A New Scientometric Dimension for User Profile

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***Abstract*— Personalization aims to facilitate the expression of user needs and enables him/her to obtain relevant information. The data describing the user are grouped in a profile, which varies according to the application context and the type of users and their needs. By focusing on a particular type of applications (dedicated to scientific research) and a particular type of users (researchers), we note that existing personalization approaches only partially solve problems related to personalization quality (accuracy, freshness, validity period, response time, source credibility), but lacks a model involving scientific quality (content, author, container and affiliation quality). The scientific quality is assessed by a set of quantitative and qualitative measures, which are the scientometric indicators. In this paper, we propose a profile model based on scientometrics to involve the qualitative relevance of information in a retrieval system dedicated to scientific research. The proposed model will be the basis of building an ontological user profile able to store scientometric preferences.**

Keywords-user modeling; scientific quality; scientometrics; quality evaluation; user profile; profile model.

I. Introduction

Faced with a large number of heterogeneous information resources, the user is unable to express his preferences and select relevant information while referring to reliable sources of confidence.

Particularly, in the field of scientific research, the validity of scientific production and even the scientific process relies on the quality of the information. The users of information systems dedicated to scientific research are researchers. This particular kind of users is interested in the relevance of information as well as in its scientific quality. In this context, we define scientometrics, which is the set of quantitative methods that are devoted to the evaluation of scientific production (researcher, scientific paper, research group, laboratory...). Scientometrics is based on a set of quantitative metrics and measures called scientometric indicators, which include publications, citations, h-index, g-index, hi-index, hc-index, AWCR, and AW-index [1], and the qualitative measure H_X [2].

In this paper, we are interested in the personalization of user profile in the field of scientific research to meet the needs of researchers. Our user profile personalization approach comes to fill the absence of a personalization approach that involves the scientific quality of the information. This approach is based on the proposal of a profile model integrating scientific quality measured by scientometric indicators. This model is able to collect quality preferences from the user. It is based at the first level on the quality of: content, containing, author and affiliation. At the second level, going up a level of abstraction, we find the quality of: the source of document, the editor of the scientific journal, the association of the conference, the research organization and career of the authors.

This work comes as part of the proposal and the implementation of a personalized information retrieval system dedicated to scientific research and based on the scientific quality of the information processed at different stages.

This paper is organized as follows: Section II summarizes the state of the art on personalization, profile modeling, scientometrics and the works oriented to the ontological user profiles. In Section III, we present the profile models that we propose. In Section IV, we show the process of building the profile ontology and its evaluation. We finish with a conclusion in Section V.

II. Related Work

The user profile is the core concept of personalization in information retrieval (IR). The user profile is defined by contextual elements directly related to the user, such as their interests, search preferences, etc. All of this information is represented in profile model. A profile model includes all the knowledge necessary for efficient query evaluation and production of relevant information tailored to each user. A profile can be defined as a personalized access to information model while a query is the expression of detailed needs that the user wishes to see in his/her profile.

The user profile is part of the user's cognitive context according to the multidimensional taxonomy presented in context [3]. Several definitions of the profile have been discussed in the literature. We distinguish the cognitive profile [4][5], the qualitative profile [6] and the multidimensional profile [7][8]. The cognitive profile exploited in several customized systems is analog to the user's cognitive context addressed in the context of the multidimensional taxonomy [3]. The qualitative profile in [6] is linked to the user's search preferences for the quality of information returned by the system (freshness, credibility of sources of information, consistency, etc.). These criteria concern the context of qualitative document processed in the context of the multidimensional taxonomy [3]. In some studies, the profile covers in addition to the interests and preferences of the user, the characteristics of the environment and the system, thus defining a

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multidimensional profile [8][9]. A multidimensional profile covers all possible dimensions involved in the interaction of the user with the system. P3P (Policy Languages Interest Group) [9] standard to secure the profiles, allows to define classes that distinguish between demographic attributes, professional and behavior attributes. In [8], Amato and Straccia proposed a profile model for users of a digital library consisting of five categories: personal data, collected data, delivery data, behavior data and safety data. Moreover, the authors simple profile information categories make their model extensible with difficulty. In [7], Kostadinov proposed a profile model based on Amato and Straccia profile model [8] and consisting of eight classes: centers of interest, ontologies, personal data, quality, customization, security, client feedback and divers. Based on Kostadinov's profile [7], Bouzeghoub and Kostadinov [9] enriched the profile by two other categories: delivery preferences and query history. In [11], the authors proposed a profile model combining profile content, context and preferences.

