Construction of an Ontology-based Document Collection for the IT Job Offer in Morocco

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***Abstract*—Information Technology (IT) job offers are available on the web in a heterogeneous way. It is difficult for a candidate looking for an IT job to retrieve the exact information they need to locate the ideal match for their profile, without wasting time on useless searches. Traditional IT job search systems are based on simple keywords that are generally not adapted to provide detailed answers because they do not take into account semantic links. In this article, an ontology is developed to meet the expectations of IT profiles from the IT job descriptions accumulated and pre-annotated using the UBIAI tool. The classes and subclasses of the ontology are designed using the Protégé 5.5.0 editor. Then the properties of objects and data are defined to improve the ontology. The ontology results are validated using DL queries by asking a number of questions to retrieve the requested information for each IT profile, and the ontology answers all these questions adequately. Finally, various plugins are used to display an ontology in a graphical representation.**

***Keywords*—Ontology; IT job descriptions; semantic links; DL query, protégé 5.5.0**

I. INTRODUCTION

The Web has become one of the most important sources of electronically accessible information, providing a gigantic mass of information as the number of resources on the Web grows exponentially and the number of users increases daily. Unfortunately, the Web is so huge and unstructured that finding accurate and useful information has become a time-consuming task. As a result, the documents accessible via the Internet, and web pages in particular, need to be structured, and this structuring is based on a very important attribute called "semantics".

This vision of the Web of the future depends on the construction of Web resources with information that can be exploited by software agents. Research has led to the birth of the semantic web, and a whole series of new technologies and concepts.

Over the past few years, the IT sector in Morocco has undergone significant change. With the challenge of digital transformation, recruitment for digital professions is a priority for companies. There is a wide range of profiles and skills in IT, with different descriptions.

Today, access to information plays an important role in the acquisition of knowledge, and is considered an important characteristic for the user. Despite the role played by traditional systems based on simple keywords and/or semantic similarity, they are generally not well suited to providing good job descriptions, as they do not take into account the links between concepts. On the other hand, as a recent graduate looking for a first job in IT, or in search of a career change, it's not always easy to find the ideal niche, so he needs access to the best tools to help him find the position that perfectly matches his profile, without wasting time with irrelevant recommendations and manual searches.

Consequently, the search for information led to the construction of the ontology that forms an important part of the Semantic Web, which on the one hand seeks to build on models of Web documents that represent IT job offers, based on the conceptual representation of the domain concerned and, on the other, aims to enable programs to make inferences on them. Clearly, ontologies are based on vocabularies and concepts that are explicitly specified in a representation language.

The study will be applied to unstructured data representing job offers requested in Morocco in the IT sector. The approach presented starts by extracting domain knowledge from a text, then representing it in the form of OWL ontology.

This paper is organized as follows. Section II mentions the background of our research, including definitions, components applications of ontology, and steps of Ontology Development followed by the general methodology for our research and the main steps to build our ontology in Section III. After that, the steps of evaluation and analysis are described in Section IV. The main results are discussed in Section V. Finally, the conclusion is presented in a Section VI.

II. BACKGROUND

In this section, some definitions of ontology are presented, then we present some domains of ontology application, and then we will present the methodology of development of ontology.

A. Ontology Definition

In computer science, ontology is a branch of knowledge engineering that focuses on creating structured and organized representations of information that can be understood by both humans and machines. It is a formal representation of knowledge that describes concepts and relationships within a particular domain.

Many authors have proposed several definitions of this concept. Notable among these have already been, formally [1]

defines ontology as set of concepts and the relationships between them. Concepts can be divided into classes, subclasses, attributes, relationships, and instances.

On the other hand, [2] presented the ontology as formalized and structured representation Co-conceptualized concepts and relationships. More precisely, it can be defined as a concept, the relationships, attributes, and hierarchies that exist in the domain.

In the context of computer systems, [3] declared that an ontology is a clear, structured description of common concepts. Ontologies include vocabularies and explanations of the relationships between classes.

Another effort is made to define an ontology was proposed by [4]. The authors consider it like a data modeling technique for structured data repository premised on collection of concepts with their semantic relationships and constraints on domain.

These definitions provide a range of perspectives on the concept of ontology in informatics and emphasize its role as a formal representation of shared conceptualizations and knowledge structures within a given domain.

B. Ontology Components

The components of ontology can vary depending on the specific approach and context; the essential elements of the ontology are presented as follows:

1) Concepts or classes: Concepts represent the entities or categories in a domain. They can be hierarchically organized, forming a taxonomy or a class hierarchy. Concepts capture the essence of the domain and serve as the building blocks of an ontology.

2) Properties or attributes: Properties define the characteristics, features, or attributes of concepts. They describe the relationships, roles, or qualities associated with concepts. Properties can be classified as object properties (defining relationships between concepts) or data properties (defining attributes with specific values).

