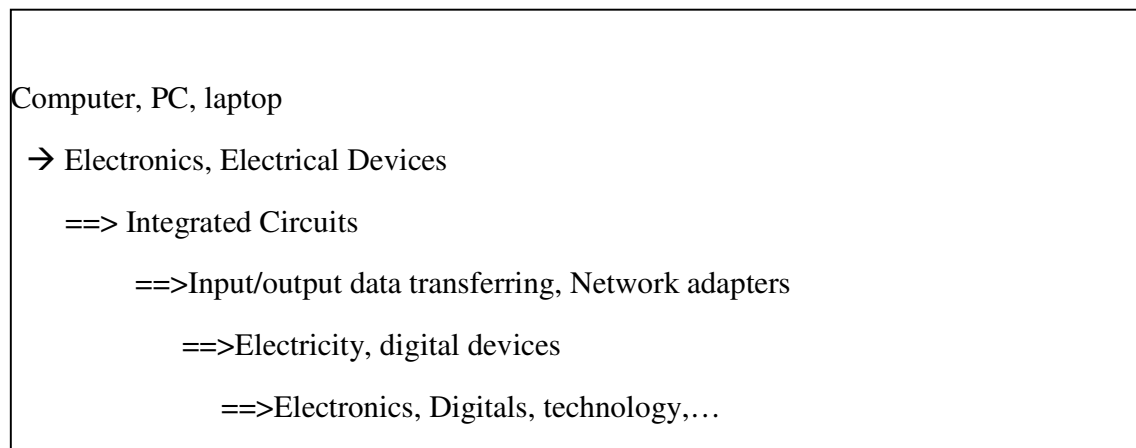
Figure 2-1 WordNet Process.

3   CHAPTER THREE: CONSTRUCTING ONTOLOGY

3.1   Preface

This chapter will discuss the preparation to construct cloud CRM knowledge domain ontology. This preparation is done by collecting and analyzing many documents related to the field of cloud CRM applications. The chapter also will discuss how to use these documents to extract and create our ontology domain concepts' using KAON and OntoGen tools; wup measure will also use to create ontology concepts "group concepts" in addition to those concepts which was extracted from the used tools. In this chapter we also will discuss how to construct the relationships for our ontology.

3.2   Construct Ontology

The process of developing an ontology in a specific domain is not easy and time consuming task. In order to do this task properly and to get the desired benefit from the ontology many parameters must be considered. These parameters aid in depicts the final structure of ontology which are looking for. The essential parameters we should identify at the beginning are the knowledge domain the ontology will be covered and the intended users that will use it. The other parameter should be considered is specifying the motivation of ontology development; in other word identifying ontology purposes and uses. Identify all those parameters will be aid to determine the methodology for

constructing the ontology. The ontology can be built either from reuse existing ones which are constructing previously in the chosen domain or built from scratch. Our domain will be cloud CRM and the ontology which will construct to use with a query answering system to assist the cloud CRM customers in choosing the best provider depending on our demand requirements. The semantic information existing in ontology offer more precise answers for cloud CRM customer's query. Moreover there is no available ontology in this domain, thus we need to construct our cloud CRM ontology from scratch but we can benefits from cloud and CRM ontologies to identify the some of its concepts. Constructing new ontology involves many steps must follow in order to construct it effectively and we should focus on two main aspects: 1) how can extract the domain ontology concepts and 2) how can extract the relationships between those concepts. Extract ontology concepts include collecting and studying large amount of documents which describe the domain. Concepts will be extracting from these documents using ontology constructing tools. The extracted concepts will be studied, analyzed, filtered in a way that serves the target of ontology around. In order to make our ontology beneficial to the end user, however almost all cloud CRM providers use the same single concepts to describe their services. We find that cloud e-CRM ontology must be constructed from two types of concepts. Thus our ontology will construct from a single and group of concepts. For example if the customer queries about the service of product management to be exist in the demand cloud CRM system, constructing our ontology from just single concept (e.g. Product and Management) will not give the accurate answer about the providers services because it will match with almost all cloud CRM provider concepts. The existing of group concepts (e.g. Product. Management) in our ontology will give more specific answer to the customer. The single

concepts "Product" and "Management" may be exist in our ontology through other provider services (such as product catalog or contact management), so that grouping concepts will reflect the services behind the single concepts and will support our system to suggest more accurate answers. As mention earlier, the other important aspect in constructing ontology is extract the relationships among the domain concepts. The relationships will be constructing in different technique and we will use WordNet semantic relatedness to construct the most part of them. Figure 3.1 summarize the steps to construct ontology.
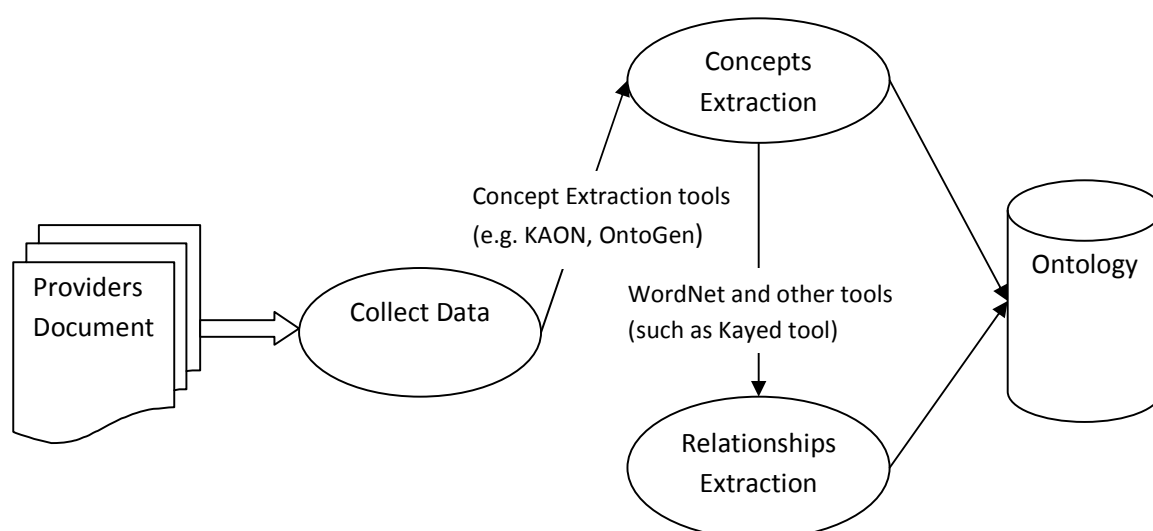
Figure 3-1 Ontology Building Steps.

3.2.1   Collecting Cloud Providers Data

In order to construct our domain ontology, first we needed to prepare text corpora. In linguistics, text corpora consist of large set of electronically processed and stored texts. To do that, we visit various cloud CRM providers, sites, documents, and reports and subscribe

with them to collect their data. The domain of cloud CRM is very big and include many providers compete for providing the best services to the end users. Depending to Stacy Bennett from reviews journal[1], Samara Lynn from Pcmag journal[2] and others, our research will include four of the most popular cloud CRM providers. These cloud CRM providers are Salesforce, Zoho CRM, SugarCRM, and Commence CRM. Moreover these providers are chosen based on:

1. The availability level of data describes their provided services. These data is necessary for concepts extraction process which is used then in constructing the ontology.

2. Besides that, these providers have a variety of the provided services, editions (subscriptions), size (small, medium and large) and serve large scale of business in different fields (industry solutions).

For each of these providers, we collect as much as possible of what we could reach to of documents from their sites (such as brochures, white papers, reports, and user guide) that describe the provided services. The collected documents were about 60 different documents from all providers. These collected documents were studied, filtered and picked the most related ones for each provider.

3.2.2 Ontology Concepts Extraction

There are many ontology constructing tools are available to assist in generate ontology candidate concepts and relationships. KAON and OntoGen are one of these tools. The open-source, easy creating and editing the ontology, constructing the ontology from underling textual data, easy for use, and the efficient user interface were among many

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[1] http://www.reviews.com/crm-software/
[2] http://www.pcmag.com/article2/0,2817,2361503,00.asp

reason to choose KAON and OntoGen tools. In order to use these tools the collected documents for each provider were converted to text files as KAON and OntoGen support this format.

- **KAON Tool**

The prepared text corpus (from related documents) for each of our providers added to the KAON tool by using the New Corpus function. Figure 3.2 shows the creation of the prepared corpus.
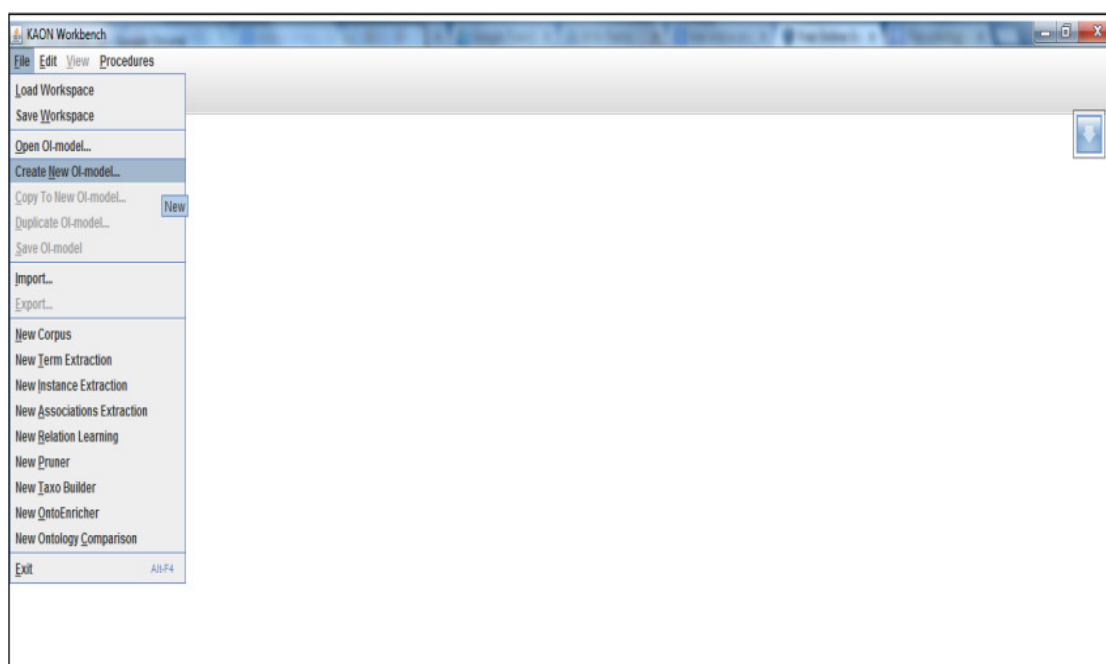
Figure 3-2 Creating a Text Using KAON Tool.

Later, the New Term Extraction function was used to extract concepts from the provided text corpus. This tool extracts concepts using a parameter. The frequency threshold was set

to 10 and the number of word for retrieved concepts set on one unique word as a term. The result was 160 concepts for one of our providers. These concepts were studied and considered as initial provider domain ontology concepts. Figure 3.3 shows this step and some of the resulted concepts.
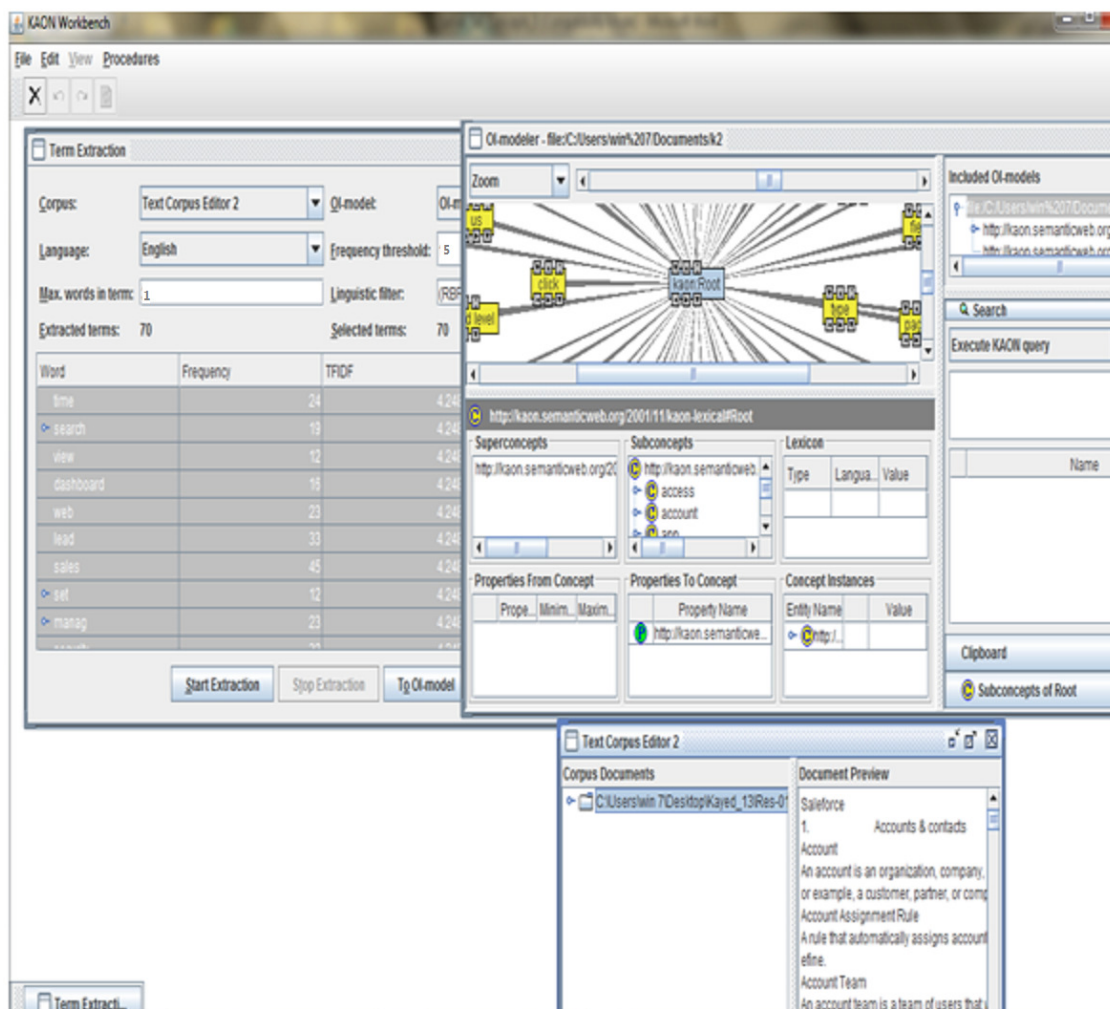
Figure 3-3 Concepts Extraction Process Using KAON Tool.

In order to refine the resulted concepts, an elimination process was applied for the stopping words (common words like CRM, cloud, system, service, work, etc) and the words which

is synonym or shortcut for other concepts. The result of this part was 104 concepts, which was suggested as provider single concepts. Table 3.1 below presents some of these concepts. For more details see table 1 in the appendix.

Table 3-1 Some of the Extracted Single Concepts for Salesforce Using KAON Tool.

Concept	Concept	Concept	Concept
Access	Function	Level	Page
Account	Go	Line	Partner
Adopt	Group	List	People
Align	Help	Mail	Perform
Appexchang	Inform	Make	Plan
Approach	Island	Manage	Platform
Assign	Layout	Market	Point
Build	Lead	Mean	Portal
Builder	Team	Metric	Process
Campaign	Territory	Mini	Product
Click	Time	Page	Profile
Code	Top	Mobile	Project
Competitor	Track	Model	Level
Contact	Train	Need	Search
Content	Type	Number	Secure
Contract	User	Object	Quote
Control	View	Opportunity	Real

After that, KAON tool was used to extract relationships between the extracted concepts. The tool was provided with the text corpus which was prepared previously and with the concepts which want to study the relationships between them. When we run this step, the used tool provided us with about 990 relationships. These relationships will be handled as a group of the related concepts and presented as pair group of concepts. Table 3.2 presents some of the resulted relationships. For more details see table 2 in the appendix.

Table 3-2 Sample of the Relationships Resulted from KAON Tool.

Concept1	Concept2	Freq.
Time	access	28
Lead	campaign	12
Work	data	34
Report	territory	18
Step	business	26
Access	field	32
function	level	7
Email	field	32
Search	layout	12
Team	crm	17
Record	opportunity	20
workflow	type	14
User	view	12
App	page	21
contact	opportunity	20
business	account	22
Web	user	35
opportunity	report	33
account	opportunity	20
appexchang	process	13
business	com	11
Report	user	35
dashboard	summary	9
business	service	15
Metric	data	34

These concepts (single and group) which were suggested as provider ontology concepts.

