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An experience of integration of service repositories

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ABSTRACT

In the service development life cycle it is worthwhile to distinguish between a conceptual phase, that leads to model abstract services, and a production phase that produces concrete services. Both abstract and concrete services produced by a provider organization can be organized, for reuse purposes, in structured repositories of services. As occurs in database design for conceptual schemas, in a single provider organization several repositories of services may coexist, potentially characterized by heterogeneities and conflicting representations. In this paper we present an experience of integration of repositories of abstract services, based on a methodology currently under development.

Indexing terms/Keywords

Service science, service, abstract service, service repository, integration, correspondence.

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1. INTRODUCTION

In the last ten years Service Science [7] has evolved from a pioneering field to an emerging multidisciplinary research area, attaining a growing mainstream resonance and scientific recognition. The consolidation of the area is currently an on-going challenge reflected by the number of frameworks and modeling efforts available in the contributing disciplines, such as information systems, service marketing, service engineering and computing.

Notwithstanding the multidisciplinary efforts, the design and planning of services in digital service ecosystems still sees a focus on the technological perspective as the prevailing one. Indeed, the Service Oriented Computing paradigm and service oriented design and development methodologies support the realization of service-based ICT infrastructures [23], covering only one perspective among the many considered in initiatives aimed at designing and planning services in service ecosystems. As pointed out by [12], a service ecosystem is a marketplace for trading services that are developed, published, sold and used; accordingly, design and evaluation frameworks are required, considering all the different features of a service ecosystems: from technology to social and psychological issues implied by the service experience.

Due to the above limitations of actual research on services, several researchers are investigating multidisciplinary approaches to govern the service life cycle. Among them, we are developing a methodology called "Services and Meta-Services for smart eGovernment" (SMART in short), whose aim is to consider in an interdisciplinary framework all social, organizational, economic and technological issues that play a role in service design.

One of the paradigms that inspires the methodology, is that, as in other production processes of ICT artifacts such as e.g. database design, two representation levels for services are significant, that we call:

- Abstract services, established by law and having an owner (e.g. for a business, the service "obtain an authorization to open a cafeteria" whose owner are Chambers of Commerce) and
- Concrete services, provided by a specific provider, e.g. the previous service provided by a Chamber of Commerce or by a private provider.

Another relevant concept in SMART is the repository of services, that plays in the service life cycle the role of the software applications repository in software engineering. The repository of services is the integrated representation of all services produced or managed in the provider organization: in this paper we will focus on repositories of abstract services. In order to provide the repository with a semantic structure, highlighting similarities among services, two different semantic relationships are defined in the repository, the is-a and part-of relationships, see Section 3. Repositories of services structured in such a way can be used in the service life cycle as an effective tool for reuse, since service design is not performed from scratch, but is positively influenced and made more efficient by previously developed services.

Repositories of services show similar problems to those of databases and database schemas in data management in the life of an organization. Since databases are produced in time by different designers for different purposes, database schemas representing the same universe of discourse or overlapping universes of discourse show several types of heterogeneities. In order to produce a global schema of the information content of an organization, we need an integration step, that has been deeply investigated in the literature (e.g. [1] and [27]). Also for repositories of services an integration step is needed, to create a reconciled and integrated representation of all services produced and managed in the organization: this is the problem discusses in the paper. Besides reuse, integration of repositories has several interesting applications in the area of service provider companies mergers and acquisitions; the assets of companies are their repositories of services, and a relevant step in the merger/acquisition procedure is the integration of the assets.

This paper is organized as follows. We first analyze (Section 2) related work in the literature on repositories and integration methodologies. In Section 3 we provide basic definitions. Section 4 discusses the service repository integration methodology, and applies it to a real life case study. Section 5 discusses conclusions and future developments.

2. RELATED WORK

Information systems integration [15][5][10] represents a critical and strategic challenge for business, when dealing with complex organizational initiatives such as, e.g., mergers and acquisitions [9][11][17] . Likewise, the integration of services, database schemas, and software components is a key issue in all information systems where several levels of cooperation have to be established between different organizations or players [13][29][14]. Concerning schema integration [1][2], the research moved from the analysis of conflicts and heterogeneities in data bases [27][28] to a focus on semantic integration through ontologies [16], due also to an increasing interest in web services raised by Service Oriented Computing [23][24]. In this context, it is worth noting the renewed relevance and diffusion of repository technologies and registries of services such as the web services standard UDDI[1]. Accordingly, repositories of web services are a central subject of research on service semantics and Ontological Matching [26].

