A Proposed Ontology-Based Sociocultural Context Model

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Abstract: The global business landscape, including the handicraft sector in the Maghreb region, has witnessed a significant transformation with the emergence of Information and Communication Technologies (ICT). To adapt to this evolving landscape, many businesses have made the strategic shift to online operations, capitalizing on the vast opportunities offered by ICT. By establishing a strong online presence through e-commerce platforms and social media, handicraft businesses can expand their customer reach and tap into a broader market. However, the adoption of ICT remains a formidable challenge for handicraft women. This challenge stems from multiple factors such as poverty, gender disparities, language barriers, and limited literacy. To address these obstacles and provide personalized services with relevant information, a context ontology integrating socio-cultural aspects is proposed. This ontology serves as a comprehensive framework, capturing the socio-cultural nuances of the handicraft sector. By leveraging this ontology, tailored ICT solutions can be developed, taking into account the socio-cultural challenges faced by these women. This approach allows for the provision of personalized services that align with their specific requirements, fostering the effective adoption of ICTs and empowering handicraft women in the Maghreb region to thrive in the digital age.

1 INTRODUCTION

The rapid changes in Information and Communication Technologies (ICTs) have profoundly impacted the global landscape, reshaping how people live, work, and communicate. ICTs have become indispensable tools for running competitive businesses, presenting new opportunities for handicraft women to start and expand their ventures. Through various forms of ICTs, both traditional and emerging, handicraft women are able to connect with customers, increase efficiency, and grow their businesses in ways that were previously inaccessible to them (UNCTAD, 2013) (Women, 2017).

However, the adoption of ICTs remains a significant challenge for handicraft women from emerging countries. This challenge can be attributed to a range of factors, including poverty, gender inequality, language barriers, limited literacy levels, and sociocultural factors. These barriers impede women's access to and effective use of ICT tools and resources, limiting their ability to fully harness the benefits of digital technologies(UNCTAD, 2013).

Simultaneously, technological advancements have revolutionized the way users interact with digital systems and devices. Traditional computing approaches have focused on processing data and providing static solutions. However, the emergence of context-aware computing has brought about a paradigm shift. Context-aware computing enables systems to dynamically adapt and respond to users' contextual information, creating personalized and adaptive functionalities.

The fundamental concept behind context-aware computing is recognizing that users' needs and preferences can vary depending on the specific context in which they are interacting with a system. By integrating contextual information, systems can offer tailored experiences, improving intuitiveness, efficiency, and responsiveness to users' requirements.

In this context, context-aware computing holds the potential to address some of the challenges faced by handicraft women in adopting ICTs. By considering the specific contextual factors that influence women's engagement with ICTs, such as their sociocultural background, language preferences, and literacy levels, context-aware systems can provide more inclusive and customized solutions. This can help bridge

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the digital divide and empower handicraft women in emerging countries to effectively leverage ICTs for their entrepreneurial pursuits.

This research is founded on a project that investigates how women engaged in handicrafts in developing or emerging regions employ modern technologies to foster both their creativity and business initiatives. The objective of this research is to introduce a personalized framework based on ontology, facilitating both training and organizational solutions tailored for handicraft women. This approach takes into account the incorporation of social and cultural aspects within the context model, which constitutes the primary focus of this paper.

The subsequent sections of this paper are structured as follows. Section 2 presents a review of existing research and studies that have explored ontology-based context models. Section 3 outlines the ontology development process employed in this study. Section 4 describes the elements proposed in the ontology. Section 5 concentrates on the validation phase. Finally, section 6 summarizes the conclusions and suggests directions for future research.

2 RELATED WORK

In the past few years, numerous research endeavors have been dedicated to the development of context ontologies. However, there is currently no universally accepted model that can be readily applied for context knowledge representation across various applications.

