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Approaches used for Ontology Matching in eRecruitment

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Abstract---In the last past decade there are numerous of researches has been carried out in the field of Ontology but researchers always pay a special attention especially in the field of eRecruitment domain. In this survey paper, we would like to take a closer look on the current scenario in the field of Ontology such as eRecruitment. In Semantic Web technology using ontology and ontology matching techniques helps the eRecruitment process for semantically matching the posted job and applicant's profile with the help of Ontology application. Most of the paper that we reviewed used the existing standards and classification to construct the human resource ontology, by this they recreate the path for the applicant to fulfil the positions in the semantic way but some of the researchers build recruitment prototype by the help of their own created HR ontologies. We have reviewed a number of papers and articles to understand the purpose for applying these ontology matching techniques and also try to identified how these ontologies work in that respective domain for matching.

Keywords— Ontology, Ontology Matching, Human Resource Ontology, eRecruitment.

1. INTRODUCTION

The internet or World Wide Web (WWW) builds a fast growing worldwide platform in which the people and applications can share the information and services. Ontologies played a key role in supporting the mechanism in which information can be shared but this can only be happening with the help of Semantics and extended syntactic interoperability of the Web. In this, the sharing of information between Semantic web application can be achieved by Ontology matching in which tasks like job postings and application in an eRecruitment domain can be done.

Researchers carried out many researches in the diverse areas of ontology for last past decade for so many purposes. In most of the areas, so many useful and authenticated ontological solutions have been proposed and applied, and so many are on their way to serve and some of them gaining so much attention from researchers. However, ontology [1] can be classified into two categories. For determining any particular domain then set of structured concepts is needed which is provided by Domain Ontologies; it is applied in many fields like medicines, agriculture, jobs, military, automobiles and so on [2]. Domain ontology is a very vast field that contains so many terms which are interrelated. And set of terms that contain some describing aspects of the world, which can be space, time or plans comes under the category of Theory Ontologies. Comparatively theory ontology is more abstract and likely to be smaller than domain ontology. So by these classifications we can define ontology as a collective set of structured concepts and the relationship between them in a specified domain.

The large amount of information or we can say that flood of information can be accessible only because of the developments in the field of communication and information technologies. Due to these technological development, managing the heterogeneity between diverse information sources is becoming challenge and increasing day by day, however, to overcome semantic heterogeneity, two steps must be accomplished. First, entities should be matched to specify an alignment such as a set of correspondences and second interpretation of an alignment according to the needs of an application such as the translation of data and answering to the particular query. Problem of semantic heterogeneity can be resolved by using ontology matching which finds correlation between entities related to each other semantically among different sources of ontologies [3]. On the other side, various applications have a number of ontologies in which interoperability cannot be possible [4].

This is due to; several ontologies have entities which introduced under several different names and they use different languages in order to address the same set of terms [2]. Mapping of different terms in different ontologies can be achieved with the help of

ontology matching [5]. The technique ontology matching which is used to discover the cognition between entities of giving ontologies; in this each and every ontology has a number of entities such as classes, rules, properties.

The process of matching identifies an alignment X (to be defined) for a set of ontologies O1 and O2. According to this purpose, we accredit that the entities set O1 and O2 are sets of finite. Domain experts confirm that the association of ontologies creates Reference alignment [6]. Evaluation of matching systems done annually by internationally coordinated initiative OAEI (Ontology Alignment Evaluation Initiative) and it also manages it. Evaluation of matching algorithms can be done according to the following measures which inspired from information retrieval consists of precision and recall, whereas precision is the measure of correctness and recall is the measure of the number of completeness and F-measure, which aggregates precision and recall [3, 6]. However the process of matching can be depicted as a function (f) which, from a set of ontologies O1 and O2 to match, alignment X as an input, a pair of parameters p and resources r and a set of oracles, which returns an alignment Y between these ontologies [7]:

