THE PROPOSAL OF AN ONTOLOGY FOR THE RECRUITMENT PROCESS

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Abstract: *The paper presents a useful ontology for managing activities within a recruitment company, using Protégé 3.5. A well-designed recruitment ontology must contain clearly defined terms and relationships. The ontology classes are: Candidate, Job, Company, Department, Interview, Education_level, Experience_level, Skills, Foreign-languages, Recruitment_team, Evaluation, Offer, Status_job. Within the classes, two-dimensional many-to-many relationships and one-to-many bidirectional relationships were established. The article presents theoretical notions of the concept of "ontology" and the recruitment activity. Additionally, scientific articles that focus on different ontologies in the recruitment process are presented. The static modeling of this application is represented by the construction of the class diagram. After adding the instances, the ontology can be queried to provide answers to the following questions: the names of candidates applying for a specific position, the names of candidates who match certain jobs, the names of candidates scheduled for a particular interview, the names of candidates who have received the offer, which positions are accepted or which positions are declined. The purpose of the application is that after the corresponding data for the positions and candidates has been entered, the appropriate candidates to be scheduled for interviews are determined through queries. Also, through the queries, a list of the names of the candidates accepted after the interviews is displayed. These candidates receive the job offer which they can accept or decline. Thus, at the end of the recruitment process, each job receives the status of either 'vacancy' or 'not available'.*

Keywords: *ontology, Protégé, recruitment*

JEL Classification: *C63; J23, M12*

1. Introduction

Regardless of education level, every adult is a job candidate. Job supply and demand intersect in the labor market, and recruitment plays a crucial role in the placement of labor in any field. A prospering economy needs an efficient recruitment process that ensures the right match between the skills of candidates and the requirements of employers.

Ontology in recruitment appears as an innovative tool that facilitates the understanding and organization of knowledge related to the personnel selection process.

A properly established recruitment ontology must contain clearly defined terms and relationships. In this way, the ontology allows access to information on

candidates, competences, job requirements. Ontologies can facilitate both faster and more
accurate assessments of applicants, as well as the creation of automated selection systems. In this context, this article explores how Protégé can be integrated into the recruitment process to optimize knowledge management and support better-informed decision-making.

This article aims to enhance the role of ontologies in recruitment, exploring how they can improve decision-making and selection efficiency, contributing to the identification of the most suitable candidates.

2. What is ontology?

The term "ontology" has been approached from several points of view. Initially, the term was explained in antiquity by Aristotle, as the science of "being qua being," the study of attributes that belong to things because of their very nature (Guarino, 2009). Thus, we can say that ontology is a branch of philosophy that studies existence.

In Computer Science, “we refer to an ontology as a special kind of information object or computational artifact”. (Guarino, 2009).

Gruber originally defined the notion of an ontology as an “explicit specification of a conceptualization” (Gruber, 1993). In his articles, Gruber referred to the notion of "conceptualization", quoting the authors Genesereth and Nilsson (1987): a body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them. A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose. Every knowledge base, knowledge-based system, or knowledge-level agent is committed to some conceptualization, explicitly or implicitly.”

Ontology is an explicit specification of a conceptualization, which facilitates the exchange of knowledge in a field (Băjenaru, et all, 2015).

In Information Science, an ontology is a structured framework for representing knowledge within a domain. More simply, it connects objects and concepts through defined relationships, creating a model that enables better data organization, interoperability, and intelligent automation (https://factorfirm.com/posts/ontology-101-what-it-is-why-it-matters-and-how-to-use-it/)

Enterprise Knowledge defines an ontology as “a defined model that organizes structured and unstructured information through entities, their properties, and the way they relate to one another.” (Hilger, J., 2017).

Ontology gives a specific and common understanding based on the different concept of a domain (Uba, et all, 2019).

Ontologies are used to facilitate the understanding, organization and processing of information in a logical, coherently structured way.

Basically, the ontology provides vocabulary to describe data with semantics that computers can understand (Hoag M., 2019). To create an ontology, a thorough analysis of the domain is necessary. Ontology is a very popular research topic mainly due to what it promises: a way of capturing a shared and common understanding of

a domain that can be understood and used as well by humans as programs (Tricot, et all, 2016).