3) Relations or relationships: Relations represent the connections and associations between concepts. They define how concepts are related to each other within the ontology. Relations can be symmetric, asymmetric, transitive, or other types depending on the nature of the relationship.

4) Instances or individuals: Instances represent specific instances or examples of concepts within a domain. They represent concrete objects or entities that belong to a particular class or concept in the ontology. Instances provide specific data or real-world examples to populate the ontology.

5) Axioms or constraints: Axioms capture the logical rules, constraints, or assertions about the concepts, properties, and relationships in the ontology. They define the semantics and rules that govern the relationships between different components in the ontology.

6) Annotations or metadata: Annotations provide additional descriptive information about the components of the ontology. They can include labels, definitions, synonyms, examples, and other metadata that enhance the understanding and usability of the ontology.

These components collectively form the structure and knowledge representation in an ontology. They enable the formal representation of domain-specific knowledge, relationships, and semantics. The specific representation and organization of these components can vary depending on the ontology language or framework used, as well as the requirements of the specific domain and application.

C. Ontology Application

Ontology finds applications in various domains. An overview of different domains is provided (Fig. 1), where ontology has been applied. For example, in the field of education, ontology is applied to learning analytics [10] and curriculum design [11], in the healthcare domain, it is used for clinical guideline [12], data integration [13] and data patient [14], also in the energy and environment domain, it has been applied to energy management [15], and smart grids [16]. Ontology development is also being applied in the agricultural domain, for example to precision agriculture [17], and pest control [18]. Some common domains of ontology application as follow:

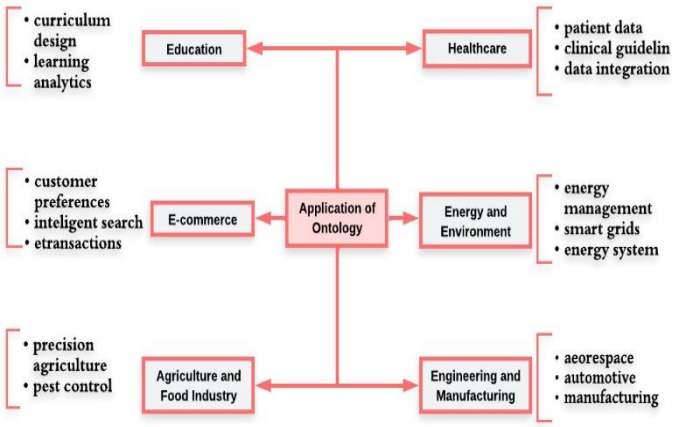

Fig. 1. Application domains for ontologies.

These are just a few examples of the diverse domains where ontologies have been applied. Ontology's versatility allows it to be utilized in various fields to enable knowledge representation, data integration, semantic interoperability, and intelligent systems.

D. Ontology Development

On the one hand, several methods have been developed to design ontologies either from scratch or by reusing existing ontologies. The process of building an ontology is similar to a commercial rather than a technical task [4]. Each design team or group can follow its own guidelines and decide which criteria and stages to work on and which can be skipped. Of course, this will depend on the scale of the ontology we intend to build." Systematic review on ontology applications in virtual reality training domain: design components, roles, and research directions ».

On the other hand, this involves defining a domain of interest, determining concepts and relationships within that

domain, and formalizing the knowledge representation using ontology tools and languages. Here are the main steps involved in developing an ontology:

Identify the Domain: Specifies the domain or domain on which the ontology is built. Clearly define the scope and boundaries of the ontology.

1) Knowledge gathering: Collect and analyze existing resources, such as domain-specific documents, databases, and sources, to understand concepts and relationships within the domain.

2) Conceptualization and modeling: Create a conceptual model that captures key concepts, their relationships, and the overall structure of the ontology. This can be done using graphical tools, such as UML diagrams or ORM, to visualize the conceptual model.

3) Define classes and properties: Define the classes (concepts) that represent the entities within the domain. Specify the properties (attributes) that describe the characteristics and relationships of the entities.

4) Establish relationships: Define relationships between classes using attributes.

5) Formalize the ontology: Use an ontological language, such as RDF or OWL, to formally represent concepts, attributes, and relationships in an ontology. Apply language structures and syntax to create machine-readable representations.

6) Validate and evaluate: Evaluate the quality and effectiveness of the developed ontology.

Ontology development is an iterative and collaborative process involving domain experts, ontologists and other stakeholders. It requires a combination of domain expertise, ontology engineering skills, and knowledge representation techniques.

III. Proposed Solution

A. Ontology Building Methodology

Fig. 2 shows the general methodology for the research, which consists of main steps to build our ontology as follows:

- Collect Data (IT Job Document): the systematic approach of bringing together and measuring information from a variety of sources to obtain a complete and accurate view of the area of interest.
- Data Annotation: is the process of attributing, tagging or labeling data to help algorithms understand and classify the information they process.
- Ontology Data Modeling: the process of graphically representing data flows.
- Construct IT Job Ontology: representing general properties of what exists in a formalism that supports rational processing.
- Evaluation and Analysis: arriving at a conclusion with in-depth study of the ontology to better understand the information being presented.

