PRIVACY-AWARE DATA PROVIDING WEB SERVICES COMPOSITION

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Abstract: Web services are increasingly used to promote data sharing in collaborative environments such as *e*Business, *e*Health, *e*Enterprise, etc. They facilitate data integration and interoperability across autonomous independent information systems in the collaboration environments. Many mediation solutions were proposed for data integration using Web services. Unfortunately privacy aspects were not addressed in these solutions. In this paper, we proposed a framework for privacy-preserving data integration based on Web services. Our proposal is a centralized access control mechanism allowing for the specification and enforcement of privacy rules in Web services composition based on domain ontologies.

1 INTRODUCTION

Web services are highly recognized in collaborative environments for their ability to provide flexible integration and high interoperability across autonomous independent information systems. Recently many research works have proposed the use of Web services as the means to large scale data sharing in collaborative information systems (Srivastava et al., 2006; Carey, 2006). Our work is based on the mediator system proposed in (Barhamgi et al., 2008). In this system legacy databases are wrapped by services allowing partners to collaborate. This type of Web services are called Data Providing Web Services (DPWS), each one is modeled as an RDF view over a mediated ontology. Users expresses their queries on the mediated ontology using SPARQL language. Queries are resolved by composing Web services.

Web services can provide data that can be private for two types of entities: the organizations that offer these services (e.g., hospitals) and the data objects whose data is stored by these organizations (e.g., patients). These entities may have various privacy policies and preferences regarding the disclosure of their confidential data. Such aspects of data privacy have not been taken into account in previous systems of data sharing based on Web services composition.

1.1 Motivation

Assume we have a set of DPWS, for example, in a healthcare facility, contact patients informations are accessible through an administrative Web service and medical patients informations are accessible through an health Web service. Now suppose that this healthcare facility wants to apply privacy policies to expresse that contact patients informations (e.g, address, phone number, etc.) are only accessible for some administrative staff whereas medical informations (e.g, disease, medical test, etc.) are only accessible for some medical staff. But in case of medical emergency, qualified personal may access to all informations of the patient. This situation shows the complexity of expressing and applying such policies.

The challenge that we address in this paper relates to devising such mediator, taking into account the privacy aspects.

1.2 Problem

Our goal is to preserve data privacy in the query answering process based on Web services composition. The semantic query expressed with SPARQL is rewritten in terms of available Web services to enable the composition of DPWS.

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In this paper we consider privacy centralized at the mediator system (i.e., Web services share data without any privacy protection). The problem is to allow a context-based access only to authorized users (e.g., scientist for infectious diseases researches). The control access mechanism should be able to specify: First, privacy policies as applied on the schema of the data (e.g., policies to disclose patients address in the hospital). Second, the privacy preferences applied for each data objects (e.g., patients preferences to disclose theirs diseases for scientific researches).

1.3 Contribution

In this paper we propose a new privacy-preserving method for data integration based on Web services composition. We devised a centralized access control mechanism allowing for the specification and the enforcement of privacy access rules in Web services composition based on ontologies domain:

- It allows the high level privacy policies and preferences specification. Based on the mediation ontology and the access rules propagation process. This reduces the efforts required for specification.
- The access rules are extended with conditions expressed on the mediated ontology. This gives more richness to it.
- We have proposed a new method to apply the access rules for Web services composition, this method is based on query rewriting techniques.

Our contribution extends the mediator system proposed in (Barhamgi et al., 2008) as shown in Figure 1.

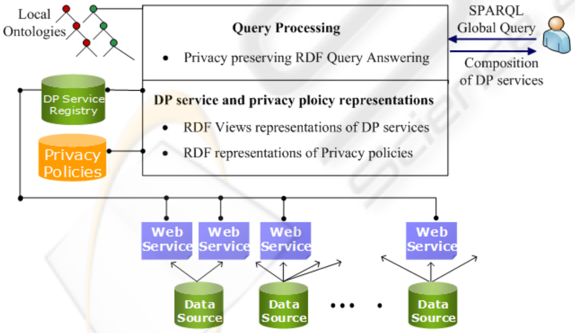


Figure 1: Mediator system for DPWS composition.

In the rest of the paper we describe in the next section our access control mechanism, followed by the section 3 where we give a short overview of related works and finally we concludes the paper and give some directions in section 4.

2 ACCESS CONTROL FOR DPWS COMPOSITION

In this section we present our control access mechanism. There are two distinct steps, see Figure 2. First, privacy policies are specified in the form of access rules on the mediation ontology. In the second step these policies are enforced into services composition process.

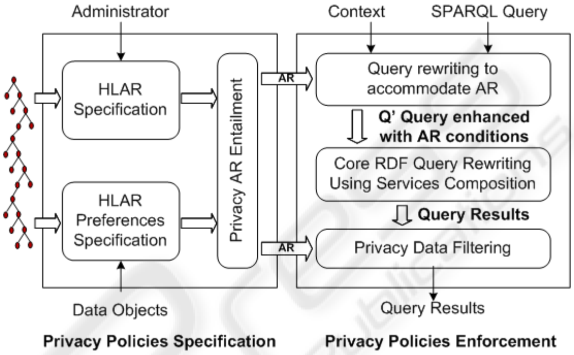


Figure 2: Privacy preserving mechanism.

