Product Classification Integration for E-commerce

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Abstract

A marketplace is the place where the demand and supply of buyers and vendors participating in a business process may meet. Therefore, electronic marketplaces are virtual communities in which buyers may meet proposals of several suppliers and make the best choice. In the electronic commerce world, the comparison between different products is blocked due to the lack of standards (on the contrary, the proliferation of standards) describing and classifying them. Therefore, the need for B2B and B2C marketplaces is to reclassify products and goods according to different standardization models. This paper aims to face this problem by suggesting the use of a semi-automatic methodology to define a mapping among different e-commerce product classification standards. This methodology is an extension of the MOMIS-system, a mediator system developed within the Intelligent Integration of Information research area.

1. Introduction

The large amount of Internet sites which have grown in the last few years, has increased the availability of information on the web, even if this information is less and less machine-readable and machine-understandable. Companies have been putting their databases and product catalogues on the web offering Internet-based solutions. Consequently, customers and suppliers have increased the amount of information available, but also the "noise" generated from these information sources has increased. This situation has allowed a third party, called the marketplace, to assume a key role in electronic commerce.

A marketplace is the place in which the demand and supply of buyers and vendors may meet. Then, marketplaces seem to be an interesting solution for electronic commerce actors, because they show products, distributed by different vendors, and make the user able to compare them. In the electronic commerce environment, the comparison between different products is blocked due to the lack of standards describing and classifying them. Numerous proposals of classification standards have resulted in each supplier describing his own product in his own way (cf. [7,10]).

Considering B2B e-commerce marketplaces, an economic transaction is further made by the buyers' need to use only one standard to classify and describe products provided by different vendors, so as to assure an easy integration with its ERP system. Hence, the marketplace has to provide a mediator environment to integrate different standards and to produce different output standards. In this way, each actor of the business process may exchange information using his own standard.

This paper aims to face this problem by suggesting the use of a semi-automatic methodology to define the mapping among different e-commerce product classification standards. The methodology was developed for the MOMIS-system ([1,2,3]) within the Intelligent Integration of Information research area. MOMIS (Mediator envirOnment for Multiple Information Systems) is a mediator-based system aiming to extract and integrate information from heterogeneous data sources, such as relational, object, semistructured sources (XML). Starting from source descriptions, the system generates an integrated global virtual schema of all data sources that is expressed in XML. The global virtual schema is created by using different techniques, and by creating a common thesaurus of intra- and inter-schema relationships, which defines an ontology of the terms used to represent the information provided by the different sources. The common thesaurus contains intra-schema relationships extracted by using inference techniques, inter-schema relationships obtained using the lexical WordNet system (www.cogsci.princeton.edu/wn) (which identifies the affinities between inter-schema concepts on the basis of their lexicon meaning) and inter-schema relationships explicitly given by the integration designer. In addition, MOMIS enriches the thesaurus using the Artemis system [6], which evaluates structural affinities among inter-schema concepts and ODB-Tools Engine [3], a tool based on Description Logics, which performs consistency checking, and subsumption computation. As an example of our integration methodology, we show how it is possible to define a mapping between a fragment of the ECCMA/UNSPSC and a fragment of the ecl@ss standard. With respect to previous works on MOMIS, we introduce a wrapper for semistructured data able to map XML/XML-Schema/RDF file into the common languages of MOMIS; a new method to create a mapping between XML/RDF sources and an XML representation of this mapping.

The paper is organized as follows. Section 2 introduces the two chosen e-commerce code product standards, namely ecl@ss and ECCMA/UNSPSC; section 3 describes our methodology and the results of the mapping process, and finally, section 4 gives some concluding remarks.

2. Product classification systems and E-commerce

Coding products and services according to standardized classification systems is useful for speeding up commerce among companies. In addition, the development of e-commerce solution, and in particular the B2B marketplace, has rapidly increased the requirement of machine-readable product names that assists marketing and sales functions to find customers and provide better customer and distribution channel services.