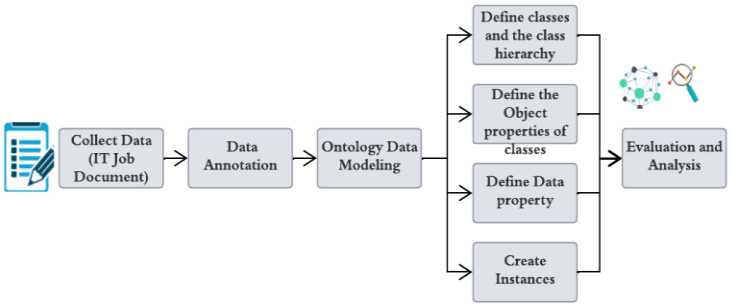

Fig. 2. Ontology construction methodology.

Each step has a well-defined role and each is essential for the success of the work, the following section is devoted to detailing each phase.

B. Data Gathering

The data used in our work consists of collecting 150 job descriptions requested in Morocco, related to the information technology (IT) sector from several job websites such as (Rekrute, indeed, Linkedin...). The data was stored in text files with the description as shown in Fig. 3.

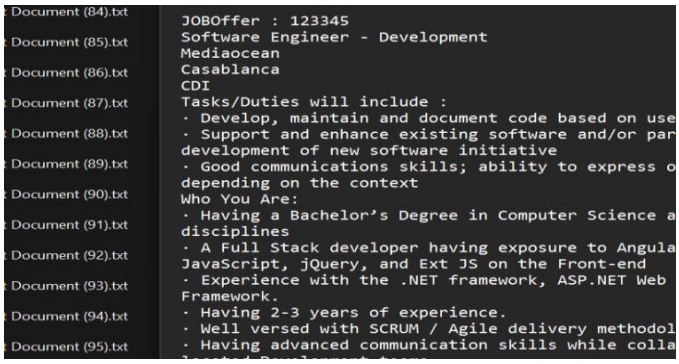

Fig. 3. An overview of the job offer description.

The scrapping of job offers in the IT field is done manually, to study and deepen our knowledge of the IT field in Morocco, and extract the information needed to develop our ontology, such as profile, company, location, responsibilities or missions, soft skills, IT skills, diploma, training, and experience...

In this study, the UBIAI annotation tool is used because it saves us a lot of time and will help us minimize manual annotation. It also offers extensive features such as dictionary-based auto-annotation, regular expressions, and rules Team collaboration to share annotation tasks Direct export of annotations.

UBIAI is an Oregon based startup that provides cloud-based solutions and services in the field of Natural Language Processing (NLP), to help users extract actionable insights from unstructured documents. It can annotate any type of document whether it's PDF, images, or text. Also, it can train machine learning models and train state-of-the-art deep learning models on annotated datasets like Named Entity Recognition, Relation, and Extraction Document Classification, with few clicks and save up to 80% of annotation time.

We proceeded by annotating texts while identifying key entities such as (profile, company, location, responsibilities, skills, diploma, training, experience...) and the relationships between these entities as shown in Fig. 4.

Fig. 4. An overview of the annotation sheet for the job offer.

After extracting the entities from the job descriptions and building the database, we first need to know how they are distributed.

In Fig. 5, the distribution is non-homogeneous for the entities with 1190 data for the IT Skills entity, and 1098 data for the Responsibility entity. These two entities represent the largest distributions in the diagram compared to the other annotated entities, which means that in the field of IT job offers, we focus more on the IT skills and responsibilities required.

C. Ontology Data Modeling

Before starting to build an ontology, the ontology modeling phase is very important, as it provides us with a conceptual map and a clear and correct vision of the work to be carried out. It's easier to represent concepts graphically than to represent them in a serialized (Resource Description Framework)/ (Extensible Markup Language) format. This is why we have chosen to represent concepts using object-role modeling (ORM). The early 1970s saw the emergence of ORM, a semantic modeling methodology that distinctly interprets the world in terms of objects fulfilling roles [5].

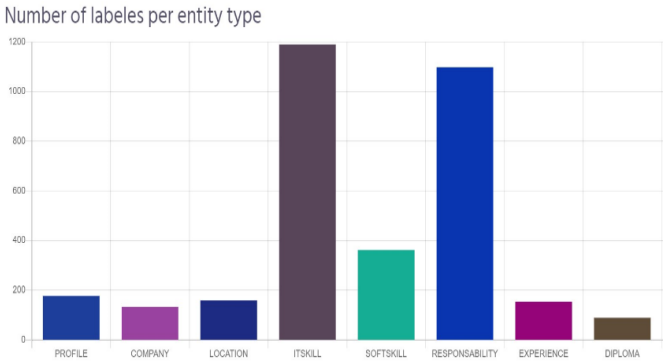

Fig. 5. Distribution of the labels per entity type.