Within an organization, ontology contributes to: manage content more effectively, improve findability and discoverability of information, increase the reuse of unknown information, improve search engine optimization (Patil, et all, 2021).
Ontologies can be created for any domain: financial field (Tănăsescu, 2016), medicine, education.
A classification of ontologies from the point of view of conceptual coverage (Gălățescu, 2001) is presented as follows:

- superior ontologies for covering general concepts, applicable in many fields' domain ontologies, designed to be useful in a single domain
- application ontologies, designed for a single application within a domain.

In another article (Andone, 2006) these types of ontologies are explained as follows:

- ✓ subject-independent ontologies are called top-level ontologies and define concepts that are valid for all domains.
- ✓ domain ontologies define the relevant objects in a specific field of application.

examples of ontologies in the field are those related to airline planning (Valente, 1999), those related to calendar planning (Smith and Becker, 1997), and those for medicine (Gangemi, 1998).

2.1. Protégé

Protege is one of the most popular tools for creating and managing ontologies. Protégé is an open-source editor that enables the development and visualization of ontologies, including in OWL and RDF formats. It is very flexible software and supports integration with various databases and technologies.

Languages for ontologists began to be created in the early 1990s, normally as an evolution of existing languages of knowledge representation. Among the most relevant languages are: Resource Description Framework (RDF), Ontology Web Language (OWL) and Extensible Markup Language (XML). OWL is a semantic Web language designed for the representation of semantically enriched knowledge. The structural units of the OWL are: classes (describe the concepts), data type properties (describe various attributes of the classes), object properties (represent the relationships between classes), Individuals (instances of classes, representing objects within the field of interest) (Băjenaru L., 2015).

OWL (Ontology Web Language) is being considered as the standard language for representing ontology for semantic web. For ontology editing, Stanford University has introduced the open source Protégé tool, which defines ontological concepts such as classes, properties, semantic categories, and different restrictions (Hoag M., 2019)
An ontology includes the following components (Tănăsescu, Bodea, & Pătrașcu, 2008):

- categories, fundamental concepts or classes (include objects of the same type);
- the properties of the concepts that describe their different characteristics and attributes (slots, roles);

- defined restrictions on slots (facets or defined restrictions on roles). The steps in creating an ontology are: domain analysis, defining concepts, hierarchy of concepts, defining relationships, ontology check.

3. Recruitment process

Recruitment is the process of searching, attracting, and hiring qualified applicants for employment in an organization (Devi M. B. R, 2014).

The recruitment process involves finding as many qualified candidates as possible, so that the hiring company can select the right person for the job. The purpose of a recruitment team is to find the ideal candidates for vacant positions. Unsuitable hiring decisions affect the operations of the department in which a person has been employed. The recruitment and selection process are a critical component of an organization's human resources management, determining the quality of new employees and influencing overall organizational performance.

The recruitment process begins with the publication of the announcement. The advancement of information technology has a major impact on the recruitment process. Internet has become the main medium to select and recruit candidates (Bizer C., et all, 2005).

During the last 15 years, the massification of computers and the Internet have had an impact on the way humans search for jobs and employees (Rafter R., et all, 2000). In the digital era, there are various recruitment channels: websites, social media, specialized platforms. Thus, a person interested applies for a vacant position.

On the other hand, recruitment firms use these recruitment channels to “target” potential candidates. The selection process follows, a stage in which recruiters choose candidates based on the job requirements. These requirements must be clearly stated by the hiring company. After the CV selection process, recruiters schedule candidates for an interview.

The feedback received from the evaluation processes is used to make the final hiring decision. The candidate who passes the interview stage will be offered the position (Singh A., et all, 2010).

The expectations of job seekers are classified into financial criteria (attractive salary), professional criteria (sense of achievement, opportunity for advancement), and personal criteria (friendly team, pleasant working atmosphere).

4. Related works

Over time, there has been research regarding the improvement of performance in the recruitment process. Thus, a decision support system was presented (Singh A, et al., 2010) that assists recruiters in the quicker selection of candidates. These systems can enhance information about job offers and/or resumes.