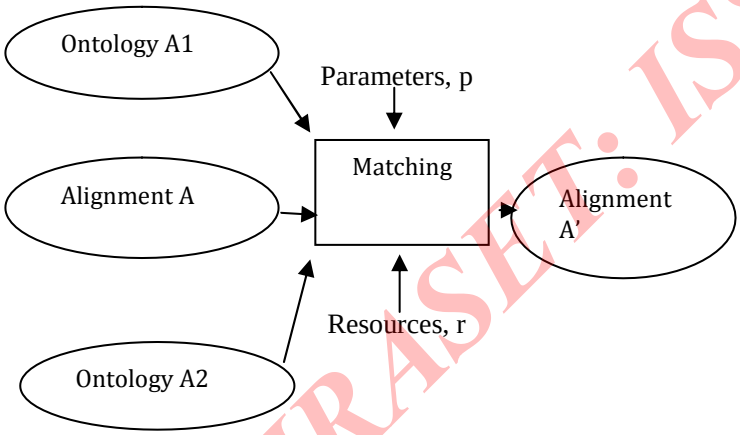

FIGURE 1: The matching process [7]

The Online job portals market are very vast and rapidly grown, and there are so many online job portals which offer online recruitment, these online job portals are divided into small chunks where job applicant or job seeker find himself in a very difficult situation where it is almost impossible for them to get the relevant information of all the open positions. To publish the job posts to online job portals will add some publishing cost, consequently the employers bind to publish these job posts into a limited number of job portals and limited job advertisement on these portals prevents the job to reach of all potential candidates, so that, the employers should pick the candidate from a limited pool of candidates for an open position [8].

The primary step to develop eRecruitment is to create HR ontology which its main concept depends on "Applicant: the person or candidate applied for the job", "Employer: The organization or company that offered the job to applicant", "Job description: The type of job offered by the employer to the candidate or applicant", and "Job Profile: The required applicant's experience and qualification information" [9]. While creating HR ontologies for eRecruitment, they are using some existing standards and classification for their integration which contains clear and well recognized description of occupational titles, associated [10].

However, the main aim of offering the jobs online is to reduce the cost of publishing the job and they like to employ pre-selecting technique to choose a suitable candidate in order to reduce the number of applicants applied for the job. By the help of these online applicants would like to get through the access of transparently open positions in the job market with their search statements in the portals of online recruitment [8]. For those reasons so many papers have been published which talks about semantic- ontology matching techniques within recruitment processes. In this paper, I would like to survey some of them.

2. ONTOLOGY MATCHING TECHNIQUES AND CLASSIFICATION OF ERECRUITMENT ONTOLOGIES

2.1 Ontology matching/alignment techniques

Ontology matching is a technique in which the relationship between the items of two or more different ontologies can be found. The main aim of ontology matching in any domain can be reached by creating a number of several techniques. For combining ontologies we used the terms which are frequently used like mapping, matching and alignment. The following terms can be described or defined by recent studies as follows [11]:

- Ontology merging: it is a technique which combines two different ontologies from the equivalent subject area into a unique ontology.
- Ontology integration: it is a technique which combines two ontologies from a distinctive subject area into a new ontology.
- Ontology alignment: It used to identify the correspondence between the source ontologies.
- Ontology mapping: It finds equal parts in different source of ontologies.
- Ontology matching: It finds similar parts in the source of ontologies or finding translation rules between ontologies.

To represent the theoretical basis, researchers have been drifted out so many researches to provide basic classification to distinguish them and specify different types of ontology matching techniques. So, here we provide some classification of ontology matching methods [12].

1. Terminological Matching: This is computing similarities according to the classes of string and properties name which includes String-based: some examples that are widely used in matchmaking systems are edit distances, and n-gram, suffix, prefix [13], Semantic dependent are the semantic definitions of strings which is used as names of ontology concepts, the meaning of these terms is acquired from an outside source. The semantic meaning of the concept in a thesaurus is identified according to a group of possible definitions of the principle and a set of terminological alliance between the concepts and other concepts [14], and Lexicons based: are the strings of characters which is used as names of ontology concepts. Now according to this, natural language processing techniques might be implemented to parse these strings, as it can be processed using semantic linguistic techniques such as elimination, tokenization, heuristic, lemmatization and grammar analysis [14].

2. Structural Level Matching: It computes associations by analyzing how the elements and their concepts appear together in a structure. Internal Structure: this compares the internal configuration of entities. External Structure: this compares the correspondences of the classes with other classes. Taxonomical structure: this compares the location of the entities within the taxonomy.

3. Extensional Comparison: this is used to compare certain extension of classes. Some of the instance matching techniques which include GLUE [15].