By inserting the codes in various electronic trade documents and media such as product catalogs, Web sites, purchase orders, invoices, computer applications throughout an extended supply chain (seller, buyer, distributor, independent sales representative, end user) can process transaction data automatically and can perform management, analysis and decision functions in time-critical and labor-efficient ways that would not be possible without the codes. A useful product classification scheme should be hierarchical, so that individual commodities represent unique instances of larger classes and families. Hierarchical organization allows a given company to focus on a level of specificity that best suits its purposes and situation.

Within the different standard classification systems proposed, the most used in U.S. is the United Nation Standard Products and Services Code System (UNSPSC), a hierarchical classification with five levels developed by Dun & Bradstreet in conjunction with the United Nations. The levels allow users to search products more precisely (because searches will be confined to logical categories and eliminate irrelevant hits) and it allows managers to perform expenditure analysis on categories that are relevant to the company's situation.
Each level contains a two-character numerical value and a textual description as follows:

XX **Segment**	The logical aggregation of families for analytical purposes
XX **Family**	A commonly recognized group of inter-related commodity categories
XX **Class**	A group of commodities sharing a common use or function
XX **Commodity**	A group of substitutable products or services
XX **Business Function**	The function performed by an organization in support of the commodity

In the e-commerce area, the ECCMA (*Electronic Commerce Code Management Association*) (www.ucec.org), has proposed an initiative to enhance the UNSPSC with local attributes to describe the bottom level. The current version consists of more than 16.000 terms.
An other important european initiative that built a new classification scheme from scratch is ecl@ss (www.eclass.de), proposed by the Cologne Institute for Business Research in cooperation with leading German industries. Ecl@ss is a standard for information exchange between suppliers and their customers and is characterized by a 4-level hierarchical classification system with a key-word register of 12,000 words. Ecl@ss maps market structure for industrial buyers and supports engineers at development, planning and maintenance.

The previously mentioned product classification systems are only some of the many proposed and used in B2B marketplaces, where industrial standard are emerging to define the overall interchange process (RosettaNet ebXML, OAGIS, BizTalk, xCBL, cXML,…).

3. Reconciliation of different standards

We propose an information reconciliation methodology for product mapping and reclassification among different code classification systems. The methodology is shown over a fragment of ECCMA/UNSPSC and ecl@ss standard but is easy scalable to the whole product code system.

Our methodology uses MOMIS in order to obtain a mapping between elements of the different schemas that correspond semantically to each other. We show that the use of MOMIS at the metadata level, i.e. the schemas involved in the integration process describing the two chosen e-commerce standards, is effective to perform the mapping process between the two chosen standards in a semi-automatic way. In [4] it is provided a largely orthogonal classification of the algorithms used by match systems. On the basis of these criteria, our approach may be described as follows.

- *Schema derived*: our methodology considers schema-level information. Nevertheless, we are considering how to apply extensional knowledge in the process.

- *Matching granularity*: the match can be performed for combinations of objects, such as complex schema sub-graph. It is possible to set specific parameters in order to control the dimension of sub-graph matched and reduce it to individual schema objects.
- *Language derived*: Our matcher uses a linguistic-based approach by interacting with a lexical database system (WordNet).
- *Auxiliary information based*: Our approach can exploit further information given by the user input.

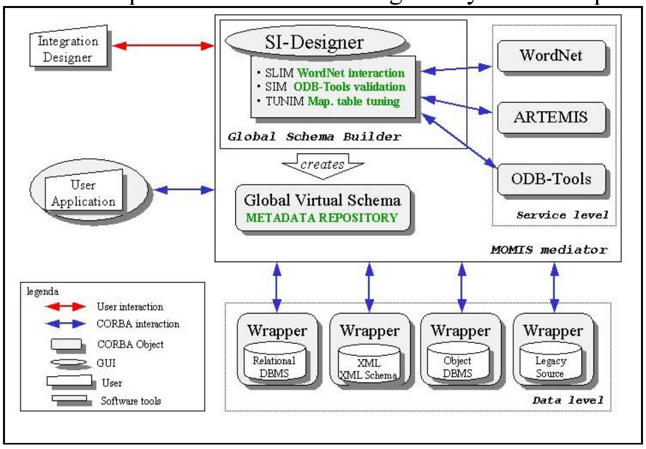

Figure 1 The MOMIS Architecture

3.1. Overview of the MOMIS system

The MOMIS system (see Figure 1) follows a "semantic approach" to information integration based on the conceptual schemata of the information sources, and on the mediator architecture [11]. In the MOMIS system, each data source provides a schema and a global virtual schema of all the sources is obtained in semi-automatically way. The global schema has a set of *mapping descriptions* that specify the semantic mapping between the global schema and the sources schema.