The quality was incorporated into the profile models of [9][11]. In these works, they involve the quality of personalization process and content quality:

- The quality of the query execution process and the quality of delivery data: measured by the response time. Other measures of the personalization process have been proposed by Mobasher et al. [12] as the Weighted Average Visit Percentage (WAVP), precision, coverage, F1 measure and R measure.
- The quality of content and information provider: characterized by the freshness of the information, which include the time elapsed since the establishment of the information or the time of the last update. Also the precision and accuracy of the data, which requires the opinion of an external expert.

Recent researches are oriented to design a new generation of personalization systems based on context, social networks and ontologies. In [13], the authors combined search technologies and knowledge about query and user context into a single framework. The works in [14] and [15] added the notion of context and situation. In [16], the authors proposed an ontological user profile modeling for context-aware personalization. In [17], the authors proposed an ontology-based user profile for modeling user behavior. In [11], the authors proposed an ontological user profile able to store the profile dimensions, the context and preferences. In [18], the authors used the social network annotation in user profile.

All of these techniques already mentioned are not dedicated to recognize users while remaining independent of the quality. For this, our work is oriented to design a new personalization system based on scientific quality. Our contribution aims to deliver qualitative information relevant and appropriate to the researcher needs.

The quality that has been integrated into existing personalization approaches is process oriented (independent of the information), or content oriented (decided by an expert). In this case, we confront the problems of information independency and relativity and subjectivity of experts' judgment.

We focused in this paper on the representation of an extension of existing personalization approaches.

III. MULTIDIMENSIONAL MODEL FOR REPRESENTATION OF SCIENTOMETRIC PREFERENCES

To solve the problem of absence of personalized approach involving scientific quality, we propose a new qualitative dimension to represent the expectations of researchers. Our contribution is the integration of a new dimension "scientometric preferences" to construct a multidimensional user profile concerned with the quality of scientific research.

In our approach, we study all the elements of the scientific process, which affect the scientific quality. To each element we associate the scientometric indicators, which measure its quality.

Based on works already done in the context of multidimensional profile modeling [7][9], we propose a reusable multidimensional profile that involves the scientific quality. We define a generic model, which will be instantiated to draw the profile model, which can be exploited by other user profiles.

A. *Generic model*

Figure 1 shows our representation of the generic profile model. This representation can be structured in the form of hierarchy of classes which are:

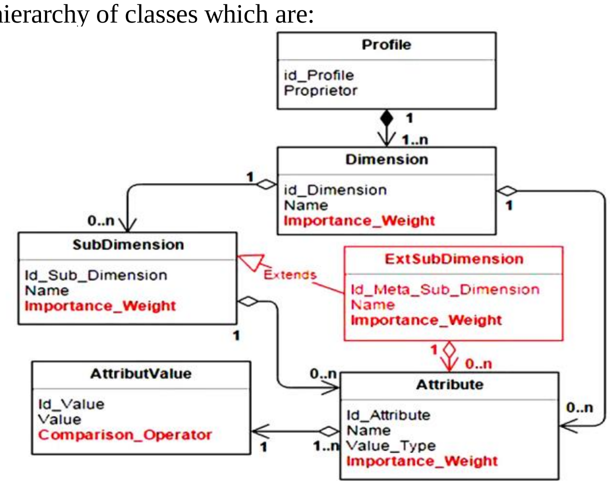

Figure 1. Generic model.

