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SEMANTIC INTEROPERABILITY CONFLICTS IN PAN-EUROPEAN PUBLIC SERVICES

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Abstract

This work presents ongoing research in Pan-European Public Services (PEPS) and Pan-European E-Government Services (PEGS). This field of work is relatively new and has attracted the attention of the European Commission and of many research organizations and businesses as well. The semantic interoperability issues that may arise when a citizen of one Member State requests a public service from the public administration of another Member State are examined in this paper. The semantic conflict types that may arise in this case are identified and classified according to the Governance Enterprise Architecture (GEA) object model concepts. This conceptual modeling can be the basis for the building of a semantic gateway that will resolve these issues at a pan-European level.

Keywords: semantic interoperability, GEA object model, semantic conflict types, Pan-European E-Government Service, Pan-European Public Services, cross-border services, semantic gateway

1   INTRODUCTION

The area of cross-border public services provision at a pan-European level is a relatively new but vivid research area. The work conducted there is supported by the European Commission itself, as well as by IDA (Interchange of Data between Administrations) and IDABC (Interoperable Delivery of pan-European E-Government Services to Public Administrations, Businesses and Citizens). Moreover, many research organizations and businesses are active in the field.

In previous works of IDABC, the definitions of Pan-European E-Government Services (PEGS) and of cross-border services have been given (e.g. (European Commission (IDABC) 2004b)). Moreover, in (Witters & van Overeem 2004) an architecture for providing PEGS has been proposed. In the Consultation document (European Commission (IDA) 2002) four types of government e-service that have a cross-border dimension are defined, namely cross-border users, information exchange between Europe's public administrations (PA), life events for citizens and enterprises at the European level, and European-level services. The e-Government subgroup has published (E-Government subgroup 2004) a working paper with the objective to provide the background for a discussion on e-Government beyond eEurope 2005. Recently the European Commission published the Communication on interoperability for Pan-European E-Government Services (European Commission 2006a). This Communication highlights the importance of developing cross-border e-Government Services and the key role that interoperability plays when developing such services.

In this paper we try to identify the problems that come up when actors, information and services from different Member States (MS) need to cooperate and/or interoperate during the public service provision process (Peristeras & Tarabanis 2004). Specifically, semantic interoperability is considered a key issue in this service provision domain. Thus, this paper provides an analysis of the specific types of semantic interoperability conflicts that are likely to occur in pan-European public services. To better identify these types, we use some core Governance Enterprise Architecture (GEA) concepts (Peristeras 2006) and combine them with a well-known interoperability classification framework of information systems (Park & Ram 2004). Although a significant part of the subsequent analysis may be also applicable to cross-border PA service provision in general (ie outside the scope of the EU), our interest remains at the analysis of EU-internal service provision.

This paper is organized as follows: Section 2 gives the service definitions in the Pan-European Public Services domain. The motivation for our work is presented in section 3. In section 4 a classification of the basic conflict types that might occur between different MS is presented, based on the GEA basic concepts and the semantic differences framework of Park and Ram. Finally the conclusions and future work are given in section 5.

2   DEFINITIONS

In this section, we present definitions that are relevant in the pan-European service provision context. We discuss in detail the notion of Pan-European Public Services (PEPS) and we differentiate them from Pan-European E-Government Services (PEGS).

- **Cross-border services** are services provided from one country to users based in another country. For example, a customs service that is provided by the Canadian customs office to American citizens who want to import goods from Canada can be considered as a cross-border service.
- **Cross-border electronic services** are services provided from one country to users based in another country over telecommunication or data networks (Mattoo & Wunsch 2004). For example, the same customs service described above would be characterized as a cross-border electronic service in case an electronic form was filled for each imported good.

These two definitions are valid both for private and public sector services.

- **Pan-European Public Services (PEPS)** are public administration services provided by European public administrations to European clients. These services involve actors, and/or information and/or other services from at least two Member States irrespective of the technology used.

This definition of PEPS is slightly different (and in a sense broader) from the IDABC definition of cross-border public services. In (European Commission (IDABC) 2004b), these are defined as services supplied by (or under the political responsibility of) a public administration, which can be accessed by or delivered to users based in another country. In this definition the only criterion for characterizing a service as pan-European is that of the different client-service provider location.