In this section, we will conceptualize our data model for the ontology to be developed. This model seeks to examine the interactions [9] between descriptive components of job offers. In order to accomplish the goals of our application, the model represents several sorts of entities along with their attributes and relationships among them.

The schema for the data model is displayed in the following Fig. 6 and Table I.

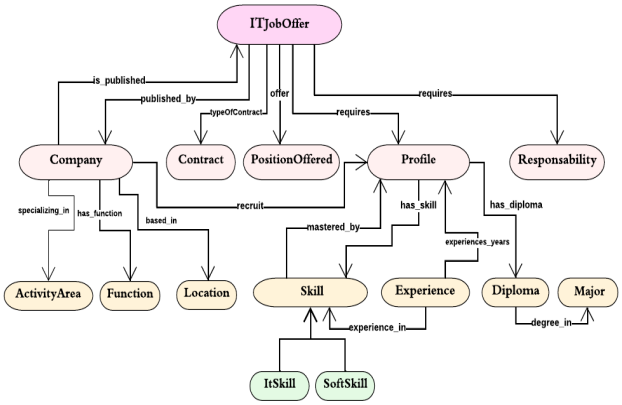

Fig. 6. Conceptual model of IT Job offer ontology.

TABLE I. DESCRIPTION FOR NODE AND IT'S ATTRIBUTES

Node	Node Description	Attribute	Attribute Description
IT JobOffer	The IT job offer launched by the company	Id	A unique identification of the node.
		name	The name of the IT job offers
PositionOffred	The position offered by the IT Job Offer	id	A unique identification of the node.
		name	The name of the position offered
Company	the name of the company posting the job offer	Activity Area	the business sector of the company
		Function	the functions performed by the company
		Location	Location of the company that posted the offer
		id	A unique identification of the node.
Profile	The type of candidate concerned by the IT job offer	Id	A unique identification of the node.
		Profile	IT profile name
Skill	The required knowledge and competencies for entry into the position.	id	A unique identification of the node.
		Soft Skill	The skills that enable the candidate to fit in at a workplace. They include personality, communication, attitude, flexibility, and motivation.
		IT Skill	Also known as technical skill or hard skill which are directly relevant to the job to which the candidate applying.

Responsibility	The task and the responsibility that must perform the candidate.	id	A unique identification of the node.
		name	The name of task and responsibility required
Diploma	The diploma qualification that a candidate must possess to satisfactorily perform the job duties and responsibilities.	id	A unique identification of the node.
		name	the name of the diploma obtained by the candidate
Formation	The formation associated to the required diploma.	id	A unique identification of the node.
		name	The name of formation.
Experience	The experience required in a specific skill.	id	A unique identification of the node.
		experience	The number of years' experience or experience required.
Contract	the type of contract offered by the company	type	The type of contract
		id	A unique identification of the node.

D. Ontology Construction

The ontology development process is complex. This is why it is necessary to use a method or methodology to support the ontology construction process. This is why the method used is to design ontologies from scratch using conceptual data models.

To develop our ontology, it is important to choose an appropriate ontology editor. The Protégé editor was chosen, as it has established itself over the last 20 years as one of the best tools for ontology creation and information presentation [6].

Protégé is widely considered one of the most popular and widely used ontology development tools for several reasons: It's an open source and free, it has a large and active user community, including developers and domain experts, it offers a user-friendly interface and intuitive features, it can handle complex ontologies and is extendable through plugins. Protégé allows users to collaborate on ontology development projects by supporting multiple users working on the same ontology simultaneously.

This is the main step in the development process. To design the class hierarchy, we need to refer to the list of terms in Table I and choose the most appropriate concepts to represent superclasses and subclasses. As a result, 26 classes are described in total, as seen in Fig. 7.

The ITJobOffer Class is the mother class of all classes included five main sub classes that included: Company (Activity_Area, Functions and Location), Contract, Position_offered, Required_profile (Diploma, Experience, Major Skills), Required_Responsabilities.

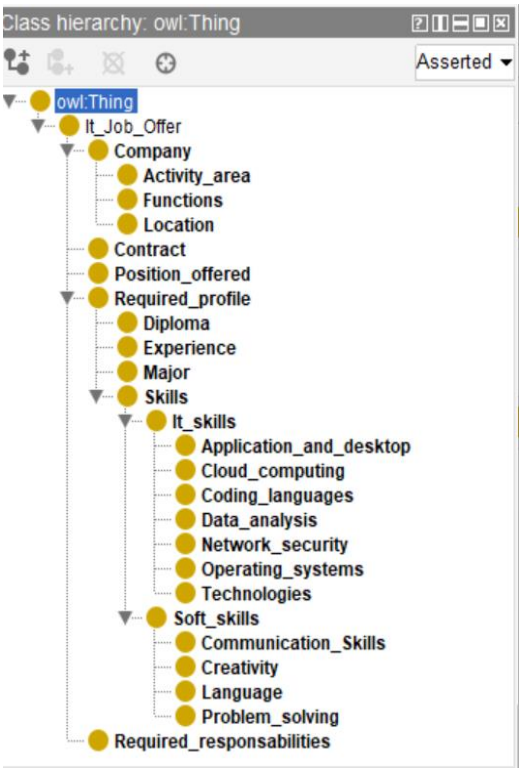

Fig. 7. Ontology class hierarchy.