The system architecture is composed of functional elements that communicate using the CORBA standard. A common data model, ODM_{I3}, and a language, ODL_{I3}, derived from ODMG standard, are used to describe source schemas. ODL_{I3} is a source-independent language and can be used to describe schemas of heterogeneous data sources. In particular, you can specify the following *terminological relationships* in ODL_{I3}:

- SYN (synonym of) is a relationship defined between two terms t_i and t_j where $t_i \neq t_j$ that are synonyms in every involved source.
- BT (broader terms) is a relationship defined between two terms t_i and t_j where t_i has a broader more general meaning then t_j. The opposite of BT is NT (narrower terms)
- RT (related term) is a relationship defined between two terms t_i and t_j that are generally used together in the same context in the considered sources.

The Global Schema Builder (GSB) module processes and integrates descriptions received from wrappers to derive the global shared schema by interacting with different service modules, namely ODB-Tools, an integrate environment for reasoning on object oriented database based on Description Logics, WordNet lexical database that supports the mediator in building lexicon-derived relationships, and ARTEMIS tool that performs the clustering operation of similar classes [6].

3.2. Wrapping of source schemas

During the MOMIS integration process, a wrapper translates the schema of a source into the common data model of the mediator. For a conventional structured information source, schema description is always available and can be directly translated by the available wrappers. For semistructured information sources, a schema description is in general not directly available at the sources, in fact, a basic characteristic of semistructured data is that they are "self-describing", hence the information associated with the schema is specified within data [5].

3.2.1 Modeling semistructured sources. Semistructured data represent irregular, unknown or often changing structure for a set of data. Thus, to integrate a semistructured source, a specific wrapper has to implement a (semi)-automatic methodology to extract and explicitly represent the schema of the source.

According to the different proposed models [5], MOMIS represents semistructured information sources as rooted, labeled graphs with the semistructured data as nodes and labels on edges. A semistructured object can be viewed as a triple of the form <id, label, value>, where id is the object identifier, label is a string describing what the object represents, and value is the value, that can be atomic or complex. The atomic value can be integer, real, string, …, while the complex value is a set of semistructured objects, that is, a set of pairs (id,label). A complex object can be thought as the parent of all the objects that form its value (children objects). A given object can have one or more parents. To represent the schema of a semistructured source S, we introduce the notion of object pattern. All objects so of S are partitioned into disjoint sets such that all objects belonging to the same set have the same label. An object pattern is then extracted from each set to represent all the objects in the set. Then, an object pattern is representative of all different objects that describe the same concept in a given semistructured source. According to our data model (ODM_{I3}), we developed a wrapper to manage XML files. This wrapper aims to map the data structure of an XML file into the corresponding object pattern in ODL_{I3}. This wrapper could be thought as the core of further extensions that aim at managing other XML based files as XHTML files. An XML file may be thought as self-describing like a semistructured data source. The main analogies may be summarized as follows:

- *object pattern* attribute → XML tag
- *object pattern* → DTD element
- atomic value of an *object pattern* attribute → PCDATA value

Our wrapper parses the DTD associated to each well-formed XML file and generates a translation from an XML statement into an ODL_{I3} statement. This mapping implies some critical aspects due to the lack of semantics of XML w.r.t. ODL_{I3}. In particular, the most important are: the relevance of the order of the DTD attributes, the translation of the concept of attribute from XML language into ODL_{I3} language, the poor type system provided by XML and the weak semantics of intra-schema references. In this last case, to avoid loss of information during the translation process, the designer may be asked to supply further information by a graphical interface.

The Resource Description Framework (RDF) is a foundation for processing metadata; it aims at providing a method to describe metadata in a manner, which guarantees the interoperability among different sources on the web. RDF allows the web resources to express their semantics by using a standard language. Our XML wrapper has been extended in order to manage the knowledge generated from the RDF description of the sources that use XML language to express their own information. In particular, the wrapper translates *RDFS classes* into *object pattern*, *RDF properties* into *object pattern attribute*, the *RDFS subClassOf property* into a *parent-child relationship* and the *RDFS seeAlso property* into a *part-of relationship*.