Among the early works, the CoDAMos ontology (Aguilar et al., 2018) emerges, encompassing four primary entities: user, environment, platform, and service. Another notable example is the CONON (CONtext ONtology) (Wang et al., 2004), which employs logical reasoning to deduce implicit and explicit context within pervasive computing environments. It incorporates fundamental concepts like person, activity, computational entity, and location, which can be extended by incorporating domain-specific concepts.

The SOUPA ontology (Chen et al., 2004) serves to model context for pervasive computing environments, comprising the SOUPA Core, which defines general terms applicable to different pervasive computing applications, and the SOUPA extensions, which introduce additional concepts to support specific application types.

CAMeOnto (Aguilar et al., 2018) is an ontology that captures generic concepts at a higher level by facilitating the hierarchical extension of specific contextual information. It is utilized by the context-aware reflective middleware called CARMiCLOC and is designed based on the 5W principles: who, when, what, where, and why. Additionally, the CAMeOnto consists of six contextual classes: user, activity, time, device, services, and location.

(Yin et al., 2015) introduced an alternative study that suggests a hierarchical model for context, focusing on the features of work-based learning. This model includes a shared layer with a common ontology and a domain-specific layer containing a generalized ontology for work-based learning and a specific ontology for work-related contexts.

Another approach presented in (Ouissem et al., 2021) is a generic context model based on ontology for ubiquitous learning. The model provides a framework for representing and managing context information in a way that supports adaptive and personalized learning experiences in ubiquitous learning environments.

In (Cabrera et al., 2019), the 3LConOnt represents a three-level model comprising an upper-level ontology representing the highest abstract level, a middle-level ontology consisting of reusable modules adaptable within the same level, and with the upper and lower-level ontologies, and a lower-level ontology that characterizes domain-specific classes and properties.

While these research works primarily focus on modeling context of a physical nature, such as location, time, and activity, there have been limited efforts in investigating socio-cultural contexts, including educational level and emancipation level. Some endeavors (Chen and Kotz, 2000), (Dey, 2001) have attempted to adopt and extend the Friend of a Friend (FOAF) (Perera et al., 2013) ontology to represent social relationships. Other works (Kabir et al., 2014) have established effective social information management platforms and proposed the SCOnto ontology, which defines general concepts like social role, social relationship, social interaction, and social situation, and extends these concepts to incorporate domain-specific elements.

3 THE ONTOLOGY DEVELOPMENT PROCESS

The process undertaken in this paper to build the ontology involved two main stages: the knowledge acquisition stage, and the ontology construction stage.

3.1 Knowledge Acquisition

In the knowledge acquisition stage, the essential information for constructing the ontology was obtained

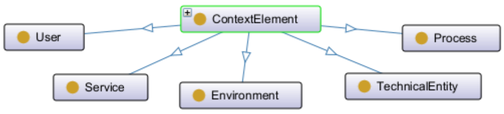

Figure 1: The Upper Ontology.

from a variety of credible sources, including domain experts' opinions such as sociologists and association members, recent literature and guidelines, as well as interviews conducted with 77 handicraft women of diverse backgrounds coming from both rural and urban areas. These interviews mainly center around socio-demographic data, craft production nature, production process, coordination and communication tools used, and implicit needs.

3.2 Ontology Construction

In the realm of ontology design, various research groups have endeavored to facilitate the process of ontology engineering leading to the proposal of different methodologies (Fernández-López et al., 1997; De Nicola et al., 2009; Staab et al., 2001), all considering essentially the following steps:

3.2.1 Specification Phase

This phase states the scope and the purpose of building the ontology. The main objective of the proposed ontology is to introduce context-awareness concepts that can effectively address pervasive environments. These pervasive environments encompass various parameters such as location, service, environment, and others, as depicted in the upper ontology illustrated in Figure 1. Moreover, the ontology aims to integrate the socio-cultural characteristics that are crucial in shaping individual behaviors within this context.