- Profile: describes the criteria that characterize a user. It contains several dimensions. For example: personal data, centers of interest, scientometric preferences, etc.
- Dimension: describes information characterizing user preferences; this information is grouped and structured in the form of a set of open dimensions. To each dimension we associate a weight describing its importance compared to other Dimensions relative to the user.
- SubDimension: information that is grouped and structured as part of a specific dimension. To each

SubDimension we assign an id, a name and an importance weight.

- ExtSubDimension: information that is grouped and structured as an extension of a specific SubDimension. This information is from a higher level of abstraction. To each ExtSubDimension we assign an id, a name and an importance weight.
- Attribute: this class represents an elementary attribute to which we assign (id, name, value type and importance weight).
- AttributeValue: describes the possible values that are associated with each attribute. To delimit the interval of the values of preference, the user has to specify a precise value accompanied by a comparison operator (<,<=,>,>=,=).

Our proposed generic model is:

- Open: it can be extended by other kinds of profiles in an easy way;
- Flexible: it is able to acquire the main categories of knowledge in the current personalization systems;
- Multifacets: it can be analyzed from different angles (dimensions, attributes, etc.);
- Evolutionary: it allows any changes or updates;
- Independent of any information system or any technology and the specialization, generalization and instantiation of this model is easy.

B. *Profile model*

Our profile model is an instantiation of the generic model described in the previous section. This model is one of the possible instances of the generic model. Because the proposed generic model is open, flexible and independent of any data, it can be instantiated with different values.

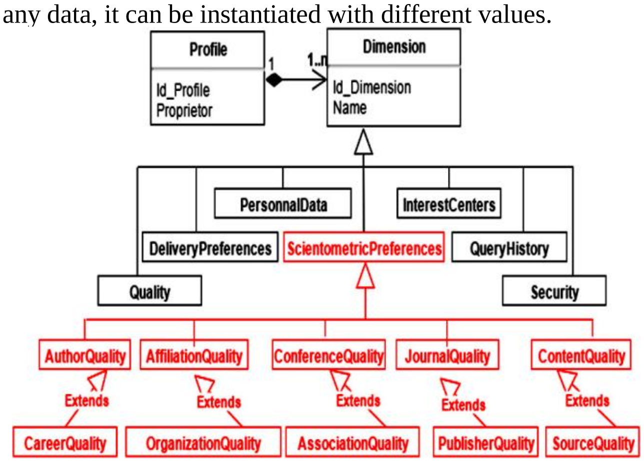

Figure 2. Profile model.

Based on the profile model of Bouzeghoub and Kostadinov [9], we propose a set of existing dimensions enriched by a new qualitative dimension which is the scientometric preferences. This proposed dimension contains the different information characterizing the scientific quality preferences introduced by the user.

In Figure 2, we present our proposed model enriched by the new scientometric dimension (scientometric preferences). Our model can be exploited in a personalization process of a scientific retrieval system.

Scientometric preferences store the necessary information describing the quality of a scientific document according to the researcher's needs. These preferences are organized into five SubDimensions which are the scientific entities affecting the scientific quality of documents. The quality of each scientific entity is measured by a set of scientometric indicators which represent the attributes of each SubDimenson. On the other hand, each SubDimesnion is extended on ExtSubDimension by moving to a higher level of abstraction. Each ExtSubDimension will be organized into attributes which represent the scientometric indicators measuring its quality.

In the following, we detail the elements of the dimension "scientometric preferences."

1) *Quality of author and career*

The quality of author is one of entities which affect the scientific quality of documents. Author quality is measured by the mean of four scientometric indicators (Figure 3):

- H-index (Hirsh index): is an indicator of the researcher impact. A researcher has an index of h if his/her papers are cited at least h times each [1].
- Citation number: is the number of citations received by his/her published scientific papers.
- Author position: is the position of the author in the co-authors list. He/she can be the first author, second co-author, third co-author and so on.
- Publication number: is the number of scientific papers published by the author.

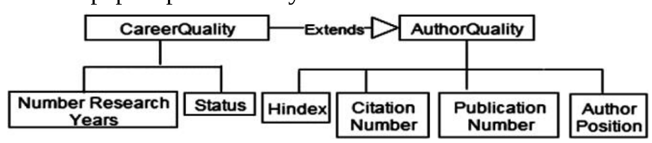

Figure 3. Quality of author and his career.