3.3. The MOMIS integration process

In order to create a global virtual schema of the involved sources, MOMIS generates a common thesaurus of terminological intensional and extensional relationships describing intra and inter-schema knowledge about classes and attributes of the source schemas. On the basis of the common thesaurus contents, MOMIS evaluates affinity between intra and inter-sources classes and groups similar classes together in clusters using hierarchical clustering techniques. A *global class*, that becomes representative of all the classes belonging to the cluster, is defined for each cluster. The global view for the involved source data consists of all the global classes.

The example of the 'writing paper'. Let us apply the MOMIS methodology to a fragment of the two standard targets. A tool, Source Integration Designer (SI-Designer) supports the MOMIS methodology. Both the sources represent an extract of classification standard related to the domain of writing paper. The first source describes the hierarchical representation of the fragments of the ecl@ss standard schema. The second one describes the same domain using ECCMA/UNSPSC standard (Figure 2). Since ecl@ss contains a standard set of attributes only at the last level and ECCMA/UNSPSC is not descriptive on the attribute level, in the following we take into account only the category names.

We assume that these standard schemas have been provided using XML-based files. An ECCMA/UNSPSC representation in RDF Schema has been provided by Michel Klein (www.cs.vu.nl/~mcaklein/unspsc), while the ecl@ss system is provided in a spreadsheet format that can be straightforward translated in XML standard.

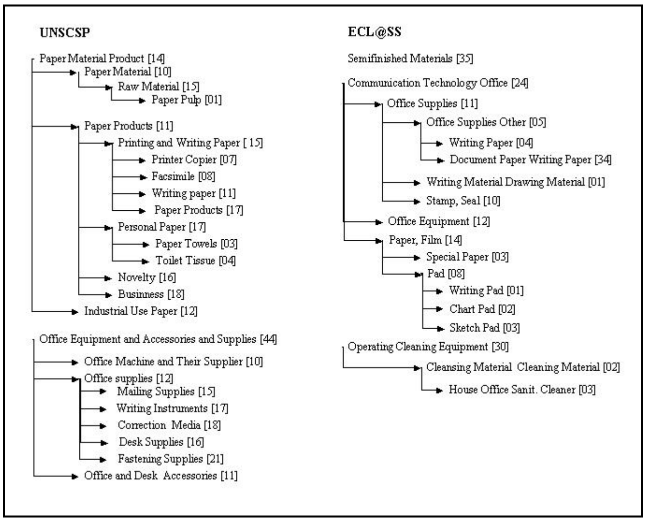

Figure 2. The example of writing paper

3.3.1. Building the common thesaurus An important feature of semantic integration is the availability of a shared ontology providing a reference vocabulary on which to base the identification of heterogeneity and the subsequent resolution for conflicts. To achieve this goal we build a common thesaurus that expresses inter-schema knowledge in the form of terminological knowledge (such as SYN, BT, NT and RT) between classes and attribute names by exploiting WordNet-supplied ontology and Description Logics supplied by ODB-Tool. The common thesaurus is built through an incremental process during which relationships are added in the following order: schema-derived relationships, lexicon-derived relationships, designer-supplied relationships and inferred relationships. Using the SI-Designer tool, the designer is assisted during all the integration process and can refine lexicon-derived explicitly supplied relationships at each step of the integration process.

Schema-derived relationships. MOMIS extracts intensional relations from schemas' structure, by analyzing each ODL_{I3} schema separately. In particular, MOMIS extracts each intra-schema RT relationships from the specification of foreign keys in relational source schema and from part-of relationship in hierarchical sources (i.e. XML files representation). When a foreign key is also a primary key both in the original and in the referenced relation, MOMIS extracts a BT-NT relationship. BT-NT relationships are also generated from the inheritance relationships in object-oriented schema and from ID-IDREF couples in XML file. Remember that in this latter case it is necessary that the designer, interacting with SI-Designer, identify the proper couple ID-IDREF.

