An Ontology for Municipal Government

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Abstract

The expansive growth in usage of information systems by organizations during the last decades has exponentially increased the amount of stored data. As new needs, and therefore applications, emerge the requirement for reusability of information within and outside the borders of organizations comes into view. This is particularly the case in Local Public Administration an area that by its nature comprises numerous different entities with an inherent need in reusing and exchanging information. Furthermore as various e-Government initiatives are being realised in municipalities throughout the world, policy makers and technology providers start to understand the importance of standardization in local administration e-Government systems in order to foster the necessary reuse of information. Municipalities are often the closest Point of Service for the European citizens and enterprises, having access to all the necessary information and usually providing the final service – a fact that makes their e-Services Portals a very important link in the e-Government chain. Ontologies, by modeling process and data relationships, make possible the description of a domain in a machine processable way. A feature like that is especially useful in the field of e-Government: Local public administrations show great interest in reusing and exchanging information concerning their electronically provided services, in an attempt to standardize the operation and achieve interoperability of their systems. The present paper presents an ontology in Web Ontology Language (OWL), supported by Protégé ontology management tool, that models services provided by municipalities together with their respective data, thus allowing the standardisation and interoperability of respective e-Government systems.

Keywords: e-Government, Municipal Services, Knowledge Representation, Ontologies, OWL, Protégé

1. Introduction

Municipalities are a crucial part of public administration, most notably because they provide numerous services to citizens and businesses, like the issuing of certificates, permits and licenses, but also as they usually are the common point of service for various other administrative acts [Capgemini (2005)]. Therefore a great amount of information is kept by them in several and very often heterogeneous registries which they have to support and update constantly. Furthermore, local public administrations are constantly in a state of information exchange internally, within their departments, as well as externally, with other municipalities and organizations, in order to perform their administrative tasks.

Municipalities are autonomous organizations capable of defining, to a great extend, their internal structure and way of operation irrespective of one another based on a diversity of different needs they have to cover. Such reasons – as well as political decisions, timing and funding – have led to very different implementations of their information systems but also of their emerging e-Government portals [Tambouris et. Al. (2006), Hall (2006)].

The IT infrastructure of a municipality usually consists of terminals connected to a Local Area Network (LAN) that provides access to several custom made software applications and a number of servers. Such an architecture expects employees to use standard interfaces of an application on their terminals in order to access, insert, modify and delete data stored in databases. The conceptual schema of each one of these is based on the covering of current needs and does not follow any formal guidelines. The local network of the municipality may also be connected to other governmental networks and ideally other Wide Area Networks and the Internet. Through that, employees have the chance to communicate with other organizations as well as citizens and businesses for the faster completion of their activities and the provision electronic services to the public.

Nevertheless, the fact that each local public administration authority adopts its own conceptual schema for its information system causes problems of data duplication, different representation schemes and difficulty in relating common data [Abecker et. Al. (2004)]. Same types of information are kept in databases and other means of storage under different labels. Variations in terminology make data incompatible even though they may represent the same entities. Moreover, information in text format does not provide any semantic context whatsoever, so that any kind of access to it is made through plain text search techniques which simply provide possible documents in which desired data might be totally leaving aside the semantic content of information.

Additionally, incompatibilities within the same municipality have a great impact, as resources need to be accessed by different departments of the same organization that each requires a different view of the same set of information. These problems are often solved by ad hoc parameterizations of the information systems that have a high cost in time and effort and leave the system in an inconsistent state – i.e the same information being updated by several points/departments replacing valid information with unchecked data.

Apart from the cooperation of different departments within the municipality, local government activities usually require a great deal of interaction with other municipalities and governmental organizations. Administrative acts require a number of documents that prove citizen status or support its claim, in order to deliver the final service. These usually come from the central government, the police, tax authorities, social security, banks or other agencies. In addition, municipalities are the responsible authorities for keeping records that involve citizen civil status, urban planning, operational licenses of businesses and local taxes.

It is apparent that even basic process/data standardisation and interoperability capabilities between the information systems of all these parties could bring great benefits to their operation [Benamou (2006)].

2. Standardisation and Interoperability in Municipal e-Government Systems

The landscape of municipal information systems in Europe is quite complicated, as there is a great divergence of environments in which these organizations operate. Although local public administration is often regarded as a whole, the difference in conditions and objectives make it necessary to view this domain as a collection of distinct entities [Abecker et. Al. (2004), Benamou (2006)], each required to utilize its own set of processes and tools to reach its goals and conclude its actions, under a changing statutory framework.