- **OntoGen Tool**

OntoGen tool will also use to extract ontology concepts and relationships. OntoGen tool aids in extract single concepts and relationships. It presents these relationships as group concepts. The previously prepared text added to the tool using new ontology function. Figure 3.4 shows the preparation to create new ontology.
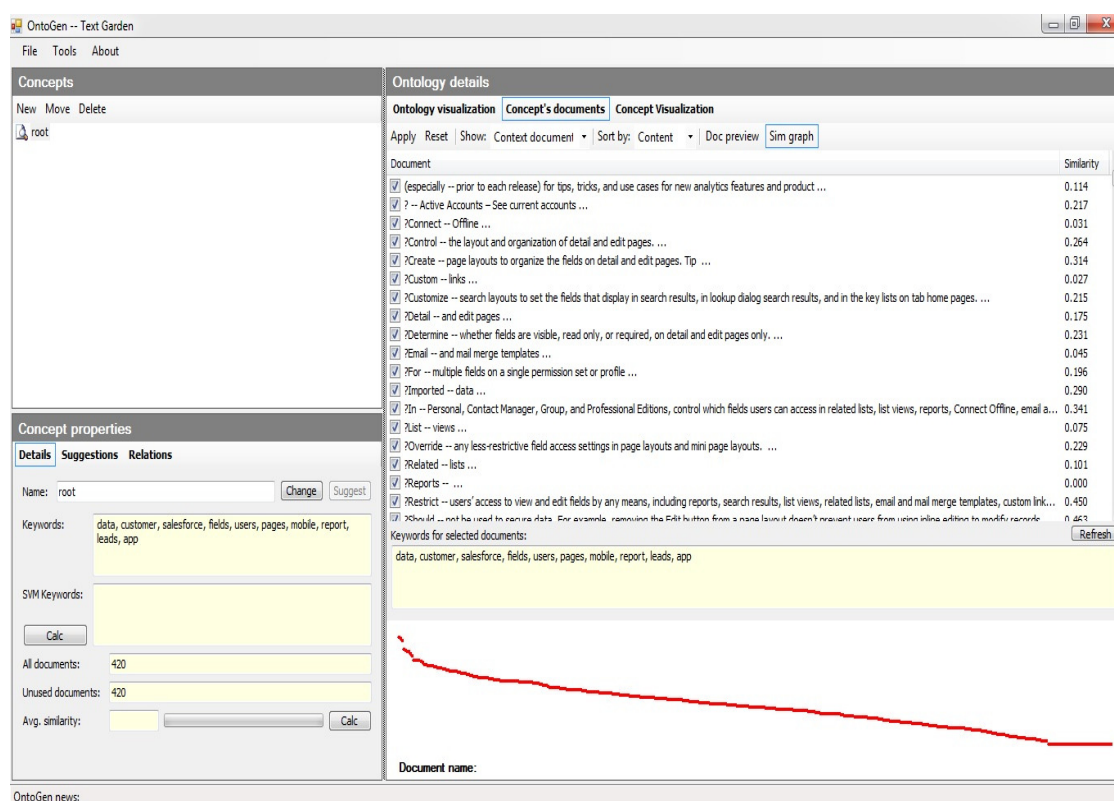
Figure 3-4 Text Preparation to Create Salesforce Ontology Using OntoGen Tool.

At the first, OntoGen tool can extract as maximum as 30 concepts. These concepts present in a different forms (single and group concepts). Concepts make groups based on the relationships between these concepts in the underling documents which provided the tool

with it. After that, this tool can extract 30 concepts from each of those concepts extracted early as maximum. This step provided us with about 700 single and group concepts. Figure 3.5 presents this step and some of the resulted concepts. For more details about the resulted concepts, table 3 in appendix presents these concepts.
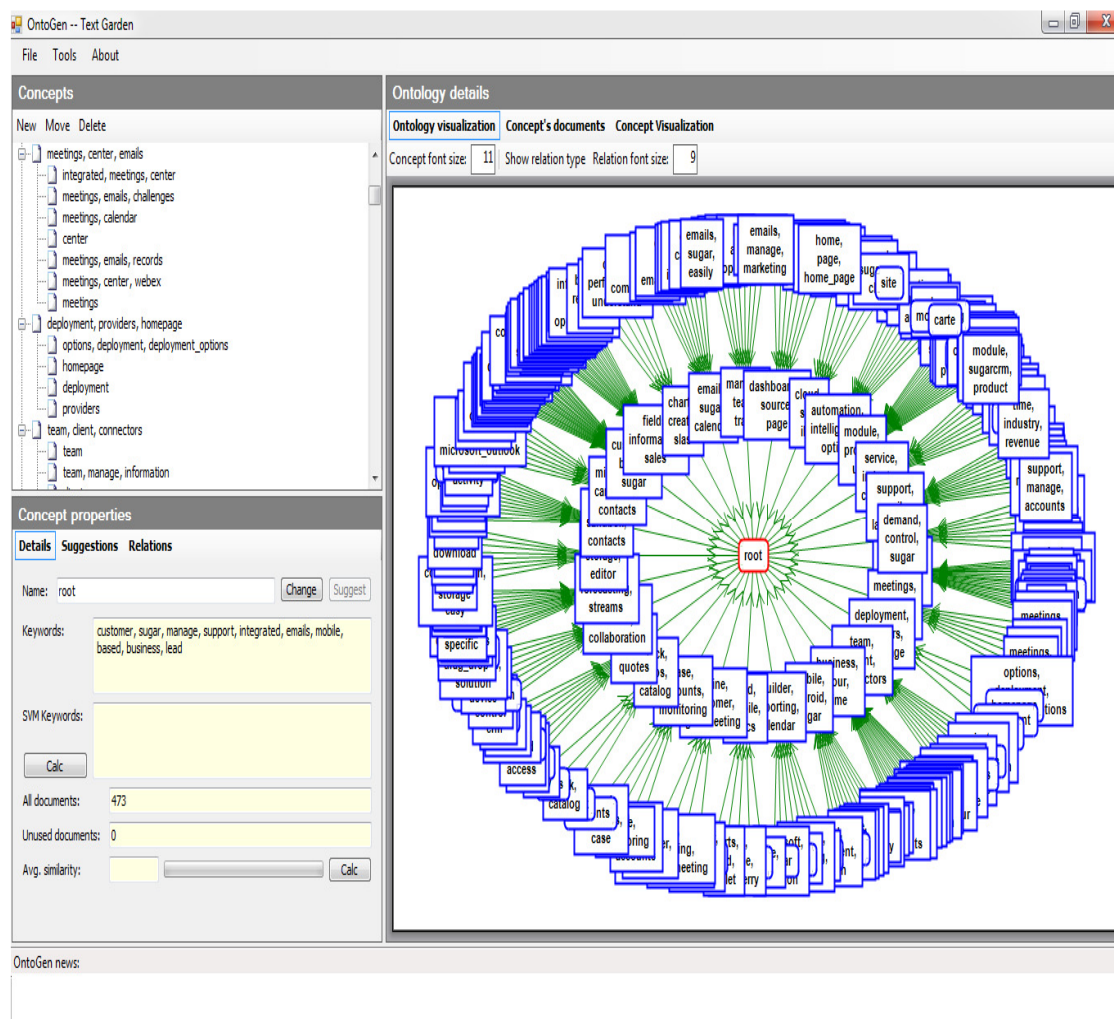
Figure 3-5 Salesforce Concepts Extraction Using OntoGen Tool.

The extracted concepts were collected and applied an elimination process for them. The eliminated words were the synonym (such as track and follow) or shortcut (such as app and application) for others, and also eliminate unmeaning group concepts (such as

details_edition and make_easy) and concepts contain multiple words (such as readoptionally and evaluatortrained). After that, we separate between the single and group concepts. The result of this part was being around 160 single and 70 groups which suggested for one of our providers ontology concepts. Table 3.3 & 3.4 below presents some of the remained single and group concepts.

Table 3-3 Salesforce Single Concept Extracted Using OntoGen Tool.

Concept	Concept	Concept	Concept
Account	Calendar	Training	Partner
Contact	Type	Online	Individual
Contract	Make	Storage	File
Mail	Sandbox	Support	Size
Document	Developer	Post	Large
Report	Full	Vote	Social
Library	Snapshot	Comment	Active
Analytic	What-if	Chat	Deactivate
Backup	Define	Task	View
Unlimited	Model	Application	Modify
Relate	Tab	Template	Layout
Industry	Chart	Automation	Create
Object	Assignment	Case	website

Table 3-4 Salesforce Group Concepts Extracted Using OntoGen Tool.

Group Concepts	Group Concepts	Group Concepts
Account. Record	Level. Security	Online. Trained
Build. Report	Mail. Merged	Sale. Process
Connect. offline	Mobile. Access	Account. Team
Customer. Field	Page. Layout	Account. Individual
Field. Access	Sale. Team	Build. Dashboard
Field. Security	User. Access	Approval. Automate
Lead. Opportunity	Production. Service	Related. List
Lead. Source	Opportunity. Email. Case	Trained. Users

Track. Campaign	Security. Level	Create. Report
Template. Mail	Record. Offline	Access. Fields

In order to ensure that the extracted (single and group) concepts using KAON and OntGen tools were belong to the knowledge domain of cloud CRM applications. As well as to know which tool give us more related concepts to the studied domain and able to achieve the target the ontology built upon, an evaluation process for these concepts must be done. To do that, 20 scenarios are built. These scenarios are customer's query when looking for cloud CRM services. These scenarios and our provider's information are sent to human experts that participant in the field of CRM and cloud CRM. However, we asked them to help us in condensing these scenarios as well as asked them to give us how much each provider achieve from these scenarios' requirements. After a while the results were sent back from experts. It were collected and studied upon the results of all experts. They all evaluated the scenarios as a good example for the studied field services and they give us in percentage how much each provider achieve from the scenarios' requirements. Table 3.5 presents sample of the result of this step. For more details see table 4, 5, 6, and 7 in the appendix.

Table 3-5 Query Scenarios & Human Experts Percentage for each Provider.

NO.	Query scenario	Human Percentage			
		Salesfoce	Zoho	Sugar	Commence
1	Managing sales chance and lead for industrial company in Canada with multiple language and world clock application integration	67%	67%	50%	100%
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales foresting and quoting	40%	40%	100%	40%
3	Mobile entrance to the system with boundless custom field and online training for CRM user places in Australia	67%	33%	33%	67%
4	Contact and inventory management and able	75%	50%	75%	50%

	to follow the competitor for communication industry				
5	Follow business account and can automate marketing and mange product in the middle east countries	75%	75%	100%	50%

To get the desired benefit from the previous step, keyword matching technique was applied to match the concepts of query scenarios and the concepts extracted from KAON and OntoGen tools. To do so, at first scenarios concepts were matched with the concepts extracted from KAON tool. The number of matching concepts present in percentage. Then, the error was calculated by subtracting human percentage from the matching percentage. Equation 3.1, 3.2 was used to calculate the percentage of error.

$$Ps = \frac{\sum(\textit{the Number of Match Concepts})}{\textit{Weight}} \%$$

Equation 3-1

Ps is the provider percentage.

The Number of Matched Concepts is the number of concepts (single and group) match between scenario and KAON tool.

Weight is same for each type of concepts match technique; we give 1 for each technique.

If we take query scenario no. 1 in table 3.5 as an example, salesforce achieves 67% from this query requirement according to the human expert percentage. When we apply the keyword matching to the concepts extracted from KAON tool, the result was matched 42% single concepts and 20% group concepts. According to equation 3.1 the number of match concepts will be 62 (42 for the single concepts matching plus 20 for the group concepts matching) and because we have two types of concepts (single and group) the average weight will be 2 (1 for each type of these concept type). Thus the provider resulted percentage will be 31 %.

Then

$$error = |Ps - H|$$ **Equation 3-2**

H is the human expert percentage for the query scenario and it is 67% for salesforce provider in the previous example. Thus the error here will be 36 %. After that, the error was calculated for all scenarios, the overall error calculated using Excel sheet. The result show 43% overall error for this provider. Table 3.6 presents part of the result of this step. For more details see table 8 in the appendix.

Table 3-6 Error of Salesforce Extracted Concepts Using KAON tool.

No.	Query Scenario	Human Percentage	Single Concept	Group Concept	Result	Error
1	Managing sales chance and lead for industrial company in Canada with multiple language and world clock application integration	67%	42%	20%	31%	36%
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales foresting and quoting	40%	33%	3%	18%	22%
3	Mobile entrance to the system with boundless custom field and online training for CRM user places in Australia	67%	50%	28%	39%	28%
4	Contact and inventory management and able to follow the competitor for communication industry	75%	43%	11%	27%	48%
5	Follow business account and can automate marketing and mange product in the middle east countries	75%	56%	11%	34%	41%

The evaluation process which we doing for the concepts extracted from KAON tool was applied again to the concepts extracted from OntoGen tool. The overall error for OntoGen tool was 36 %. Table 3.7 presents part of the results using OntoGen tool. For more detail see table 9 in the appendix.

Table 3-7 Error of Salesforce Extracted Concepts Using OntoGen tool.

No.	Query Scenario	Human Percentage	Single Concept	Group Concept	Result	Error
1	Managing sales chance and lead for industrial company in Canada with multiple language and world clock application integration	67%	58%	10%	34%	33%
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales foresting and quoting	40%	67%	3%	35%	5%
3	Mobile entrance to the system with boundless custom field and online training for CRM user places in Australia	67%	60%	18%	39%	28%
4	Contact and inventory management and able to follow the competitor for communication industry	75%	71%	0%	36%	39%
5	Follow business account and can automate marketing and mange product in the middle east countries	75%	78%	6%	42%	33%

The detail about query scenarios concepts extraction and how we calculate the matching percentage are mentioned in the next chapter.

Equation 3.3 calculates the ratio of error decreases when using the concepts extracted from OntoGen tool then KAON tool.

$$Ed = \frac{(|Pervios\ Error - Current\ Error|)}{Previous\ Error} * 100 \qquad \textbf{Equation 3-3}$$

Ed is the error decreases.

Previous Error is the overall error using KAON tool, it was 43 %.

Current Error is the overall error using OntoGen tool, it was 36 %.

According to this equation, the error decreased by 16 % when we match query concepts with the concepts extracted from OntoGen tool. So that, OntoGen tool will be handle to extract our ontology domain concepts. The concepts extraction process which done previously to one of our providers was repeated to all of our providers. The extracted concepts number differs from one provider to another depending on the size of collected documents for each provider. Table 3.8 presents the single and group concepts number for each of our providers extracted using OntoGen tool.

Table 3-8 Providers Single & Group Concepts Number.

Provider	Single Concepts	Group Concepts
Salesforce	160	70
Zoho CRM	125	40
SugarCRM	173	55
Commence CRM	120	25

Our ontology will contain the single and group concepts extracted from all of our providers. The ontology single concepts are about 230 single concepts gathered from all of our providers and 80 relationships (group concepts). Other relationships will be added to

the OntoGen relationships to improve the results of ontology matching. These relationships are:

1. Synonym Relationship.

2. Instance Relationship.

3. General Relationship.

3.2.3   Ontology Relationship Extraction

Extracting the relationships between ontology concepts is an essential step in ontology constructing process. Many previous studies and researches have been published about this subject (Maedche, A. and Staab, S., 2004) (Schutz, A. and Buitelaar, P., 2005) (Alani H. et al., 2003). But, when the decision was to proceed in this step; extracting and creating relationships between the ontology concepts; the result was that if we want to create detailed and complete ontology relationship. Then, this work will be large enough to be a thesis. Such details go beyond our work scope and then we suggested to be done in the future. So, we tended to extract and present a basic and general representation of the relationships that serve the target the ontology built upon. In order to extract these relationships between our suggested ontology domain concepts, the extracted concepts and many possible customer queries samples was studied and analyzed. As mention earlier, the main objective of this research was built cloud CRM ontology to use in semantic similarity matching. Thus, semantic relations will be added to our ontology. Many types of these relations are existing, but our ontology will contain three types of them.

1. Synonym Relationship

Added synonym relationship to our ontology ensures matching ontology concepts with all related term if they share the same meaning. The concepts "contract" in the ontology, for example, is also expressed by the term "deal", "declaration" and "agreement". If customers using one of these terms when they query, the term will directly match with the related concepts in the ontology. Thus, we will construct synonym relationship for each of our ontology single concepts. The similarity measurements which perform here to extract the synonym relationships will use the synset in the lexical similarity, defined in WordNet. To do that, we take each of our single concepts and enter to a WordNet. Figure 3.6 shows the synonyms of contract concepts using WordNet 2.1.
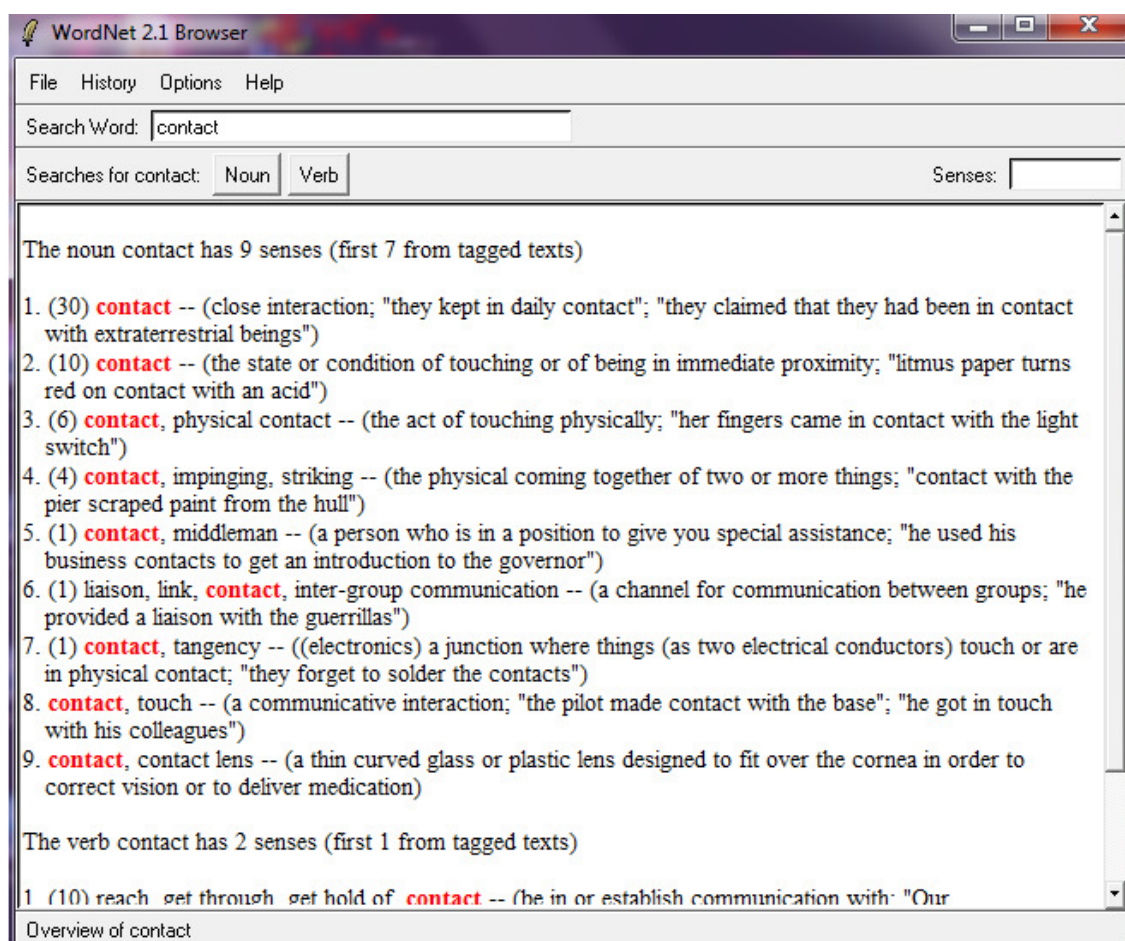
Figure 3-6 Synonyms of Contract Concept.