[1] http://uddi.xml.org

The concept of repository has been investigated in the area of conceptual schemas. In [5] the repository is built through integration and abstraction primitives applied to schemas. Experiences of usage of schema integration models and large-scale repositories of conceptual schemas have been carried out in particular in the Public Administration domain [32][6][4].

Repositories of ontologies are proposed in several papers, in the area of Semantic Web [20] and in the Web Services area [18]. The alignment and integration of ontologies is investigated e.g. in [30], where information integration is enabled by adopting a standard common terminology.

Integrated service modeling is claimed in [31] to be the most critical and effective goal in eGovernment projects to achieve the "one-stop-shop" approach in interactions among Public Administration and citizens. The role of a service repository in platforms for one-stop-shop of e-Government services is discussed in [31]. An approach based on a semantic repository to support the interactions between service providers and customers in the Government to Business (G2B) context is discussed in [22], enabling semantic navigation and providing metrics and an algorithm to support businesses in selecting the most valuable services from their perspective.

3. BASIC DEFINITONS

We first recall a definition of service adapted from [8] and integrated with the perspective proposed in [19]:

Definition 1 –A *service* s consists in an activity or series of activities, of more or less intangible nature, that they have place in an exchange between a supplier and a customer, where the object of the transaction is an intangible good, so that both the supplier and the customer co-create and obtain value from the transaction.

A service can be distinguished along several classifications, here we introduce the following:

Definition 2 – An *elementary service* (es) is a service that is atomic, namely not made or else not perceived as a set of other simpler services.

Definition 3 – A *composite service* (cs), is a service modeled in terms of

- a set of 0 to n elementary services [Ø, es_1, es_2, …, es_n], where Ø is the void service;
- a set of 0 to m composite services [Ø, cs_1, cs_2, …, cs_m];
- an *orchestration function* (see [25]).

As an example, we consider the production of a certificate for a change of address as an elementary service (named "Certificate of residency"), since we are not interested to further represent it in terms of atomic components such as, say, the acquisition of the ID of the citizen, an access to the address data base, and the print of the certificate. Furthermore, an example of composite service is the (management of a) change of address of a single citizen from one municipality to a different municipality ("Change of Address (single)"); indeed, if we assume that addresses are represented in data bases managed in municipalities, the service is composed of at least three components that we may consider elementary services:

a) the cancellation of the citizen address and record from the data base of the source municipality,
b) the insertion of the citizen address and record in the data base of the destination municipality, and, in case
c) the production of the residency certificate.

Besides this basic classification, we now introduce two different relationships, *part-of* and *is-a*, that provide a conceptual structure to services in the repository (see Figure 1). These relationships are inherited from conceptual models adopted in database and information systems design [21] and they are defined as follows:

Definition 4 – A *part-of relationship* holds between a service s_1 (the part) and a service s_2 (the whole) when the production of service s_1 contributes to the production of service s_2.

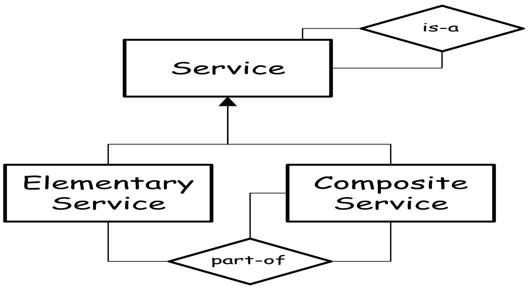

Figure 1. The conceptual schema of the repository of services adopted in the paper

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Definition 5 – An *is-a relationship* holds between two services s_1 and s_2, called *child service* and *parent service*, when s_1 inherits all properties of s_2.

Besides part-of and is-a, a service is characterized by other two types of properties, called in the literature functional and non-functional properties (see [24]); we will not consider explicitly such properties in the integration methodology.

We need also to adopt a graphic convention for representing small fragments of repositories, made of is-a and part-of structures. See in Fig.2 the representation of the change of address service and two groups of services that are related with it through the is-a and part-of hierarchies.