One paper (Karaa W. B. et all, 2011) showed how to build and implement an ontology that regroups basic information in the resume. The ontology was designed

for both recruiters and applicants. It was named Ereco and was built using the Protege 2000 software.

The proposed ontology (Çelik D, et al., 2013) was summarized as the extraction of information from the CV. The overall objective of the proposed ORP system is based on concept matching task and ontological rules for English and Turkish résumés which provide for semantic analysis of data and parse related information such as experiences, features, business and education information from a résumé. The system contains its own Ontology Knowledge Base (OKB).

Another specialized article focused on using ontology mapping in screening candidates' problem to recommend the best mapped candidate resumes suitable for the job requirement using similarity measurement. The authors (Senthil K. et all, 2013) called the ontology EXPERT.

The system E-Gen (Kessler, 2012) was created in order to automating the recruitment process. E-Gen is a Natural Language Processing (NLP) and Information Retrieval (IR) system composed of three main modules:

- ✓ the first one extracts the information from a corpus of e-mails of job offers from Aktor's database.
- ✓ the second module analyses the candidate's answers (i.e. splitting e-mails into cover letter (CL) and curriculum vitae).
- ✓ the third module analyses and computes a relevant ranking of the candidate's answers.

Other authors (Faliagka, et all, 2013) have implemented an integrated company-oriented e-recruitment system that automates the process of evaluating and pre-selecting candidates by offering scores to candidates that reflect how well their profile fits.

Another researcher (Cabrera Diego et all, 2015) developed a Résumé Detector based on a Support Vector Machine (SVM).

Another ontology (Gang Zhao, Robert Meersman, 2005) was created in order to improving the recruitment process. The authors explained the balance between scalability and logical consistency. They said that the design scalability is concerned with the size (number of vertices and arcs) and complication of ontology models (complexity of logical relationship among the vertices, arcs and axioms). The formal requirement of logical roundness and validity of the model has a big impact on the size-complication relation. Scalability refers to the model's ability to grow without becoming too unwieldy or inconsistent. At a certain point, the ontology may reach a saturation point where further additions or modifications become difficult.

5. Application design with UML

The first step in designing an information system is to establish a model that highlights the important aspects of the software. The UML class diagram is a conceptual model used for designing the logical model of the information system.

The crucial advantage of designing system by utilizing UML lies in its ability to describe, and reflect the real world of information systems better. (Hoag M., 2019) Numerous visualization methods for ontologies have been proposed and many software tools implementing them have been developed, ranging from newly

designed approaches to approaches reusing the Unified Modeling Language (UML) by leveraging on the similarities between Knowledge Engineering and Software Engineering. (Dudáš M., et all, 2018)

UML is a graphical notation used for many years in software design across various fields. UML is supported by widely-adopted CASE tools. These UML CASE tools are more accessible to software practitioners than current ontology tools from the research community such as Ontolingua and Protege, which require expertise in knowledge representation. Real world industrial agent-based systems need to interact with legacy enterprise systems, which often have existing UML models (Kogut, 2002).

There are several options for creating UML diagrams: online tools, specialized software. In this paper, the class diagram was created with Draw.io.

The class diagram is made up of 13 classes of objects (Figure 1). Within the classes, the following association relationships are established:

✓ two-dimensional many-to-many relationships (a candidate applies for one or more jobs, and a job can also have one or more candidates; a candidate has one or more job requirements, and a job requirement can also be met by several candidates).

✓ one-to-many bidirectional relationships (a candidate receives an offer, but an offer is presented to one or more candidates; a recruitment team selects one or more candidates, but a candidate is selected only by one recruitment team; a recruitment team conducts several interviews, but an interview is handled by only one recruitment team; a department belongs to a company, but a company has multiple departments; a candidate receives an evaluation, but an evaluation is given to several candidates; a job belongs to a department, but a department has multiple jobs; a job receives a status, but a status is given to multiple jobs).