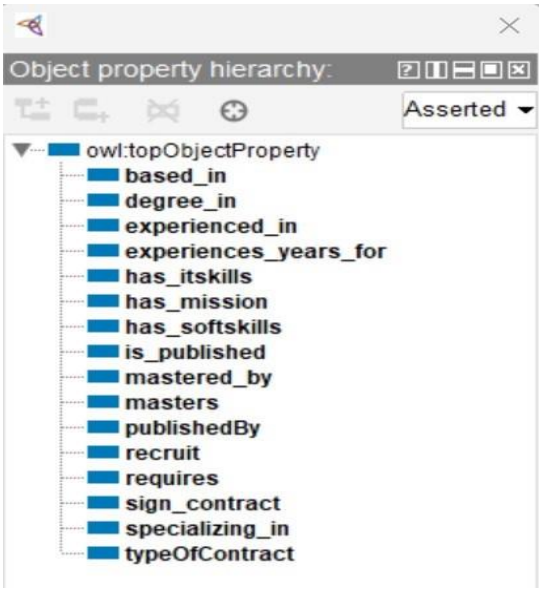

Fig. 8. Object property hierarchy.

Fig. 8 shows the object property hierarchy that represents the relationships between classes. For example, "masters" and "mastered_by" are two inverted object properties that describe the relationship between the "required_profile" and "skills" classes. The intention of this phase is to establish connections between classes that enable the ontology to answer our questions.

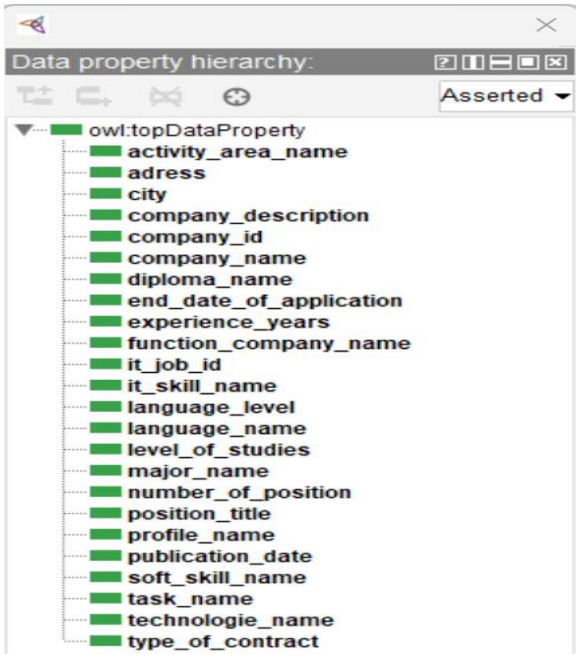

Fig. 9. Data property hierarchy.

On the other hand, Fig. 9 shows the data properties that describe the information relating to each individual, for example "company_description", "company_name", "function_company" are used to define instances of the class “Company”.

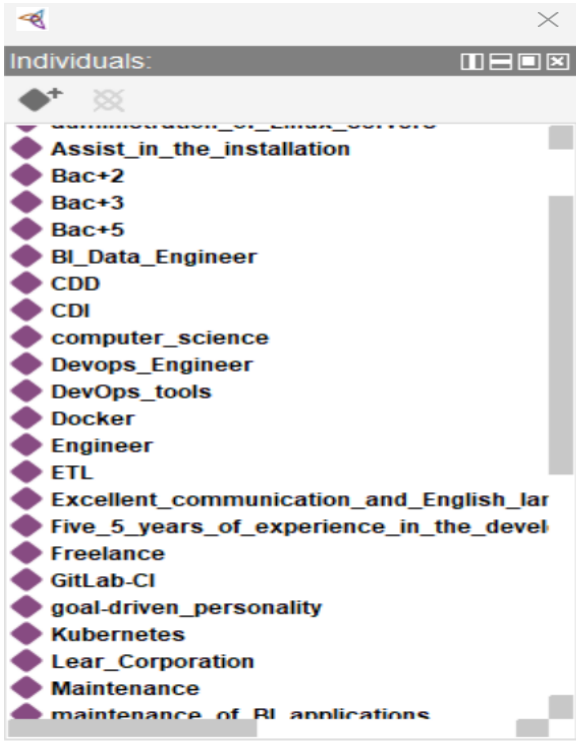

Fig. 10. Individuals.