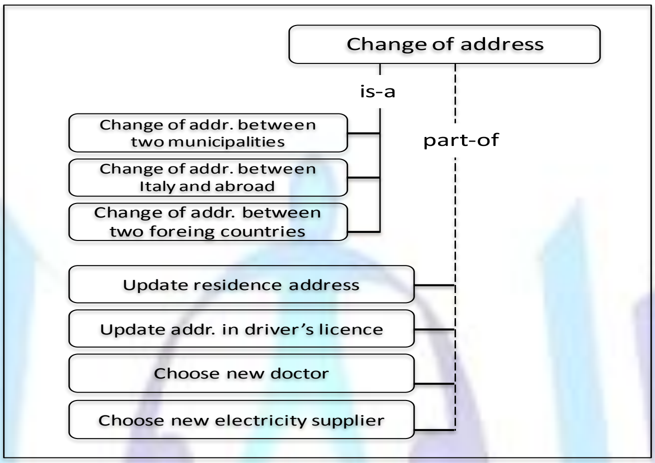
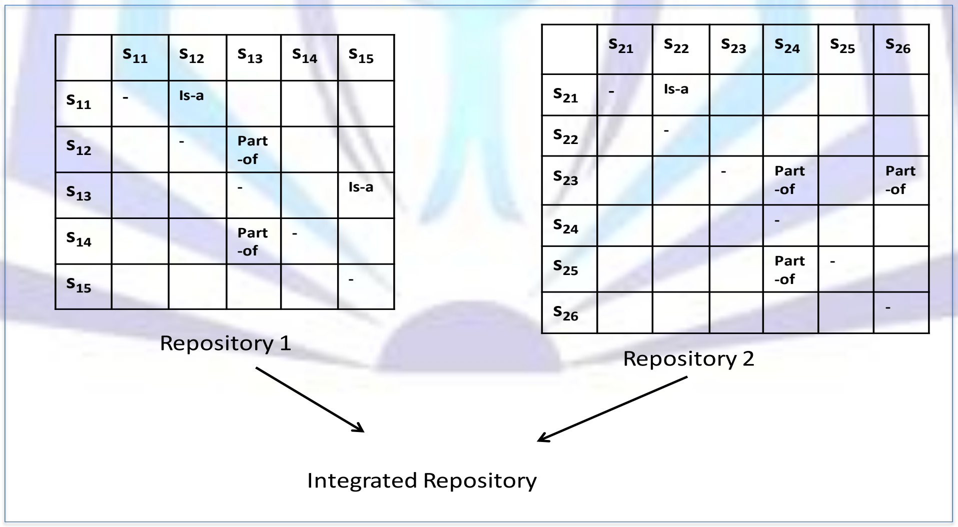


Figure 2: A graphical representation of a fragment of the repository

4. A METHODOLOGY FOR SERVICE REPOSITORY INTEGRATION

Figure 3 shows an input output representation of an activity of repository integration, where Is-a and Part-of in cells represent the is-a and part-of relationships among the services represented in rows and columns.



	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}
s_{11}	-	Is-a			
s_{12}		-	Part-of		
s_{13}			-		Is-a
s_{14}			Part-of	-	
s_{15}					-

	s_{21}	s_{22}	s_{23}	s_{24}	s_{25}	s_{26}
s_{21}	-	Is-a				
s_{22}		-				
s_{23}			-	Part-of		Part-of
s_{24}				-		
s_{25}				Part-of	-	
s_{26}						-

Figure 3: Input output representation of a repository integration process

In its more general form, a methodology for service repository integration is organized in three steps:

1. Correspondence analysis;
2. Conflict analysis;
3. Repository integration;

We now describe the three steps, applying the methodology to a real life case we developed within two domains, the Smart-City and the Tourism domains. The main goal of SMART is to design services that add value both to citizens (in this case the value in-use of the service is relevant), and to providers (value in exchange). The main heuristic adopted to add value to services is to build from elementary services composite ones; in such composition, bundles of services offered by mixed public and private providers are created. Initially the value-oriented analysis of services in the two domains has been performed by two distinct groups of analysts, which produced two repositories characterized by the following structure.

- The Smart-City (SC) repository is made of 63 services, among them 58 are elementary services, and 5 are composite. 15 services are in Is-a relationships, and 29 are in Part-of relationships. As to providers, in 33 elementary services the provider is a Municipality, in the other 30 it is a private provider (Museum, Accommodation Manager or Local Operator).
- The Tourism (T) repository is made of 93 services, among them 84 are elementary services, and 9 are composite. 37 are in Is-a relationships, and 66 are in Part-of relationships. As to providers, in 29 elementary services the provider is a Municipality, in the other 54 it is a private provider.

We omit the representation of the two repositories for reasons of space.