Each municipality is an autonomous organization; thus decisions regarding its information system are taken internally according to its needs and resources [Tambouris et. Al. (2006), Hall (2006)]. Computerization of activities has brought a wide spectrum of advantages, most notably the acceleration of service providing and the reduction of paperwork as well as the decreased need for manpower resulting to cut of expenses [Busson A. et. Al. (2006)]. Unfortunately, at the time this process was being realized, issues regarding interoperability were usually not taken into consideration with the focus being on infrastructure provision and network connectivity. But as the use of information systems by the public increased and connectivity costs dropped, possibilities such as electronic governance has started gaining ground within administrative authorities. At that point the need for reusability of information resources emerged. There is a need for capturing, mapping, processing knowledge concerning Municipal Government services in order to support reusability, to help common sharing and understanding of the domain and to avoid inconsistency. Results can serve as a conceptual base – support for any IT project in the Municipality e-Government domain through usability and reusability of the knowledge base. Future developed or existing information systems could reuse as much as possible of already existing knowledge. For example, to define their own ontology for legal aspects they should reuse the ontology representing the law at the state level (or at least at the federal level) and not to start directly from the Legal ontology. This will speed up the ontology development process and will increase the interoperability [Stojanovic et. Al. (2006)].

When it comes to the interoperability between information systems of large organizations with a strict hierarchy, the case can be relatively simple - since there can be an agreement on a set of processes and rules regarding the exchange of information in a structured way, leading to the adoption of common data schemas. In some cases, systems can even be integrated through redesign, merging of their databases and implementation of web service interfaces connections.

This form of interoperability might be effective when few and predefined parties are involved, or when a party has the power to enforce its will across the entire service chain. Nonetheless such procedures are time consuming, usually very expensive and also require supplementary personnel training and a period for adapting to the new reality of operation.

In the field of local public administration this is certainly not the case, since the number of interested parties is very large and the information systems they use are quite diverse. In addition, each party cannot know in advance exactly what the other party might want to communicate – in the long – term this might as well be every other administrative authority as well as numerous persons and businesses. Thus, a single case solution cannot be adopted. The fact that municipal information systems primarily facilitate processes and services and not just data storage must also be taken into consideration. This means that a conceptual model strictly based on where resources can be found, such as Entity-Relationship models [Brodie et. Al. (1984)] used in database design, cannot fully cover the universe of discourse formed by local public administration activities [Tektonidis D. et. Al. (2006)]. Furthermore, there are ways of modeling processes in a formal way, such as using Enterprise Modelling techniques or Unified Modeling Language (UML), but their weakness [Tektonidis D. et. Al. (2006)] is that they are either too abstract to model data relationships in a machine-processable way, or too specific to achieve the goal for their widespread use. There have been suggestions on how to form ontologies based on UML for municipal services [Barone A. et. Al. (2005), Charalabidis et. Al. (2006)] not covering through the important aspects of data modeling.

3. An Ontology of Municipal Electronic Services (MES Ontology)

3.1 The Web Ontology Language (OWL)

As the amount of information managed by information systems is radically enlarging over the last years, conceptual modeling approaches and data abstraction attempts are becoming more and more important in an effort to inter-relate information structures. However, the usual lack of semantic content of stored data, combined with the numerous different sources of it, makes data interoperability a hard task. Taking these matters into account, the World Wide Web Consortium envisaged the Semantic Web initiative [Berners-Lee et. Al. (2001)]. This initiative aims at providing the entire semantic framework for automated information discovery and reasoning over data in the field of World Wide Web. Part of this effort is the Resource Description Framework (RDF) [Manola et. Al. (2005)] which provides a way of representing relationships between data already semantically tagged using XML [Bray et. Al. (2005)] and the Web Ontology Language (OWL) [Smith et. Al. (2005)] which is used to describe ontologies, in other words conceptual models of data and abstract entities.