GLUE is a system that engages techniques of machine learning which create semantic mappings among the elements of different ontologies. GLUE uses many learning approach to hold with many kinds of information, either in illustrations or in the taxonomic architecture of different ontologies in order to measure interrelation accurately as well as other techniques proposed in [16] representatives in the matcher operating on different hierarchical type largely designed ontologies in a bottom up way for the purpose of an e-commerce application. The application field of this system is very limited, because it confides on the presence of a single id-key of every concept instance.

Table 1: Ontology Matching Techniques Analysis

Ontology Matching Technique	Characterization	Remarks
Terminological	It matches and calculates the comparative matching between texts applying labels, names or some other strings.	It helps where the comparison of matching on the ontology is depends on text strings or on the language.

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Structural	It compares the description of entities for each and every ontologies (internal structure) or the accords that each entity may have with others (external structure).	It is a valuable technique for estimating and coordinating the internal architecture of the entities or the comparability of the entities which may have towards other external structure entities.
Extensional (Instance)	It compares the instance/extension or the length of the classes of ontologies: in other terms, class instantiation or objects	It is helpful only if the comparison of different entities information is limited and needed to analyse further data or support other matching approaches for identifying where intermittently for misleading correspondences occur

Table 1: presents a classification of ontology matching techniques analysis. The main aim of matching techniques in ontology is in any domain can be attained by establishing a number of different methods, for that reason ontology matching techniques can be classified in above table contents which include: Terminological, Structural and Extensional.

In this section we tried to survey and analyzed the most extensive and phenomenal carried research efforts for applying ontologies to the eRecruitment domain. Many of the researchers in this field, as their first step to evolve eRecruitment, which create human resource ontology Which its main concept based on "Applicant which is the candidate for the job", "Employer: The organization which offered the job", "Job Description: Which type of job offered by the employer to the candidate", and "Profile: Which is the applicant's or candidate qualification and their experience information" [9].

The subsequent tables present analysis of Human Resource Ontologies according to domain of eRecruitment. This study classifies ontologies of human resource in terms of single ontology, Networked ontology and newly built approaches. During developing ontology few of the researchers have already availed some of the widespread standards and classifications and some others they developed from the ground. Some of the researchers used matching techniques which we highlighted in the tables, so, we surveyed those kind of issues and presented their study in the following tables.

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Table 2: Single ontology based-on widespread standards

Author/Year	Title	Technique	Solution	Limitation
C. Bizer, R. Heese, M. Mochol, R. Oldakowski, R. Tolksdorf, R. Eckstein. 2005	The Impact of Semantic Web Technologies on Job Recruitment Processes	Semantic similarity algorithm between concepts determined by the concept distance which is terminological matching technique	Proposed ontology for the HR domain and explained an implementation of the required prototypical infrastructure	Not focused to talk about the composition of sub-ontologies, and according to the other research works, skill is a part of competency ontology
Malgorzata Mochol, Elena Paslaru, Bontas Simperl. 2006	Practical . . Guidelines for building semantic eRecruitment applications.	None	Built Human Resource ontology to supply the intelligence of semantic matching technologies into current e-recruitment applications	Not focused to talk about the composition of sub-ontologies and they do not propose any model
Dorn, J.; Naz, T.; Pichlmair, M. 2007	Ontology Development for Human Resource Management.	None	Designed two dissimilar projects: a meta-search engine for searching about jobs in job portals and for university competence management system to analyze the competence of student profiles.	Focused nothing much for recruitment ontologies instead focused not implemented any information system to prove the projects
Tabbasum Naz, et al.,2010	Configurable Meta-Search in the job domain	Used terminological-level techniques, structure-level techniques and ontology-based techniques	Constructed a configurable meta-search engine for eRecruitment to search jobs as a job search engine.	The study lacks details of sub-ontology development.

Table 2: It demonstrates the Ontology matching based on standards and classification for single ontology; however, to develop HR ontology they used to integrate some already widespread existing standards and classifications which contains clear and well recognized descriptions of occupational titles, associated skills and qualification mostly in the national scope. After creating this ontology of HR, it is ready to be deployed in eRecruitment applications in order to have managed electronically available job posting and candidate profiles.