An important aspect of PEPS that deserves attention even at the definition level is that many PA services may "evolve" to PEPS during run time. This means that a simple national service, i.e. marriage, can become a PEPS if the bride comes from a different country and evidence placeholders should move from one country to another. From a different perspective this also means that PEPS do not exist separately from national public service, but are defined as a specific instance of them.

- **Pan-European E-Government Services (PEGS)** are cross-border electronic services that support the execution of PEPS and are provided to European businesses and citizens by means of interoperable trans-European telematic networks between public administrations.

This definition of PEGS is also slightly different from the one used by the IDABC program (European Commission (IDABC) 2004b). This is due to the fact that in our analysis, we clearly distinguish between public administration business services as business services that provide business value versus the electronic services that are used to facilitate the execution of the real services.

For example consider the case of an Italian citizen that wants to establish a new business in Greece. The service called "business establishment" is normally a national public service when it refers to Greek citizens, but becomes a PEPS when the potential entrepreneur comes form an EU country. In order to facilitate this PEPS, different PEGS as parts/components of a PEGS infrastructure/architecture may be set up i.e. a web portal for getting information on the service prerequisites and workflow, e-forms for applying for the service, e-monitoring of the service execution process. All these are considered PEGS related to the specific PEPS.

3   MOTIVATION

According to the definitions given above Pan-European Public Services (PEPS) may be considered as a special case of the general term "cross-border public services". The additional characteristic is obviously the European dimension. It must be noticed that this is not a simple geographical instantiation e.g. equivalent to Pan-African Public Services, as the European Union provides a unique political and institutional environment for the development of this type of services. "Cross-border public services" seems to be also a specialization of an even more general term "cross-border service". This later refers to both public and private (e.g. commercial) services that take place in a multi-national environment.

In a similar way cross-border private services acquire specific interest in a globalized economy, PEPS acquire a similar great interest in the EU economic and political perspective. Thus, in the EU environment it is highly likely for every European citizen and/or company to be engaged in some type of cross-border activity that could trigger the execution of some PEPS. Furthermore, the development of PEPS is not only inline with the principle of the European Single Market and the European citizenship; it rather acts as an essential enabler to transform this principle from theory to practice. Therefore, the development of Pan-European cross-border public services (PEPS) have been included as one of the EU's priorities in the i2010 E-Government Action Plan (European Commission 2006b).

However, the cooperation between European public administrations addresses important issues such as:
- In what depth do European MSs really want to integrate their service provision (depth of integration)?
- Which public administration services (e.g. in which policy domains) have to be provided at a pan-European level and which should remain under the exclusive jurisdiction of national public administration (width/scope of integration)?
- How can public administration agencies that provide such services work together in order to provide PEPS (how to achieve integration)?

The first two issues should be addressed at the political/institutional level and have recently caused a lot of discussions in the EU (OECD 1998, Olsen 2003, Shapiro 2001). However, the third issue is more interesting for our analysis as it deals with the means to achieve the necessary administrative integration.

Developing and making available PEPS in an efficient and effective way is not trivial. On the contrary it is a very complex process that requires, except from taking into consideration clients real needs, dealing with various problems that are caused due to the pan-European nature of PEPS. This nature is characterized by the following:
- Clients and service providers may come from different MSs .
- Information from one MS may need to be communicated to another MS either before of after a service execution.
- Services from different MSs may be combined to provide the needed output to the client.
- Different legislative frameworks, different cultures, different languages may cause several conflicts in the interpretation and the usage of terms, concepts, documents etc.

3.1 Information systems semantic interoperability

Taking the above into consideration, we perceive information systems interoperability as an important means for achieving and enhancing integration and providing the necessary infrastructure in order to practically allow the execution of PEPS.

Thus, we argue that defining and solving interoperability problems amongst the information systems of European PA agencies is a necessary precondition for successfully developing PEPS.