In the field of ontological design, OWL is a concise and powerful framework as it presents a set of key features. Primarily, its usage is not limited to web applications but can be expanded virtually to any domain – the term Web in its definition refers to the use of Uniform Resource Identifiers (URIs) which are, however, not required to represent existing web resources, something that is also the case in XML. OWL embodies all the expressive power needed to represent any universe of discourse through its abstraction power [Corradini (2006)]. The key element of OWL is Class, which is a collection of entities, or Things using OWL terminology, which are collections of concrete or abstract concepts. These might be data but also services, people, applications or anything that expresses a set of things with common characteristics. These are arranged in a tree form using standard inheritance rules like in object-oriented programming languages [Brodie (1984)]. Nevertheless, forming a hierarchical structure of classes is not enough since it is necessary to correlate classes in various ways except inheritance. For this purpose object properties are used. Finally, one can also create predefined instances of classes.

3.2 The Field of Application

As stated in previous chapters, the need for conceptual modeling in the domain of local public administration and municipal e-Government systems is already well established. Defining a service/data ontology that will act as a generic model and then re-use it over different municipalities constitutes an effective solution towards service standardization and systems interoperability.

The universe of discourse of the ontology presented in this paper comprises of the most common services provided by Greek municipalities to citizens and business. These services have to do with citizen civil status, public order, economy and trade, municipal resources and income, social security and urban planning [Charalabidis et. Al. (2006)]. This set of services has been defined by the Greek Ministry of Internal Affairs, as the set of most popular services in the field of municipal government based on European directives and the frequency of requests made by citizens and businesses towards the Greek Citizen Service Centres (GCSC), that act as common intermediaries between citizens and public administrations in Greece [Greek Citizen Service Centres (2006)]. The GCSCs handle approximately 1,000 Public

Administration (PA) services. More than 200 organizations from Ministries to Municipalities and Prefectures are involved in the provision of those services and around 3,000 hundred documents are exchanged in their context. The GCSC portal receives over 9 million visits each month and its operation is supported by more than 1,000 Citizen Service Centres spread around Greece and linked together by an IP network. A huge amount of statistical information was retrieved from the operation of the GCSCs and was elaborated on during the present study in order to derive the most common municipal services in Greece. For instance, statistics report 3.001.038 citizens' requests concerning provision of 739 specific services that were addressed by the Citizen Service Centres during the year 2005.

It should be noted though that these offices are simply accepting requests (which are submitted in person by the applicant or by an authorized proxy) and push them to the responsible authority either electronically but most frequently by fax or mail. The local authorities themselves have to carry out the services and later respond to the offices which in turn provide the applicant with the result of his request. This procedure denotes the interoperability issues of such organizations. The Citizen Service Centres do not have direct access to municipal registries, so they cannot complete services such as the issuing of a birth certificate on their own. Moreover, they don't have the ability to modify data kept by municipalities, so administrative acts such as the transfer of citizenship between municipalities which is very common and does not require any kind of subjective decisions (such as a resolution of the municipal council) cannot be carried out.

3.3 Basic Principles and Architectural Guidelines of the e-Government Ontology

The presented Municipal Electronic Services Ontology, or MES-Ontology, is based on the most common municipal services in Greece. It models the data on application forms, required documents and other aspects such as the demand for physical presence of the applicant or an authorized proxy for identification purposes, cost and time of delivery. It also includes abstract concepts, such as the fact that each person has a father and a mother, a name and a surname. These pieces of information are needed for a more complete modeling of the represented concepts but can also form a base for other ontologies.

As every OWL ontology, municipal e-government ontology has a tree form with its root being the element owl:Thing. Subclasses of it are the classes Application, Complex Data, Person, Required Document, Service and Simple Data as shown in Figure 1.

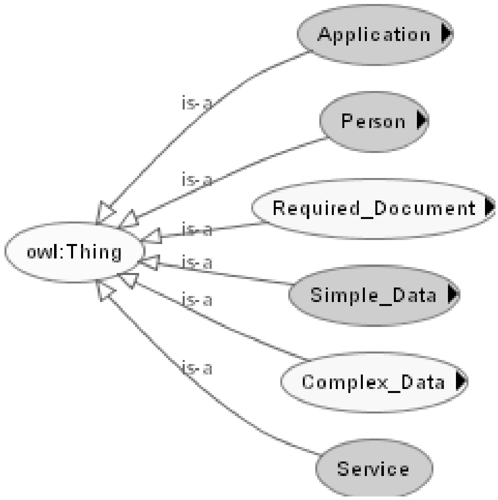

Figure 1. *Subclasses of owl:Thing*

Class **Simple Data** is composed by a number of abstract classes such as Surname, E-mail, Marital Status, Time in Days, and Year. Properties are not assigned to these classes intentionally as we want to preserve their abstractivity, so their use is merely as placeholders. This is the case because at a later stage they can be assigned with properties according to their use. For example within the class Surname there can be a declaration on where instances of this class can be found as entries in a database. Furthermore, Simple Data is also the base on which class Complex Data stands.