3.2.2 Conceptualization

This step identifies and defines the key concepts and entities within the domain. Determine the relationships between these concepts, such as hierarchies, associations, attributes, and dependencies by establishing a structured representation of the domain knowledge. An excerpt of the concept glossary is depicted in Table 1.

3.2.3 Formalization

This phase transforms the outcome of the previous action into a formalized model using a suitable ontology language. In the present study, the OWL language (Web Ontology Language) is employed for this purpose. OWL is a widely used ontology language that provides expressive capabilities for representing knowledge and defining relationships between entities in a structured manner.

Table 1: Excerpt of the concept glossary.

Concept	Description
ContextElement	The main concept representing the entry point to the model
User	end-user, participant, performer, etc.
TechnicalEntity	Technical concepts such as device, bandwidth, etc.
Environment	Presentes the surrounding environment that can be physical (weather, temperature, etc.) or socioProfessional
SocioProfessional Environment	presentes socioprofessional relationships
SocioCulturalProfile	User's sociocultural profile
GossipImpact	Numerical value indicating the degree of influence that gossip has on individuals
EmancipationLevel	Numerical value indicating the degree of liberation from sociocultural constraints
Languages	Natural languages used by the user
Religion	User's religion (Muslim, Christian, etc.)
ICTUsage	Modality of ICT used by the user
Location	Indicates the user's position
MaritalSituation	Can take the values: married, single, divorced, widow

3.2.4 Implementation

The implementation phase of ontology development requires the use of a suitable tool that facilitates ontology modeling, editing, visualization, and reasoning. In this paper, the Protégé[1] framework is used. Protégé provides a comprehensive set of features and functionalities that aid in the development and management of ontologies. It offers a user-friendly interface, support for various ontology languages, integration with reasoners, and visualization tools, making it an ideal choice for implementing ontologies in this

[1] https://protege.stanford.edu/

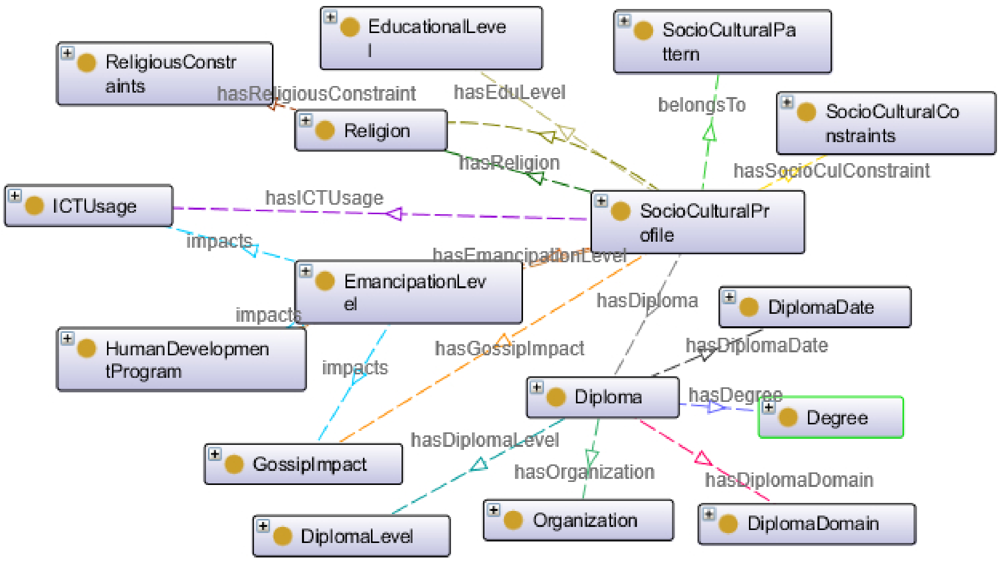

Figure 2: The Socio-cultural Profile Ontology.

research.

3.2.5 Validation

Validate the ontology is the step to ensure its correctness, completeness, and adherence to the intended design. Conduct tests and evaluate the ontology against predefined criteria to identify any inconsistencies, ambiguities, or errors that need to be addressed.