By ascending a level of abstraction, we associate the quality of career to the author quality as an extension. The quality of author career is measured by the number of years spent by the author on research in a specific discipline, and his current scientific grade (PhD student, assistant professor, professor, etc).

2) *Quality of content and source*

Another entity that affects the scientific quality of documents is the quality of content, to which we assign the following attributes (Figure 4):

- Citation number: the number of citations received by the published scientific document. A larger number of citations reflects a better quality of document content.
- Co-authors number: the number of authors who contributed to the realization of the scientific document.

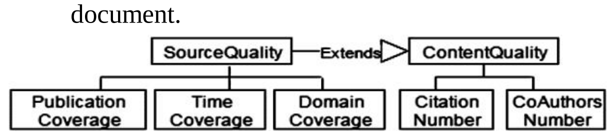

Figure 4. Quality of content and its source.

We designate by the source of scientific documents the bibliographic databases such as: Google Scholar, Scopus, dblp, MS Academic Search, etc. The quality of information source is measured by the number of publications, the interval of time and the number of domains covered by the source.

3) Quality of journal and publisher

Scientific journals are containers of scientific documents. A good quality of the journal promotes the selection of the document. As shown in Figure 5, the quality of a journal is evaluated by:

- Impact factor: is a measure of the frequency with which the average article in a journal has been cited in a particular year or period. Thus, the impact factor of a journal is calculated by dividing the number of current year citations by the source items published in that journal during the previous two years. The journal impact factor is provided by the annual Journal Citation Report (JCR) [19] of Thomson Reuters or by SCImago Journal & Country Rank (SJR) [20].
- Ranking: journal ranking is the classification of journals according to its quality. SCImago Journal & Country Rank (SJR) provides a journal ranking into four classes: Q1, Q2, Q3 and Q4. Another type of journal ranking is provided by ERA [21] into four classes: A*, A, B and C.
- Citation number: the number of citations received by all the journal publications.
- Self-citation number: when a paper published in a journal cites a previously published paper in that same journal.
- Response time: the time period taken by the publisher to provide the first response to submitted manuscript.
- Publication number: the number of publications in the journal.

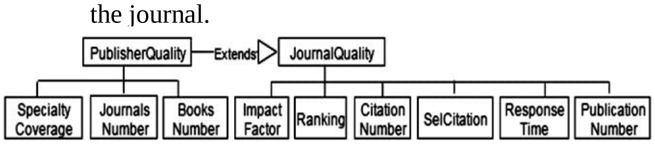

Figure 5. Quality of journal and its publisher.

The quality of journal can be extended to the evaluation of publisher quality which can affect the scientific quality of documents. As examples of journals' publishers we cite: Elsevier [22], Springer [23], Emerald [24], Sage [25], ACM [26] etc. The publisher quality is measured by the number of specialties, the number of published journals and the number of published books.

4) Quality of conference and association

In the same way, we describe the SubDimension "quality of conference" and its extension "association quality". Conferences are the other type of document container. In Figure 6, we describe the different measures of the conference quality consisting on:

- Conference ranking: is the classification of conferences according to their quality. ERA provides conference ranking into four classes: A*, A, B and C.
- Citation number: the number of citations received by all the papers published in the conference.
- Self-citation number: when a paper published in a conference cites a previously published paper in that same conference.
- Publication number: the number of papers published by the conference.

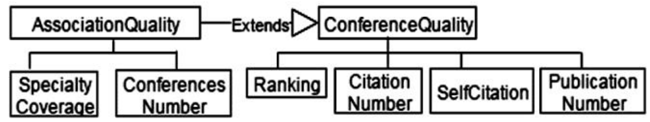

Figure 6. Quality of conference and its association.

To each conference, we join its association, such as: IEEE [27]. The quality of conference association is measured by the number of specialties and the number of conferences organized by the association.