Fig. 10 summarizes some of the individuals created based on our collected database. For example, for the "soft_skills" subclass, we have described differents values that a "BI_DATA_Engineering" profile must master:

"Strong_analytical","Team_work","Communication_skill”.

This step is used to create instances after completing the ontology model, describing the instances or individuals, which involve assigning a unique name to each individual after specifying the class to which it belongs and defining the values of these attributes (data properties).

IV. Evaluation and Analysis

A. DL Queries

The evaluation and analysis steps are a critical one, where we have to make queries to find answers to our research questions and evaluate our ontology.

We used the DL query tab, available in the protected 5.5.0 software, to enter queries and launch the reasoner before executing the DL queries. The structure of the ontology is validated using the HermiT reasoner [19], which is used to check the consistency and coherence of a model and to verify and evaluate the ontology's correct functioning. This allows us to answer the questions: "Is the world of IT offers well represented by Ontology? and "Are IT profiles satisfied with the answers to their questions?

The result shows direct classes, subclasses, superclasses and instances. DL queries can be added to the ontology to extract more precise information.

Some examples of DL queries and their results are shown below with results answering a set of questions:

- What are the different soft skills mastered by the "BI Data Engineering" profile? (Fig. 11)
- What are the different IT skills mastered by the "Devops engineering" profile? (Fig. 12)
- What are the different skills that must master the "BI Data Engineering" profile? (Fig. 13)
- What are the companies that recruit the BI Data engineering profile, also the experience and skills required for this candidate? (Fig. 14)

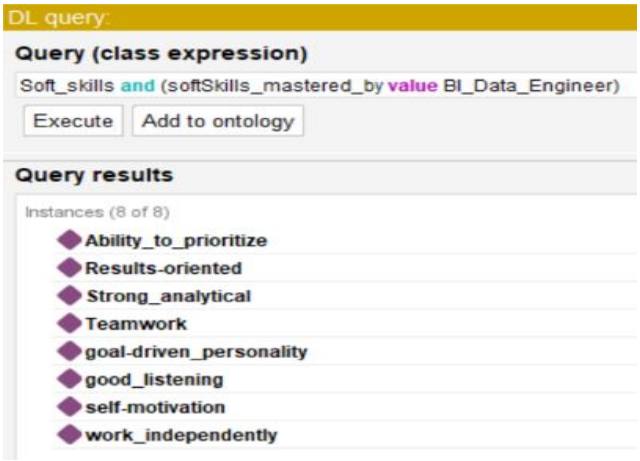

Fig. 11. Query 1.

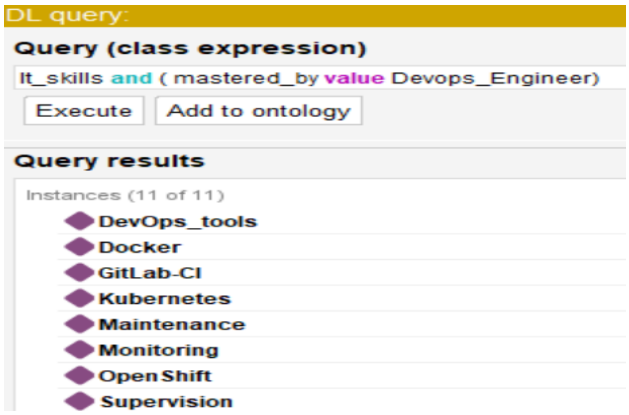

Fig. 12. Query 2.

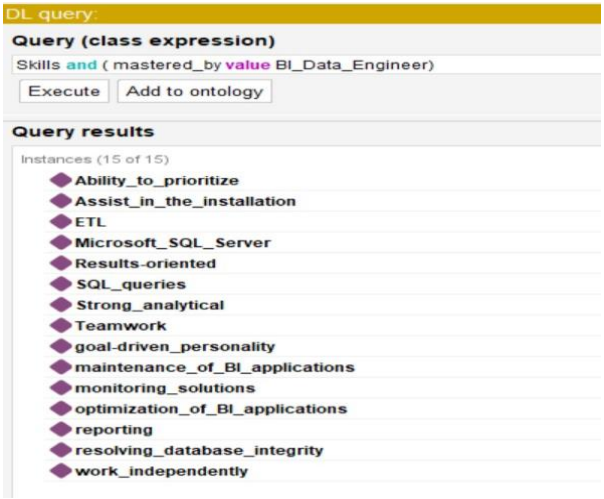

Fig. 13. Query 3.