Complex Data comprises subclasses formed by the use of properties which have as a range Simple Data or which show special characteristics in their structure – such as Birth Data, Address and Sex. For instance, class Address is connected with class Street Number by object property hasStreetNumber and class Sex contains only two predefined instances, Male and Female. Classes like latter are used when we want to cover our conceptual domain by inserting predefined values which can be used as semantic tags in an XML or RDF document.

The approach for modeling metadata in the ontology as separate structures (Simple Data / Complex Data) is compatible with relevant metadata standardization initiatives such as the DublinCore [Dublin Core Metadata Initiative (2006)], or the UN/CEFACT ebXML Core Components Technical Specification [Core Components Technical Specification (2005)].

Class **Service** comprises 36 distinct services. Its structure resembles that of subclasses of Complex Data. It is placed on the first level of the hierarchical tree, as it is conceptually distinct and also has an important feature, its instances have object properties with a preset value (which must be an instance).

Required Document is a class with 75 subclasses which represent types of documentation required during the submission of a municipal service request. These are documents like identification cards, building designs, business permits and others.

Class **Person** represents people. It is consisted by subclasses Applicant, Deceased, Father, Female Spouse, Juvenile, Male Spouse, Mother and Proxy. It is not though an enumerated class i.e. a person doesn't have to necessarily be a member of any of these subclasses. This is in order to avoid incompatibilities during the merge of the ontology with some other ontology in which a person might not have any of these attributes. Compatibility issues were taken under consideration throughout the design process as it is desired for the ontology to have the most extensive application possible. The subclasses of Person actually represent roles of people participating in one way or another in the various services (for example a marriage certificate involves a male and a female spouse).

Finally, class **Application** represents the actual requests for services. It contains 36 subclasses, one for every kind of service. Each of these subclasses might have instances that are the actual requests for services by citizens or businesses. It can be said that the class Application is the center of the ontology, since it is the spot where all other entities intersect.

3.4 Object Properties

MES-Ontology, has been described until this point as a simple hierarchical tree. The only relationship that exists between classes is the Is-a relationship that certainly does not cover all aspects of the domain. Property definition is an important step towards the forming of a complete ontology. OWL defines two types of properties: object properties and datatype properties. Both of them have as their domain a class (or classes). The difference between them is their range. Object properties can have as a value an instance of a class while datatype properties a datatype that can be either user-defined or an existing type of XML Schema. It can be said that datatype properties are instantiated since their values are not modeled entities, but literals.

Furthermore, object properties can have certain characteristics. Primarily, a property can have an inverse property. For example, property *hasIDNumber* has as its inverse property *isIDNumberOf* (referring to the identification card number, a data often used in Greece). Although the inverse could be defined for every property, that is not necessary and is done only when the inverse property is considered to be important in the domain – so that it will assist matching with existing municipal systems or applications. Additionally, a property can be stated to be Functional which means that an instance can only have, at most, one value for that property. In our case *hasIDNumber* is functional since an individual cannot have more than one ID numbers. There is also the Inverse Functional characteristic i.e. the inverse of a property (whether it is defined or not) is functional. A property can also be

Symmetric, for example, the property *hasSpouse* is declared to be symmetric which means that if instance A *hasSpouse* instance B then one can conclude that instance B *hasSpouse* instance A. Finally, the last property characteristic is transitivity which is not used in MES-Ontology.

Properties drive the correlation of classes in distinct ways, something that reflects the structure of our domain. MES-Ontology contains more than 100 object properties which give the required expressivity to the model.

3.5 Describing and Defining Classes

Although the property characteristics described provide expressivity so we can define relationships between classes better, they are not enough. Further restrictions must be applied to properties in order to cover our domain.