Some of the relationships automatically extracted from the ecl@ss and ECCMA/UNSPSC writing paper fragments are the following:

<eclass.semifinishedmaterials rt eclass.paper>
<eclass.notebooksbooks rt eclass.paperfilm>
<unspsc.personalpaperproduct rt unspsc.paperproducts>
<unspsc.mailingsupplies rt unspsc.officesupplies>

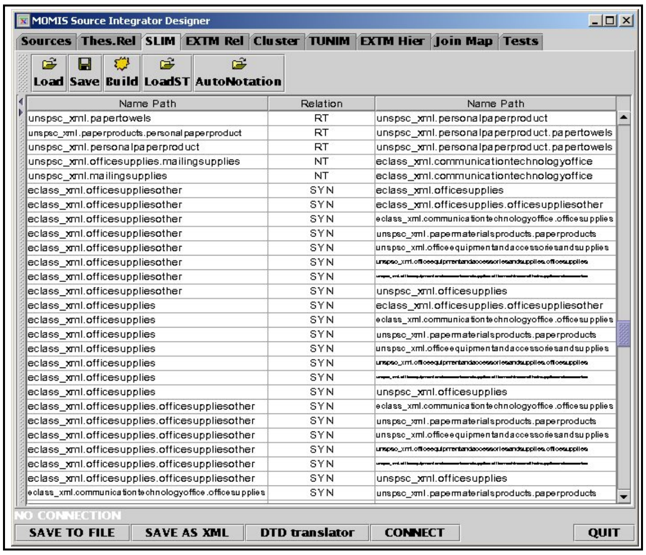

Figure 3. A part of the lexicon-derived relationships

Lexicon-derived relationships. MOMIS extracts the lexical relationships by analyzing different source schemas, according to the WordNet ontology (www.cogsci.princeton.edu/wn). WordNet's starting point for lexical semantics comes from a conventional association between the forms of the words – that is, the way in which words are pronounced or written – and the concept or meaning they express. These associations, which are of the many-to-many kind, give rise to several properties, including synonymy, polysemy and so forth. Synonymy is the property of a concept or meaning that can be expressed with two or more words (a synonym group is called a *synset).* Only one synset exists for each concept or meaning. In contrast to synonymy, polysemy denotes the property of a single word that has two or more meanings. For each element composing the schemas of the involved sources, the user has to choose the associated word (the base form and the meaning). Our system tries to automatically suggest a base form. When MOMIS does not find a base form, or there is an ambiguity, or the proposed base form is not satisfactory the user should manually introduce the base form. The next operation is to relate a name to one, more than one, or even no meaning at all. Starting from the base form and the meanings associated to each sources' element, the system inserts into the common thesaurus the lexicon-derived relationships obtained by exploiting the properties of the names stored in WordNet.

Figure 3 shows some of the generated relationships. In particular, we have:

```
<eclass.officeSupplies SYN unspsc.officeSupplies>
<eclass.pad  SYN unspsc.notebooksBooks>
<unspsc.paperProducts BTeclass.writingPaper>
<eclass.paper RT unspsc.officesupplies>
```

Designer-supplied relationships. The designer may supply relationships to capture specific domain knowledge about the source schemas. For example in the ECCMA/UNSPSC the element *mailing supplies* may be considered as a more general concept of the element *stamp* in the ecl@ss standard. This relationship may be defined as follows:

```
<unspsc.mailingSupplies BT eclass.stamp>
```

This is a critical operation because the new relationships are added to the common thesaurus and will be used to generate the global virtual view. This means that if the designer supplies nonsense or incorrect relationship the consequent integration process can produce a wrong global virtual schema.

Checking consistency and inferring new relationships. In this step, MOMIS performs reasoning about the common thesaurus relationships by exploiting the subsumption and inheritance computation, reasoning techniques of Description Logics performed by ODB-Tool. In Figure 5 we show some of the generated relationships (no incoherence has been detected). Some significant inferred relationships are:

```
<unspsc.industrialusepaper NT eclass.writingpaper>
<unspsc.businesspaper NT
eclass.writingmaterialdrawingmaterial>
<unspsc.toilettissue RT
eclass.houseofficesanitcleaner>
```

Clustering ODL_{I3} classes. To integrate the ODL_{I3} classes of the different sources into a global ODL_{I3} classes, we employ hierarchical clustering techniques based on the concept of affinity. In this way, we identify ODL_{I3} classes that describe the same or semantically related information in different source schemas and give a measure of the level of matching of their structure. This activity is performed by ARTEMIS [6], evaluating a set of affinity coefficients for all possible pairs of ODL_{I3} classes on the basis of the relationships of the common thesaurus. The output of the clustering procedure is an affinity tree, where the classes themselves are the leaves and intermediate nodes.