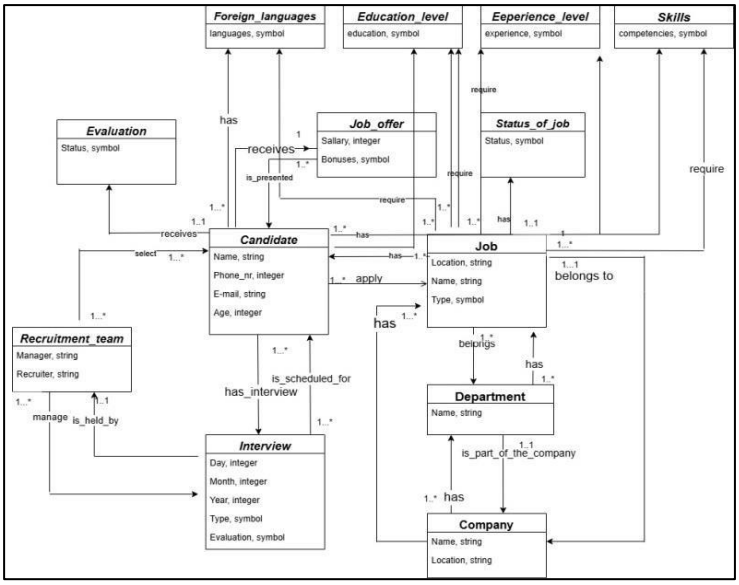

Figure 1 – The Class Diagram
Source: made by author

6. Proposed ontology

The ontology domain is represented by recruitment process. The ontology is composed of the classes: Candidate, Job, Company, Department, Interview (Date_of_inteview and Evaluation subclases), Education_level, Experience_level, Skills, Foreign-languages, Recruitment_team, Offer, Status_job (Figure 2).

Figure 2 – The ontology for recruitment process
Source: made by author

The following relationships are established between these classes: a company has multiple departments, a department has multiple jobs, a candidate applies for multiple jobs, a job has multiple requirements (Education_level, Experience_level, Skills, Foreign languages), a candidate possesses certain qualities (Education_level, Experience_level, Skills, Foreign languages), a candidate is selected for an interview, a candidate is evaluated, a candidate receives an offer, an offer has a status.
The Candidate Class (Figure 3) has the following slots: name, e-mail, age, phone number, competencies, experience level, education, lanuguages. The instant slots that make the links with the other classes are:

- ✓ candidate_has_interview – connects with the interview class
- ✓ candidate_is_selected_by – connects with class recruitment_team
- ✓ for_company – connects with the company class
- ✓ for_job - connects with the job class
- ✓ evaluation_after-interview – connects with evaluation class

Name	Cardinality	Type	Other Facets
Age	required single	Integer	
candidate_has_interview	required single	Instance of Interview	inverse-slot=interview_is_for_candidate
candidate_is_selected_by	required multiple	Instance of Recruitment_Team	inverse-slot=select_a_candidate
Candidate_name	required single	String	
competencies	required multiple	Symbol	allowed-values={JAVA,MS-OFFICE,CSS,PHP}
E-mail	required single	String	
Education	required multiple	Symbol	allowed-values={hight_school,University_degree,Master_degree}
evaluation_after_interview	required single	Instance of Evaluation	
experience_level	required single	Symbol	allowed-values={entry_level,mid_level,senior_level}
for_company	required single	Instance of Company	
for_job	single	Instance of Job	inverse-slot=candidates_for_job
languages	required multiple	Symbol	allowed-values={English,Italian,French,German}
Phone_number	required single	Integer	

Figure 3 – The Candidate Class
Source: made by author

The Company Class (Figure 4) has the slots Company_location, Company_name, company_has_department (links to the Department class), Company_has_job (instance of the Job class). The Job class has the slots candidate_for_job and job_belongs_to that link to the Candidate and Company classes.