4.1 Correspondence analysis

In this step pairs of services s(SC) and s(T) of repositories Smart-Cities and Tourism are analyzed in order to identify the presence of correspondences among them. With the term *correspondence* among two services s(SC) and s(T) we mean one of the following semantic relationships:

1. *Identity*, when s(SC) and s(T) correspond to the same service.
2. *Similarity,* when s(SC) and s(T) are recognized as different services sharing common properties.
3. *Part-of,* when s(SC) and s(T) are such that s(SC) part-of s(T).
4. *Is-a,* when s(SC) and s(T) are such that s(SC) is-a s(T).

Correspondence analysis consists of two sub-steps that look for potential correspondences among repositories and decide for their presence and type, according to the following procedure:

1. *Correspondence search* - Decide the strategy of visit of the two repositories.
2. *Correspondence discovery* - For each pair of services s(SC) and s(T) encountered in the visit:
   2.1 consider their description and properties (namely, names of services, and structure of is-a and part-of relationships in which s(SC) and s(T) are involved).
   2.2 decide for the existence of a correspondence, and its type.

Once the correspondences have been discovered, they may result, with reference to the integrated repositories, in two possible types:

- *Conflicts*, when some property of one or both services has to be modified in order to merge them in the integrated schema. Conflicts are considered in Conflict Analysis, see Section 4.2.
- *Interschema properties*, when the two services can be represented in the integrated schema without applying transformations to them, but new (is-a or part-of) relationships have to be included, that were not present in the two source repositories. Interschema properties are considered in Repository integration, see Section 4.3.

In Figure 4 we represent a set of correspondences and related conflict types. Notation s_i-(Is-a) means the set of services s_j such that s_i Is-a s_j, similar meanings for notations (Is-a)-s_i, s_i-(Part-of), (Part-of)-s_i.

#	Correspondence	Property of services si, i=[1,2]	Type of conflict
1	Identity	Name	Synonymy
2	Similarity	Name	Homonymy
3	Identity	Type	Different types
4	Identity	si-(Is-a) relationships	Nonoverlapping is-a relationships
5	Identity	si-(Is-a) relationships	Partially overlapping is-a relationships
6	Identity	(Is-a)-si relationships	Nonoverlapping is-a relationships
7	Identity	(Is-a)-si relationships	Partially overlapping is-a relationships
8	Identity	si-(Part-of) relationships	Nonoverlapping part-of relationships
9	Identity	si-(Part-of) relationships	Partially overlapping part-of relationships
10	Identity	(Part-of)-si relationships	Nonoverlapping part-of relationships
11	Identity	(Part-of)-si relationships	Partially overlapping part-of relationships

Figure 4: Correspondences and related conflict types

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4.2 Conflict analysis

In this section we highlight examples of the first three types of correspondences in Figure 4, related conflicts and possible solutions that we have encountered in our project and inspired the above approach.

Case 1: Correspondence = Identity; Property = Name; conflict = Synonymy

In Figure 5 we have the case of two services that are considered identical, and have different names (*Hotel reservation* and *Inn reservation*). Here, we have changed the name of one of the two services, and merged them. Another possibility is to change both names.

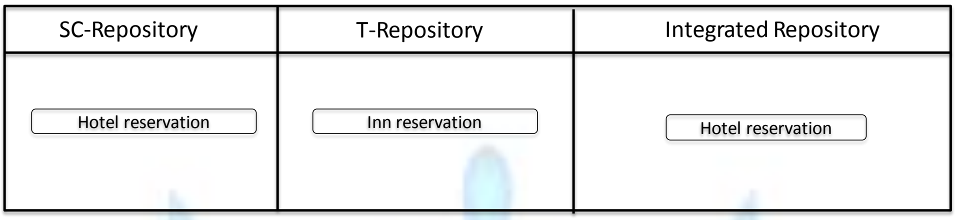

Figure 5: Synonymy among services

Case 2: Correspondence = Similarity; Property = Name; Conflict = Homonymy

In this case we have two services that share the same name *City tour on two wheels*. An analysis of the properties of the two services led to the conclusion that they are different, while sharing some properties. So, we have to rename one of the two or both of them. In the case shown in Figure 6, we decided to rename both, and created a new service, to which we assigned the original common name.