5) Quality of affiliation and organization

In our profile model, we consider the quality of author(s) affiliation. The author affiliation is represented by the research environment or the research community such as: laboratory, research unit, university department or group of researchers working in the same discipline. Affiliation quality is measured by specific scientometric indicators represented in Figure 7:

- Group H-index: Hirsh index of a researchers group having the same affiliation is defined as the number of all the articles of the group which have been cited at least h times each.
- Citation number: the number of citations received by the papers published by the group of researchers having the same affiliation.
- Self-citation: when two members of the same affiliation site each other.
- Publication number: the number of papers published by the group of researchers having the same affiliation.

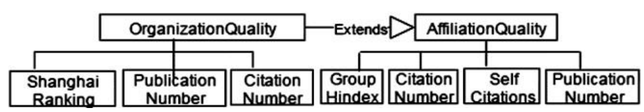

Figure 7. Quality of affiliation and its organization.

The quality of affiliation is influenced by the quality of the organization or the institution of reference, such as universities. So, we extended the affiliation quality to the organization quality measured by the Shanghai ranking [28] (in the case of academic organizations), the number of papers published by the different research entities belonging to the same organization and the number of citations received by the papers published by the different entities belonging to the same orginization.

IV. SCIENTOMETRIC ONTOLOGY

The profiles are containers of knowledge about the user. The user's preferences represent the expectations of the user.

To apply the model of the proposed profile, we opted for an ontology to represent the scientometric preferences of the user. An nntology is a good candidate for representing knowledge about users. It allows having a shared understanding between people or software agents and their relations, and a controlled vocabulary, which implies a formal definition of concepts. In addition to their contribution in terms of reusability, modularity and knowledge sharing, ontologies are used to define a precise vocabulary, which is the basis of communication between different users.

A. From the generic model to ontology

Ontology, such as generic models of UML (Unified Modeling Language), models the universe of discourse by means of hierarchical classes by properties association. However, an ontology has five differences compared to generic UML models [29]:

- Semantics: Ontologies are used in an Open World Assumption (OWA). In contrast, UML models are used in a Closed World Assumption (CWA).
- Goal: In ontology, the focus is generally on concepts and relations between them. In contrast, a generic model of UML emphasized the operational side of a particular computer system.
- Atomicity: In UML, each concept only makes sense in the context of the model in which it is defined. In ontology each concept is individually identified and is a basic unit of knowledge.
- Consensuality: In ontology of domain, concepts are represented as consensus of a community. Similarly, the semantic integration of all systems based on the same ontology can be easily made.
- Canonicity: Unlike generic models that use a language (UML) to describe domain information, ontologies use (OWL) formal semantics (describing logic).

The next step is to transform the classes and attributes of the profile model into concepts and slots of ontology.

B. Implementation of the scientometric dimension

In this section, on the basis of the generic model that we proposed in Section III, we will show the process of building our ontological user profile following the Noy's method [30].

Most ontologies were created using the OWL (Web Ontology Language) [31]. OWL is designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of Web content than that supported by XML (Extensible Markup Language), RDF (Resource Description Format), and RDF-S (RDF Schema) [31]. It provides additional vocabulary along with a formal semantic. OWL has three increasingly-expressive sublanguages: OWL Lite, OWL DL, and OWL Fulls [31]. Proposals for the design of ontologies on the theoretical and practical view can be found in [30]. Our ontological profile was implemented using OWL-DL. There are many methods for ontology engineering. In our case, we opted for Noy's method [30] proposed by Stanford University. We considered the fact that the tool with which we will build the ontology in this case PROTÉGÉ [32] which is developed by the same university.

The ontology design process can be summarized in the following steps:

- Step 1: determine the domain, scope and users of the ontology. The ontology domain is going to cover the scientometric domain (assessment tools, measures and indicators) conducted for a scientific research evaluation. The purpose of using our ontology is to describe the qualitative preferences of the user (researcher). The ontology must respond to user requests, taking into account the semantics of those requests.
- Step 2: consider reusing existing ontologies: Existing ontologies in the field of personalization systems did not satisfy our needs. So, we built our ontology fully based on our research.
- Step 3: our study of both scientometric field and user profile management, allowed us to identify a list of important terms. We can list some terms: dimension, attribute, sub-dimension, author quality, affiliation quality, source quality, citation number, journal impact factor, conference ranking etc.
- Step 4: the definition of classes and class hierarchy described in Figure 8: classes provide an abstraction mechanism for grouping resources with similar characteristics. Like RDF classes, every OWL class (OWL:class) is associated with a set of individuals called the extension of class.