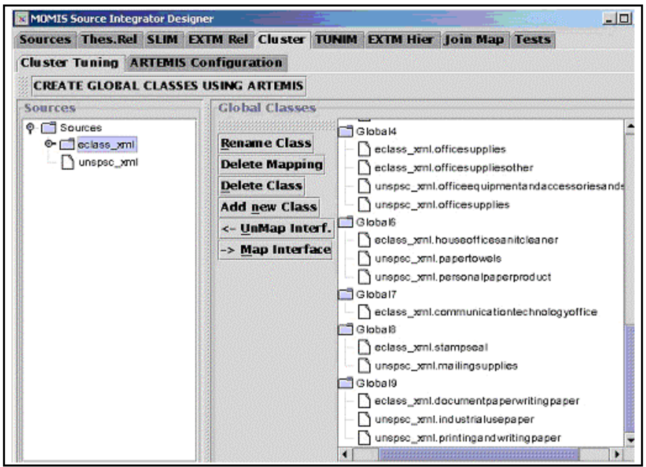

Figure 4. The generated clusters

Global virtual schema generation. The latter phase of integration methodology consists in the generation of a global virtual schema composed of ODL_{I3} global classes derived from the clusters. This is a synthesis activity performed interactively with the designer. Let Cl_i be a selected cluster in the affinity tree and gc_i the global ODL_{I3} class to be defined for Cl_i. First, we associate with gc_i all classes belonging to Cl_i and a set of global attributes corresponding to the union of the attributes of these classes. Furthermore, ODL_{I3} provides the designer with the syntax and semantics to define mapping rules among global and local classes/attributes and to refine the unification process proposed by the system. As in our example we considered only product categories (no attributes), we concentrate our attention on the global/local classes mapping. For example, global cluster "Global9", re-defined by the designer as "Writing paper", contains the categories "Printing and writing paper" and "Industrial use paper" of the ECCMA/UNSPSC standard and the class "Document paper, writing paper" of the ecl@ss one. In the following table, we show the global class "Writing Paper", the involved categories and the correspondent code of the native standards.

Sources	Class (Category) name	Code
Mediator Shared Level	Writing Paper	Writing Paper
ECCMA/UNSPSC	Printing and writing paper	14.11.15.00
ECCMA/UNSPSC	Industrial use paper	14.12.00.00
ecl@ss	Document paper, writing paper	AAB203

The mapping between concepts of the two standards is graphically shown in Figure 5, with dashed lines.

The system produces the whole global shared schema in an XML-like format, where, for each global class the mapping into the local sources' classes is described. In particular, the MOMIS output for the obtained mapping is an XML file according to this trivial DTD:

```
<!ELEMENT cluster (interface)>
<!ATTLIST cluster name CDATA #IMPLIED>
<!ELEMENT interface EMPTY>
<!ATTLIST interface name CDATA #REQUIRED>
<!ATTLIST interface code CDATA #REQUIRED>
```

For example, we show how "Writing Paper" cluster is exported using our formalism:

```
<cluster name="Writing Paper">
<interface name="eclass.documentpaperwritingpaper"
code="AAB203" />
<interface          name="unspsc.industrialusepaper"
code="14.12.00.00" />
<interface   name="unspsc.printingandwritingpaper"
code="14.11.15.00"/>
</cluster>
```