This will have done manually, but we can use a tool to do that. Such a tool takes the concept, connects with Wordnet and gives the synonyms. This step provided us with almost 210 synonyms resulted from 230 single concepts. Table 3.9 presents part of the result of this step.

Table 3-9 Ontology Single Concepts & Synonyms.

Concept	Synonym	Concept	Synonym
Contract	Deal	Train	Develop
	Declaration		Prepared
	Agreement		Educate
	Direction		Remark

Management	Supervision	Comment	Notice
	Running		Commentary
Source	Root	Connect	Linked
	Origin		Associate
	Reference		Join
Industry	Manufacture	Mass	Bulk
	Diligence		Volume
	Industriousness		Multitude
Filter	Trickle	Forecast	Estimate
	Dribble		Reckon
	Strain		Predict
Track	Path	Activity	Action
	Follow		Activeness
	Running		Motion

2. Instance Relationship

Instance relationship is one of the important relations for our domain ontology; it defines the specific details of the ontology concepts. Add this relationship to the ontology is very important because of some of our ontology single concepts (such as language, country, industry, etc.) have instances and ontology constructing tools which we used did not extracted. For example, "Arabic" and "English" are instances for the "language" concept. The instances will be extracted from those ones available in WordNet. Figure 3.7 shows the instances of language concepts extraction.
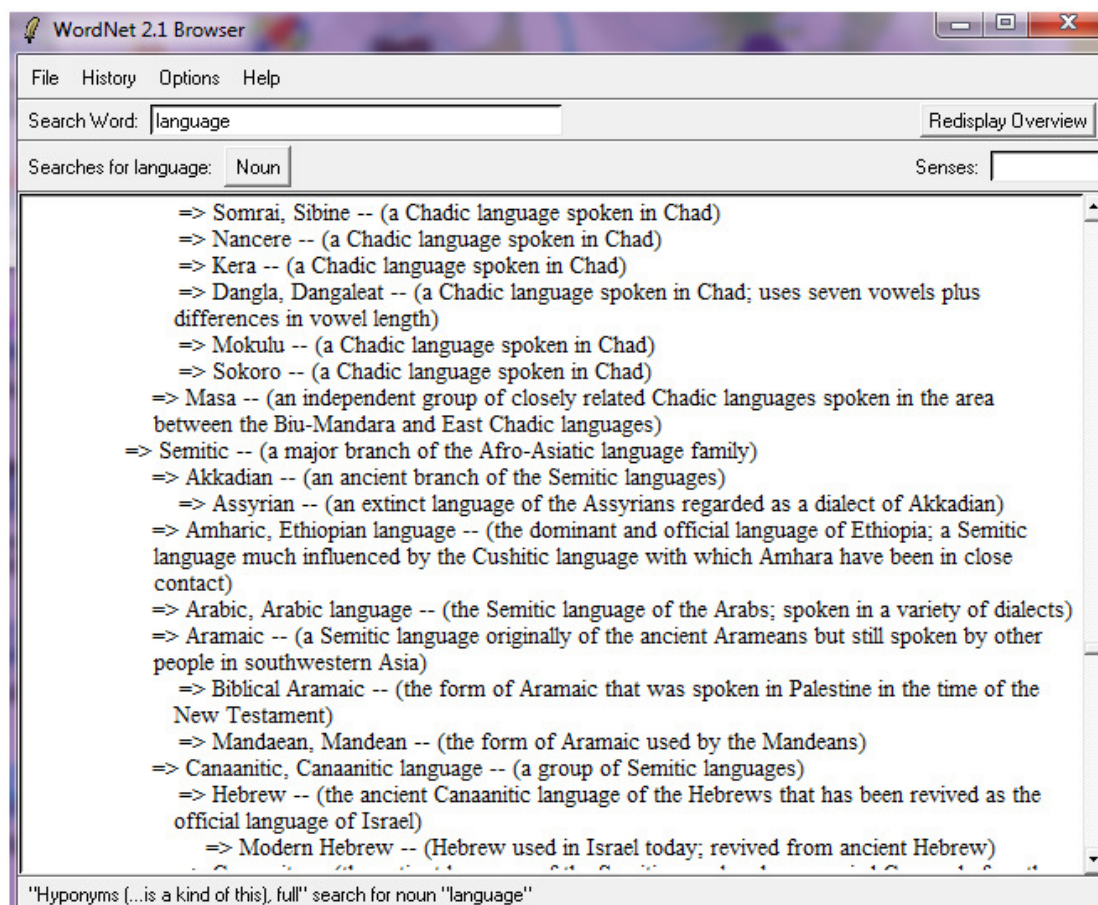
Figure 3-7 Instances of Language Concept.

This step provided us with almost 300 instances resulted from the 230 single concepts. After we had the resulting instance concepts, we reach to the final step in instance concepts extraction. A refinement process was applied to present the instance in more readable way inside our ontology. Table 3.10 below presents some of the suggested instance with the related single concepts.

Table 3-10 Part of Ontology Single Concepts & Related Instances.

Concept	Instance Concept	Concept	Instance Concept
Language	English	Industry	Automobile
Language	Japanese	Industry	Chemical
Language	Chinese	Industry	Computer
Language	Dutch	Industry	Construction
Language	French	Industry	Automobile
Language	German	Industry	Entertainment
Language	Portuguese	Industry	Communication
Language	Brazil	Industry	Electronic
Language	Korean	Industry	Aviation
Language	Finnish	Industry	Hawala
Language	Danish	Industry	Fashion
Language	Italian	Industry	Financial
Language	Russian	Industry	Government
Language	Spanish	Industry	Media
Language	Swedish	Industry	Nonprofit
Language	Thai	Industry	Retail
Language	Australian	Industry	Healthcare
Language	Latin	Industry	Life- science
Language	Arabic	Industry	Manufacturing
Language	Turkish	Industry	Education

3. General Relationship

As mention earlier, extracting and creating full ontology relationships is large enough work to be a thesis. Although it's important to ensure that the most important relationships includes in our ontology regardless of the type of these relationships. In order to do that, we will construct relationships named as a general relationship associated between two of our ontology single concepts. Two single concepts are associated if they are related semantically. After that, these relationships present as pair group of concepts in our

ontology. To be able to construct these relationships (groups), we need to select the most appropriate semantic relationship to our ontology single concepts. To do this, we apply the semantic similarity measures available on WordNet to a golden sample. This sample consists of pairs of our ontology single concepts and it already exists in almost all of our provider services definition. This sample was sent to human experts (professors, doctors, and practitioners) in the field cloud CRM and CRM to check its relatedness. The result of this part was 20 pair groups which suggested as good sample to check their semantic relatedness. According to the relatedness results of these groups, we can identify the best similarity measure to be used. We calculated the relatedness ratio for each of these groups using WordNet similarity measures[3]. After that, we compare these ratios with the maximum ratio for each measure. The result of this step shows that wup (WordNet similarity measure which is based on path lengths between the concepts to calculate the similarity between them) measure out 15 strong relations from 20. Those relations exceed the 0.5, since that the maximum ratio for wup measure is 1. Table 3.11 present these golden samples with the semantic similarity measures.

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[3] http://marimba.d.umn.edu/cgi-bin/similarity/similarity.cgi

Table 3-11 Golden Samples of Group Concepts with Similarity Measures.

N O.	Concept1	Concept2	path/ 1	lch/ 3.68 89	wu p/ 1	res/ 11.76 58	jcn/ 1287669 9.5	lin / 1	les k/ 597 9	vect or/ 1	vector_p airs/ 1	hs o/ 1 6
1	Account	Contact	0.3	**2.2**	**0.7**	3.1	0.1	0.3	83	0.2	0.1	4
2	Task	Track	0.1	1.7	**0.7**	3.3	0.07	0.2	42	0.1	0.03	0
3	Applicati on	Custom	0.2	**2**	**0.7**	4.7	0.09	0.4	57	0.1	0.03	3
4	Mass	Email	0.1	1.4	**0.6**	2.8	0	0	51	0.1	0.03	0
5	Report	Track	0.2	1.7	**0.6**	4.6	0.07	0.0 9	50	0.1	0.03	0
6	Mobile	Access	0.1	1.6	**0.6**	2.4	0	0	51	0.1	0.05	0
7	Idea	Post	0.1	1.6	**0.5**	3.1	0.1	0.2	88	0.4	0.04	0
8	Field	Security	0.1	1.7	**0.6**	3.1	0.09	0.3	115	0.2	0.03	0
9	Integrate	Email	0.1	1.3	0.2	0	0	0	18	0.07	0.02	0
10	Manage ment	Opportun ity	0.0 9	1.2	0.3	0.7	0.07	0.1	38	0.2	0.03	0
11	Data	Share	0.1	1.6	**0.5**	1.7	0.08	0.2	38	0.1	0.02	0
12	Report	Analyze	0.2	**1.9**	0.4	0	0.08	0	65	0.2	0.04	0
13	Languag e	Support	0.1	1.8	**0.6**	5	0.1	**0.5**	131	0.3	0.2	2
14	Multiple	Currency	0.0 7	1.04	0.3	0.7	0	0	47	0.1	0.01	0
15	Dashboar d	Custom	0.0 7	1.1	0.2	0	0	0	29	0.09	0.01	0
16	Case	Escalatio n	0.1	1.4	**0.5**	2.6	0.08	0.2	17	0.09	0.07	0
17	Sale	Forecast	0.2	**2**	**0.7**	4.7	0.07	0.4	29	0.1	0.02	3
18	Inventory	Manage ment	0.1	1.6	**0.6**	2.6	0.06	0.1	31	0.1	0.04	0
19	Competit or	Track	o.1	1.6	**0.5**	1.3	0.06	0.1	41	0.1	0.01	0
20	Lead	Capture	0.2	**2**	**0.8**	**9**	0.1	0.4	42	0.2	0.08	3

If we take column 5 in table 3.11 as an example, lch is the name of the similarity measure and 3.6889 is the maximam possible ratio which obtained by this measure when associating two quite similar concepts. The ratio of 2.2 (raw 2, column 5) is obtained by associating Account (raw2, column2) and Contact (raw2, column3) concepts. Ratios in bold underling font in this table mean that the relationship between the associating

concepts is good. To get benefits from the previous step, the wup measure will used to make relationship between the ontology single concepts. The wup measure used as input with all single concepts for each one of our providers to a tool; a tool created by Kayed. Such a tool accounting similarity among concepts based of the pre-identified measure. This tool provided us with about 4000 pairs of concept when enter 200 single concepts. Figures 3.7 shows part of the results when using this tool.

	A	B	C	D	E
1	ID	concept1	concept2	Measure	Count
2	105	account	SMS	wup	0.4706
3	106	account	send	wup	0.7143
4	107	account	Plug	wup	0.7143
5	108	account	access	wup	0.6
6	110	account	train	wup	0.7692
7	111	account	source	wup	0.7778
8	112	account	route	wup	0.2857
9	114	account	support	wup	0.7059
10	115	account	post	wup	0.7692
11	116	account	vote	wup	0.7059
12	117	account	comment	wup	0.9474
13	118	account	location	wup	0.7059
14	119	account	user	wup	0.3077
15	120	account	storage	wup	0.6
16	121	account	escalation	wup	0.6
17	122	account	update	wup	0.8333
18	123	account	chat	wup	0.6154
19	125	account	filter	wup	0.25
20	128	account	template	wup	0.4706 </p>

Figure 3-8 Salesforce Pair Group Concepts Result from Kayed Tool.

After we had the resulting 4000 group concepts from this tool, we need to select the groups which are more related to the studied domain to be included on our ontology. To do that, first we constructed a pair groups from the query scenarios which we prepared previously in section (3.2.2). Table 3.12 presents some of these groups.

Table 3-12 Query Scenarios & Its Group Concept.

Query Scenario	Query Single Concept	Group Concept		wup
		Concept1	Concept 2	
Managing sales chance and lead for industrial company in Canada with multiple language and world clock application integration	managing	management	sale	0.6667
	sales	management	opportunity	0.375
	chance	management	lead	0.6667
	lead	management	company	0.6667
	industrial	management	multiple	0.4211
	company	management	language	0.5
	Canada	management	world-clock	
	multiple	management	application	0.7059
	language	management	integration	0.8
	world-clock	sale	opportunity	0.8889
	application	sale	lead	0.6667
	integration	sale	company	0.6667

The previous table presents a query scenario in column 1. Column 2 presents all the extracted single concepts from the query. Column 3 presents the group concepts constructed from query single concepts and column 4 present the wup ratio obtained when associating two single concepts. The details about the query analysis will discuss in the next chapter.

The overall constructed groups from all scenarios were about 510 pairs. A large Part of these groups have no meaning (such as "Management. World-Clock") in cloud CRM environment. The other part of these groups are really reflect the requirements which the customers looking for (such as "Management. Lead", "Sale. Opportunity", and "Multiple. Language"). The number of these groups was about 107 pairs.

After that, the resulted groups with the wup ratios were collected and analyzed. We noticed that, almost all groups which belong to our domain were associated in the ratio between 0.5 and 0.7. Thus, the chosen option was selected the groups which belong to one of these ratios (0.5, 0.6, and 0.7 and above) in order to be included in our ontology. Table 3.13 presents the wup ratio with the number of groups match from scenarios.

Table 3-13 Wup Ratio & Matching Groups Number.

Wup	All Groups (510)	Really Want Groups (107)
0.5 and above	290	71
0.6 and above	180	59
0.7 and above	119	26

This table presents the number of groups match for each ratio in compare with all constructed groups number (510) and the number of group which the customer really want (107). Raw 2 for example presents that in the ratio of 0.5 and above, match 290 groups from all groups number and 71 groups from the really customer want groups.

Then, the result was analyzed and we find that:

1. In the ratio of 0.5 and above, the number of group in the ontology will be huge and large numbers of these groups have no meaning.

2. And in the ratio of 0.7 and above, the matching groups are too small and that will impacting on the final ontology matching results.

3. The choice is to take the ratio of 0.6 and above; to have a suitable pairs group in our ontology (not too big) and the matching results will be acceptable to be handle.

In addition, part of the customer really wants groups (107 pairs) did not match at all. The number of these groups is about 34 pairs. Parts of these unmatched groups are:

- Either under the ratio which we choose to be included in our ontology.

- Or did not result from the wup measure although they had a strong relation with others in the cloud CRM environment. The relationship between these concepts did not calculate because one or the two concepts which make group did not include / read by WordNet. For example, wup does not result "Offline. Connect" and "Online. Access" relationship because offline and online concepts did not read by WordNet.

We take those concepts and construct its relationships with others. The existing of these in our ontology groups are essential and it will improve the results for our ontology matching. As a result, we will have pair group of concepts for each of our provider extracting in different way:

1. Directly suggested by OntoGen tool with about 15 percentages.

2. Constructed using the wup similarity measure with about 80 percentages.

3. Constructed by us with about 5 percentages.

After that, our ontology concepts and relationships are ready. An evaluation process must be done to see how much the added groups and relationships to these extracted from OntoGen tool will enhance the ontology matching results to suggest the appropriate cloud provider to the cloud CRM customers. That what we are discussing in the next chapter. And we will discuss the algorithm to extract concepts from customer query and how we calculate the matching results.

4   CHAPTER FOUR: CLOUD PROVIDER DISCOVERY SYSTEM

4.1   Preface

This chapter explains, in detail, the use of the ontology which built in chapter3. This will be done through develop a query answering system named as a Cloud Provider Discovery System (CPDS). The CPDS allows cloud CRM customers for query, analyses the query semantically and matches its requirements with the appropriate cloud provider through consults the cloud CRM ontology.