In OWL, there are three types of available restrictions: quantifier restrictions, cardinality restrictions and the *hasValue* restriction. When creating a property, its domain, range, and characteristics should be defined. The first issue that occurs here is the fact that a property might have as a domain more than one classes. In this case, it is possible that the property might have different characteristics according to what kind of instance is applied on. For example, property *hasSpouse* is defined to be a symmetric property with domain the classes *Male Spouse* and *Female Spouse* and range the same two classes. Though, it must be clarified that a male spouse must have only a female spouse and vice versa. For this reason, we create a set of two restrictions, one for each class. In OWL terms, the first one says that *Male Spouse* has an *allValuesFrom* Female Spouse restriction on property *hasSpouse*, which means that property *hasSpouse* when applied to class *Male Spouse*, if it has values, they all must be from class *Female Spouse*.

For legal purposes, when an applicant submits a request for a service, he/she must submit a statement that all the information submitted is correct. This statement (modeled by class Declaration) is a type of required document that must accompany an application. To state that, we created a restriction on property *hasRequiredDocument*, whose domain is class Application and range class Required Document, which is *someValuesFrom* Declaration. This means that when property *hasRequiredDocument* is applied on class *Application* it has at least one value from class *Declaration*, as shown in Figure 2.

This way we expressed the fact that every application must be accompanied by a statement of that kind while it might have more required documents of other types.

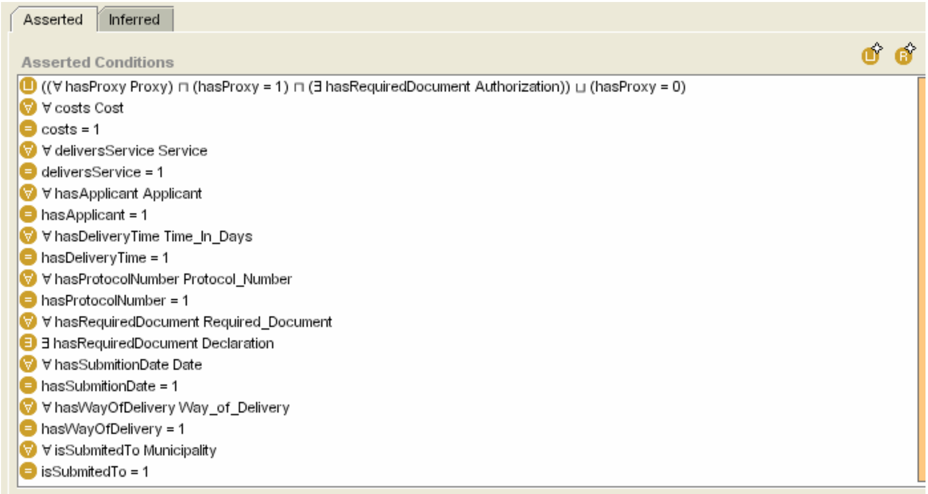

Figure 2. *Asserted Conditions for OWL Class "Application"*

Cardinality restrictions allow us to make statements on how many values a property might have. We can set a property to have a maximum, a minimum or an exact number of values. For instance, class Father is the domain of property *isFatherOf* which has the class *Person* as a range. It should be stated though that a person in order to be a father, must have at least one child. Thus we created the minimum cardinality restriction *isFatherOf* ≥ 1 which states that this property, when applied to an instance of class Father must have more than one value. As mentioned earlier functionality of a property means that a property cannot have more than one value. This is equal to a maximum cardinality of 1 restriction. Though sometimes, we must state that a property has exactly one value. For instance, in MES-Ontology, property *hasBirthcity*, with domain class *City* and range class *Birthcity*, is stated to have a cardinality of one, i.e. a person must have *exactly* one city of birth.

Finally, *hasValue* restriction states that if instances of a class have a value for a certain property, this must be a predefined instance of the range. For example, we need to define that a father is a male person. Property *hasSex* has domain class *Person* and range class *Sex*. When it is applied on class *Father* we state that *hasSex hasValue Male*. As mentioned earlier, *Male* is one of the two instances of class *Sex*. This statement is not enough though as it says that if an instance of *Father* has a value for property *hasSex* that it should be *Male*. This is why this statement is accompanied by the cardinality restriction of 1 for property *hasSex*, in order to ensure that a father is a male person In OWL, we have the chance to use the standard set theory operations of intersection, union and complement in order to combine restrictions. A complex restriction in MES-Ontology that uses these operators is the following from class *Application*:

Complex Restriction	*((hasProxy allValuesFrom Proxy)* and *(hasProxy=1)* and *(hasRequiredDocument someValuesFrom Authorization))* or *(hasProxy=0)* .