Template Slots

Name	Cardinality	Type	Other Facets
candidates_for_job	multiple	Instance of Candidate	inverse-slot=for_job
competencies	required multiple	Symbol	allowed-values={JAVA,MS-OFFICE,CSS,PHP}
experience_level	required single	Symbol	allowed-values={entry_level,mid_level,senior_level}
job_belongs_to	required single	Instance of Company	inverse-slot=company_has_job
job_location	required single	String	
job_name	required single	String	
job_type	required single	Symbol	allowed-values={part-time,full-time,remote}
languages	required multiple	Symbol	allowed-values={English,Italian,French,German}

Figure 4 – The Company Class
Source: made by author

The Interview Class contains the concrete class Date_of_interview which holds the slots day, month, year, hour, location, interview_type, evaluation. Instance-type slots are Interview_for_job, interview_is_for_candidate, interview_team. The Job_offer class includes the slots salary, bonus, feedback, and the instance slot for_candidate. The purpose of the application is that after the relevant data for the positions and candidates are entered, the suitable candidates are established to be scheduled for the interview, through queries.

After entering the necessary data, a query was created (Figure 5) through which the names of the candidates suitable for the position in terms of experience level are displaied (other requirements can be added). For the Data Analyst job, the desired experience level is mid-level, and the candidate who applied for this job and has the required experience was displayed in the query results.

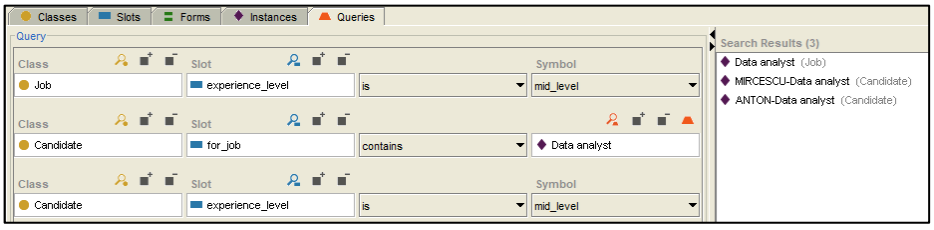

Figure 5 – The query for match the candidates to jobs in terms of experience level
Source: made by author

In this way, the recruitment team can schedule the respective candidates for the interview (Figure 6) by filling in the slot's year, month, day, and hour.

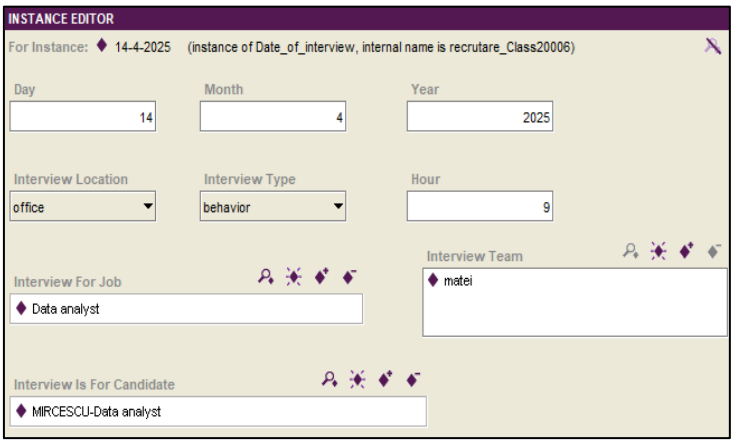

Figure 6 – An instance for scheduled candidate
Source: made by author

After the interview, the recruitment team provides an assessment of the candidate: accepted or rejected (Figure 7), in the Evaluation Class.
This form contains the name of the candidate and the position for which the candidate was interviewed.

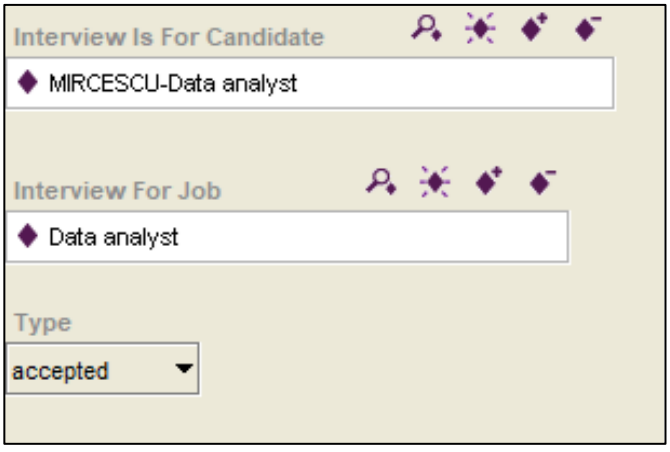

Figure 7 – An instance of Evaluation Class
Source: made by author

Thus, at the end of the recruitment process, the form for each selected candidate (Figure 8) will include all the information: the candidate's details, the position for which the candidate was selected, the date of the interview, and the obtained status.