Information systems interoperability is an active research field for decades but has attracted a lot of interest during the past few years, e.g. (Vitvar & Kerrigan & van Overeem & Peristeras & Tarabanis 2006), (Tambouris & Tarabanis 2005).

In relevant literature various definitions for interoperability can be found (e.g. (Peristeras, 2006)). Here we present two of them:
- IEEE defines interoperability as the ability of two or more systems or components to exchange information and to use the information that has been exchanged (Institute of Electrical and Electronics Engineers (IEEE) 1990).
- The "European Interoperability Framework for pan-European e-Government services" (European Commission (IDABC) 2004a) defines interoperability as the ability of information and communication technology (ICT) systems and of the business processes they support to exchange data and to enable sharing of information and knowledge.

Several different types of interoperability aspects should be considered when discussing interoperability between the information systems of public agencies from different countries at a pan-European level.

For identifying these aspects, we group them in three categories, following the three interoperability types proposed by the European Interoperability Framework (EIF) (European Commission (IDABC) 2004a):
- Technical incompatibilities, e.g. among the technical infrastructure of PAs from different MSs.
- Semantic incompatibilities, e.g. different meaning and usage of documents, information.
- Organizational incompatibilities, e.g. among different business processes, goals.

While technical incompatibilities are related to and can be solved with technical solutions that are currently more or less available and comparatively easy to be implemented, the other two interoperability aspects are more difficult to be addressed. Although we understand the importance of organizational interoperability, the scope of this work is on the semantic interoperability problems in a PEPS environment. Therefore, we further provide two definitions for semantic interoperability:
- The European Interoperability Framework defines semantic interoperability as the type of interoperability which deals with cases where the information exchanged between organizations is interpreted differently by each side.
- A more technical and detailed definition was provided by Yanosy (2005). According to this definition semantic interoperability encompasses the capacity for mutually consistent semantic interpretation of intention and shared knowledge within a situational and purposeful context, as a result of a semantic interaction, where intention, context, and knowledge are explicitly represented and expressed in some language of discourse or are implied by convention and use.

In (FIDIS Project 2005) a framework has been proposed, which aims at providing a holistic view of interoperability. This framework consists of three layers: the technical, the formal (policy and standards) and the informal. Actually, the technical is the core layer and is contained in the formal one, which in turn is contained in the informal one.

In the "Netcentric Semantic Linking Report: An Approach to Enterprise Semantic" (MITRE 2004), the experience of exploring the "Network Centric Semantic Linking" as a potential solution for integration across the U.S. Military Enterprise is presented. At a conceptual design level, the approach

demonstrates the use of a reference ontology for linking a set of domain ontologies to achieve interoperability across domains, which has been proven to be a powerful solution. This approach obtains particular interest in the e-Government domain, especially, when the focus is on the interoperability problem between different countries administrations.

According to (Witters & van Overeem 2004) the use of the semantic gateway is proposed as a means to overcome semantic interoperability problems. The semantic gateway provides a set of services which aim to harmonize the meaning of the information exchanged between PAs from different MSs. In order to fulfil its objective the semantic gateway needs to have access to context data in the MSs, as well as to other kinds of data, including metadata translation tables.

In this paper we elaborate on the concept of the semantic gateway and we examine the types of semantic conflicts that such an infrastructure should solve. As our analysis remains at the conceptual level, we try to present a bird-eye view on the existing semantic problems. To the best of the authors' knowledge no such conceptual analysis using this framework exists in the literature for PEGS.

4   TYPOLOGY OF SEMANTIC INTEROPERABILITY CONFLICTS IN PAN-EUROPEAN PUBLIC SERVICES

In this subsection we try to identify the general types of interoperability inconsistencies that arise in the public service provision process at the pan-European level. As we have already discussed above, the public service provision process is more complex when it is conducted in a pan-European environment due to the heterogeneity of the various actors/information/services from different MSs that participate in the service provision. In order to identify and classify these conflicts, we will use:
- The work of Park and Ram (2004), where general types of semantic interoperability conflicts were identified and discussed regardless of the application domain.
- Core GEA concepts (Peristeras 2006). These concepts help us to instantiate the work of Park et al. in the PEPS domain.