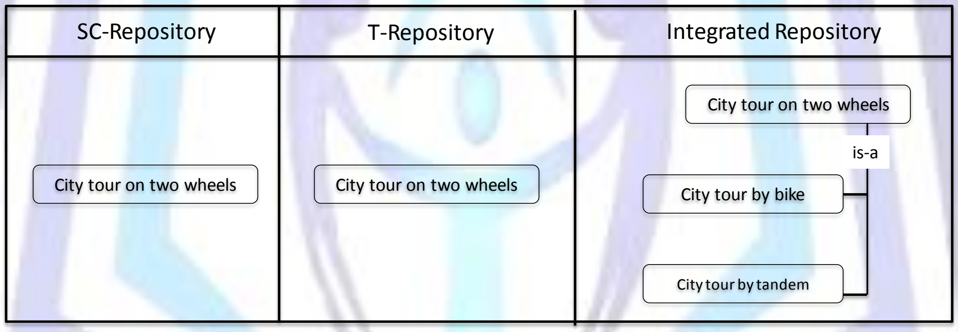

Figure 6: Homonymy between two services and possible transformation

Case 3: Correspondence = Identity; Property = Type; Conflict = Different types

In this case we have two services with the same name *Wine tour,* that in the SC-Repository is a composite service, while it is an elementary service in the T-Repository. An analysis of the properties of the two services led to the conclusion that they are the same service, but in the SC-Repository *Wine tour* is modeled more properly, because a child service of *Wine tour* has been represented named *Reservation of a wine tour*. Accordingly, in the Integrated Repository we maintained the SC-Repository representation (Figure 7).

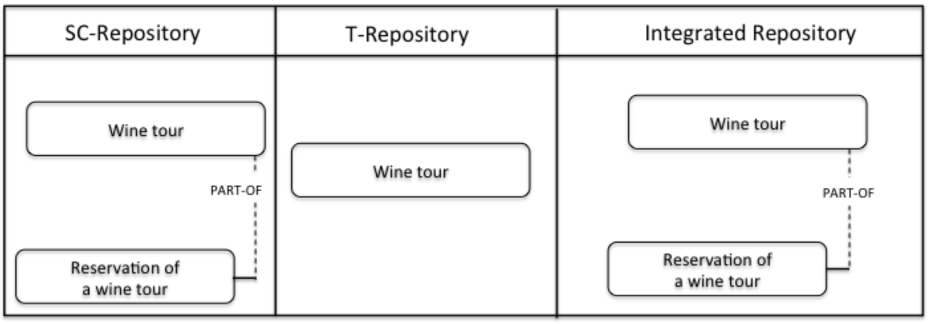

Figure 7: Different types of the same service and possible transformation

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4.3 Repository integration

Besides correspondences that give rise to conflicts, other correspondences result in adding to the pair of repositories new concepts and/or semantic relationships that in our methodology are classified as interschema properties. This is what happens everytime the correspondence is of type Is-a or Part-of; other interschema properties arise from similarity correspondences. In Figure 8 we show a case in which a similarity correspondence is discovered for two services, s6 and s9, that differ only in the presence in Repository B of service s8 part-of s9. In this case we can resolve the correspondence creating an interschema is-a between s9 and s6.

Once the interschema properties are added to the integrated schema, a consistency check has to be made to avoid the creation of cycles in Is-a and Part-of relationships.

We show in the following an example of interschema property in our case study.