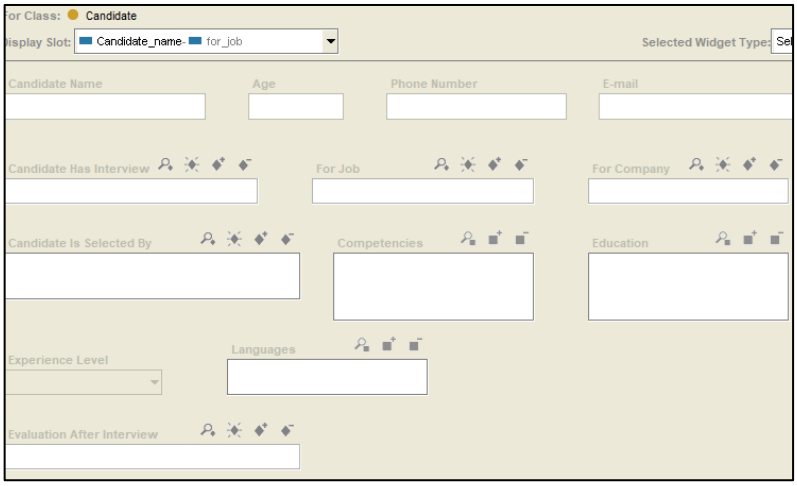

Figure 8– The form for each selected candidate
Source: made by author

The admitted candidates will subsequently receive the offer, for which they will give a status: accepted or declined. After the submission of the offers, the query regarding the candidates' feedback displays which positions were accepted or rejected. In example (Figure 9), the author wanted to highlight the name of candidates who accepted the job offer. From Candidate Class the slot “for_job” was used. From Job_offer Class, the slot “feedback” with condition “is accepted_offer” were used

.

The result of this query showed the names of candidates and the names of jobs.

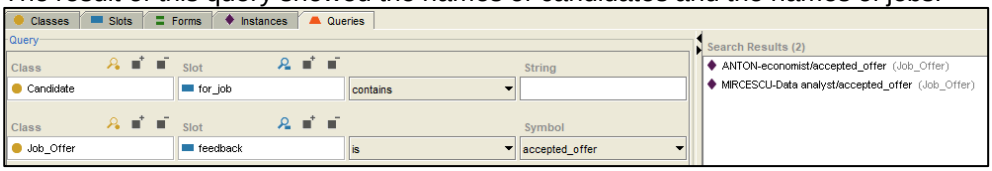

Figure 9– The query containing the candidates' feedback
Source: made by author

The final step that the recruitment team goes through, after the position has been accepted or not by a candidate, is to determine the job status (figure 10): not available or vacancy. This information is needed in Status of job class.

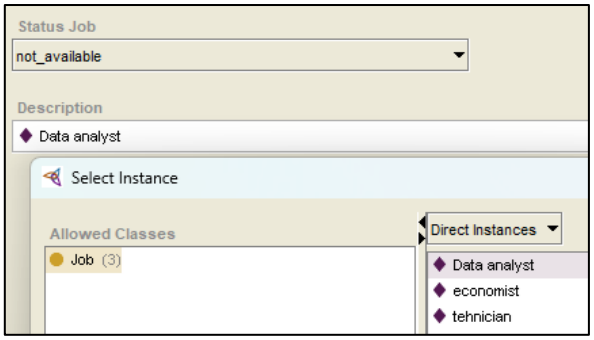

Figure 10– An instance of Status_Job Class
Source: made by author

7. In conclusion

This ontology is intended to enhance the management of activities in a recruitment company. Ontology is organized in classes: Candidate, Job, Company, Department, Interview (Date_of_inteview and Evaluation subclases), Education_level, Experience_level, Skills, Foreign-languages, Recruitment_team, Offer, Status_job**.** The purpose of the application is the possibility of automatic selection of candidates for the interview. In this way, the recruitment team can schedule candidates who possess the requirements for the position (experience, education, skills). After the evaluation process, the accepted candidates will receive the offer, for which they will give a status: accepted or declined.