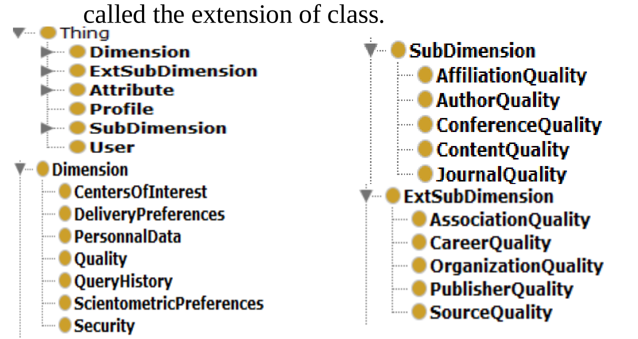

Figure 8. Class hierarchy.

- Step 5: define properties of classes. A property can be considered as an attribute (a value, the importance weight of the class, the comparison operator of the attributes etc.), or as a binary relation between two classes. OWL distinguishes two kinds of properties:
  Data property: the properties of data type (class properties) have a range of data value, and bind individuals to data values. For example: property "Name" for class "User".
  Object property: object properties (relationship) have a range of values of class individuals. For example, the property "Extends" applies to an object of class called "ExtSubDimension" and takes its values in the class called "SubDimension".

- Step 6: create instance: the instances are all objects of classes.

C. Profile validation

To test the profile ontology, we use the Pellet reasoner available directly from PROTÉGÉ. Pellet is a complete and capable OWL-DL reasoner with very good performance, extensive middleware, and a number of unique features [33]. Pellet is written in Java and is open source under a very liberal license. It is used in a number of projects, from pure research to industrial settings.

Pellet is the first sound and complete OWL-DL reasoner with extensive support for reasoning with individuals (including nominal support and conjunctive query). It has user defined data types, and debugging support for ontologies [33]. It implements several extensions to OWL-DL including combination formalism for OWL-DL ontologies, a non-monotonic operator, and preliminary support for OWL/Rule hybrid reasoning. It has proven to be a reliable tool for working with OWL-DL ontologies and experimenting with OWL extensions.

In this section, we describe three tests provided by Pellet: consistency checking, classification test and queries test.

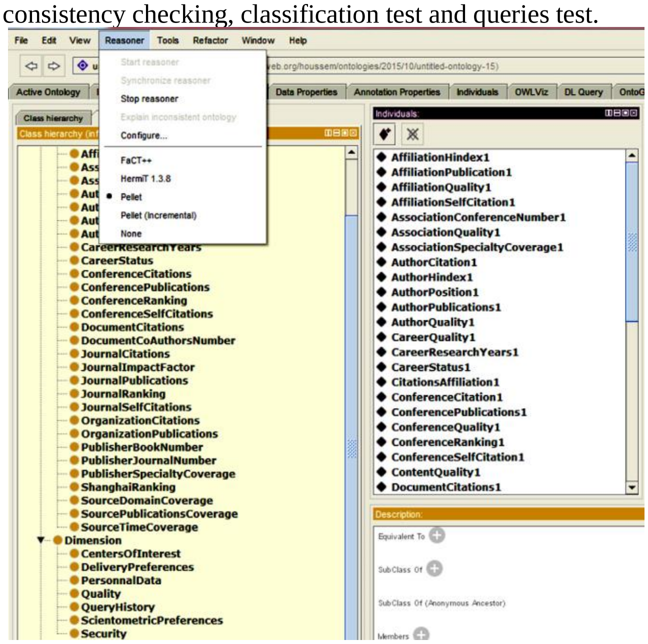

Figure 9. Inferred class hierarchy.