Table 3: Networked ontology based-on widespread standards

Author/Year	Title	Technique	Solution	Limitation
Valle, E.D., Cerizza, D., Celino, I., et. al. 2008.	SEEMP: A Semantic Interoperability Infrastructure for e-government services in the employment sector.	None	Proposed an approach relies on the idea of services and semantics to allow information sharing among many public and private Employment services that exist in Europe.	Not implemented real world information system to prove the idea.
Boris Villazón-Terrazas, Jaime Ramírez , Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez. 2011	A network of ontology networks for building e-employment advanced systems.	None	Explained methodological guideline for building ontologism.	Not implemented any information system to prove the proposed framework

Table 3: It presents approaches for ontology matching for networked (local and referenced) ontologies which include language dependent local ontologies which are associated with the reference ontology in English version with the respect of job offers, and CVs can be mediated from any employment services in the region. However, they used to develop the ontology for human resource (for reference and local) existing widespread standards and classifications containing clear and well-recognized descriptions of occupational titles, qualifications and associated skills.

Table 4: Ontologies based-on newly-built approaches and its associated matching algorithms

Author/Year	Title	Technique	Solution	Limitation
L. Yahiaoui, et al., 2006	Semantic Annotation of Documents Applied to e-recruitment	Used semantic matching computation coefficient as matching algorithm which is terminological matching technique.	Proposed a scenario of automatic eRecruitment web which the applications and job descriptions matched through semantic annotation and indexing based on competency profiles.	Not implement as a real world prototype to validate the proposed model.
Mochol, M.; Jentzsch, et al., 2007.	Suitable employees wanted? Find them with semantic techniques.	None	Proposed eRecruitment based on semantic web. They adopted ontology from Knowledge nets.	Not focused much about ontology components and their development
Fazel-Zarandi, M.;	Semantic Matchmaking	Node-based semantic	HR ontology is	Not mentioned the

Fox, M.S. 2009	for Job Recruitment: An Ontology-Based Hybrid Approach	similarity measure which is terminological matching technique	presented in this work where they propose an ontology-based hybrid approach to efficiently match job seekers and job descriptions.	composition of sub-ontologies or does not propose any model.
Chaoxiang Chen, et al., 2009	Design and Implementation of SMS Employment Agent Based on Ontology	Concept compatible matching algorithm which is terminological matching technique	Presented SMS recruitment web service using ontology and agent systems.	Not focused to talk about ontology components and their development.
Lv Hexin; Zhu Bin;, 2010	Elastic Information Matching Technology and its Application in Electronic Recruitment	Used semantic similarity algorithm determined by distance of a concept tree structure, it is both terminological and structural.	Presented an approach to develop ontology based framework, its semantic matching similarity algorithm.	Not focused details of domain ontology and real world implementation prototype.

Table 4: It presents ontology matching based on newly built ontology approaches and their associated algorithms for their matching. These algorithms mostly used by the researchers which used skill ontology and its matching criteria. They built HR ontology by themselves especially skill ontology in order to apply eRecruitment application using its respective matching algorithms.

3. DISCUSSION AND LIMITATIONS

3.1 Discussion

In the semantic web, eRecruitment is becoming a more important aspect along with the development of the semantic web technologies, that's why semantic web is most effective carrier for eRecruitment which is based on ontologies and techniques of ontology matching in order to perform necessary to locate and match candidates for the job and the positions offered. However, the primary step to create eRecruitment is to develop a Human Resource Ontology which its main concept is based on applicant, employer, profile and job description. The communication or interoperability between candidate's profile and employer's job description are based mainly on bunch of existing vocabularies of widespread standards, which provide collective concepts for describing occupational titles, educational qualifications and required skills. Moreover, there are so many approaches which describe ontologies in the domain of HR, in which each of them solving with a unique problem. HR ontology can be categorized into single, networked and newly built each of which uses different ontology matching techniques as we presented in the tables above.

3.2 Limitations

As different ontologies can be used to present several domains such as eRecruitment, there is much need for efficient techniques of ontology matching that can allow different information to be gotten easily exchanged and matched between different heterogeneous systems according to recruitment portals. In recruitment domain none of the techniques used for matching is unique. Although, a particular technique opted for a particular ontology, and its underlying characteristics, such as relation types, background knowledge and structure which provides very good performance in determining correspondences between ontologies such as skill, job offer, profile, competency and organization to be matched. Consequently, this arises a major concern for the semantic web, where heterogeneous ontologies are expected to interoperate for exchanging employee resumes and job postings.