4.1   General types of semantic interoperability conflicts

Park et al. argue that semantic conflicts can occur at two different levels: at the data level and at the schema level.
- Data-level conflicts are differences in data domains caused by the multiple representations and interpretations of similar data.
- Schema-level conflicts are semantic conflicts which are characterized by differences in logical structures or inconsistencies in metadata of the same application domain.

Moreover, Park et al. propose that data-level can also be classified according to granularity of the information unit in the following two categories, namely object and object properties and their values.

4.2   Governance Enterprise Architecture (GEA) concepts

GEA (Peristeras 2006) is a top-level, generic enterprise architecture for the overall governance domain, which currently consists of seven models at different levels of analysis. One of these models, namely the GEA object model, describes the basic concepts of a PA service. Our work in this paper is based on this model and the GEA concepts that are used here are the following:
- Client that is a citizen, a business or another PA, which requests a service from a service provider.
- Service Provider that is the PA agency that is competent for providing a specific service.
- Preconditions that are a set of checks which are defined by business rules and law. Preconditions are used to validate the input of a service.

- Evidence that is the information that the service requires for its execution. Evidences are used to check the precondititions of the service.
- Evidence Placeholder that is the part of input of the service that contains evidences. The most typical type of evidence placeholders in the PA domain is administrative documents.
- Outcome, which is provided after the execution of a service and consists of:
  - Output that is the acquisition of information by the client of the service after the execution of the service. Output documents an administrative decision and is usually provided in the form of an evidence placeholder.
  - Effect that is a change in the state of the world that is caused by the execution of a service.
  - Consequence that is information related to the executed service that is of interest to a third party.

A typology of semantic interoperability conflicts in PEPS using the GEA concepts is proposed below. It is important to mention at this point that in the subsequent analysis we present the more prevailing and interesting case of these conflicts. This means that we may find e.g. that data value conflicts may also occur in more GEA concepts than those presented below, but here we highlight and focus on those that seem more relevant, important and challenging to be handled in a PEPS environment.

4.3   Data level conflicts

This type of conflicts occurs due to data differences in the different PA domains. They are depicted in Figure 1. A detailed explanation follows.
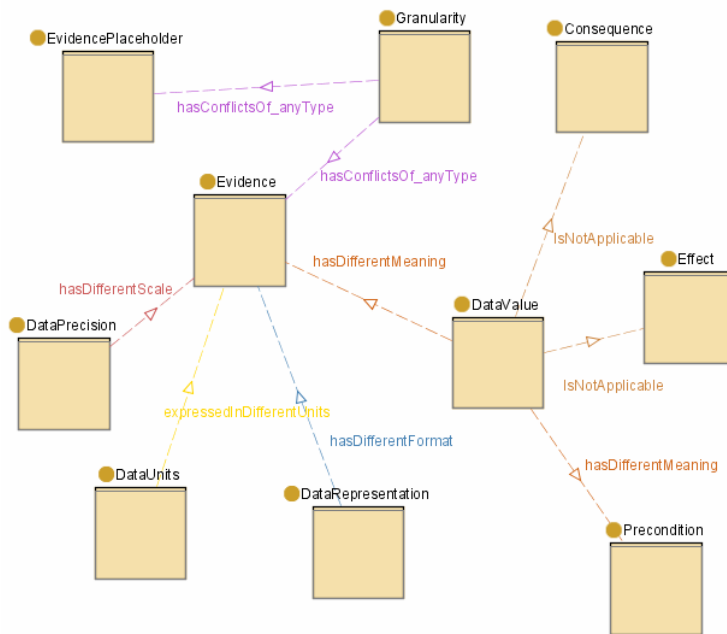

Figure 1: Data level conflict types

4.3.1   Data value concepts

Differences in evidence domains caused by the multiple representations and interpretations of similar evidence.

To start with, interoperability conflicts of the data-value type are raised in evidences (= information required as input by the service). These conflicts come up when the same notion or term that is used as

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evidence is defined differently among different MSs, usually due to differences in legislation or to cultural differences. For example, there may be different definitions for what is meant by the terms "adult" or "disabled" etc in different MSs, i.e. in MS A all people over 18 are considered to be adults while in MS B the age limit is 17.