4 ONTOLOGY DESCRIPTION

4.1 The Upper Ontology

The generic ontology illustrated in Figure 1 is an upper-level ontology that captures the fundamental contextual entities found universally in all pervasive environments. Context can be classified into five main categories namely User (user profile, socio-cultural background, skills), Environment (physical, computational), Process (activity, business process, learning process), service (computing services, social services), and TechnicalEnity (Device, Software, etc.).

4.2 User Ontology

This ontology refers to an individual who interacts with a system, application, or environment. It represents the entity that utilizes and engages with the functionalities, services, and resources provided by the system. In this ontology, the user concept captures various attributes and characteristics of the user that are relevant to the system or application being considered. It covers the personal profile, socio-cultural profile, and socio-professional profile.

- Personal profile: specifies the personal information about a user, demographic information, hobbies, preferences, handicaps, disabilities, and personality traits.
- User profile: describes the information needed to use the system such as login and password, etc.
- Learner profile: covers the information related to a learner such as learning aims, learner's level, learning preferences, etc.
- Socio-cultural profile: describes the user's cultural background such as emancipation level, gossip impact, etc.
- Business profile: consists of the user's job information, skills, diplomas, etc.

Figure 2 and Figure 3 present an excerpt of the sociocultural profile ontology and business profile ontology respectively.

4.3 Environment Ontology

The environment constantly provides information that enables users to make suitable decisions or has the potential to impact their behaviors. In the proposed model, the environment ontology is composed of two main components:

- The physical environment: which describes the physical conditions and the ambient parameters such as weather, temperature, location, time, etc.

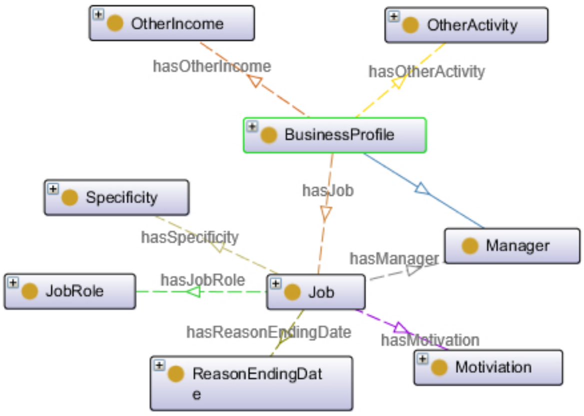

Figure 3: The Business Profile Ontology.

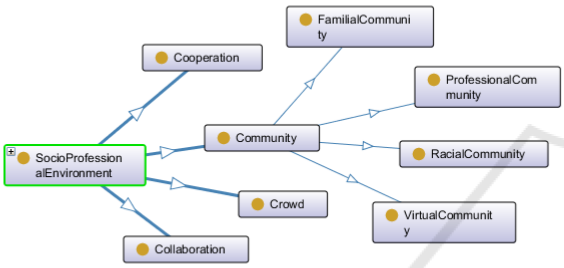

Figure 4: The Socio-professional Environment Ontology.

- The socio-professional environment: illustrated in Figure 4, shows the different socio-professional relationships between users and their role in various existing communities such as professional communities, and social communities.

4.4 Technical Ontology

The technical ontology shown in Figure 5 describes information about the device used, equipment, sensors, software, and computational parameters.

4.5 Process Ontology

The process ontology provides a description of the main elements of a process. A process is composed of some activities which are decomposed into tasks. A transition describes the passage from one activity to another under certain conditions. The Resources concept describes tools and materials used to accomplish a specific task. The business process ontology describes the main steps to complete a specific work in the handicraft domain such as making carpet, making pastry, and making pottery. Figure 6 present an excerpt of the business ontology.

4.6 Service Ontology

The service ontology models information about computational services and socio-professional related services.