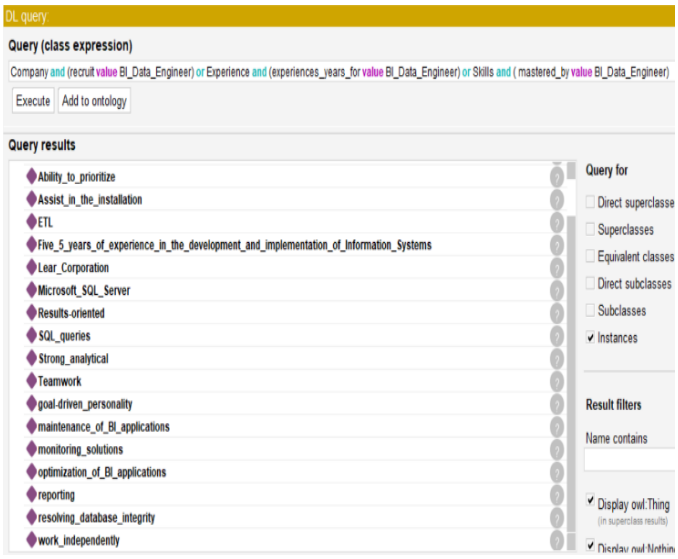

Fig. 14. Query 4.

V. Results and Discussion

Several individuals created for the "requested_profile" class. Fig. 15 shows a sample of individuals in the IT jobs ontology after representation in OWL, this profile named "profile_2" belongs to the Devops engineering sector, has IT skills (maintenance, administration of linux servers and storage) , soft skills (Good communication , teamWork) experienced in (automation , script language and Devops Tools) and has a Bac +5 diploma.

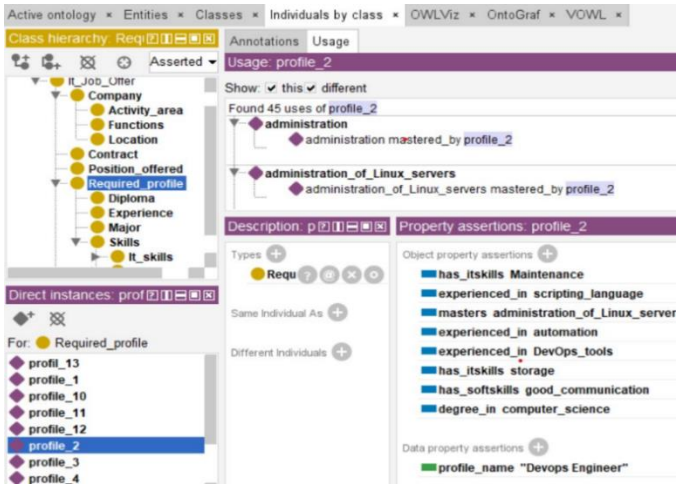

Fig. 15. Sample of individuals in IT Job offer ontology after supported in protégé.

In Fig. 16, we visualize the structure of the ontology of the IT job offer using the OntoGraf tab of the Protégé editor. The elements of this structure are automatically organized, and the different relations are supported: subclass, individual, domain/range, object properties and equivalence [7].

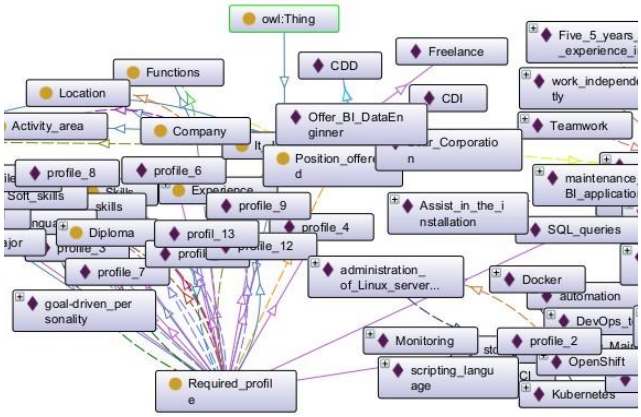

Fig. 16. Overview of Ontograf visualization for IT Job offer ontology.

Using the OWLVIZ tab in protected, we generated a visual representation of the IT job posting ontology shown in Fig. 17, but we installed GraphViz before working on this tab.

To validate our ontology, there are a number of plugins available in our Protégé editor [8]. One of these plugins is named VOWL, which offers a graphical representation of an ontology layout. To use this tool, we download the JAR file and then copy it to the appropriate plugin folder. then you must activate the Protected VOWL plugin via the Window → Tabs → VOWL option. For example, Fig. 18 displays a VOWL visualization of the IT job offer ontology, illustrating a graphical overview of the job.

Fig. 17. Ontoviz visualization for IT Job offer ontology.