Differences in preconditions domains caused by the multiple representations and interpretations of

similar preconditions.

The conflicts in evidence data values may also cause problems in service pre-conditions (= logical statement that should be fulfilled). Due to the different legislation that governs the public service provision process in different MSs, differences in the preconditions of a service usually rise. For example, a precondition that demands someone to be an adult in order to be eligible for a particular service may be interpreted differently by different administrations depending on the definition of the "adult" concept.

Differences in effect domains caused by the multiple representations and interpretations of similar

effects.

Data-value conflict types may also appear in the effects (= changes in the real world) of a service. As a result, the effect of a service may not be valid outside the MS where the service was executed. For example in Ireland someone can acquire a provisional car driving license. The effect of this service is the fact that he/she is allowed to drive a car. But this effect is not accepted as such in other countries (e.g. Germany, Greece), where only the full version of a driving license exists and thus no permission for driving is given to the holders of provisional driving licenses.

Differences in consequence domains caused by the multiple representations and interpretations of

similar consequences.

Data-value conflict types in the consequences (= information about the service execution to be communicated to third parties) of a service may also occur. For example, in Greece it is mandatory for all adult males to fulfil their military service. In case they do not, the entitlement to certain civil rights and services is affected, e.g. they cannot obtain a passport. Though, these consequences may not be recognised in other MSs.

4.3.2 Data representation conflicts

Data representation and data unit conflicts may be perceived as technical (according to EIF) and not as semantic interoperability problems. As the boundary between the two interoperability types is not always clear, we have included these types of problems here following the initial classification proposed by Park and Ram.

Differences in evidence domains caused by the multiple representations of similar evidence.

Evidences are involved in data representation conflicts. In such cases, the same evidence is represented differently among different MSs. For example, in MS A they represent the date of Birth like "dd/mm/yy" while in MS B they represent it like "mm/dd/yyyy".

Differences in preconditions domains caused by the multiple representations of similar preconditions.

The data representation conflicts in evidences could lead to data representation conflicts in preconditions as well. For example, in Greece one of the preconditions for receiving a certain grant could be "income<20.000" while in Ireland this precondition for the corresponding Irish service would be "income<20,000". In both case it is meant that the citizen's income should not overcome 20,000 euros in order for him/her to receive the grant, but due to the different signs used to represent the decimal point in the two countries the precondition is represented differently.

4.3.3   Data unit conflicts

Evidences may also be involved in data unit conflicts. These conflicts are usually caused due to the fact that different countries may use different metric systems or may have different currencies etc. For example in the United Kingdom the amount of money for the unemployment benefit is calculated in pound while in Greece or in Germany it is calculated in euros. Likewise the height of an individual would be measured in Greece in metres and centimetres while in the UK in feet and inches.

4.3.4   Data precision conflicts

Furthermore, evidences could appear in data precision conflicts. Here we examine the case where different granularity is used to express similar evidence value. For example, in one MS the university degrees may be graded using a three point scale ("A", "B" and "C") while in another they may be graded using a 5-10 scale.

4.3.5   Granularity of the information unit

Park and Ram classified data-level interoperability conflicts in another dimension, using two different levels to express the granularity of the information unit. These levels are:
• the objects' properties and their values (attributes)
• the objects themselves (entities).

The equivalence in our domain could be the conflicts we may find in
• The evidence and their values, as the basic information unit in the service provision process and equivalent to the attribute concept.
• The evidence placeholders, as the equivalent to the "object" concept.

For example, we may have an Evidence Placeholder (object) e.g. "Birth Certificate", which encapsulates several evidences (attributes) e.g. "First Name", each having its own value (attribute value) e.g. "John". We examine two levels of similarities or differences between (a) evidence placeholders or (b) between specific evidences contained in these evidence placeholders. For example, there might exist evidence placeholders that although they seem to be irrelevant to each other they contain similar evidences, while on the other hand there might exist evidence placeholders which seem to be similar, i.e. have the same name, but contain completely different evidences.