- A computational service is a functionality that can be consumed by users, applications, or other services In this work we adopt the OWL-S (Martin et al., 2004) ontology which gives information about service providers with a set of classes describing services' characteristics by specifying the service functionalities (service model), service description (service profile), and access details (service grounding), for example: order service, delivery service, and e-payment service. The Figure 7 shows an excerpt of this ontology.
- A socio-professional services presented in Figure 8, specify human-related services that help the users manage a a specific part of their business, for example, the financial helps provided by the government or associations, the training services offered to help the handicraft woman learn new methods or to use new tools.

5 VALIDATION

The validation step in the ontology development process is a crucial stage that aims to ensure the quality, correctness, and reliability of the ontology. It involves conducting various tests and assessments to evaluate the ontology against predefined criteria and requirements. In this paper, two main strategies are applied: consistency checking, and rule-based reasoning.

5.1 Consistency Checking

This strategy involves conducting consistency checking, which verifies the logical coherence of the ontology by examining the defined relationships and axioms. Its purpose is to ensure that there are no contradictory or inconsistent elements in the ontology's logical structure. To accomplish this, the Pellet reasoner is used (Sirin et al., 2007). Figure 9 shows that the ontology did not produce any misinterpretations when the reasoner was active. In this figure, the whole ontology consists of 2071 Axioms, 186 classes, 134 object properties, 36 data properties, and 507 individuals.

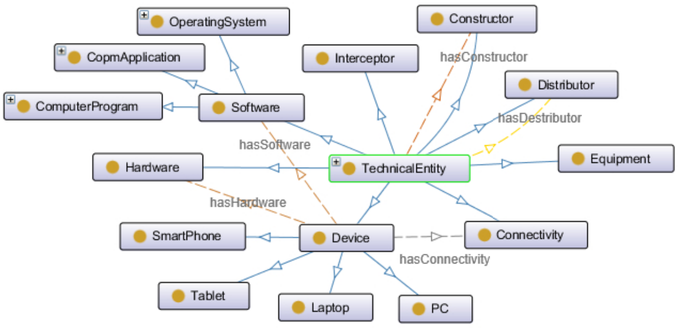

Figure 5: The Technical Concept Ontology.

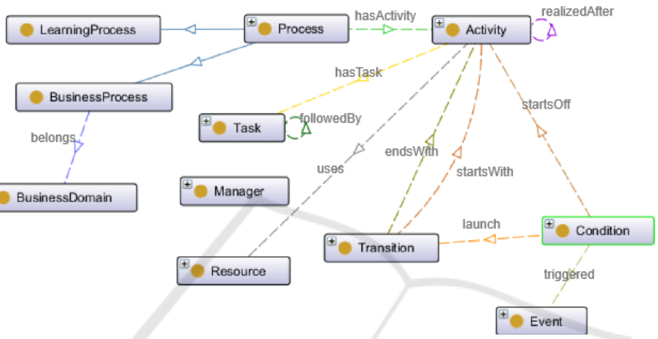

Figure 6: The Process Ontology.

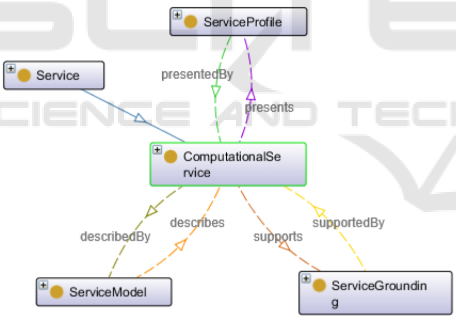

Figure 7: The Computational Service Ontology.