After the submission of the offers, the query regarding the candidates' feedback displays which positions were accepted or rejected. The filled and vacant positions appear in the job management system.

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References

1. Andone, I. (2006), Ontologiile și Modelarea informaţională a întreprinderii, Analele Ştiinţifice Ale Universităţii „Alexandru Ioan Cuza” Din Iaşi, Tomul LII/LIII, Ştiinţe Economice 2005/2006
2. Băjenaru, L., Balog, A., Smeureanu, I., Marinescu, A. I. (2015), Abordare bazată pe ontologii a unui sistem de e-learning în domeniul managementul resurselor

umane într-un spital universitar, Revista Română de Interacţiune Om-Calculator 8(2) 2015, 139-156
3. Bizer, C., Heese, R., Mochol, M, Oldakowski, R., Tolksdorf, R., Eckstein, R., (2005, "The impact of semantic web technologies on job recruitment processes," in *Wirtschaftsinformatik 2005*. Springer, 2005, pp. 1367–1381 [accessed March 2025].
4.Cabrera-Diego, L.A., Lafon, M. (2015), How can we measure the similarity between résumés of selected candidates for a job?, Conference: DMIN 2015 International Conference on Data Mining At: Las Vegas, Nevada USA, [online] available https://www.researchgate.net/publication/275954089_How_can_we_measure_the_similarity_between_resumes_of_selected_candidates_for_a_job [25 Mar 2025]
5. Çelik D., Karakas A., Bal G, Gultunca C, A. Elçi, B. Buluz, and M. C. Alevli, (2013), "Towards an Information Extraction System Based on Ontology to Match Resumes and Jobs," in *Computer Software and Applications Conference Workshops, 2013 IEEE 37th Annual Computer Software and Applications Conference Workshops*
6. Devi, M. B. R., Banu, P.V., (2014), "Introduction to Recruitment," SSRG Int. J. Econ. Manag. Stud. SSRG-IJEMS, vol. 1, no. 2, p. 4.
7. Dudáš, M., Lohmann, S, Svátek*, V., P*avlov, *D.,(2018), Ontology visualization methods and tools: a survey of the state of the art, The Knowledge Engineering Review, Vol. 33, doi:10.1017/S0269888918000073use, [online] a*vailable https://www.researchgate.net/publication/326578306_Ontology_visualization_methods_and_tools_a_survey_of_the_state_of_the_art [16 Mar 2025].
8. Faliagka, E., Iliadis, L., Karydis, I. *et al.* (2014), On-line consistent ranking on e-recruitment: seeking the truth behind a well-formed CV. *Artif Intell Rev* 42, 515–528 [online] available https://doi.org/10.1007/s10462-013-9414-y [16 Mar 2025]
9. Gălățescu, A (2001), Rolul ontologiilor într-un sistem multiagent pentru reingineria proceselor de afaceri, *Revista Română de Informatică și Automatică*, ISSN 1220-1758, vol. 11(1), pp. 42-52
10. Genesereth, M.R., Nilsson, N.J., (1987), Logical Foundations of Artificial Intelligence. Morgan Kaufmann, Los Altos, CA, 1987, PII: 0004-3702(89)90072-6 [Mar 16 2025]
11. Gruber, T. R. (1993), A Translation Approach to Portable Ontology Specifications *Knowledge Acquisition*, 5(2), 1993, pp. 199-220.
12. Gruber, T. R. (1995), Toward principles for the design of ontologies used for knowledge sharing?, International Journal of Human-Computer Studies, Volume 43, Issues 5–6, 1995, Pages 907-928, ISSN 1071-5819
13. Guarino, N., Oberle, D., Staab, S. (2009). What Is an Ontology?. In: Staab, S., Studer, R. (eds) Handbook on Ontologies. International Handbooks on Information Systems. Springer, Berlin, Heidelberg, [online] available https://doi.org/10.1007/978-3-540-92673-3_0 [16 Mar 2025]
14. Hilger, J. (2017), What is an Ontology and Why Do I Want One?, What is an Ontology and Why Do I Want One? - Enterprise Knowledge, [accessed March 2025]
15. Hoang Minh Lien Vo, Hoang Quang (2019), Transformation of UML class diagram into OWL Ontology, Journal of Information and Telecommunication, DOI: 10.1080/24751839.2019.1686681
16. https://factorfirm.com/posts/ontology-101-what-it-is-why-it-matters-and-how-to-use-it/, [20 Mar 2025]