2.1 Ontology based Privacy Policies Specification and Propagation

Privacy policies specification is the first step in defining a access control mechanism. Also we consider that policies can be specified and imported from service providers. Defining such policies are the results of analyzing the security and privacy requirements, carried out by the security administrator. The administrator can specify the High Level Access Rules (HLAR) on an RDFS ontology. In our approach, the HLAR is a set of 4-tuple comprising the Purpose, the Subject, the Object and the set of Authorized Property-Conditions couples:

```
[ P, S, O, Ai<Pi,Ci> ]
```

For example, the rule $R1$ express the fact that the subject “Specialist” has only access to properties “Name”, “Disease” and to “Test” under the condition of location (e.g., the same floor in the hospital):

Rule $R1$.

```
[ P : Emergency,
  S : Ont:Specialist,
  O : Ont:Patient,
  Ai : { <Ont:HasName, - >
         <Ont:HasDisease, - >
         <Ont:HasTest,
          Ont:Patient.Location =
          Ont:Specialist.Location> } ]
```

The data objects expresses her privacy preferences with the same format augmented by the identifying attribute:

```
[ Id, P, S, O, Ai<Pi,Ci> ]
```

After HLAR have been expressed, we process it to propagate all Access Rules (AR). We use a top-down algorithm based on the subjects hierarchy of the mediated ontology.

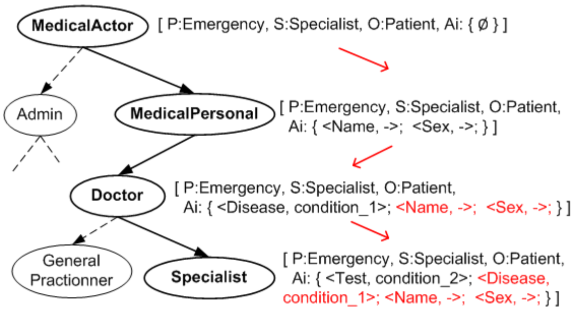

MedicalActor
[P:Emergency, S:Specialist, O:Patient, Ai: { Ø }]
Admin
MedicalPersonal
[P:Emergency, S:Specialist, O:Patient, Ai: { <Name, ->; <Sex, ->; }]
Doctor
[P:Emergency, S:Specialist, O:Patient, Ai: { <Disease, condition_1>; <Name, ->; <Sex, ->; }]
General Practionner
Specialist
[P:Emergency, S:Specialist, O:Patient, Ai: { <Test, condition_2>; <Disease, condition_1>; <Name, ->; <Sex, ->; }]

Figure 3: AR propagation through hierarchical part of the mediated ontology.

An example part of these AR propagation is shown in Figure 3. Where AR are inherited through the subjects hierarchy from the higher level subjects (e.g. “MedicalActor”) to the lower levels subjects (e.g. “Specialist”, etc).

2.2 Enforcing Policies into DPWS Composition

In this section we explain how AR are enforced into the DPWS composition, we explain this with an example. Suppose that the user express the query Q:

```
SELECT ?Name ?Disease ?Test ?Address
WHERE { ?P rdf:type Ont:Patient
        ?P Ont:HasName ?Name
        ?P Ont:HasDisease ?Disease
        ?P Ont:HasTest ?Test
        ?P Ont:HasAddress ?Address }
```

Assume that we have the following context informations associating the request Q with the rule $R1$ seen in the previous subsection:

```
{ Purpose:Emergency, Subject:Specialist,
  SubjectName:Pavlov }
```

In our mechanism, privacy is enforced by the query rewriting techniques based on AR. Algorithm 1 describe this process, lines (4–5) allows to remove all unauthorized properties into the query to denied it, and lines (6–7) allow to switch-on all authorized properties with his conditions into the query.

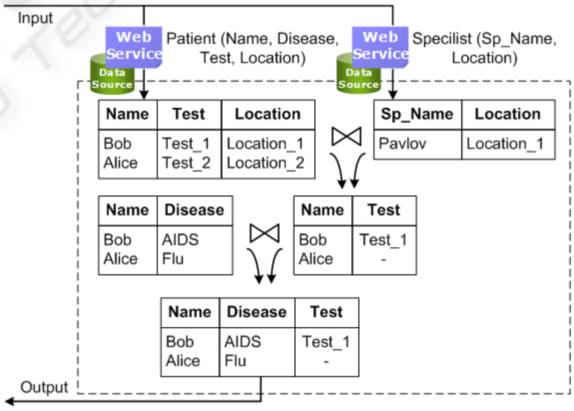
In our example, the query Q must be rewritten as the following query Q' to denied access to the property “Address” and switch-on condition with the property “Test”.