4.4   Schema-level conflicts

Schema-level conflicts in this case are semantic conflicts which are characterized by differences in logical structures or inconsistencies in metadata of the PA domain. They are shown in Figure 2.

4.4.1   Naming conflicts

Naming conflicts happen when the label of a concept is somewhat arbitrarily assigned by different MSs. A very common case is to have naming conflicts in service providers and evidence placeholders.

Naming conflicts in Service Providers

In two different MSs we could have two service providers that may be called differently but in fact are competent for the same services, or the opposite, which means that we could have two service providers that have different jurisdiction and are competent for the provision of different sets of services despite the fact that they have the same name.

Naming conflicts in Evidence Placeholders

In different MSs evidence placeholders with the same name but different purpose and usage may exist or evidence placeholders with different names may have similar usage and hold similar evidences.
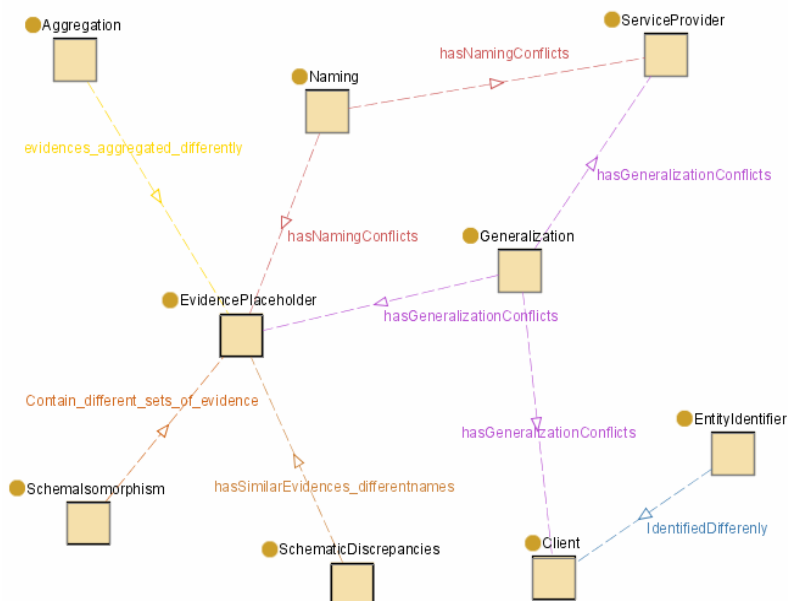

Figure 2: Schema level conflict types

4.4.2   Entity identifier conflict

A common conflict type where the client is involved is the one of entity identifier. It is very likely to come across this conflict type during the public service provision process in a pan-European level since in most of the MSs the clients are identified using different types of identifiers. This holds true for both citizens and businesses. For example, in Greece citizens are identified using the ID card number, while in Belgium every citizen has a National Number, which is created by using the citizen's date of birth (encoded in six digits), followed by a serial number (three digits) and a checksum (two digits). On the contrary in Germany, there is no unique national identification number. In another example, in Greece every taxpayer is identified by a 9-digit tax registry number. This taxpayer unique identifier does not exist in the same way in other MSs.

4.4.3   Schema-isomorphism conflicts

Schema-isomorphism conflicts occur in general when the same concept (entity class/evidence placeholder) is described by a dissimilar set of attributes/evidence, that is, the same concept is represented by a number of different attributes.

Evidence placeholders are heavily involved in schema-isomorphism conflicts in PEPS. Different sets of evidences are contained in the same evidence placeholder issued by public administrations of different MSs. For example the ID card or the Birth Certificate issued by the Greek authorities may contain different evidences from those issued by the German authorities.

4.4.4   Generalization conflicts

Generalization conflicts may be found in evidence placeholders, service providers and clients.

Generalization conflicts in evidence placeholders

As far as evidence placeholders are considered this means that an evidence placeholder in one MS may map to more than one evidence placeholders in another MS or the opposite. For example, a birth certificate in MS A may contain the super-set of information which is contained in a birth certificate and a family certificate in MS B.