17. https://www.internationaljournalssrg.org/IJEMS/2014/Volume1-Issue2/IJEMS-V1I2P102.pdf
18. Karaa W.B.A., Mhimdi N., (2011) "Using ontology for resume annotation," *International Journal of Metadata, Semantics and Ontologies*, vol. 6, no. 3, pp. 166–174, 2011.
19. Kessler, R., Béchet, N, Roche, M., Torres-Moreno, J-M, El-Bèze M. (2012), A hybrid approach to managing job offers and candidates, Information Processing & Management Volume 48, Issue 6, November 2012, Pages 1124-1135
20. Kogut P. (2002), UML for Ontology Development, [online], available https://www.academia.edu/53500346/UML_for_ontology_development, [22 March 2025]
21. Patil, S.B, Karane, S. (2021), Developing a Library Management Ontology Using Protege Software, (PDF) Developing a Library Management Ontology Using Protege Software [22 Mar 2025]
22. Rafter, R, Bradley, K, Smyth, B. (2000), "Automated Collaborative Filtering Applications for Online Recruitment Services," in *Adaptive Hypermedia and Adaptive Web-Based Systems*, ser. Lecture Notes in Computer Science, P. Brusilovsky, O. Stock, and C. Strapparava, Eds.Springer Berlin Heidelberg, 2000, vol. 1892, pp. 363–368.
23. Senthil Kumaran V., Int. J. Metadata (2013), Towards an automated system for intelligent screening of candidates for recruitment using ontology mapping (EXPERT), Semantics and Ontologies, Vol. 8, No. 1
24. Singh, A., Rose, C, Visweswariah, K., Chenthamarakshan, V., Kambhatla, N. (2010), "PROSPECT: a system for screening candidates for recruitment," in *Proceedings of the 19th ACM international conference on Information and knowledge management*. ACM, 2010, pp. 659–668.
25. Tănăsescu, A., Bodea, C.N., & Pătrașcu, A. (2008), An Environmental Ontology Design, *Buletinul Universității Petrol-Gaze din Ploiești*, Seria Științe Economice, *50* (5B), 181-188.
26. Tănăsescu, A. (2016), A financial reporting ontology design according to IFRS standards. Economic Insights-Trends & Challenges, 68(4), 37-44.
27. Tricot, C., Roche, C. (2006), Visualisation of Ontology: a focus and context approach
28. Uba, H. U., Abubakar, R. S., Ibrahim, M. Y. (2019), Developing Model for library Ontology Using Protégé Tool: Process, Reasoning and Visualisation, International Journal of Advanced Scientific and Technical Research, Available online on http://www.rspublication.com/ijst/index.html Issue 9 volume 6 Nov — Dec. 2019, DOI : https://dx.doi.org/10.26808/rs.st.i9v6.02
29. Zhao, G., Meersman R., (2005), Architecting Ontology for Scalability and Versatility, DOI: 10.1007/11575801_42, Conference: On the Move to Meaningful Internet Systems 2005: CoopIS, DOA, and ODBASE, OTM Confederated International Conferences, CoopIS, DOA, and ODBASE 2005, Agia Napa, Cyprus, October 31 - November 4, 2005, Proceedings, Part II
30. https://drawio.com [accessed March 2025]
31. https://protege.stanford.edu/ [accessed March 2025]