4.2   Proposed Model

Our proposed model for a query answering system (CPDS) mimic the generic system suggested and used in cloud service discovery system (Han & Mong Sim, 2010), (Han &Mong Sim, 2011). Figure 4.1 will show the component for model. There is an online interface available on World Wide Web (WWW) allows customer to query about the demand requirements. The system will 1) analyze the customer query semantically 2) extract query concepts 3) consult cloud CRM ontology and 4) match query concepts with the ontology concepts to suggest the most appropriate cloud provider to the customer. Next, the system components will discuss in detail.
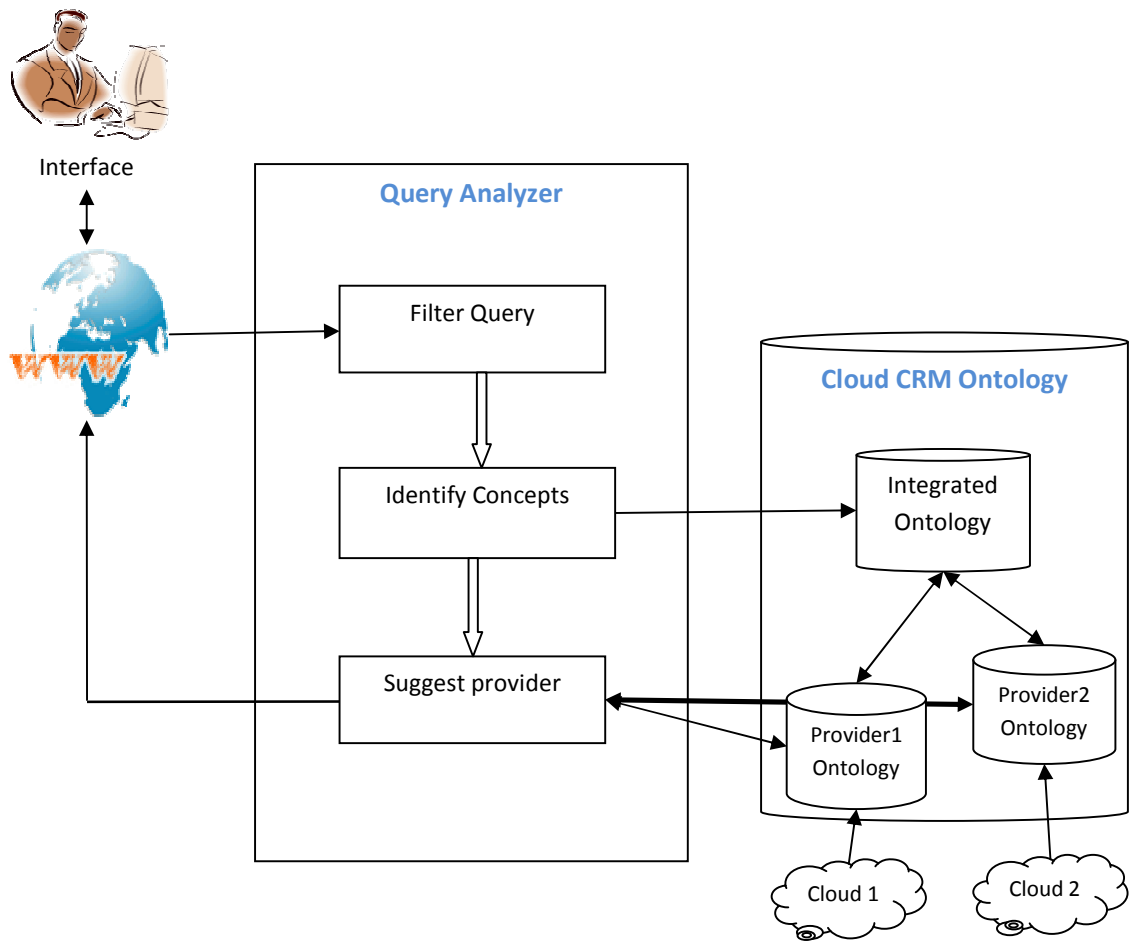
Figure 4-1 Cloud Provider Discovery System.

4.2.1 Cloud CRM Ontology

Our proposed ontology for cloud CRM will consist of two parts. These parts are:

1. Integrated Ontology: The Integrated ontology in this work represent the upper part in cloud CRM ontology. It includes the common single concepts extracted from the studied providers which are 230 single concepts. It also includes the synonym and instance relationships for the ontology concepts.

2. Provider Ontology: The provider ontology represents the lower part of cloud CRM ontology. It includes the own set of single concepts for each provider. It also includes 1) the synonym relationships 2) the general relationships between the single concepts which were represent as pair group of concepts and 3) the Instance relationships for the single concepts. Figure 4.2 shows the structure of the cloud CRM ontology.

Cloud CRM Ontology

Single Concept	Synonym	Instance
Follow	Track	
	Tail	
Business	Commerce	
	Trade	
Language	Speech	English
		French

Unified Ontology

Single Concept	Synonym	Group Concept	Instance
Follow	Track	Follow. Business	
	Tail	Follow. Account	
Business	Commerce	Business. Account	
	Trade		
Language	Speech	Language. Contact	English
			French

Provider Ontology
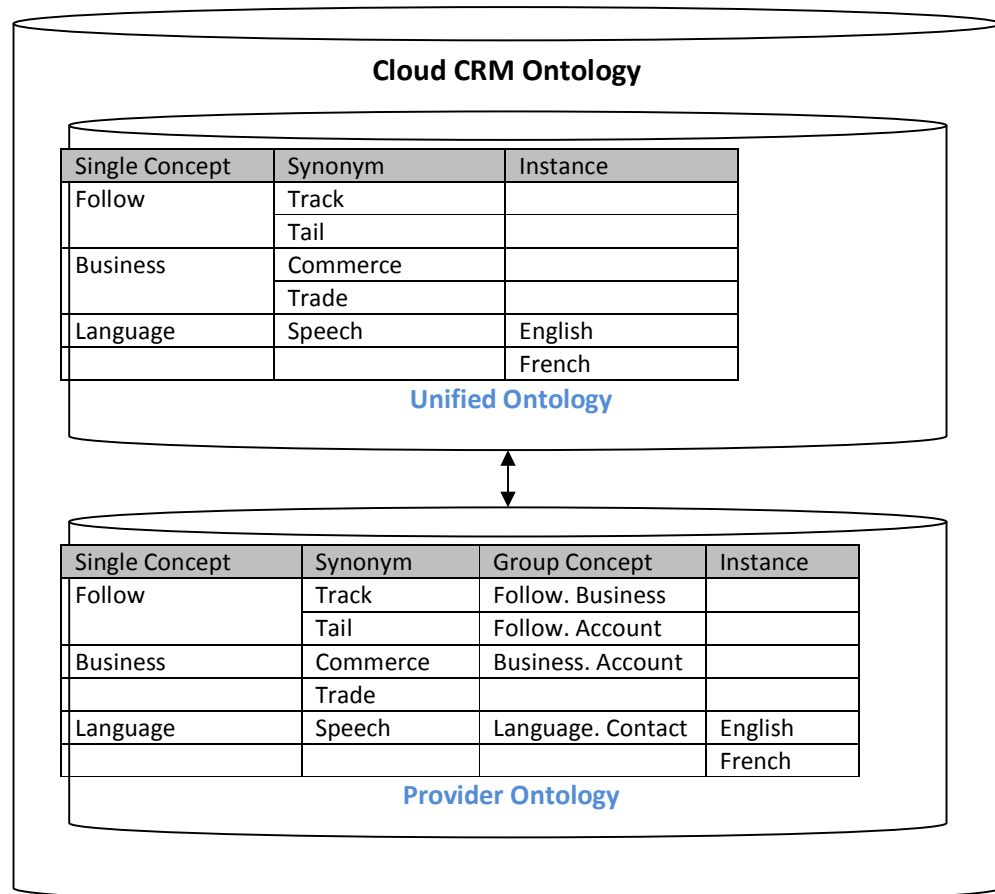
Figure 4-2 Cloud CRM Ontology.

4.2.2   Filter Query

Using the semantic matching technique in the query answering system enables it to suggest more prices answer to customers then using the Keyword matching. To do this, multiple steps must be done to extract concepts from the text (query). These steps include pre-processing the text, and defining the heuristics to identify the concepts to be extracted. For example, a query like "a cloud CRM system which is able to entrance from mobile with boundless custom field service and online training for CRM user's places in Australia" cannot be easily return precise answered using the traditional keyword matching techniques. This query needs to be filtered and analyzed to return the answer which the customer look for. To do that, our approach in this stage takes the input from the on-line customer interface. The input is a query sentence; this sentence contains word need to be filter. These words are the stop words which were identified previously in the system. These words are 1) the words which are common in the studied domain (such as CRM, cloud, system, service, work, etc.) and 2) the function words (such as the, is, at which, on, etc.). These stop words are remove from the query sentence, other remaining words treated as a single concepts which are need to match with our ontology concepts.

4.2.3   Identify Concepts

The extracted concepts from the previous stage will be looking for it in cloud CRM ontology. As mentioned earlier, cloud CRM ontology was construct from single and group concepts, and it consists of two parts (integrated and provider) ontologies. All common

single concepts which exist in the integrated ontology and the own set of provider single and groups concepts exist on this provider ontology.

- **Single Concepts**

In this stage, the system inquires whether the remaining query single concepts are existing or not in the domain ontology, regardless in which provider it exists. To do this, several steps must be followed. These steps are 1) look for these concepts in the integrated ontology and match between the query and ontology concept if they share the same string form "keyword matching" 2) look for the concepts which did not match from the previous step on the synonym "semantic matching" and returned it back to the original form in the unified ontology and 3) ignore the concepts which have never match in the earlier steps.

- **Group Concepts**

To get benefit from group concepts of our ontology, group concepts of query will be constructed to match it with these groups in our ontology. To do this at first, query instances will extract from the single concepts resulted from the previous stage. Instances were identified early in the providers' ontologies. Thus, instances were extracted by consult providers' ontologies. After that, the system constructs groups from the remaining query single concepts. Two approaches are possible to construct query groups:

1. **Approach1:** This approach associates the query single concepts with all other concepts, the resulted groups number of this approach can be expressed as that O (n^2) where n is the number of concepts. For example, if the query includes 7 single concepts, single concepts are C1, C2, C3, C4, C5, C6, and C7. Then the number of

groups will be 21, group concepts are G1, G2, G3, G4, G5, G6, G7... and G21. Group concepts resulted from this approach are that:

G1(C1C2)   G2(C1C3)   G3(C1C4)   G4(C1C5)   G5(C1C6)   G6(C1C7)

G7(C2C3)   G8(C2C4)   G9(C2C5)   G10(C2C6)   G11(C2C7)

G12(C3C4)   G13(C3C5)   G14(C3C6)   G15(C3C7)

G16(C4C5)   G17(C4C6)   G18(C4C7)

G19(C5C6)   G20(C5C7)

G21(C6C7)

 Figure 4.3 depicts the way to construct these.
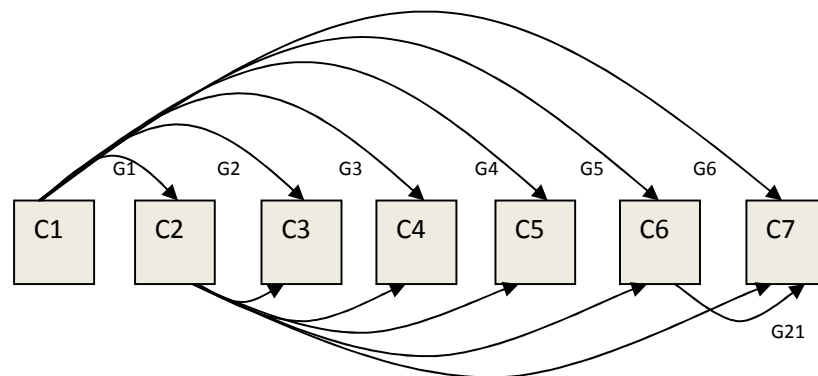
Figure 4-3 Groups Construction (Approach 1).

2. **Approach2:** This approach associates query single concepts with half of query concepts, on the condition that these concepts was arranged in the same order which is in the customer query, unlike the first approach which is the order of concepts not essential. It associates the first query single concept with the followed

concepts until the middle one if the number of these concepts is odd. However, if the number of query concepts is even then it associates the first concept with the followed concepts until the middle one by one concept. Group concepts resulted from this approach are that:

G1(C1C2)   G2(C1C3)   G3(C1C4)

G3(C2C3)   G5(C2C4)   G6(C2C5)

G7(C3C4)   G8(C3C5)   G9(C3C6)

G10(C4C5)   G11(C4C6)   G12(C4C7)

G13(C5C6)   G14(C5C7)

G15(C6C7)

Figure 4.4 depicts group concepts construction for the previous example.
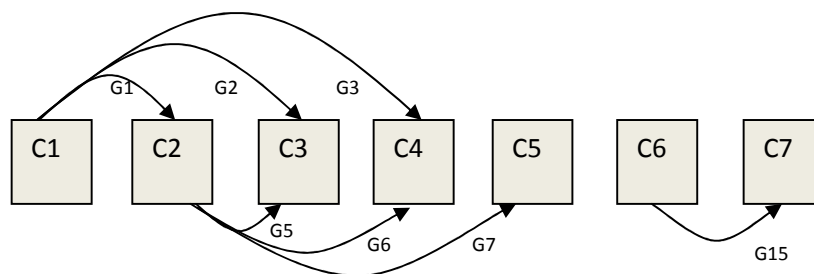
Figure 4-4 Groups Construction (Approach2).

We can notices that, approach1 ensures include all the possible relations between the query single concepts but 1) these groups will include many redundant data (unmeaning groups) and 2) the number of these groups is large which is effects the query responds time. For example, a query like: "follow contact business account and able to automate marketing campaign". After the filtration process, resulted single concepts will be "Follow",

"Contact", "Business", "Account", "Automate", "Marketing", and "Campaign". Group concepts constructed using approach1 will be "Follow. Contact", "Follow. Business", "Follow. Account", "Follow. Automate", "Follow. Marketing", "Follow. Campaign"… "Marketing. Campaign". Groups like "Follow. Automate" are unmeaning group concept which will result in redundant data. In order to enhanced that, many queries were studied and analyzed belong to the studied domain and other domains. We find that, the single concepts which indicate to one requirement (such as follow contact business account) will came one after the other. Therefore, approach2 was proposed to construct the group concepts. When we apply approach2 to the previous example, the "follow" concept will make a group with only "Account", "Business", and "Account" concepts. This will reduce the number of redundant groups (such as "Follow. Automate"). Approach2 is also reduced the number of group concepts to 15 groups while it was 21 groups in approach1. The experiments in next chapter will apply the two approaches to distinguish which approach gives us more precise answer.

4.2.4 Provider Suggestion

Suggest the most appropriate cloud CRM provider to customer is the last stage in our model. The system computes the similarity between provider services and customer requirements based on the previous stages. Therefore, compute the similarity is an accumulative process, calculated by sum the number resulted from matching same string, synonym, instance, and group concepts by consulted the integrated and provider ontologies. As a results, the system presents a list contains providers names with the related similarity percentages. The final provider percentage calculated using formula 3.1 in section (3.2.2)

The following example will summarize the steps to suggest the cloud CRM provider to customer. If we take a query no. 3 in table 3.5 as an example "Mobile entrance to the system with boundless custom field and online training for CRM user places in Australia", this query matches with providers following these steps:

Step 1: Remove the stopping words (most common words (CRM, system) and functional words (to, the, with, and, for, in)) from the query sentence.

Step 2: Treated each word remained in the query sentence as a single concept (Mobile, Entrance, Boundless, Custom, Field, Online, Training, User, Places, and Australia).

Step 3: Look for these single concepts in the integrated ontology,

- Match these concepts (Mobile, Custom, Field, Online, Training, User, and Australia) with the integrated ontology concepts based on the same string match.

- Look for the remain concepts (Entrance, Boundless, and Places) in the synonym and return the match one to the original concepts in the integrated ontology. The match concepts are (Access, and Unlimited) which are synonym for (Entrance, and Boundless).

- Ignore (Places) concept from the query single concepts which is not match from the same string and synonym.

Step 4: Look for all the matched single concepts (same sting and synonym) in provider ontology to extract the instances, "Australia" is instance in all of our providers' ontologies.

Step 5: construct group concepts from remained single concepts, the concepts are "Mobile", "Access", "Unlimited", "Custom", "Field", "Online", "Training", "and Users". Table 4.1 presents the group concepts from these single concepts using approach 1, 2.

Table 4-1 The Single & Related Group Concepts.

Single Concepts	Group Concepts (Approach1)	Group Concepts (Approach1)
Mobile	Mobile. access	Mobile. access
Access	Mobile. unlimited	Mobile. unlimited
Unlimited	Mobile. custom	Mobile. custom
Custom	Mobile. field	Access. unlimited
Field	Mobile. online	Access. custom
Online	Mobile. training	Access. field
Training	Mobile. users	Unlimited. custom
Users	Access. unlimited	Unlimited. field
	Access. custom	Unlimited. online
	Access. field	Custom. field
	Access. online	Custom. online
	Access. training	Custom. training
	Access. users	Field. online
	Unlimited. custom	Field. training
	Unlimited. field	Field. users
	Unlimited. online	Online. training
	Unlimited. training	Online. users
	Unlimited. users	Training. Users
	Custom. field	
	Custom. online	
	Custom. training	
	Custom. users	
	Field. online	
	Field. training	
	Field. users	
	Online. training	
	Online. users	
	Training. Users	

Step 6: Now the system can suggest the provider final percentage. Table 4.2, 4.3 presents the provider final percentage.