Generalization conflicts in service providers

When it comes to generalization conflicts in service providers, we refer to the fact that the authorities of a service provider in a MS may be divided in more than one service providers in another MS. For example the same public services provided by the regional authorities in Greece, namely the Prefecture and the Region, may be provided by the Federal State in Germany.

Generalization conflicts in clients

Finally, when we discuss about clients being involved in generalization conflicts, we describe the case where classifications for the client exist in on MS but not in another. For example, enterprises may be grouped in different categories and sub-categories in different MSs.

4.4.5   Aggregation conflicts

It is likely that in evidence placeholders issued by PAs of different MSs the same information exists in a different number of fields. For example, in a Birth Certificate from MS A we may have the field full name, which contains the full name of its owner, while in a Birth Certificate from MS B we could have two or three different fields, i.e. surname, middle name, name, to capture the same information. In such cases we have to deal with aggregation conflicts in evidences.

4.4.6   Semantic discrepancies

Schematic discrepancies can occur when a set of evidences and their values belonging to an evidence placeholder in one MS are organized to form a different evidence placeholder structure in another MS. This is quite similar to the situation presented above as "naming conflict in evidence placeholders".

In table 1 below, we summarize all the above presented typed of conflicts. As one can observe, evidences and evidence placeholders are involved in most of the conflict types.

Conflict Type			Country A	Description	Country B
Data level	Data-value		Evidence A Precondition A Effect A Consequence A	Different meaning Different meaning Is not applicable or valid Is not applicable or valid	Evidence B Precondition B Effect B Consequence B
	Data representation		Evidence value A	Different format	Evidence value B
	Data Units		Evidence value A	Expressed in different units	Evidence value B
	Data precision		Evidence value A	Expressed in different values scale/grade	Evidence value B
	Granularity	Object Property	Evidence A	Conflicts of any type	Evidence B
		Object	Evidence Placeholder A	Conflicts of any type	Evidence Placeholder B
Schema Level	Naming		Service Provider A Evidence Placeholder A	Similar names/different services Or different names/similar services Similar names/different usage Or different names/similar evidence	Service Provider B Evidence Placeholder B
	Entity Identifier		Client A	Identified differently	Client B

Schema-isomorphism	Evidence Placeholder A	Contain different set of evidence	Evidence Placeholder B
Generalization	Evidence Placeholder A Client A Service Provider A	EP1 in one country = EP1+EP2 in another Different categorizations/groups Different administrative and organizational structures	Evidence Placeholder B1+B2 Client B Service Provider B
Aggregation	Evidence Placeholder A	Evidences aggregated differently	Evidence Placeholder B
Schematic discrepancies	Evidence Placeholder A	Similar evidences different names	Evidence Placeholder B

Table 1: Interoperability conflicts in PEPS

5 CONCLUSION – FUTURE WORK

In this work basic definitions and motivation for research in public service provision at a pan-European level has been given. Moreover, the semantic conflict types that may occur and present difficulties in Pan-European E-Government Services have been identified and presented. The whole analysis is based on the GEA object model and a well-known interoperability classification framework of information systems (Park & Ram 2004). Our analysis indicates that semantic interoperability problems can exist in both data and schema level. Most of these semantic conflicts involve evidences and evidence placeholders.

Based on the above the functionality of a semantic gateway that will resolve theses issues can be described. In fact building such a semantic infrastructure is part of our future work. The functionality of the semantic gateway will be based on ontology mapping between different ontologies from different information systems in order to resolve semantic conflicts in data. Actually, the semantic gateway will translate the information exchanged between public administrations of MSs without changing its meaning. The semantic gateway will be developed using WSMO technologies (Roman & Lausen & Keller 2005). Specifically, WSMO OO mediators will be used. WSMO OO mediators describe elements that handle interoperability problems between different ontologies.

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Appendix – List of Abbreviations

EIF	European Interoperability Framework
EU	European Union
GEA	Governance Enterprise Architecture
MS	Member State
OO	Ontology-Ontology
PA	Public Administration
PEGS	Pan-European E-Government Services
PEPS	Pan-European Public Services
WSMO	Web Service Modeling Ontology