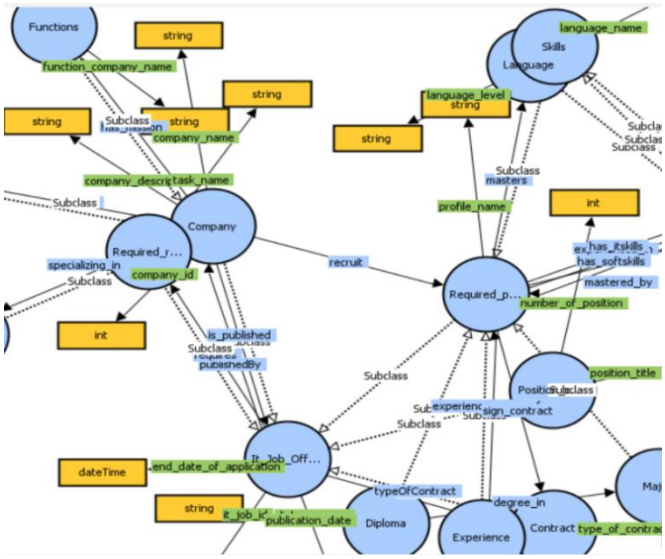

Fig. 18. Overview of VOWL visualization for IT job offer ontology.

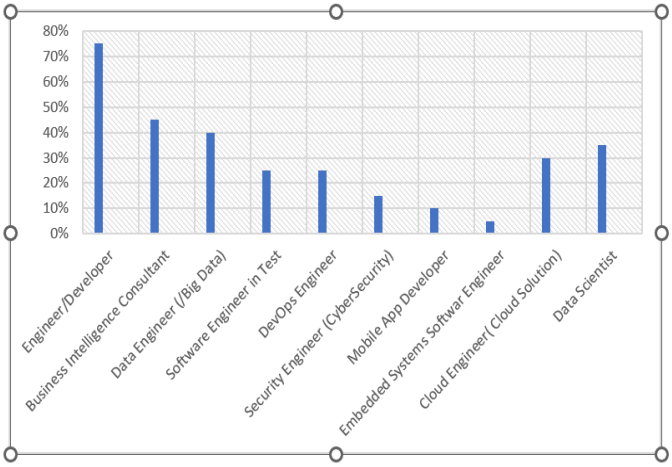

Fig. 19. Diagram of the percentage of the most requested IT profiles in Morocco.

The data analysis software used in this case study is Microsoft Excel, which is perfectly useful for data analysis thanks to simple and practical operations, to present, and to interpret from spreadsheets, a multitude of data.

Referring to the accumulated and annotated data, Fig. 19 shows that the largest share of profiles in demand in the IT sector in the year 2023, is for IT engineers and developers, accounting for almost 75% of the recruitment market for IT profiles in Morocco, followed by Business Intelligence and Data engineering profiles, while the IT security sector accounts for only 15% of the demand in Morocco.

In order to obtain an in-depth comparison, it is essential to generate additional SPARQL queries that provide numerical results to assess the accuracy of the evaluation procedure. This will enable a more representation of the main result. SPARQL is a standard query language and protocol for Linked Open Data and RDF databases. It is designed to query a variety of data, it can effectively extract information hidden in different data stored in different formats and sources).

To this end, we have queried our developed ontology to count the number of profiles most in demand in the Moroccan IT job market, comparing it with the first result found in Fig. 20, the ontology answered the question well.

SPARQL query:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdfs: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.semanticweb.org/user/ontologies/2023/3/untitled-ontology-7>
SELECT? Requested_profile (count (?It_job_offer) as ?Number_of_ItJobOffers)
        WHERE { ?It_job_offer dss:requires? Requested_profile.
                ?Company dss:recruit ?Requested_profile.
              }
ORDER BY ?Requested_profile
```

Requested_profile	Number of ItJobOffers
Software Engineer	"45" ^^<http://www.w3.org/2001/XMLSchema#integer>
Business Intel igence Engineer	"30" ^^<http://www.w3.org/2001/XMLSchema#integer>
Data Engineer	"25" ^^<http://www.w3.org/2001/XMLSchema#integer>

Fig. 20. Counting of requested profiles in IT job offers in on Protégé.

Ontology evolution is an important aspect of the Semantic Web and knowledge representation, constantly evolving to meet the changing needs of various industries, including IT. Several potential new features in ontology development for IT Recruitment enable efficient integration of data from various online sources to provide a holistic view of information and form knowledge graphs that support advanced analysis.

VI. CONCLUSION

In this article, we propose an analysis of the problem related to the Information Retrieval domain and those specific to the IT sector. As the web is a very extensive data resource, data accumulation and knowledge extraction is the first step in our system, consisting of extracting keywords according to their semantic weights and domain values. Our contributions focus on the crucial step of conceptualizing the accumulated textual documents into concepts and relationships. This work proposes the process for building an ontology that semantically demonstrates the job offers requested in the IT sector in Morocco. The use of semantic technology can help IT profiles

to find the job that perfectly matches their profile by answering their questions in a relevant way.

We intend to extend this research in the future by incorporating an educational application based on the constructed ontology, as well as applying machine learning algorithms for the extraction of named entities and the relationships between them.

ACKNOWLEDGMENT

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