Table 4-2 Providers Percentages Calculation.

Technique	Single Concept No.	Provider Concepts No.				Provider Percentage			
		Salesforce	Zoho	Sugar	commence	Salesforce	Zoho	Sugar	commence
Same String	10	7	5	5	5	70 %	50 %	50 %	50 %
Synonym	10	9	6	6	7	90 %	60 %	60 %	70 %
Instance	1	1	1	1	1	100 %	100 %	100 %	100 %
Group (Approach 1)	12	4	1	2	3	33 %	8 %	17 %	25 %
Group (Approach 2)	8	3	1	2	3	38 %	13 %	25 %	38 %

Table 4-3 Providers Final Percentages.

Providers	Approach	Same String	Synonym	Instance	Group	Final Percentage
Salesforce	1	70 %	90 %	100 %	33 %	73 %
	2	70 %	90 %	100 %	38 %	75 %
Zoho	1	50 %	60 %	100 %	8 %	55 %
	2	50 %	60 %	100 %	13 %	56 %
Sugar	1	50 %	60 %	100 %	17 %	57 %
	2	50 %	60 %	100 %	25 %	59 %
Commence	1	50 %	70 %	100 %	25 %	61 %
	2	50 %	70 %	100 %	38 %	65 %

If we take raw 1 in table 4.2 as an example, 10 is the number of query single concepts.

When we apply same sting matching technique, salesforce match 7 concepts, Zoho, Sugar,

and commence match 5 concepts. Thus, salesforce gets 70 % (70/10 *100) from same string matching technique, and each of Zoho, Sugar, and Commence get 50 %.

Raw 1 in table 4.3 presents salesforce percentages using approach 1, it presents 70 % for same string matching, 90 % for synonym matching, 100 % for instance, and 33 % for group matching. These percentages sum and divided to the average (100 for each technique) to calculate the final percentage for salesforce (73%) using mention equation 3.1 in section (3.2.2). Figure 4.5 shows the workflow of query answering system in detail.
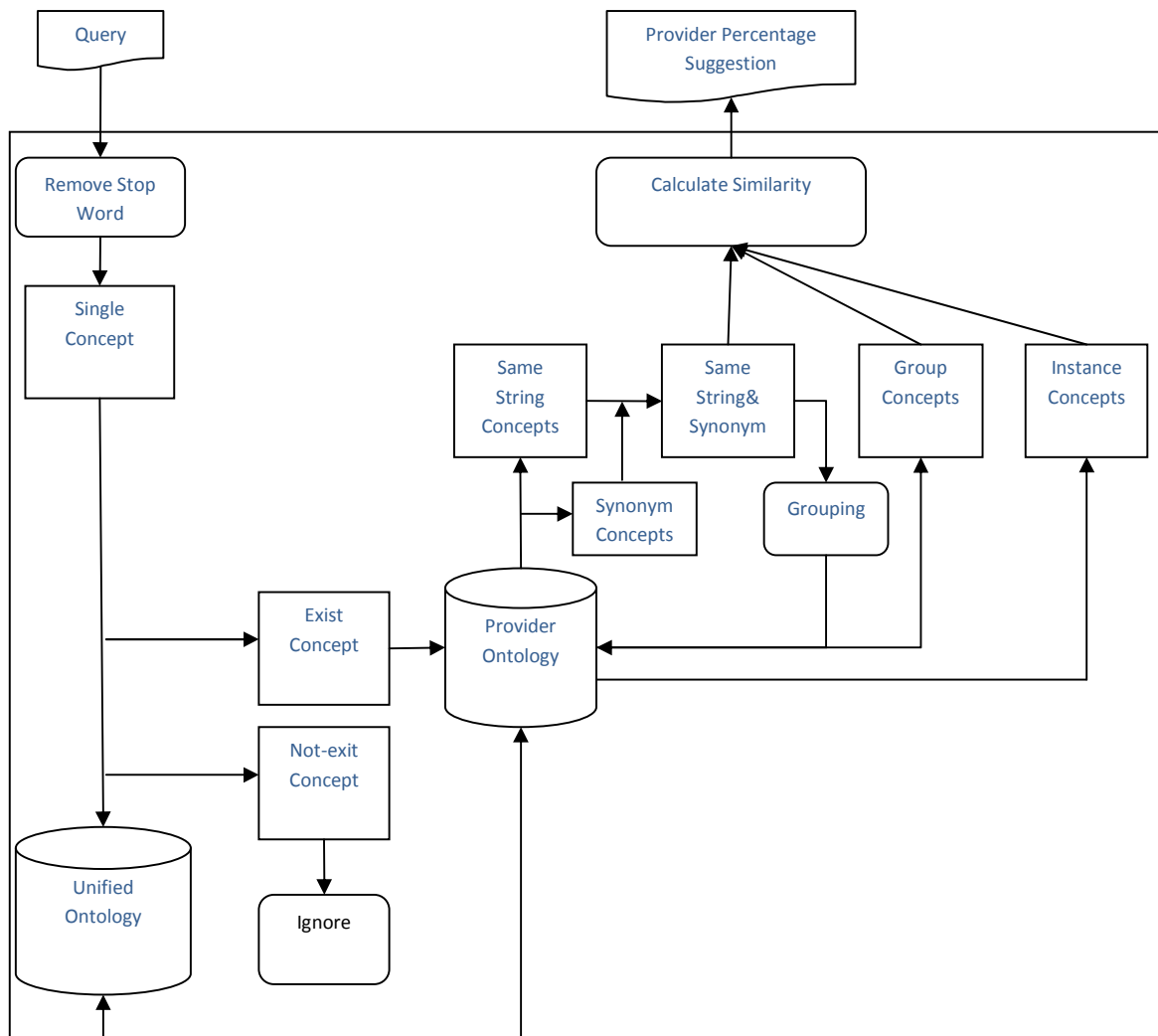
Figure 4-5 Query Answering System Workflow

5 CHAPTER FIVE: EXPERMENTIAL RESULTS

5.1 Preface

This chapter presents the conducted experiments with their used settings and results. These experiments conduct on a synthetic data set that was previously used in our work. Section 5.2 introduces the performance measures for evaluating and comparing the quality of the used techniques. The experiments in Section 5.3, 5.4, and 5.5 evaluate the traditional matching techniques. Section 5.6 evaluates the performance of our proposed technique. Analysis of the results discuss in section 5.7.

5.2 Evaluation Methods

The experimental evaluation was applied on a sample of customer query scenarios which was previously prepared (showed in table 3.5) in section 3.2.2. The experiments compared the human expert (used as a base measure) percentage for this sample with the percentages resulted from applying four techniques which used to match the customer query requirements and appropriate provider services. Table 5.1 presents the used techniques with its description.

Table 5-1 Glossary of Approaches.

Approach	Description
Keyword Matching Technique	Match customer query and our ontology concepts when it have the same sting form (the same keyword).
Semantic (Synonym only) Matching Technique	Match customer query and our ontology concepts when • It have the same sting form, • Or it are synonyms.
Semantic (with Instance) Matching Technique	Match customer query and our ontology instances.
Our Technique	Match customer query and our ontology semantically based on • Single (same string , synonym, and instance) concepts • Group concepts.

5.2.1 Keyword Matching (Match the Same-Sting Concept)

We used the traditional keyword matching technique used by several existing search engines (Google, Yahoo, Baidu, etc.) to match customer requirement with the appropriate provider. In order to do that, this technique matches the query concepts with our ontology concepts if it shares exactly the same string form. Thus, the single concepts the 20 query scenarios was extracted and matched with each of our provider's single concepts. The results presents percentage the numbers of concepts shared between it. Table 5.2 presents part of the results of matching according to this approach. For more detail see table 10 in appendix.

Table 5-2 Human Experts vs. Keyword Matching.

Que ry	Human Experts				Keyword Matching				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	67 %	50 %	100%	67%	58 %	58 %	75%	0%	9%	8%	25%
2	40%	40 %	100 %	40%	75%	67 %	83 %	67%	35%	27 %	17 %	27%
3	67%	33 %	33 %	67%	70%	50 %	50 %	50%	3%	17 %	17 %	17%
4	75%	50 %	75 %	50%	71%	57 %	71 %	57%	4%	7%	4%	7%
5	75%	75 %	100 %	50%	89%	89 %	89 %	78%	14%	14 %	11 %	28%

If we take query 3 in table 5.2, salesforce presents 3 % as an error rate. This rate presents when compared the percentage of human expert (67%) with the percentage of keyword matching (70%) using equation 3.2. The overall error rate using this technique was 17 %.

5.2.2 Semantic Matching (with Synonym only)

Semantic matching technique was used in this experiment to match the query concepts and our ontology concepts. Table 5.3, 5.4 presents part of the results of matching according to this approach. For more detail see table 11, 12 in appendix.

Table 5-3 Semantic Matching (Synonym only).

Que ry	Keyword Matching				Synonym Matching (Synonym only)				Result			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zoh o	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	58 %	58 %	75%	83%	67 %	75 %	92%	75%	63 %	67 %	84%
2	75%	67 %	83 %	67%	83%	75 %	91 %	75%	79%	71 %	87 %	71%
3	70%	50 %	50 %	50%	90%	60 %	60 %	70%	80%	55 %	55 %	60%
4	71%	57 %	71 %	57%	86%	71 %	86 %	71%	79%	64 %	79 %	64%
5	89%	89 %	89 %	78%	100%	100 %	100 %	89%	95%	95 %	95 %	84%

Table 5-4 The Human Experts vs. Semantic Matching (Synonym only).

Que ry	Human Experts				Semantic Matching (Synonym only)				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	67 %	50 %	100%	75%	63 %	67 %	84%	8%	5%	17 %	17%
2	40%	40 %	100 %	40%	79%	71 %	87 %	71%	39%	31 %	13 %	31%
3	67%	33 %	33 %	67%	80%	55 %	55 %	60%	13%	22 %	22 %	7%
4	75%	50 %	75 %	50%	79%	64 %	79 %	64%	3%	14 %	3%	14%
5	75%	75 %	100 %	50%	95%	95 %	95 %	84%	20%	20 %	6%	34%

If we take query 3 in table 5.3 as an example, salesforce presents 80 % as a result of the semantic matching. This result is calculated by sum the number of same string matching (70%) with the number of synonym matching (90%) and divided by 2. Then this query in table 5.4 presents 13% as an error rate. This rate presents when compared the human expert percentage (67%) with the semantic matching (80%) using equation 3.2. The overall error rate using this technique was 16 %.

5.2.3 Semantic Matching (with Instance)

This experiment takes instance into consideration in the semantic matching technique. Table 5.5, 5.6 presents part of the results of matching according to this approach. For more detail see table 13, 14 in appendix.

Table 5-5 Semantic Matching (with Instance).

Query	Keyword Matching				Semantic Matching (Synonym only)				Instance Matching				Result			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	58%	58%	75%	83%	67%	75%	92%	100%	50%	50%	100%	83%	58%	61%	89%
2	75%	67%	83%	67%	83%	75%	91%	75%	0%	0%	100%	0%	53%	47%	91%	47%
3	70%	50%	50%	50%	90%	60%	60%	70%	100%	100%	100%	100%	87%	70%	70%	73%
4	71%	57%	71%	57%	86%	71%	86%	71%	100%	0%	100%	100%	86%	43%	86%	76%
5	89%	89%	89%	78%	100%	100	100	89%	100%	100	100	0%	96%	96%	96%	56%

					%	%			%	%				

Table 5-6 Human Experts vs. Semantic Matching with Instances.

Que ry	Human Experts				Semantic Matching (with Instance)				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	67 %	50 %	100%	83%	58 %	61 %	89%	16%	9%	11 %	11%
2	40%	40 %	100 %	40%	53%	47 %	91 %	47%	13%	7%	9%	7%
3	67%	33 %	33 %	67%	87%	70 %	70 %	73%	20%	37 %	37 %	6%
4	75%	50 %	75 %	50%	86%	43 %	86 %	76%	11%	7%	11 %	26%
5	75%	75 %	100 %	50%	96%	96 %	96 %	56%	21%	21 %	4%	6%

If we take query no 3 in table 5.5 as an example, salesforce presents 87 % as a result of the semantic matching with instance. This result is calculated by sum the number of same string matching (70%) and synonym matching (90%) with the number of instance matching (100 %) and divided by 3. Then this query in table 5.6 presents 20 % as an error rate when compared the human expert percentage (67%) with the semantic matching (83%) using equation 3.2. The overall error rate using this technique was 15 %.

5.2.4 Our Technique

Our technique match query concepts with our ontology concepts depending on all the mentioned techniques, in addition to group concepts matching. As mention earlier, the group concepts of query construct using the two approaches. Table 5.7, 5.8 present part of

the results of matching according to our approach using approach1 in grouping the concepts, table 5.7, 5.8 presents part of the results of matching according to our approach using approach2 in grouping the concepts. For more details see tables 15,16,17, and 18 in appendix.

Table 5-7 Our Technique (Approach1) Matching.

Query	Keyword Matching				Semantic Matching (Synonym only)				Instance Matching				Group Matching (Approach1)				Result			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	58%	58%	75%	83%	67%	75%	92%	100%	50%	50%	100%	17%	17%	17%	28%	67%	48%	50%	74%
2	75%	67%	83%	67%	83%	75%	91%	75%	0%	0%	100%	0%	9%	9%	34%	9%	42%	38%	77%	38%
3	70%	50%	50%	50%	90%	60%	60%	70%	100%	100%	100%	100%	33%	8%	17%	25%	73%	55%	57%	61%
4	71%	57%	71%	57%	86%	71%	86%	71%	100%	0%	100%	100%	33%	56%	33%	22%	73%	46%	73%	63%
5	89%	89%	89%	78%	100%	100%	100%	89%	100%	100%	100%	0%	41%	41%	41%	35%	83%	83%	83%	51%

Table 5-8 Human Experts vs. Our Technique (Approach1) Matching.

Que ry	Human Experts				Our Technique (Approach 1)				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comm ence
1	67%	67 %	50 %	100%	67%	48 %	50 %	74%	0%	19 %	0%	26%
2	40%	40 %	100 %	40%	42%	38 %	77 %	38%	2%	2%	23 %	2%
3	67%	33 %	33 %	67%	73%	55 %	57 %	61%	6%	22 %	24 %	6%
4	75%	50 %	75 %	50%	73%	46 %	73 %	63%	3%	4%	3%	13%
5	75%	75 %	100 %	50%	83%	83 %	83 %	51%	8%	8%	18 %	1%

If we take query no 3 in table 5.7 as an example, salesforce presents 73 % as a result of our technique matching. This result is calculated by sum the number of same string matching (70%), synonym matching (90%), instance matching (100 %) and group concepts matching (33%) divided by 4. Then this query in table 5.8 presents 6 % as an error rate when compared the human expert percentage (67%) with our technique matching (73%) using equation 3.2. The overall error rate using this technique was 13 %.

Table 5-9 Our Technique (Approach2) Matching.

Query	Keyword Matching				Semantic Matching (Synonym only)				Instance Matching				Group Matching (Approach2)				Result			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	58%	58%	75%	83%	67%	75%	92%	100%	50%	50%	100%	30%	30%	30%	50%	70%	51%	53%	79%
2	75%	67%	83%	67%	83%	75%	91%	75%	0%	0%	100%	0%	14%	14%	48%	14%	43%	39%	81%	39%
3	70%	50%	50%	50%	90%	60%	60%	70%	100%	100%	100%	10%	38%	13%	25%	38%	75%	56%	59%	65%
4	71%	57%	71%	57%	86%	71%	86%	71%	100%	0%	100%	100%	20%	60%	20%	20%	69%	47%	69%	62%
5	89%	89%	89%	78%	100%	100%	100%	89%	100%	100%	100%	0%	42%	42%	42%	42%	83%	83%	83%	52%

Table 5-10 Human Experts vs. Our Technique (Approach 2) Matching.

Que ry	Human				Our Technique (Approach 2)				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	67 %	50 %	100%	70%	51 %	53 %	79%	3%	16 %	3%	21%
2	40%	40 %	100 %	40%	43%	39 %	81 %	39%	3%	1%	20 %	1%
3	67%	33 %	33 %	67%	75%	56 %	59 %	65%	8 %	23 %	26 %	3%
4	75%	50 %	75 %	50%	69%	47 %	69 %	62%	6%	3%	6%	12%
5	75%	75 %	100 %	50%	83%	83 %	83 %	52%	8%	8%	17 %	2%

If we take query no 3 in table 5.9 as an example, salesforce presents 75 % as a result of our technique matching. This result is calculated by sum the number of same string matching (70%), synonym matching (90%), instance matching (100 %) and group concepts matching (38%) divided by 4. Then this query in table 5.10 presents 8 % as an error rate when compared the human expert percentage (67%) with our technique matching (75%) using equation 3.2. The overall error rate using this technique was 12 %.

5.3 Analysis of the Results

This section summarizes and analyzes the experiments results conducted in this chapter. The experiments results showed that the error rate was decreases gradually when we using semantic matching then the traditional keyword matching. The experiment from the first approach (Keywords Matching) results in 83 % as success rate. The experiment on the second approach (Semantic Matching- with only Synonym) results in 84 % as success rate. The third approach (Semantic Matching- with Instance) experiment results in 85 % as a success rate. The experiment conducted to our technique results in 87 % as success rate in using approach 1 in grouping the query concepts, and 88 % as success using approach 2 in grouping the query concepts. The results improved when using approach2 in grouping the query concepts because the constructed group in approach2 is fewer than approach 1. Thus, approach2 has less redundant data (unmeaning groups) which is affecting the match between ontology and query group concepts. Table 5.11 presents the enhancement rate using semantic matching technique then the traditional keyword matching technique.