This restriction declares that an application can be submitted by a proxy only if the proxy has an authorization of the applicant.

Sometimes we need to state that a class may have only certain subclasses or instances. This is called an enumerated class. For example, class *Sex* has only two instances or class *Simple Data* is defined as the enumeration of its subclasses. We can also declare that a class is disjoint with some other class as it is done in the case of required documents where each subclass disjoints with its siblings since a required document cannot be of two types.

All these types of restrictions help us create a description of a class. This description is formed by a set of conditions which are inherited. We can describe a class either with a set of necessary conditions, i.e. an element of the class has to fulfill them, or with a set of necessary and sufficient conditions, i.e. an element of the class must fulfill them and if an element fulfills them then it is a member of the class. In MES-Ontology, the latter set is used when possible, that is when concept consistency is not disrupted. Necessary and sufficient conditions make it possible for an application to classify elements which have not been semantically tagged. For example, if some element has *exactly one Name and exactly one Surname* then an application can deduct that it is a *Person*.

4. Final Remarks and Conclusions

MES-Ontology is a model of the most common municipal services in Greece. It was attempted to retain as much abstractivity as possible while still fully describing its universe of discourse. Its first use is as a reference model, since it describes its domain in an extensive, as well as comprehensive way. That use is similar to that of Entity-Relationship models used in database design. The great difference between them is the fact that an ontology can describe abstract concepts and not only types of data and also the fact that it correlates entities using concepts with semantic content instead of simple pointers. If the syntactic conventions of OWL are known, MES-Ontology can be fully understood without further knowledge of the domain, both by humans and computers.

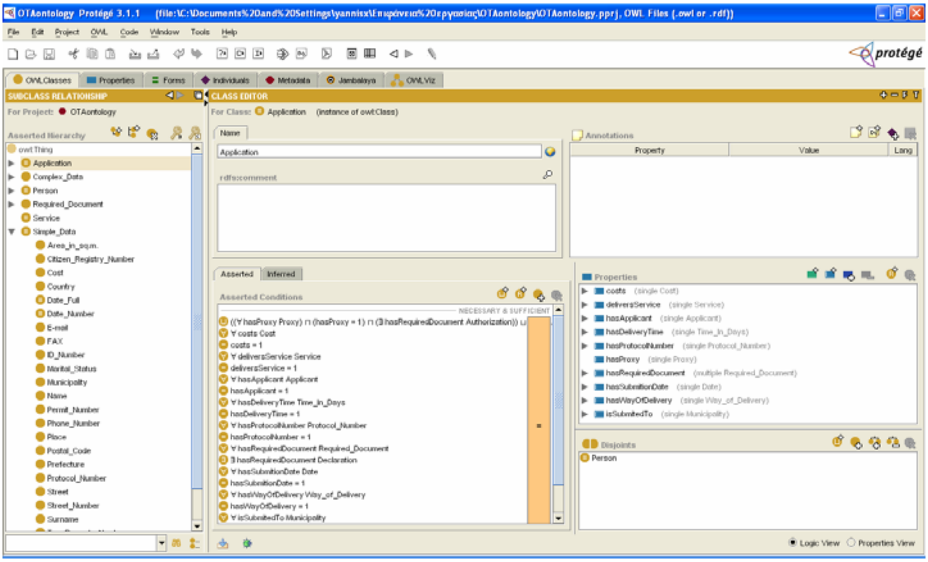

Figure 3. *MES ontology in Protégé (Class Definitions)*

MES-Ontology was written using the DL version of OWL. This choice was made because maximum expressivity was desired while still retaining the capability for machine-based reasoning. OWL DL is based on Description Logics a decidable segment of First Order Predicate Logic. This makes the computational complexity of the ontology finite, thus reasoning systems can be used to deduct valid statements.

The ontology was edited using Protégé (version 3.1.1). The concept consistency of MES-Ontology was confirmed by using the reasoner RacerPro (version 1.9).

The present stage is the utilization of MES-Ontology in the design of an e-Government system of a Municipality in Greece. Ontology classes are being used for the creation of XML documents - the consistency of which can be verified automatically by a specifically designed application. These XML documents will be the underlying layer of interfaces which in turn will be used by the municipality personnel to create, access and modify data through the Municipal Portal. The public will have the chance to start a service in an electronic way, for example by filling an electronic application form and sending images of required documents through the Internet. The consistency of submitted data can be checked automatically and the effort required for the delivery of the service will be reduced significantly.