Algorithm 1: Query rewriting for enforcing AR.

```
**Data**: query $Q$, access rules base $ARB$, purpose $p$ and subject $s$
**Result**: rewritten query $Q$
1 begin
2     foreach concept $o_j$ in $Q$ do
3         Extract the set of property-conditions couples
          $A_i = \{< pr_i, c_i >\}$ from $ARB(p,s,o_j,A_i)$;
4         forall $\{pr_k\} \in Q$ and $\{pr_k\} \notin A_i$ do
5             remove $\{pr_k\}$ from $Q$
6         forall $\{pr_k\} \in Q$ and $\{pr_k\} \in A_i$ do
7             replace $\{pr_k\}$ into $Q$ by $OPTIONAL\{pr_k \cup c_k\}$
8 end
```

```
SELECT ?Name ?Disease ?Test
WHERE{ ?P rdf:type Ont:Patient
       ?P Ont:HasName ?Name
       ?P Ont:HasDisease ?Disease
       OPTIONAL {
            ?P Ont:HasTest ?Test
            ?D rdf:type Ont:Specialist
            ?D Ont:HasName "Pavlov"
            ?D Ont:HasLocation ?Location
            ?P Ont:HasLocation ?Location }  }
```

The rewritten query Q' will be answered by the composition of available Web services, see Figure 4. The “Test” result of “Alice” are not disclosed according to the unresolved condition of location.


Input
Web Service
Data Source
Patient (Name, Disease, Test, Location)
Web Service
Data Source
Specilist (Sp_Name, Location)
⋈
⋈
Output

Name	Test	Location
Bob Alice	Test_1 Test_2	Location_1 Location_2

Sp_Name	Location
Pavlov	Location_1

Name	Disease
Bob Alice	AIDS Flu

Name	Test
Bob Alice	Test_1 -

Name	Disease	Test
Bob Alice	AIDS Flu	Test_1 -

Figure 4: DPWS composition for Q' query answering.

Before disclosing the results of Q' we verify the preferences of each data object appearing in the results. In the data filtering step (see Figure 2) we apply Q' on the local results and eventually by invoking other DPWS if the data are missing. For example, suppose that patient ”Bob” wish to disclose their ”Diseases” only to her physician contractor, in this case a second DPWS composition is executed. The results revealed in the end of this stage respects at the same time the privacy policies and preferences.

3 RELATED WORK

In many scenarios individuals supply their personal informations to data collectors under privacy constraints (e.g., patients to the hospitals). However, it's important that the collaborations and the data sharing does not affect their privacy. The control access approaches for preserving privacy are used to enable data sharing only with the authorized thirds. Conventional access control models are very studied in databases, as DAC, MAC and RBAC. Privacy-aware RBAC (Bertino et al., 2006) use conditions evaluation on hierarchy of roles and objects. However, the conditions in this models are concern only environment variables. In our system the conditions are expressed on the data domain with SPARQL.

Hippocratic databases (Agrawal et al., 2002) are distinguished by the context management and the management of privacy preferences at the cells granularity. This approach limits itself to a centralized DBMS and it is not well adapted for data sharing, even less for the composition of the Web services. There have been many research efforts (Hamadi et al., 2007; Kagal et al., 2004; Cheng and Hung, 2005) addressing privacy at the services discovery time. In (Tumer et al., 2003) the proposed mechanisms allow inferences and negotiations deal between the users preferences and the services policies. All these works proposes approaches to design privacy-preserving Web services. Our approach is designed for automatic Web services composition, allowing it to find alternatives and authorized data sources.

Notorious efforts for standardization of languages for privacy policies specification were made (e.g., P3P, XACML). It is possible to express with XACML conditions to evaluate access authorizations. In our approach we specify a semantic conditions over the mediated ontology to evaluate access authorizations through the DPWS composition. We provide also an mediation ontology based approach to specify a high level access rules, that reduce efforts of privacy analysis. To our knowledge no work related to the privacy in the data integration based on the composition of Web services. In addition, the benefits of the semantic Web have been largely exploited in our solution.

4 SUMMARY AND DIRECTIONS

In this paper we proposed a privacy-preserving framework for data integration based on Web services composition. This work extends the mediator system proposed by (Barhamgi et al., 2008) with the centralized access control mechanism. Allowing the high level privacy policies and preferences specifications. These specifications are based on the mediation ontology and the inference process, reducing the efforts of analyzing the privacy requirements. The access rules are increased by conditions expressed on the mediated ontology giving it more semantic richness. We have also proposed a new method to enforce the access rules through the Web services composition process, based on queries rewriting techniques.

Several horizons open in our privacy approach. First, we are studying the possibility to import standards policies specifications as XACML and we believe improve the rules inference algorithm. We have also intend to optimize the privacy-aware Web services composition algorithm. Finally, for lack of space we don't present an other privacy approach for anonymous data integration based on Web services composition, that can be easily combined with our access control mechanism. These approach allows we to find alternatives to unauthorized requests by processing approximative queries.

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