Table 5-11 Enhancement Rates of Using Semantic Matching Techniques Then Keyword Matching Technique.

Approach	Enhancement Rate
Semantic With Only Synonyms	6 %
Semantic With Instances	11 %
Our Technique (Approach1)	24 %
Our Technique (Approach2)	30 %

The results prove that our technique achieved the highest success rate and enhance the matching results by 30 % when using approach 2 in grouping concepts than the traditional

keyword matching. We attribute this enhancement rate to the usage of our ontology which

is based on instances and the group concepts in addition to the synonym.

6 CHAPTER SIX: CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

6.1 Preface

This chapter includes recommendations and future works besides conclusion of the thesis. Conclusion of thesis is based on practical results of experiments conducted in order to check and analyze the system efficiency. Future works aim to indicate how can exploit this thesis to construct new idea and resolve new problems.

6.2 Conclusion

From this thesis, it can be concluded that in constructing a cloud CRM ontology, OntoGen tool was used for extracting concepts and relationships of cloud CRM ontology. In addition, wup was also used in construct of the ontology relationship. The proposed ontology for cloud CRM consists of two parts:

- Integrated Ontology which represents the upper part for Cloud CRM ontology. Also, it contains all common single concepts which were extracted previously from the studied providers and the synonym relationships.

- Provider Ontology which represents the lower part of Cloud CRM ontology and it includes the own set of single concepts to the provider. It also includes: the general relationships between the single concepts which were represented as group of pair concepts and the Instance relationships.

Also, it can be concluded that attaining customer requirements and needs can be done using CPDS, where through this system; it is possible to match the cloud customer

requirements with cloud CRM provider services. The system does this through analyzing cloud customer query semantically and calculates its similarity with cloud providers using an accumulative process.

Many approaches were used for making this matching and they are summarized below with their success and error rate:

1. The first approach is traditional Keyword Matching which has 83% success and 17% error rate.

2. The second approach is Semantic Matching with Synonym only, which has 84% success and 16% error rate.

3. The third approach is Semantic Matching with Synonym and Instance which has 85% success and 15 % error rate.

4. Our approach experiments resulted in 88 % success rate in contrast of 12 % error rate.

6.3 Recommendation for Future Work

The cloud computing, ontology and semantic matching are considered as a hot and new topic, which still have many areas that future research can investigate more and concentrate on, the direction for future research points can be summarized by the following idea:

1. Develop a complete ontology in the domain of Cloud CRM and its benefits to construct its concepts from more than pair group of concepts and create detailed and complete ontology relationship.

2. Develop the discovery system for cloud providers in the domain of Cloud CRM and in other domains. This system can work as help administrative to aid users in looking for cloud provider. The users in this system search only by using words and the guide system with appropriate cloud providers.

3. Possibility to use our methodology to construct other domains ontologies.

4. Constructing "IT ontology" that contains IT terms and concepts. This ontology works as a guide for users who are searching about IT concepts.

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APPENDIX

Table 1: The extracted single concepts for salesforce using KAON tool.

Concept	Concept	Concept	Concept
Access	Function	Level	Page
Account	Go	Line	Partner
Adopt	Group	List	People
Align	Help	Mail	Perform
Appexchang	Inform	Make	Plan
Approach	Island	Manage	Platform
Assign	Layout	Market	Point
Build	Lead	Mean	Portal
Builder	Team	Metric	Process
Campaign	Territory	Mini	Product
Click	Time	Page	Profile
Code	Top	Mobile	Project
Competitor	Track	Model	Level
Contact	Train	Need	Search
Content	Type	Number	Secure
Contract	User	Object	Quote
Control	View	Opportunity	Real
Custom	Visual	Order	Record
Dashboard	Web	Organ	Report
Data	Website	Sale	Role
Deal	Work	Standard	See
Demand	Workflow	Start	Service
Detail	Support	Statue	Set
Email	System	Step	Share
Field	Success	Source	Side
Force.com	Form	Site	Business

Table 2: The relationships resulted from KAON tool.

Concept1	Concept2	Freq.
function	access	28
data	inform	19
report	salesforc	34
custom	type	14
custom	servic	15
lead	servic	15
servic	salesforc	34
data	track	18
forc	access	28
view	salesforc	34
work	exampl	17
user	time	15
manag	custom	41
click	custom	41
train	user	35
busi	control	11
field	level	7
enterpris	cloud	9
opportun	level	7
contract	report	33
report	contact	12
process	sale	24
busi	dashboard	13
data	campaign	12
time	access	28
lead	campaign	12
work	data	34
report	territori	18
step	busi	26
access	field	32
function	level	7
email	field	32
search	layout	12
team	crm	17
record	opportun	20
workflow	type	14
user	view	12
app	page	21
contact	opportun	20
busi	account	22
web	user	35

opportun	report	33
account	opportun	20
appexchang	process	13
busi	com	11
report	user	35
dashboard	summari	9
busi	servic	15
metric	data	34
com	app	23
campaign	sale	24
opportun	contract	8
wai	web	12
report	time	15
page	control	11
salesforc	team	15
applic	work	14
opportun	process	13
wai	field	32
custom	field	32
account	manag	16
organ	sale	24
inform	custom	41
contact	email	12
exampl	sale	24
train	inform	19
team	lead	29
mini	layout	12
campaign	track	18
crm	app	23
type	lead	29
custom	access	28
train	salesforc	34

Table 3: Salesforce concepts resulted from OntoGen tool.

Concept	Concept	Concept	Concept
data,	fields,	details,	users_access
customer,	customer,	requires,	security,
salesforce,	approach,	fields_level	level, fields_level,
fields,	customer_fields	campaigns,	fields,
users,	functionality,	leads,	level_security,
pages,	developer,	opportunity,	fields_level_security
mobile,	create,	level,	fields,
report,	cases,	data,	territories
leads,	force,	returns	layouts,
app	customer,	security,	security,
create,	clicks,	set,	level,
edition,	code,	level,	fields_level,
work,	point	fields_level,	fields,
time, real,	layouts,	users,	level_security,
real_time,	users,	fields,	fields_level_security
presentations,	customer,	level_security,	list,
demand,	ll,	fields_level_security	trained,
documents,	entered	fields,	security,
collaboration	process,	list,	information,
presentations	businesses,	record,	level,
demand	organization,	access,	fields_level,
customer,	customer,	set,	fields, level_security,
salesforce,	meet	type,	fields_level_security
button,	fields,	related,	fields,
details,	pages,	related_list,	profile
display,	edition,	associates,	people,
pages,	users,	fields_access	salesforce,
clicks,	edition_pages,	access,	executive,
benefit,	security,	fields,	videos
successful	level,	users,	sales,
list,	tips	based, create, campaigns	process,
display,	mobile,	app, objects,	businesses,

		appexchange	
entered,	include,	information, resources	organization,
specific,	started,	app, integration	tasks,
competitor,	resources	type, shows, chart, orders	active,
names	access,	workflow,	cloud,
users,	set,	administrators,	businesses_process,
dashboard,	model,	production_service	approval,
metrics	data,	make_easy	effort
access,	objects,	results,	quotes
information,	share	manager, territories, share, rule	leads,
users,	report,	data, important, steps	team,
users_access	sales, leads	dashboard, builds	started,
list,	shows,	viewed, mini, tab	dashboard
devices	criteria	salespeople, direct	sales,
data,	results,	mail,	team,
users,	data,	merged,	support
shows,	changing	mail_merged	trained, online

Table 4: Salesforce Human Judgment

No.	Scenario	Customer Requirements	Provider services	Human Percentage
1	managing sales chance and lead for industrial company in Canada with multiple language and world clock application contain	management sales chance	management sales lead	67% (6/4)
		management sales lead	serve industrial company	
		serve industrial company	support Canada	
		support Canada	multiple language	
		multiple language		
		contain world-clock		
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales forecasting and quoting	GoToMeeting application integration	support sale forecast	40 %
		online meeting	support sale quoting	
		shipping industry		
		support sale forecast		
		support sale quoting		
3	Mobile entrance with boundless custom field and online training for CRM users places in Australia	mobile entrance	mobile entrance	75 %
		boundless custom field	online training	
		online training	places in Australia	
		places in Australia		

4	contact and inventory management and able to follow the competitor for communication industry	contact management inventory management follow competitor serve communication industry	contact management follow competitor serve communication industry	75 %
5	follow business account and can automate marketing and mange product of the companies in middle east countries	follow account marketing automation product management serve middle-east	follow account marketing automation serve middle-east	75 %
6	contacts management and view location in google map and analyze sales and report for large business size	contact management google map integration sale analyze report analyze serve large business size	contact management report analyze serve large business size	60 %
7	Territory and Workflow Management and can be join with twitter in Thai language	territory management workflow management twitter integration support Thai language	territory management workflow management twitter integration support Thai language	100 %
8	send mass mails , integration with yahoo mail and facebook and report analytic in Petroleum domain	send mass mail yahoo mail integration facebook integration report analyze serve Petroleum domain	send mass mail yahoo mail integration facebook integration report analyze	80 %
9	knowledgebase and FAQ integration with social network and real time sale forecasting in Africa countries	knowledgebase integration with social network FAQ integration with social network social network integration real time sale forecasting serve Africa countries	knowledgebase integration with social network social network integration real time sale forecasting serve Africa countries	80 %
10	deals and marketing campaign management , has role based and field level security and database daily backup	deals management marketing campaign management role based security field level security daily database backup	deals management marketing campaign management field level security	60 %
11	support many language and currency and is possible to integrated with third party application for accounting company in Netherland	support many language support many currency third- party application integration serve accounting company serve Netherland	support many language support many currency third- party application integration	60 %

		country		
12	custom work report , has a project supervision system and can entrance from iphone and ipad device for schooling institution	report customize	report customize	80 %
		project supervision	iphone access	
		iphone access	ipad access	
		ipad access	serve schooling institution	
		serve schooling institution		
13	catch lead from web and notify its owner and CRM system email can customize and auto respond in Korean speech for retail company	catch lead from web	catch lead from web	83 %
		notify lead owner	customize CRM mail	
		customize CRM email	Auto-respond CRM mail	
		Auto-respond CRM email	Korean language	
		Korean language	serve retail company	
		serve retail company		
14	mobile can access the system, sustain oracle database with document and supply chain management in Finland	mobile access	mobile access	60 %
		sustain oracle database	sustain oracle database	
		document management	serve Finland	
		supply chain management		
		serve Finland		
15	chronicle and follow work action , chatter and marketing analyze services and for media solution in German language	chronicle of action	follow action	67 %
		follow action	chatter service	
		chatter service	serve media solution	
		marketing analyze service	German language	
		serve media solution		
		German language		
16	governance institution , accounts management and register history with role control , and with sandbox and database backup	serve government institution	serve governance institution	67 %
		account management	account management	
		account history	sandbox services	
		role control	database backup services	
		sandbox services		
		database backup services		
17	Mange approvals records and project portfolio, contact able to offline entrance the system and integration with linkedln and quick-box	manage approval	manage approval	80 %
		project portfolio management	offline entrance	
		offline entrance	linkedln integration	
		linkedln integration	quick-box integration	
		quick-box integration		
18	import contact and data from disparate systems, application custom for technology field in the Chinese language	import contact	custom application	40 %
		import data	Chinese language	
		custom application		
		technology field		

		Chinese language		
	lead management and qualify it by rating and scoring system and combine outlook with CRM system with video record call all in Hebrew language	lead management	lead management	33 %
		lead rating	combine outlook	
		lead scoring		
		combine outlook		
		video record call		
19		Hebrew language		
	send promotion SMS, have thought system that's allows to post, vote and remark to new thought for machinery industry in Japanese and Korean speech	send SMS	send SMS	100 %
		post new thought	post new thought	
		vote to the thought	vote to the thought	
		remark to the thought	remark to the thought	
		machinery industry	machinery industry	
		Japanese speech	Japanese speech	
20		Korean speech	Korean speech	

Table 5: Zoho Human Percentage

No.	Scenario	Customer Requirements	Provider services	Human Percentage
1	managing sales chance and lead for industrial company in Canada with multiple language and world clock application contain	management sales chance	management sales lead	67%
		management sales lead	serve industrial company	
		serve industrial company	support Canada	
		support Canada	multiple language	
		multiple language		
		contain world-clock		
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales forecasting and quoting	GoToMeeting application integration	support sale forecast	40%
		online meeting	support sale quoting	
		shipping industry		
		support sale forecast		
		support sale quoting		
3	Mobile entrance with boundless custom field and online training for CRM users places in Australia	mobile entrance	mobile entrance	50%
		boundless custom field	places in Australia	
		online training		
		places in Australia		
4	contact and inventory management and able to follow the competitor for communication industry	contact management	contact management	50%
		inventory management	inventory management	
		follow competitor		
		serve communication industry		
5	follow business account and can automate marketing and mange product of the companies in middle east countries	follow account	follow account	75%
		marketing automation	marketing automation	
		product management	serve middle-east	
		serve middle-east		
6	contacts management and view	contact management	contact management	80%

	location in Google map and analyze sales and report for large business size	Google map integration	Google map integration	
		sale analyze	report analyze	
		report analyze	serve large business size	
		serve large business size		
7	Territory and Workflow Management and can be join with twitter in Thai language	territory management	workflow management	50%
		workflow management	twitter integration	
		twitter integration		
		support Thai language		
8	send mass mails , integration with yahoo mail and facebook and report analytic in Petroleum domain	send mass mail	send mass mail	80%
		yahoo mail integration	yahoo mail integration	
		facebook integration	facebook integration	
		report analyze	report analyze	
		serve Petroleum domain		
9	knowledgebase and FAQ integration with social network and real time sale forecasting in Africa countries	knowledgebase integration with social network	knowledgebase integration with social network	60%
		FAQ integration with social network	social network integration	
		social network integration	serve Africa countries	
		real time sale forecasting		
		serve Africa countries		
10	deals and marketing campaign management , has role based and field level security and database daily backup	deals management	deals management	80%
		marketing campaign management	marketing campaign management	
		role based security	role based security	
		field level security	field level security	
		daily database backup		
11	support many language and currency and is possible to integrated with third party application for accounting company in Netherland	support many language	support many language	80%
		support many currency	support many currency	
		third- party application integration	third- party application integration	
		serve accounting company	serve Netherland country	
		serve Netherland country		
12	custom work report , has a project supervision system and can entrance from iphone and ipad device for schooling institution	report customize	report customize	60%
		project supervision	iphone access	
		iphone access	ipad access	
		ipad access		
		serve schooling institution		
13	catch lead from web and notify its owner and CRM system email can customize and auto	catch lead from web	catch lead from web	67%
		notify lead owner	alert lead owner	
		customize CRM email	Auto-respond CRM	

	respond in Korean speech for retail company	mail		
		Auto-respond CRM email	Korean language	
		Korean language		
		serve retail company		
14	mobile can access the system, sustain oracle database with document and supply chain management in Finland	mobile access	mobile access	40%
		sustain oracle database	serve Finland	
		document management		
		supply chain management		
		serve Finland		
15	chronicle and follow work action , chatter and marketing analyze services and for media solution in German language	chronicle of action	chatter service	33%
		follow action	German language	
		chatter service		
		marketing analyze service		
		serve media solution		
		German language		
16	governance institution , accounts management and register history with role control , and with sandbox and database backup	serve government institution	account management	50%
		account management	role control	
		account history	database backup services	
		role control		
		sandbox services		
		database backup services		
17	Mange approvals records and project portfolio, contact able to offline entrance the system and integration with linkedln and quick-box	manage approval	offline entrance	60%
		project portfolio management	linkedln integration	
		offline entrance	quick-box integration	
		linkedln integration		
		quick-box integration		
18	import contact and data from disparate systems, application custom for technology field in the Chinese language	import contact	custom application	40%
		import data	Chinese language	
		custom application		
		technology field		
		Chinese language		
19	lead management and qualify it by rating and scoring system and combine outlook with CRM system with video record call all in Hebrew language	lead management	lead management	67%
		lead rating	lead scoring	
		lead scoring	combine outlook	
		combine outlook	Hebrew language	
		video record call		
		Hebrew language		
20	send promotion SMS, have thought system that's allows to post, vote and remark to new thought for machinery industry	send SMS	Japanese speech	29%
		post new thought	Korean speech	
		vote to the thought		
		remark to the thought		

	in Japanese and Korean speech	machinery industry		
		Japanese speech		
		Korean speech		

Table 6: Sugar Human Percentage

No.	Scenario	Customer Requirements	Provider services	Human Percentage
1	managing sales chance and lead for industrial company in Canada with multiple language and world clock application contain	management sales chance	management sales lead	33%
		management sales lead	serve industrial company	
		serve industrial company		
		support Canada		
		multiple language		
		contain world-clock		
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales forecasting and quoting	GoToMeeting application integration	GoToMeeting application integration	100%
		online meeting	online meeting	
		shipping industry	shipping industry	
		support sale forecast	support sale forecast	
		support sale quoting	support sale quoting	
3	Mobile entrance with boundless custom field and online training for CRM users places in Australia	mobile entrance	mobile entrance	50%
		boundless custom field	places in Australia	
		online training		
		places in Australia		
4	contact and inventory management and able to follow the competitor for communication industry	contact management	contact management	75%
		inventory management	follow competitor	
		follow competitor	serve communication industry	
		serve communication industry		
5	follow business account and can automate marketing and mange product of the companies in middle east countries	follow account	follow account	100%
		marketing automation	marketing automation	
		product management	product management	
		serve middle-east	serve middle-east	
6	contacts management and view location in Google map and analyze sales and report for large business size	contact management	contact management	20%
		Google map integration		
		sale analyze		
		report analyze		
		serve large business size		
7	Territory and Workflow Management and can be join with twitter in Thai language	territory management	territory management	75%
		workflow management	workflow management	
		twitter integration	twitter integration	
		support Thai language		