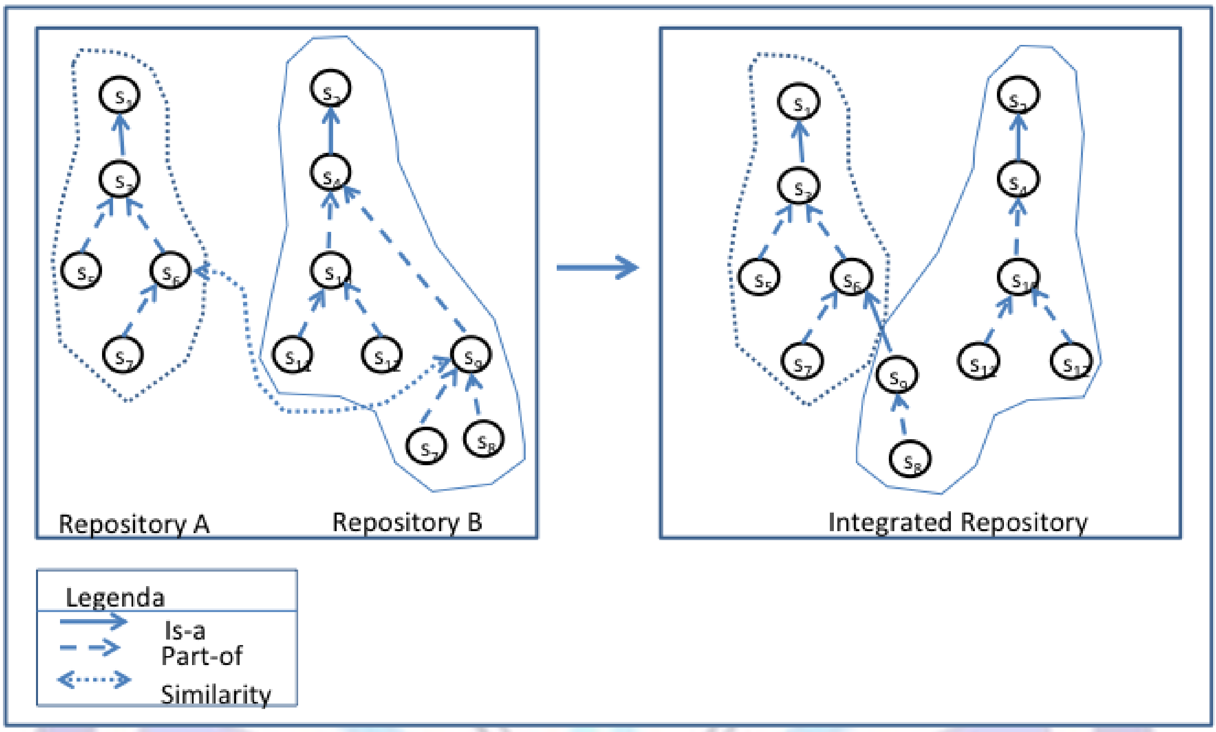

Figure 8: An example of similarity correspondence and related interschema property.

<u>Case 4: Correspondence = Similarity; Interschema property: a new service, common parent of a service in SC and a service in T</u>

In this case (see Figure 9) we have services *Hotel reservation* in the SC-Repository and *Bed & breakfast reservation* in the T-Repository.The two services can be related in Is-a with a new service *Accommodation reservation;* common part-of properties between the two services have to be associated with the new service.

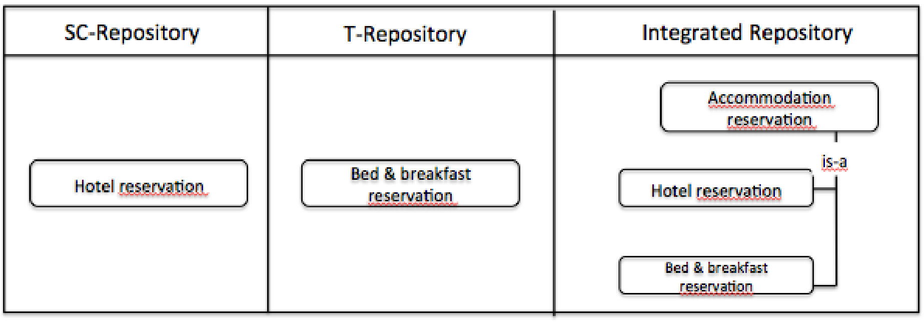

Figure 9: Similarity between services and possible solution

The final integrated schema produced at the end of the integration step is made of 153 services, among them 137 are elementary services, and 16 are composite. 57 services are in Is-a relationships, and 105 services are in Part-of relationships (see Figure 10). Notice that the total number of elementary services decreases, due to the presence of several identical services, and the number of composite services increases, due to the existence of part-of interschema properties.

Repository	# of services	# of elementary services	# of composite services	# of services in a IS-A relationship	# of services in a PART-OF relationship
Smart Cities	63	58	5	15	29
Tourism	93	84	9	37	66
Integrated repository	153	137	16	57	105

Figure 10: Number of services and relations in each repository

5. CONCLUSIONS AND FUTURE WORKS

In this paper we have presented a methodology for service repository integration that was conceived in the course of a project, whose aim was to design services in various application domains that provide value to users and providers. We focused on Smart-Cities and Tourism domains. Although the integration methodology has revealed effective, it needs several improvements. First, we have to generalize the methodology to the case of n repositories. This generalization leads to the investigation of a preliminary step, whose aim is to choose an optimal order of integration among the n repositories, where optimality corresponds to minimizing the whole effort needed in the integration activity. Then, in order to extend the methodology to concrete services, we have to enrich the representation of services including functional and non-functional properties. Further, we have to produce a complete set of correspondences, related conflicts, transformations and interschema properties. Finally we are investigating a tool that helps the designer in discovering correspondences on the basis of structural and semantic properties of services in repositories.

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