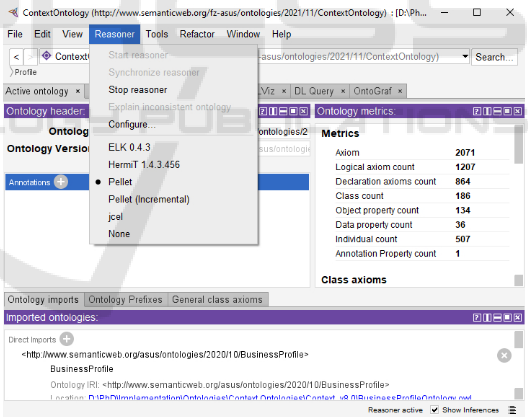

Figure 9: Consistency checking and ontology metrics.

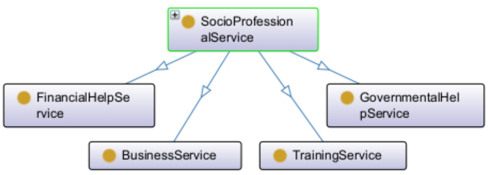

Figure 8: The Socio-professional Service Ontology.

5.2 Rule-Based Reasoning

Rule-based reasoning is a form of logical inference or deduction that uses a set of predefined rules to draw conclusions from given facts or assertions. It involves applying logical rules or condition-action pairs to derive new knowledge or make logical deductions based on the available information. Semantic web Rule Language is an important formalism for expressing knowledge in the form of rules. SWRL is used to define inference rules in knowledge models represented in OWL in a semantically consistent way (Ye et al., 2015). In this work, the ontology model has been enriched with a set of rules illustrated in Figure 10.

These rules are used to respond to some competency questions such as: to which socio-cultural pattern does a handicraft woman with specific characteristics belong? What is the socio-professional situation of a handicraft woman? The answers to these questions are illustrated in Figures 11, 12, and 13.

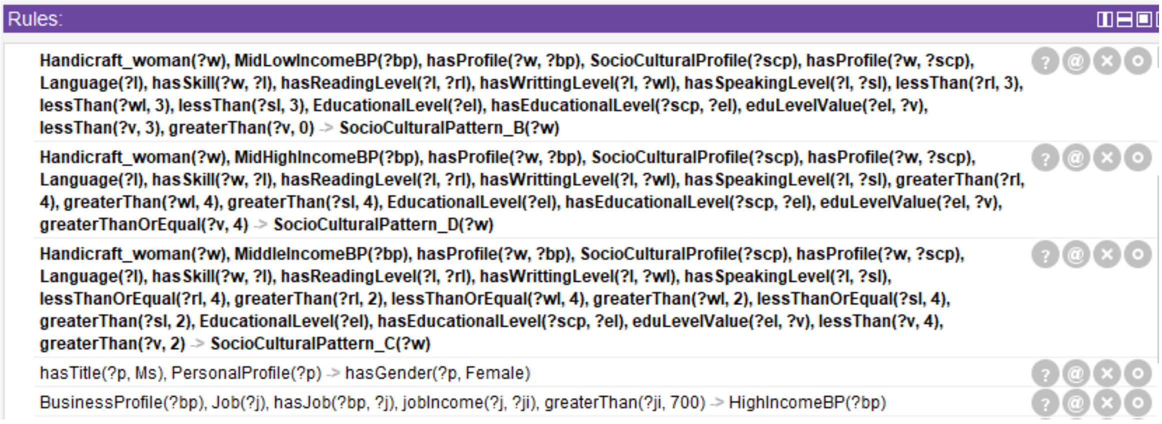

Figure 10: Excerpt of the rules used in the model.