8	send mass mails , integration with yahoo mail and facebook and report analytic in Petroleum domain	send mass mail	send mass mail	60%
		yahoo mail integration	yahoo mail integration	
		facebook integration	facebook integration	
		report analyze		
		serve Petroleum domain		
9	knowledgebase and FAQ integration with social network and real time sale forecasting in Africa countries	knowledgebase integration with social network	knowledgebase integration with social network	60%
		FAQ integration with social network	social network integration	
		social network integration	serve Africa countries	
		real time sale forecasting		
		serve Africa countries		
10	deals and marketing campaign management , has role based and field level security and database daily backup	deals management	deals management	60%
		marketing campaign management	role based security	
		role based security	daily database backup	
		field level security		
		daily database backup		
11	support many language and currency and is possible to integrated with third party application for accounting company in Netherland	support many language	support many language	60%
		support many currency	support many currency	
		third- party application integration	third- party application integration	
		serve accounting company		
		serve Netherland country		
12	custom work report , has a project supervision system and can entrance from iphone and ipad device for schooling institution	report customize	report customize	100%
		project supervision	project supervision	
		iphone access	iphone access	
		ipad access	ipad access	
		serve schooling institution	serve schooling institution	
13	catch lead from web and notify its owner and CRM system email can customize and auto respond in Korean speech for retail company	catch lead from web	catch lead from web	50%
		notify lead owner	Auto-respond CRM mail	
		customize CRM email	serve retail company	
		Auto-respond CRM email		
		Korean language		
		serve retail company		
14	mobile can access the system, sustain oracle database with document and supply chain management in Finland	mobile access	mobile access	60%
		sustain oracle database	sustain oracle database	
		document management	document management	
		supply chain management		
		serve Finland		

15	chronicle and follow work action , chatter and marketing analyze services and for media solution in German language	chronicle of action	chronicle of action	83%
		follow action	follow action	
		chatter service	chatter service	
		marketing analyze service	serve media solution	
		serve media solution	German language	
		German language		
16	governance institution , accounts management and register history with role control , and with sandbox and database backup	serve government institution	serve government institution	83%
		account management	account management	
		account history	role control	
		role control	sandbox services	
		sandbox services	database backup services	
		database backup services		
17	Mange approvals records and project portfolio, contact able to offline entrance the system and integration with linkedln and quick-box	manage approval	offline entrance	40%
		project portfolio management	linkedln integration	
		offline entrance		
		linkedln integration		
		quick-box integration		
18	import contact and data from disparate systems, application custom for technology field in the Chinese language	import contact	import contact	60%
		import data	import data	
		custom application	Chinese language	
		technology field		
		Chinese language		
19	lead management and qualify it by rating and scoring system and combine outlook with CRM system with video record call all in Hebrew language	lead management	lead management	67%
		lead rating	lead scoring	
		lead scoring	combine outlook	
		combine outlook	Hebrew language	
		video record call		
		Hebrew language		
20	send promotion SMS, have thought system that's allows to post, vote and remark to new thought for machinery industry in Japanese and Korean speech	send SMS	send SMS	43%
		post new thought	machinery industry	
		vote to the thought	Japanese speech	
		remark to the thought		
		machinery industry		
		Japanese speech		
		Korean speech		

Table 7: Commence Provider Percentage

No.	Scenario	Customer Requirements	Provider services	Human Percentage
1	managing sales chance and lead for industrial company in Canada with multiple language and world clock application contain	management sales chance	management sales chance	100%
		management sales lead	management sales lead	
		serve industrial company	serve industrial company	
		support Canada	support Canada	
		multiple language	multiple language	
		contain world-clock	contain world-clock	
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales forecasting and quoting	GoToMeeting application integration	support sale forecast	40%
		online meeting	support sale quoting	
		shipping industry		
		support sale forecast		
		support sale quoting		
3	Mobile entrance with boundless custom field and online training for CRM users places in Australia	mobile entrance	mobile entrance	75%
		boundless custom field	boundless custom field	
		online training	places in Australia	
		places in Australia		
4	contact and inventory management and able to follow the competitor for communication industry	contact management	contact management	50%
		inventory management	serve communication industry	
		follow competitor		
		serve communication industry		
5	follow business account and can automate marketing and mange product of the companies in middle east countries	follow account	follow account	50%
		marketing automation	marketing automation	
		product management		
		serve middle-east		
6	contacts management and view location in Google map and analyze sales and report for large business size	contact management	contact management	40%
		Google map integration	sale analyze	
		sale analyze		
		report analyze		
		serve large business size		
7	Territory and Workflow Management and can be join with twitter in Thai language		twitter integration	25%
		territory management		
		workflow management		
		twitter integration		
		support Thai language		
8	send mass mails , integration with yahoo mail and facebook and report analytic in Petroleum domain	send mass mail	send mass mail	80%
		yahoo mail integration	yahoo mail integration	
		facebook integration	facebook integration	
			serve Petroleum domain	
		report analyze		
		serve Petroleum domain		
9	knowledgebase and FAQ integration with social network and real time sale forecasting in Africa countries	knowledgebase integration with social network	knowledgebase integration with social network	60%
		FAQ integration with	FAQ integration with	

		social network	social network	
		social network integration	social network integration	
		real time sale forecasting		
		serve Africa countries		
10	deals and marketing campaign management , has role based and field level security and database daily backup	deals management	marketing campaign management	40%
		marketing campaign management	role based security	
		role based security		
		field level security		
		daily database backup		
11	support many language and currency and is possible to integrated with third party application for accounting company in Netherland	support many language	support many language	80%
		support many currency	support many currency	
		third- party application integration	serve accounting company	
		serve accounting company	serve Netherland country	
		serve Netherland country		
12	custom work report , has a project supervision system and can entrance from iphone and ipad device for schooling institution	report customize	report customize	100%
		project supervision	project supervision	
		iphone access	iphone access	
		ipad access	ipad access	
		serve schooling institution	serve schooling institution	
13	catch lead from web and notify its owner and CRM system email can customize and auto respond in Korean speech for retail company	catch lead from web	catch lead from web	17%
		notify lead owner		
		customize CRM email		
		Auto-respond CRM email		
		Korean language		
		serve retail company		
14	mobile can access the system, sustain oracle database with document and supply chain management in Finland	mobile access	mobile access	40%
		sustain oracle database	serve Finland	
		document management		
		supply chain management		
		serve Finland		
15	chronicle and follow work action , chatter and marketing analyze services and for media solution in German language	chronicle of action	follow action	67%
		follow action	chatter service	
		chatter service	marketing analyze service	
		marketing analyze service	serve media solution	
		serve media solution		
		German language		
16	governance institution , accounts management and register history with role control , and with sandbox and database backup	serve government institution	serve government institution	50%
		account management	account management	
		account history	account history	

		role control		
		sandbox services		
		database backup services		
17	Mange approvals records and project portfolio, contact able to offline entrance the system and integration with linkedln and quick-box	manage approval	offline entrance	60%
		project portfolio management	linkedln integration	
		offline entrance	quick-box integration	
		linkedln integration		
		quick-box integration		
18	import contact and data from disparate systems, application custom for technology field in the Chinese language	import contact	technology field	20%
		import data		
		custom application		
		technology field		
		Chinese language		
19	lead management and qualify it by rating and scoring system and combine outlook with CRM system with video record call all in Hebrew language	lead management	lead management	50%
		lead rating	lead rating	
		lead scoring	combine outlook	
		combine outlook		
		video record call		
		Hebrew language		
20	send promotion SMS, have thought system that's allows to post, vote and remark to new thought for machinery industry in Japanese and Korean speech	send SMS	machinery industry	14%
		post new thought		
		vote to the thought		
		remark to the thought		
		machinery industry		
		Japanese speech		
		Korean speech		

Table 8: Error of Salesforce Extracted Concepts Using KAON tool.

No.	Query Scenario	Human Percentage	Single Concept	Group Concept	Result	Error
1	Managing sales chance and lead for industrial company in Canada with multiple language and world clock application integration	67%	42%	20%	31%	36%
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales foresting and quoting	40%	33%	3%	18%	22%
3	Mobile entrance to the system with boundless custom field and online training for CRM user places in Australia	67%	50%	28%	39%	28%

4	Contact and inventory management and able to follow the competitor for communication industry	75%	43%	11%	27%	48%
5	Follow business account and can automate marketing and mange product in the middle east countries	75%	56%	11%	34%	41%
6	Contacts management and view location in Google map and analyze sales and report for large business size	60%	55%	10%	33%	27%
7	Territory and workflow Management and can be join with twitter in Thai language	100%	43%	14%	29%	71%
8	Send bulk mails , integration with yahoo mail and facebook and report analytic in Petroleum domain	80%	20%	13%	17%	63%
9	Knowledgebase and FAQ integration with social network and real time sale forecasting in Africa countries	80%	20%	0%	10%	70%
10	Deals and marketing campaign management , has role based and field level security and database daily backup	60%	67%	10%	39%	21%
11	Support many language and currency and is possible to integrate with third party application for accounting company in Netherland	60%	27%	6%	17%	43%
12	Custom work report , has a project supervision system and can entrance from iphone and ipad device for schooling institution	80%	45%	11%	56%	24%
13	Catch lead from web and alert its owner and CRM system mail can customize and auto respond in Korean speech for retail company	83%	33%	10%	22%	61%
14	Mobile can access the system, sustain oracle database with document and supply chain management in Finland	60%	30%	0%	15%	45%
15	Chronicle and follow work action , chatter and marketing analyze services and for media solution in German language	67%	25%	0%	13%	54%
16	Governance institution , accounts management and history with role control , sandbox and database backup services	67%	45%	11%	28%	39%
17	Mange approvals records and project portfolio, contact able to offline entrance the system and integration with linkedln and quick-box	80%	45%	12%	28%	52%
18	Import contact and data from disparate systems, application custom for technology field in the Chinese language	40%	50%	29%	40%	0%
19	Lead management and qualify it by rating and scoring system	33%	25%	3%	14%	19%

	and combine outlook with CRM system with video record call all in Hebrew language					
20	Send promotion SMS, have thought system that's allows to post, vote and remark to new thought for machinery industry in Japanese and Korean speech	100%	0%	0%	0%	100%

Table 9: Error of Salesforce Extracted Concepts Using OntoGen tool.

No.	Query Scenario	Human Percentage	Single Concept	Group Concept	Result	Error
1	Managing sales chance and lead for industrial company in Canada with multiple language and world clock application integration	67%	58%	10%	34%	33%
2	GoToMeeting application integration for online business meeting in shipping industry and sustain sales foresting and quoting	40%	67%	3%	35%	5%
3	Mobile entrance to the system with boundless custom field and online training for CRM user places in Australia	67%	60%	18%	39%	28%
4	Contact and inventory management and able to follow the competitor for communication industry	75%	71%	0%	36%	39%
5	Follow business account and can automate marketing and mange product in the middle east countries	75%	78%	6%	42%	33%
6	Contacts management and view location in Google map and analyze sales and report for large business size	60%	83%	3%	43%	17%
7	Territory and workflow Management and can be join with twitter in Thai language	100%	57%	14%	36%	64%
8	Send bulk mails , integration with yahoo mail and facebook and report analytic in Petroleum domain	80%	40%	7%	24%	56%
9	Knowledgebase and FAQ integration with social network and real time sale forecasting in Africa countries	80%	70%	0%	35%	45%
10	Deals and marketing campaign management , has role based and field level security and database daily backup	60%	67%	10%	39%	21%
11	Support many language and currency and is possible to integrate with third party application for accounting company in	60%	45%	6%	51%	9%

	Netherland					
12	Custom work report , has a project supervision system and can entrance from iphone and ipad device for schooling institution	80%	36%	0%	18%	62%
13	Catch lead from web and alert its owner and CRM system mail can customize and auto respond in Korean speech for retail company	83%	42%	3%	23%	60%
14	Mobile can access the system, sustain oracle database with document and supply chain management in Finland	60%	50%	11%	31%	29%
15	Chronicle and follow work action , chatter and marketing analyze services and for media solution in German language	67%	50%	0%	25%	42%
16	Governance institution , accounts management and history with role control , sandbox and database backup services	67%	55%	0%	28%	39%
17	Mange approvals records and project portfolio, contact able to offline entrance the system and integration with linkedln and quick-box	80%	82%	4%	43%	37%
18	Import contact and data from disparate systems, application custom for technology field in the Chinese language	40%	60%	7%	34%	6%
19	Lead management and qualify it by rating and scoring system and combine outlook with CRM system with video record call all in Hebrew language	33%	58%	0%	29%	4%
20	Send promotion SMS, have thought system that's allows to post, vote and remark to new thought for machinery industry in Japanese and Korean speech	100%	38%	0%	19%	81%

Table 10: Keyword vs. Human

Query	Human				Keyword Matching				Error			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	67%	50%	100%	67%	58%	58%	75%	0%	9%	8%	25%
2	40%	40%	100%	40%	75%	67%	83%	67%	35%	27%	17%	27%

3	67%	33%	33%	67%	70%	50%	50%	50%	3%	17%	17%	17%
4	75%	50%	75%	50%	71%	57%	71%	57%	4%	7%	4%	7%
5	75%	75%	100%	50%	89%	89%	89%	78%	14%	14%	11%	28%
6	60%	80%	20%	40%	83%	92%	75%	67%	23%	12%	55%	27%
7	100%	50%	75%	25%	86%	57%	71%	57%	14%	7%	4%	32%
8	80%	80%	60%	80%	70%	70%	60%	80%	10%	10%	0%	0%
9	80%	60%	60%	60%	80%	70%	70%	80%	0%	10%	10%	20%
10	60%	80%	60%	60%	75%	75%	75%	67%	15%	5%	15%	7%
11	60%	80%	60%	80%	64%	64%	64%	73%	4%	16%	4%	7%
12	80%	60%	100%	100%	64%	45%	55%	55%	16%	15%	45%	45%
13	83%	67%	50%	17%	58%	58%	50%	42%	25%	9%	0%	25%
14	60%	40%	60%	40%	70%	60%	60%	60%	10%	20%	0%	20%
15	67%	33%	67%	83%	33%	25%	25%	25%	34%	8%	42%	58%
16	67%	50%	83%	50%	55%	55%	73%	45%	12%	5%	10%	5%
17	80%	60%	40%	60%	91%	73%	73%	82%	11%	13%	33%	22%
18	40%	40%	60%	20%	70%	80%	80%	80%	30%	40%	20%	60%
19	33%	67%	67%	50%	58%	75%	67%	67%	25%	8%	0%	17%

| 20 | 100% | 29% | 43% | 14% | 54% | 23% | 23% | 15% | 46% | 6% | 20% | 1% |

Table 11: Semantic Matching (synonym only)

Query	Keyword Matching				Synonym Matching (Synonym only)				Result			
	Salesforce	Zoho	Sugar	Commerce	Salesforce	Zoho	Sugar	Commerce	Salesforce	Zoho	Sugar	Commerce
1	67%	58%	58%	75%	83%	67%	75%	92%	75%	63%	67%	84%
2	75%	67%	83%	67%	83%	75%	91%	75%	79%	71%	87%	71%
3	70%	50%	50%	50%	90%	60%	60%	70%	80%	55%	55%	60%
4	71%	57%	71%	57%	86%	71%	86%	71%	79%	64%	79%	64%
5	89%	89%	89%	78%	100%	100%	100%	89%	95%	95%	95%	84%
6	83%	92%	75%	67%	83%	92%	75%	67%	83%	92%	75%	67%
7	86%	57%	71%	57%	100%	71%	86%	71%	93%	64%	79%	64%
8	70%	70%	60%	80%	90%	90%	80%	100%	80%	80%	70%	90%
9	80%	70%	70%	80%	80%	70%	70%	80%	80%	70%	70%	80%
10	75%	75%	75%	67%	83%	83%	83%	75%	79%	79%	79%	71%
11	64%	64%	64%	73%	73%	73%	73%	82%	69%	69%	69%	78%
12	64%	45%	55%	55%	91%	64%	82%	82%	78%	55%	69%	69%

Query	Human Expert				Semantic Matching				Error			
	Salesforce	Zoho	Sugar	Commerce	Salesforce	Zoho	Sugar	Commerce	Salesforce	Zoho	Sugar	Commerce
13	58%	58%	50%	42%	83%	83%	75%	67%	71%	71%	63%	55%
14	70%	60%	60%	60%	80%	70%	70%	70%	75%	65%	65%	65%
15	33%	25%	25%	25%	67%	58%	67%	67%	50%	42%	46%	46%
16	55%	55%	73%	45%	64%	55%	82%	55%	60%	55%	78%	50%
17	91%	73%	73%	82%	91%	73%	73%	82%	91%	73%	73%	82%
18	70%	80%	80%	80%	70%	80%	80%	80%	70%	80%	80%	80%
19	58%	75%	67%	67%	67%	83%	75%	75%	63%	79%	71%	71%
20	54%	23%	23%	15%	92%	38%	46%	38%	73%	31%	35%	27%

Table 12: The Human Experts vs. Semantic Matching (Synonym only).