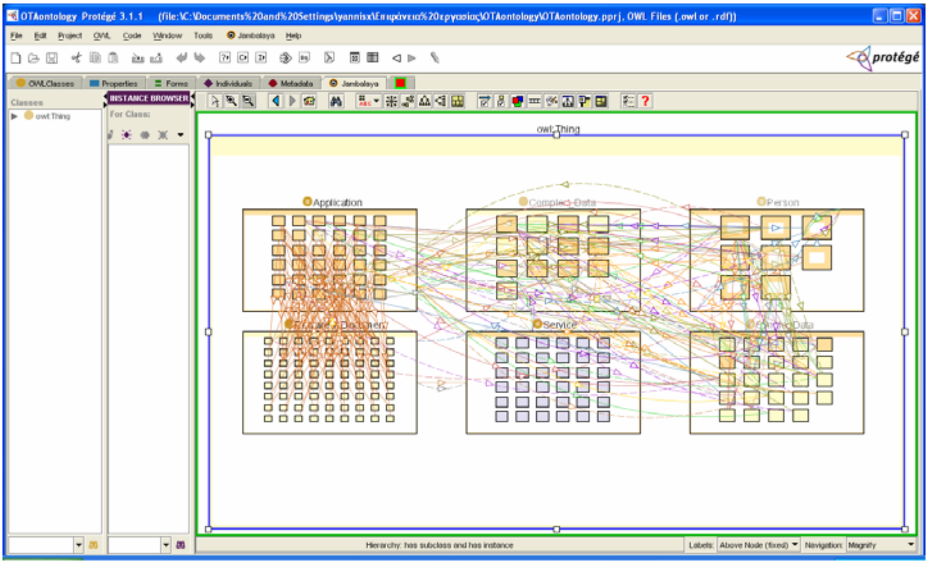

Figure 4. *MES-Ontology in Protégé (Class / Object Relations))*

Furthermore, if external applications have the ability to access the ontology, they will be in place to access the data stored in the municipality information systems, if proper descriptions are added. That is a crucial feature for government-to-government (G2G) applications, as it leads to automatic service discovery and seamless, Application-to-Application interoperability. This way, organizations of local and central public administration will be able to share data needed for the completion of services whilst saving time and money. The great advantage of using ontologies for that cause is that continuous modifications in existing information systems are not necessary.

Finally, one useful feature that derives from the use of OWL is the capability to merge different ontologies. As each data element can be part of more than one ontologies at the same time, MES-Ontology can be used in parallel with other ontologies describing different domains (such as the Greek e-Government Interoperability Framework / eGIF Ontology) achieving easy correlation of data and processes.

All this potential can be used by e-Government initiatives that will help both the local public administration organizations, by reducing the complexity for the completion of their tasks, and the citizens, by making provided services faster, simpler and definitely more reliable. Municipal e-government systems employed in other countries around the world including country portals [Poon (2002)], regional (state) portals [Gant et. Al. (2001)], and local municipality websites [Cho et. Al. (2004)], [Moon (2002)]. The services provided by these websites encompass accessing development grants and regulations [Chircu et. Al. (2003)], [Thong et Al. (2000)], paying taxes [Sia et. Al. (1997)], [Tan et. Al. (2003)], applying for permits and licenses [Chan et Al. (2003)], [Teo et Al. (1997)], accessing health information [Dongwoon et. Al. (2003)], and geographic information [Borges et. Al. (2000)], [Hall et Al. (2001)], just to name a few. All municipalities provide nearly identical services, but implementation takes place individually and is continuously repeated. Changes (e.g. in law) must be put into action for each implementation. The proposed ontology could be applied to improve the municipalities' back-office management of e-Gov services in the following ways: a) bridging the gap between decision making and technical realisation of e-Gov services, e.g. supporting all back-office phases (design, configure, deploy, run), b) considering the lifecycle of e-Gov services, e.g. simplified implementation of uniform process or supporting the management of changes in e-Gov services (preserve consistency, detect inconsistencies, propagate changes, implement changes), c) making knowledge explicit e.g. capturing knowledge about e-Gov services or tracing design decisions leading to e-Gov service models.

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