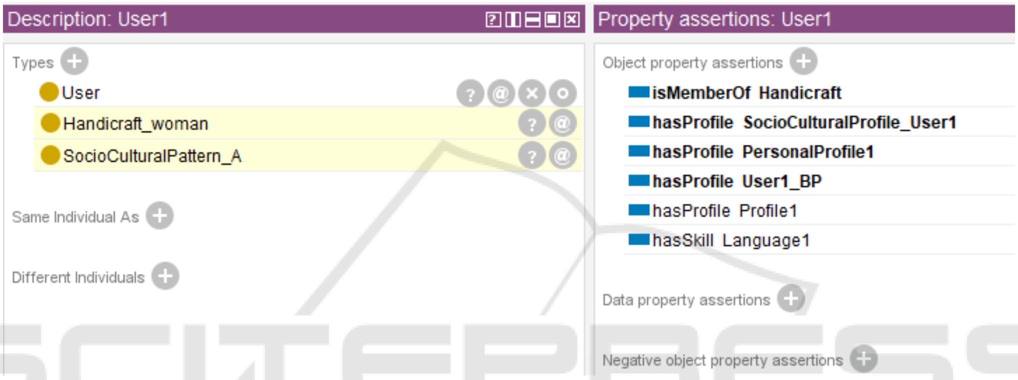

Figure 11: First Example of the inference related to the first question.

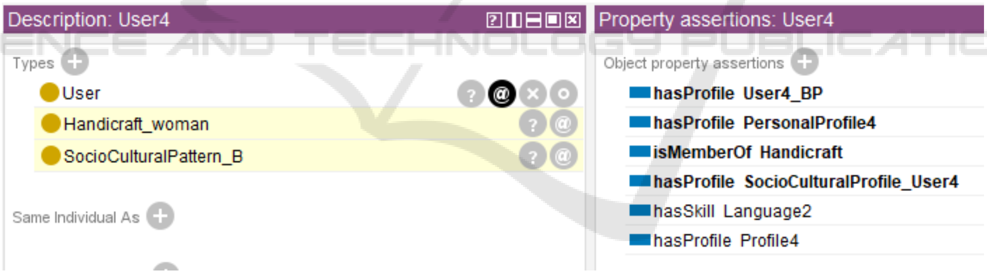

Figure 12: Second Example of the inference related to the first question.

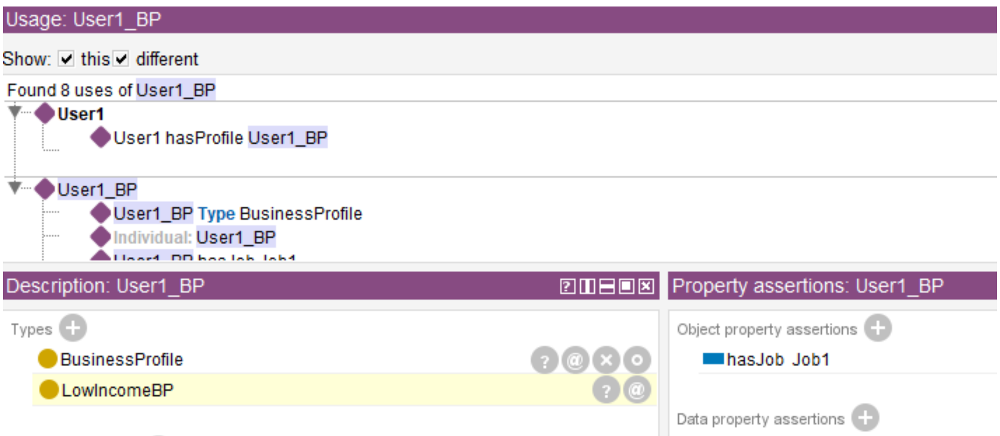

Figure 13: Example of the inference related to the second question.

6 CONCLUSIONS

This paper introduces a context model based on ontologies, which includes an upper ontology defining fundamental context concepts, as well as several ontologies that describe specific aspects of the context such as environment, service, and user. It highlights the significance of incorporating the socio-cultural and socio-professional attributes of users into the context model.

This contribution is still in progress. In future works, the intention is to utilize the context ontology and demonstrate its applicability in a real-world application, showcasing its adaptability based on captured context. Additionally, an important objective is to assist handicraft women in the Maghreb region by enabling them to adopt and adapt ICT technologies to meet their specific service requirements within diverse contextual scenarios.

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