Query	Human Expert				Semantic Matching (Synonym only)				Error			
	Salesforce	Zoho	Sugar	Commerce	Salesforce	Zoho	Sugar	Commerce	Salesforce	Zoho	Sugar	Commerce
1	67%	67%	50%	100%	75%	63%	67%	84%	8%	5%	17%	17%
2	40%	40%	100%	40%	79%	71%	87%	71%	39%	31%	13%	31%
3	67%	33%	33%	67%	80%	55%	55%	60%	13%	22%	22%	7%
4	75%	50%	75%	50%	79%	64%	79%	64%	3%	14%	3%	14%
5	75%	75%	100%	50%	95%	95%	95%	84%	20%	20%	6%	34%

6	60%	80%	20%	40%	83%	92%	75%	67%	23%	12%	55%	27%
7	100%	50%	75%	25%	93%	64%	79%	64%	7%	14%	3%	39%
8	80%	80%	60%	80%	80%	80%	70%	90%	0%	0%	10%	10%
9	80%	60%	60%	60%	80%	70%	70%	80%	0%	10%	10%	20%
10	60%	80%	60%	60%	79%	79%	79%	71%	19%	1%	19%	11%
11	60%	80%	60%	80%	69%	69%	69%	78%	9%	12%	9%	3%
12	80%	60%	100%	100%	78%	55%	69%	69%	3%	5%	32%	32%
13	83%	67%	50%	17%	71%	71%	63%	55%	13%	3%	13%	38%
14	60%	40%	60%	40%	75%	65%	65%	65%	15%	25%	5%	25%
15	67%	33%	67%	83%	50%	42%	46%	46%	17%	9%	21%	37%
16	67%	50%	83%	50%	60%	55%	78%	50%	8%	5%	6%	0%
17	80%	60%	40%	60%	91%	73%	73%	82%	11%	13%	33%	22%
18	40%	40%	60%	20%	70%	80%	80%	80%	30%	40%	20%	60%
19	33%	67%	67%	50%	63%	79%	71%	71%	30%	12%	4%	21%
20	100%	29%	43%	14%	73%	31%	35%	27%	27%	2%	9%	13%

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Table 13: Semantic match with instance

Query	Keyword Matching				Semantic Matching (Synonym only)				Instance Matching				Result			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	58%	58%	75%	83%	67%	75%	92%	100%	50%	50%	100%	83%	58%	61%	89%
2	75%	67%	83%	67%	83%	75%	91%	75%	0%	100%	100%	0%	53%	47%	91%	47%
3	70%	50%	50%	50%	90%	60%	60%	70%	100%	100%	100%	100%	87%	70%	70%	73%
4	71%	57%	71%	57%	86%	71%	86%	71%	100%	0%	100%	100%	86%	43%	86%	76%
5	89%	89%	89%	78%	100%	100%	100%	89%	100%	100%	100%	0%	96%	96%	96%	56%
6	83%	92%	75%	67%	83%	92%	75%	67%	100%	100%	0%	0%	89%	95%	50%	45%
7	86%	57%	71%	57%	100%	71%	86%	71%	100%	50%	50%	50%	95%	59%	69%	59%
8	70%	70%	60%	80%	90%	90%	80%	100%	67%	67%	67%	100%	76%	76%	69%	93%
9	80%	70%	70%	80%	80%	70%	70%	80%	100%	100%	100%	0%	87%	80%	80%	53%
10	75%	75%	75%	67%	83%	83%	83%	75%	0%	0%	100%	0%	53%	53%	86%	47%
11	64%	64%	64%	73%	73%	73%	73%	82%	0%	50%	0%	100%	46%	62%	46%	85%
12	64%	45	55	55%	91%	64	82	82%	100	67	10	100	85%	59	79	79%

		%	%			%	%		%	%	0 %	%		%	%	
13	58%	58%	50%	42%	83%	83%	75%	67%	100%	50%	50%	0%	80%	64%	58%	36%
14	70%	60%	60%	60%	80%	70%	70%	70%	100%	50%	50%	50%	83%	60%	60%	60%
15	33%	25%	25%	25%	67%	58%	67%	67%	100%	50%	100%	50%	67%	44%	64%	47%
16	55%	55%	73%	45%	64%	55%	82%	55%	100%	0%	100%	0%	73%	37%	85%	33%
17	91%	73%	73%	82%	91%	73%	73%	82%	100%	100%	100%	100%	94%	82%	82%	88%
18	70%	80%	80%	80%	70%	80%	80%	80%	50%	50%	50%	50%	63%	70%	70%	70%
19	58%	75%	67%	67%	67%	83%	75%	75%	0%	100%	100%	0%	42%	86%	81%	47%
20	54%	23%	23%	15%	92%	38%	46%	38%	100%	67%	67%	33%	82%	43%	45%	29%

Table 14: Human experts vs. semantic matching (with instances)

Que ry	Human Experts				Semantic Matching (with Instance)				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	67 %	50 %	100%	83%	58 %	61 %	89%	16%	9%	11 %	11%
2	40%	40 %	100 %	40%	53%	47 %	91 %	47%	13%	7%	9%	7%
3	67%	33 %	33 %	67%	87%	70 %	70 %	73%	20%	37 %	37 %	6%
4	75%	50 %	75 %	50%	86%	43 %	86 %	76%	11%	7%	11 %	26%
5	75%	75 %	100 %	50%	96%	96 %	96 %	56%	21%	21 %	4%	6%
6	60%	80 %	20 %	40%	89%	95 %	50 %	45%	29%	15 %	30 %	5%
7	100%	50 %	75 %	25%	95%	59 %	69 %	59%	5%	9%	6%	34%
8	80%	80 %	60 %	80%	76%	76 %	69 %	93%	4%	4%	9%	13%
9	80%	60 %	60 %	60%	87%	80 %	80 %	53%	7%	20 %	20 %	7%
10	60%	80 %	60 %	60%	53%	53 %	86 %	47%	7%	27 %	26 %	13%
11	60%	80 %	60 %	80%	46%	62 %	46 %	85%	14%	18 %	14 %	5%
12	80%	60 %	100 %	100%	85%	59 %	79 %	79%	5%	1%	21 %	21%
13	83%	67 %	50 %	17%	80%	64 %	58 %	36%	3%	3%	8%	19%
14	60%	40 %	60 %	40%	83%	60 %	60 %	60%	23%	20 %	0%	20%

Query	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
15	67%	33%	67%	83%	67%	44%	64%	47%	0%	11%	3%	36%
16	67%	50%	83%	50%	73%	37%	85%	33%	6%	13%	2%	17%
17	80%	60%	40%	60%	94%	82%	82%	88%	14%	22%	42%	28%
18	40%	40%	60%	20%	63%	70%	70%	70%	23%	30%	10%	50%
19	33%	67%	67%	50%	42%	86%	81%	47%	9%	19%	14%	3%
20	100%	29%	43%	14%	82%	43%	45%	29%	18%	14%	2%	15%

Table 15: Our Technique (Approch1) Matching

Query	Keyword Matching				Semantic Matching (Synonym only)				Instance Matching				Group Matching (Approach1)				Result			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	58%	58%	75%	83%	67%	75%	92%	100%	50%	50%	100%	17%	17%	17%	28%	67%	48%	50%	74%
2	75%	67%	83%	67%	83%	75%	91%	75%	0%	0%	100%	0%	9%	9%	34%	9%	42%	38%	77%	38%
3	70%	50%	50%	50%	90%	60%	60%	70%	100%	100%	100%	100%	33%	8%	17%	25%	73%	55%	57%	61%
4	71%	57	71	57%	86%	71	86	71%	100%	0%	100	100	33%	56	33	22%	73%	46	73	63%

		%	%			%	%				%			%	%			%	%	
5	89%	89%	89%	78%	100%	100%	100%	89%	100%	100%	100%	0%	41%	41%	41%	35%	83%	83%	83%	51%
6	83%	92%	75%	67%	83%	92%	75%	67%	100%	100%	0%	0%	8%	17%	8%	8%	69%	75%	40%	36%
7	86%	57%	71%	57%	100%	71%	86%	71%	100%	50%	50%	50%	0%	0%	0%	0%	72%	45%	52%	45%
8	70%	70%	60%	80%	90%	90%	80%	100%	67%	67%	67%	100%	25%	25%	25%	25%	63%	63%	58%	76%
9	80%	70%	70%	80%	80%	70%	70%	80%	100%	100%	100%	0%	60%	40%	40%	40%	80%	70%	70%	50%
10	75%	75%	75%	67%	83%	83%	83%	75%		0%	100%	0%	28%	28%	8%	12%	47%	47%	67%	39%
11	64%	64%	64%	73%	73%	73%	73%	82%		50%	0%	100%	33%	33%	33%	17%	43%	55%	43%	68%
12	64%	45%	55%	55%	91%	64%	82%	82%		67%	100%	100%	17%	17%	33%	33%	64%	48%	68%	68%
13	58%	58%	50%	42%	83%	83%	75%	67%	100%	50%	50%	0%	21%	29%	21%	14%	66%	55%	49%	31%
14	70%	60%	60%	60%	80%	70%	70%	70%	100%	50%	50%	50%	22%	22%	22%	22%	68%	51%	51%	51%
15	33%	25%	25%	25%	67%	58%	67%	67%	100%	50%	1000	50%	14%	0%	29%	14%	54%	33%	55%	39%

											%									
16	55%	55%	73%	45%	64%	55%	82%	55%	100%	0%	100%	0%	6%	13%	13%	13%	56%	31%	67%	28%
17	91%	73%	73%	82%	91%	73%	73%	82%	100%	100%	100%	10%	13%	9%	9%	13%	74%	64%	64%	69%
18	70%	80%	80%	80%	70%	80%	80%	80%	50%	50%	50%	50%	6%	6%	11%	0%	49%	54%	55%	53%
19	58%	75%	67%	67%	67%	83%	75%	75%		100%	100%	0%	5%	8%	8%	8%	33%	67%	63%	38%
20	54%	23%	23%	15%	92%	38%	46%	38%	100%	67%	67%	33%	13%	0%	6%	0%	65%	32%	36%	22%

Table 16: Human experts vs. our technique (approach 1) matching

Query	Human				Proposed Approach 1				Error			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	67%	50%	100%	67%	48%	50%	74%	0%	19%	0%	26%
2	40%	40%	100%	40%	42%	38%	77%	38%	2%	2%	23%	2%
3	67%	33%	33%	67%	73%	55%	57%	61%	6%	22%	24%	6%
4	75%	50%	75%	50%	73%	46%	73%	63%	3%	4%	3%	13%
5	75%	75%	100%	50%	83%	83%	83%	51%	8%	8%	18%	1%

6	60%	80%	20%	40%	69%	75%	40%	36%	9%	5%	20%	5%
7	100%	50%	75%	25%	72%	45%	52%	45%	29%	6%	23%	20%
8	80%	80%	60%	80%	63%	63%	58%	76%	17%	17%	2%	4%
9	80%	60%	60%	60%	80%	70%	70%	50%	0%	10%	10%	10%
10	60%	80%	60%	60%	47%	47%	67%	39%	14%	34%	7%	22%
11	60%	80%	60%	80%	43%	55%	43%	68%	18%	25%	18%	12%
12	80%	60%	100%	100%	64%	48%	68%	68%	17%	12%	33%	33%
13	83%	67%	50%	17%	66%	55%	49%	31%	18%	12%	1%	14%
14	60%	40%	60%	40%	68%	51%	51%	51%	8%	11%	10%	11%
15	67%	33%	67%	83%	54%	33%	55%	39%	14%	0%	12%	44%
16	67%	50%	83%	50%	56%	31%	67%	28%	11%	19%	16%	22%
17	80%	60%	40%	60%	74%	64%	64%	69%	6%	4%	24%	9%
18	40%	40%	60%	20%	49%	54%	55%	53%	9%	14%	5%	33%
19	33%	67%	67%	50%	33%	67%	63%	38%	1%	1%	5%	13%
20	100%	29%	43%	14%	65%	32%	36%	22%	35%	3%	8%	8%

Table 17: Our Technique (approch2) matching

Query	Keyword Matching				Semantic Matching (Synonym only)				Instance Matching				Group Matching (Approach2)				Result			
	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence	Salesforce	Zoho	Sugar	Commence
1	67%	58%	58%	75%	83%	67%	75%	92%	100%	50%	50%	100%	30%	30%	30%	50%	70%	51%	53%	79%
2	75%	67%	83%	67%	83%	75%	91%	75%	0%	0%	100%	0%	14%	14%	48%	14%	43%	39%	81%	39%
3	70%	50%	50%	50%	90%	60%	60%	70%	100%	100%	100%	10%	38%	13%	25%	38%	75%	56%	59%	65%
4	71%	57%	71%	57%	86%	71%	86%	71%	100%	0%	100%	10%	20%	60%	20%	20%	69%	47%	69%	62%
5	89%	89%	89%	78%	100%	100%	100%	89%	100%	100%	100%	0%	42%	42%	42%	42%	83%	83%	83%	52%
6	83%	92%	75%	67%	83%	92%	75%	67%	100%	100%	0%	0%	7%	20%	7%	7%	68%	76%	39%	35%
7	86%	57%	71%	57%	100%	71%	86%	71%	100%	50%	50%	50%	0%	0%	0%	0%	72%	45%	52%	45%
8	70%	70%	60%	80%	90%	90%	80%	100%	67%	67%	67%	10%	33%	33%	33%	33%	65%	65%	60%	78%

9	80%	70%	70%	80%	80%	70%	70%	80%	100%	100%	100%	0%	75%	50%	50%	50%	84%	73%	73%	53%
10	75%	75%	75%	67%	83%	83%	83%	75%	0%	0%	100%	0%	33%	33%	10%	14%	48%	48%	67%	39%
11	64%	64%	64%	73%	73%	73%	73%	82%	0%	50%	0%	100%	67%	67%	67%	33%	51%	64%	51%	72%
12	64%	45%	55%	55%	91%	64%	82%	82%	100%	67%	100%	100%	25%	25%	50%	50%	70%	50%	72%	72%
13	58%	58%	50%	42%	83%	83%	75%	67%	100%	50%	50%	0%	33%	44%	33%	22%	69%	59%	52%	33%
14	70%	60%	60%	60%	80%	70%	70%	70%	100%	50%	50%	50%	40%	40%	40%	40%	73%	55%	55%	55%
15	33%	25%	25%	25%	67%	58%	67%	67%	100%	50%	100%	50%	20%	0%	40%	20%	55%	33%	58%	41%
16	55%	55%	73%	45%	64%	55%	82%	55%	100%	0%	100%	0%	9%	18%	18%	18%	57%	32%	68%	30%
17	91%	73%	73%	82%	91%	73%	73%	82%	100%	100%	100%	100%	17%	11%	11%	17%	75%	64%	64%	70%
18	70%	80%	80%	80%	70%	80%	80%	80%	50%	50%	50%	50%	8%	8%	15%	0%	50%	55%	56%	53%
19	58%	75%	67%	67%	67%	83%	75%	75%	0%	100%	100%	0%	8%	12%	12%	12%	33%	68%	64%	39%

| 20 | 54% | 23% | 23% | 15% | 92% | 38% | 46% | 38% | 100% | 67% | 67% | 33% | 17% | 0% | 8% | 0% | 66% | 32% | 36% | 22% |

Table 18: Human experts vs. our technique (approch2) matching

Que ry	Human				Proposed Approach 1				Error			
	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce	Salesfo rce	Zo ho	Sug ar	Comme nce
1	67%	67%	50%	100%	70%	51%	53%	79%	3%	16%	3%	21%
2	40%	40%	100%	40%	43%	39%	81%	39%	3%	1%	20%	1%
3	67%	33%	33%	67%	75%	56%	59%	65%	7%	23%	26%	3%
4	75%	50%	75%	50%	69%	47%	69%	62%	6%	3%	6%	12%
5	75%	75%	100%	50%	83%	83%	83%	52%	8%	8%	17%	2%
6	60%	80%	20%	40%	68%	76%	39%	35%	8%	4%	19%	5%
7	100%	50%	75%	25%	72%	45%	52%	45%	29%	6%	23%	20%
8	80%	80%	60%	80%	65%	65%	60%	78%	15%	15%	0%	2%
9	80%	60%	60%	60%	84%	73%	73%	53%	4%	13%	13%	8%
10	60%	80%	60%	60%	48%	48%	67%	39%	12%	32%	7%	21%
11	60%	80%	60%	80%	51%	64%	51%	72%	9%	17%	9%	8%
12	80%	60%	100%	100%	70%	50%	72%	72%	10%	10%	28%	28%

13	83%	67 %	50 %	17%	69%	59 %	52 %	33%	15%	8%	2%	16%
14	60%	40 %	60 %	40%	73%	55 %	55 %	55%	13%	15 %	5%	15%
15	67%	33 %	67 %	83%	55%	33 %	58 %	41%	12%	0%	9%	43%
16	67%	50 %	83 %	50%	57%	32 %	68 %	30%	10%	18 %	15 %	21%
17	80%	60 %	40 %	60%	75%	64 %	64 %	70%	5%	4%	24 %	10%
18	40%	40 %	60 %	20%	50%	55 %	56 %	53%	9%	15 %	4%	33%
19	33%	67 %	67 %	50%	33%	68 %	64 %	39%	0%	1%	4%	12%
20	100%	29 %	43 %	14%	66%	32 %	36 %	22%	34%	3%	7%	8%