1) Consistency test

Consistency checking provided by Pellet is made based on the class description, which ensures that ontology does not contain any contradictory facts. Each class must have at least one individual member. A class is considered inconsistent if it cannot have any instance. The result of this test is shown in Figure 9 representing inferred class hierarchy after invoking the reasoner. All classes are consistent.

2) Classification test

The classification test can check whether a class is a subclass of another class or not. It computes the subclass relations between every named class to create the complete class hierarchy. The class hierarchy can be used to answer queries such as getting all or only the direct subclasses of a class.

When this test is invoked, the consistency test is first performed for all classes of the ontology, because inconsistent classes cannot be classified correctly. Once the classification test is performed on the class hierarchy containing the logical expressions, it is possible for the classifier to infer a new hierarchy "inferred ontology class hierarchy". This is, a hierarchy where classes are classified according to the relationship superclass/ subclasses. In this case the classification test shows that no suggestion has been produced by the reasoner Pellet and that "Asserted hierarchy" and "Inferred hierarchy" are identical, indicating the validity of classification of our ontology.

3) Test queries

PROTÉGÉ allows querying your project and locating all instances that match the criteria you specify. You can create a simple query, or combine multiple criteria to restrict or expand your results. Queries are not part of our knowledge base, but are a way to identify the instances in your project, based on class and slot properties. We have created different queries using SPARQL tool [34].

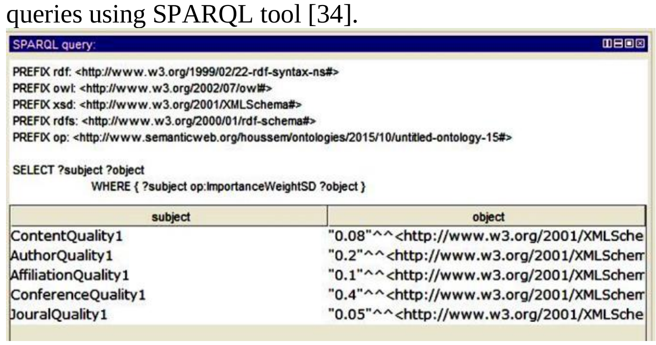

Figure 10. Query execution.

In Figure 10, we present an example of the execution of the following query: Find the importance weight preferences of all SubDimensions.

V. CONCLUSION AND FUTURE WORK

The research activity has become increasingly selective considering the importance given to the quality of scientific production and the diversity of tools and systems evaluating research activity. Researchers become selective in their choice and are more interested in the quality of information. To meet the needs of researchers, we proposed a personalization system dedicated to the researcher integrating scientific quality in the user profile.

Our contribution begins with the proposal of a generic profile model enriched by a new type of component which is the extended sub-dimension linked with an extend relationship to the sub-dimension. Our profile model was designed to be open, flexible, evolutionary, and independent of any information or technology. Its specialization, generalization and instantiation were easy. Next, we proposed a qualitative user profile which was an instantiation of our generic profile model. The novelty was the integration of a new scientometric dimension for assessing the scientific quality of the selected information. Our contribution was to improve the performance of the retrieval system in terms of information relevance and to satisfy the researcher's needs. All elements affecting the scientific quality were studied and incorporated into the user profile.

To represent user qualitative preferences, we opted for ontology. Our profile ontology is characterized by its reusability, facility of expansion, integration and instantiation. The major advantage of our ontological profile is its coherence and its consistency shown by tests on it. Thus, it is ready for future use in any personalization system that is based on user profile.

Practically, our contribution can improve the research quality and relevance. Indirectly, it can positively influence research attitudes and affect the quality of research by limiting unscientific practices, such as: considering older articles are qualitatively better; considering the number of citations as an indicator of quality; and giving equal consideration to publications at conferences and publications in journals or even publications at conferences of different classes or in journals having different impact factors.

By integrating our ontological user profile into a scientometric information retrieval system, as perspectives, we plan to apply a model for ontology evaluation based on metrics to validate our contribution.

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