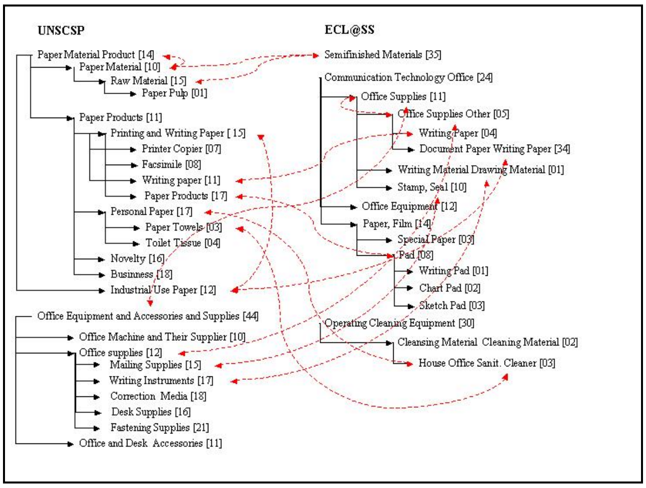

Figure 5. The obtained mapping

By considering the mapping among the clusters of the global virtual schema and the local product code, it is possible to compare two different standard categories or to consider as a unique entity all the elements contained in the cluster. In this paper, we have exemplified our mapping approach by referring to a fragment of standard classification related to the paper domain. Nevertheless, thanks to the scalability of MOMIS methodology, the process may easily be extended to map every term between the two considered standards. The approach may be further extended in order to obtain mapping among other product classification standards.

4. Concluding remarks

In this paper, we proposed a semi-automatic methodology to define a mapping among different e-commerce product classification standards. We have exemplified the methodology by showing how it is possible to create a mapping between a fragment of the ECCMA/UNSPSC and a fragment of the ecl@ss standard, but the process may be successfully applied to other product classification standards. The obtained XML mapping file may be inserted within an electronic marketplace in order to define automatic rules to manage products classified using the ECCMA/UNSPSC and ecl@ss standards. These rules may generate automatic data translation to give to the marketplace seller a unique code representing the same product that is classified by the vendors in different manners. In this way, by providing a common manner to describe goods involved in the e-commerce process, the marketplace really becomes the place in which sellers and vendors may interact without any change in their data management system.

The shown approach has permitted to use a methodology for integration of heterogeneous sources to perform a matching between two different database schemas. The main problem to be issued in this context is represented by the semantic heterogeneity arising when different sources describe the same or overlapping data in different ways. Managing semantic heterogeneity is an issue faced in literature: several architectures have been proposed, ranging from *mediation system* (integrated read-only views), *federation systems* (multiple databases sharing information), *mediation with update* (integrated read-write views), *workflow* (coordinating multiple databases) [8]. Fundamentally, there are two approaches to support read only integrated views: virtual and materialized. Materialization of integrated views offers higher performance in term of query response time than the virtual one, but has to face issues related to fusion of data coming from the local sources and to keep self-aligned the global schema and the sources. Moreover, two approaches have been proposed in order to specify mapping between the sources and the global schema [9]. In the *Global as View (GAV)* approach, the global schema is expressed as a set of views over the local schema. The *Local as View (LAV)* approach permits to specify data sources as queries over the global schema. The MOMIS system, following a GAV approach, may provide the global virtual view in an XML standard language (i.e. a DTD or a XML-Schema file) of two different standards (the ECCMA/UNSPSC standard and the ecl@ss standard).

In this scenario, the marketplace is able to really support the economic transaction between the seller and the vendor. In fact, it permits the user to retrieve a product on the basis of the name/code given in the unified global class, or the name/code defined in each specific standard. A marketplace can be implemented as a mediator system that performs retrieving of information among the integrated sources on the basis of a user query. Therefore, when a user requests the marketplace for a specific product list, the system has to translate the concept associated to the product into the different ones for each standard. In this way, mapping knowledge is used to rewrite the user query into a corresponding one following the classification standard of the source. By performing this operation, it is possible to map the category chosen by the user into the corresponding ones in all the standards and providing the user with a result that is the unified view of all the results obtained from each source. Moreover, the operation of translating a source schema into different ones is made easy if a DTD or an XML-Schema file expresses the schema. In fact, the W3C provides a language (XSLT language) to translate a file into another having a different structure but expressing the same concepts.

The MOMIS system contains Query Manager component that processes queries over the global virtual view and provides the user with a unified answer. The MOMIS system enriched with the integrated product catalog standards may thus be considered as a system able to support a marketplace environment.

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