4. CONCLUSION

In this paper, it has been investigated and granted a number of articles for Human Resource Ontology in eRecruitment domain. The papers described the human resource ontology used within

ontology matching techniques, which produces the means for a semantic matching approach to match job seekers and job notifications in a recruitment domain. Most of the papers used comprehensive standards and classifications to build ontologies. Some of the papers have suggested an intelligent employment framework, while others developed an eRecruitment prototype to validate their models.

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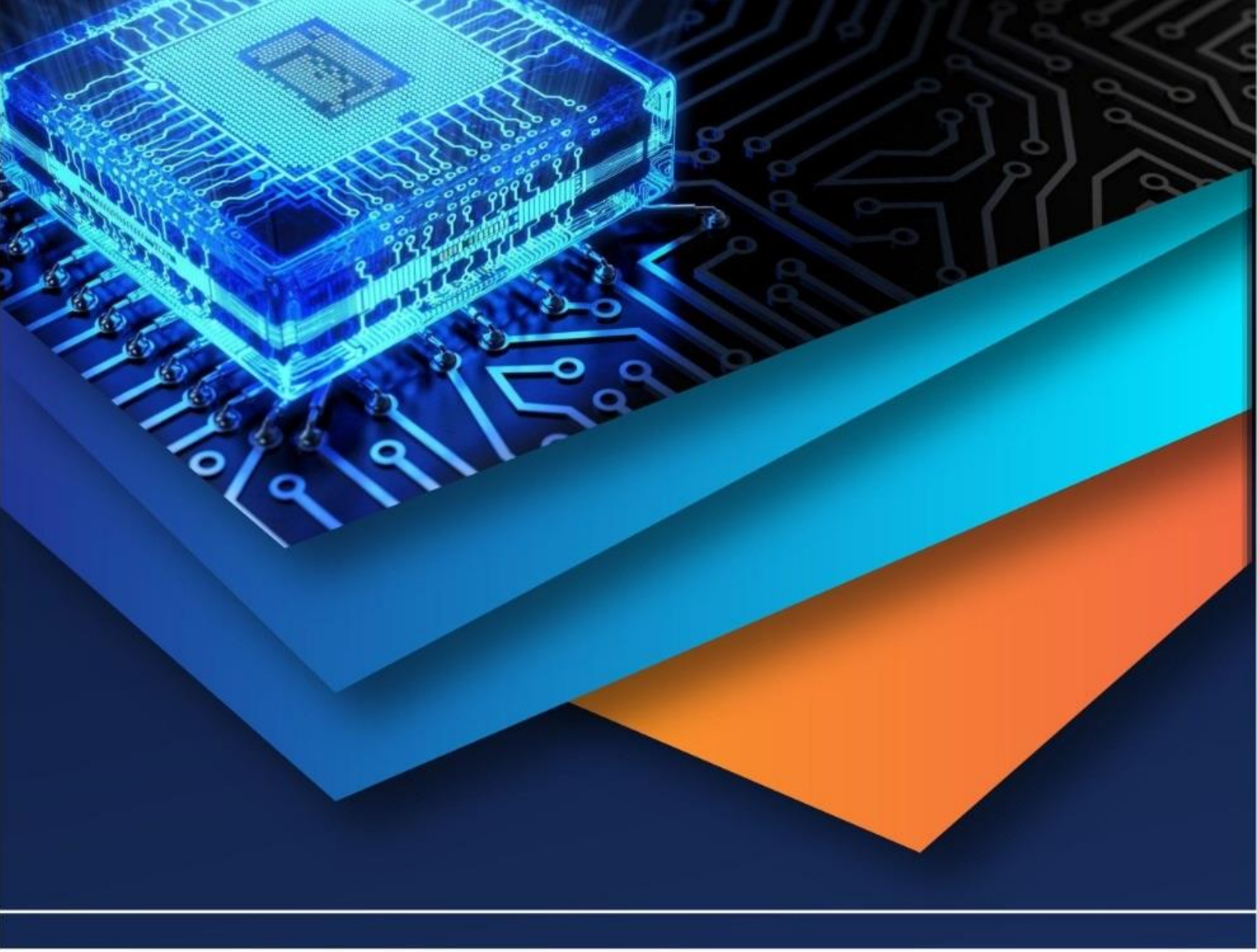

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