Semantic Repositories for Service Provision: An Approach to Enhance the Business Perspective

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ABSTRACT
In business interactions, a major issue consists in enhancing the business perspective over service provision by developing strategies and tools to provide support in the choice of services according to the value they have for businesses. This means to provide (i) a way to determine the value of services according to specific business criteria, and (ii) technologies that support the sharing of such kind of knowledge involved in service provision. In this paper we present an approach based on the development of semantic repositories starting from our past experience with a repository built for the Italian Public Administration. The repository provides a business perspective over service provision, based on the association between services and business processes. The relevance of a value-based perspective on services modeling is related to the relevant problem of supporting businesses in the value-driven service selection. This perspective can be sensibly enhanced by exploiting expressive semantic representations and reasoning, in order to move towards the design of semantic repositories of services offering more intelligent service provision and supporting businesses in the service choice according to their value. In particular, we focus on how the semantic approach proposed can support the value-driven service selection, by presenting a case study.

Categories and Subject Descriptors
H.4 [Information Systems Applications]: types of systems—decision support

General Terms
Design, Management, Measurement

Keywords
Service/Process Modelling, Repositories, Semantics, Service Oriented Computing

1. INTRODUCTION

Current trends exploit the Web and ICT to develop platforms for supporting business interactions (namely Business to Business and Government to Business interactions) by means of knowledge exchange [22], [21] and of the services provision e.g., through distributed P2P architectures. Moreover, according to [19] information technology has a relevant effect on competitive advantage in either cost or differentiation. In such a scenario, a major challenge is to investigate how to represent the linkages of the services to the business processes from a value perspective; such representation allows the exploitation of the knowledge of the competitive advantage of the services in business interactions. Due to the need of linking services to business processes in a strategic fashion, that is in order to individuate the sources of their competitive advantage, strategic models such as e.g. the value-chain model are needed.

Furthermore, a model of the linkages of the services to the value-chain has to support the actors, namely, the stakeholders involved in business interactions: both the requesters in their search of competitive services in networked businesses, and providers in their design activity. As said, information represents a major resource to exploit the value of linkages within and outside an organization and to enhance (i) the knowledge obtained from the information about products and services, and, (ii) the knowledge derived from information considered itself as product or service.

Our main goal is to work on strategies and tools to provide support in the choice of services according to the value they have for businesses. This means to provide (i) a way to determine the value of services according to specific business criteria, and (ii) technologies that support the sharing of such kind of knowledge involved in service provision. In this paper we start from our past experience in the Government to Business context (G2B in the following) where a conceptual model was provided and implemented in a repository for the Italian Public Administration (PA in the following), namely a meta DB, whose main features are presented in Section 2. The usefulness of the repository for G2B interactions is discussed section 2.1 and is mainly related to the choice of providing a business perspective over service provision, which is developed on the basis of the association between services and business processes. In this context the relevance of a value-based perspective on services representation is discussed and connected to the problem of supporting value-driven service selection. In order to develop this issue, formal ontologies [13] are introduced as a framework
for moving towards the design of semantic repositories of services which support service provision on the basis of the value service have for businesses and their processes. Section 3 therefore discusses the advantages given by the adoption of standard and expressive knowledge representation languages enabling reasoning in order to enhance the semantic repository’s functionalities. Section 3 focus on how the semantic approach proposed can enhance the value-driven service provision, focusing on service selection, with a case study presented in Section 4. Related works and Future work conclude the paper.

2. THE REPOSITORY OF SERVICES PROVIDED BY ITALIAN PA

In the following, we point out the usefulness of a repository of services in G2B interaction on the basis of the experience introduced in [4], that describes the main characteristics and results of a project, called Government for Business (in short G4B), granted by the Italian Ministry of Industry in years 2003-2005. The ownership of the project is of the CM Group, an Italian company. The project G4B aims at building a technological infrastructure to enable the businesses to make effective use of public administration services. In the context of the G4B project, a central role is played by the repository of services. The main goal of the repository (repository G4B in the following) was to describe the services provided from agencies to businesses in such a way to allow its effective use in the two layers of a cooperative architecture such as that shown in Figure 1, namely:

1. the front office layer, in order to: (i) simplify the service identification by hiding details on the administrations involved in service delivery, and (ii) allow businesses to choose “effective” services from the point of view of their business processes and goals;

2. the back office layer, to allow how to plan the re-engineering of administrative processes and make more efficient the development of new services.

In order to populate the repository with real services to businesses, we have analyzed on the one hand the available documentation, on the web site of the Italian Depart-
In fact, the repository G4B has been designed in such a way that it can be useful in principle for three types of players, namely public administrations, businesses, and service developers and providers. To introduce this issue, see in Figure 2 an high level representation of the conceptual schema of the repository G4B, and the three parts of the schema being of specific interest for public administration, businesses and providers. The relationship between businesses from one side, and agencies and providers from the other side is seen as the means for businesses to improve efficiency and effectiveness of their business processes (a view from the repository is represented in Figure 3).

Focusing on providers, such properties may be used in different strategic decisions, for instance:

- support business predictions in terms of (i) the size and characteristics of the potential market and (ii) the attitude of the users to spend money for a service;
- planning most effective development processes of new services on the basis of the present level of development of services in the different administrative and territorial areas.

For a public administration, instead, the repository of services aims at creating value in terms of potential reuse of the services produced and business process reengineering opportunities.

Considering the latter, here the goal is to reorganize services using, e.g. the technological infrastructure described in Figure 1. The presence of similar services among different administrations is an indication that such set of services can be re-organized using cooperation among administrations. For example, the start up of a business and all variations in relevant data, such as address, type of activity, have to be communicated to Chambers of Commerce, Social Security and Social Insurance. In the traditional, non-integrated setting, the burden of business transactions is shared between businesses and the PA. Businesses are estimated to spend about 180 million euros a year just to notify various agencies of their inception and variation events. This cumulative cost corresponds to communicating business identification data relative to 2 million events, using about 3 person/hour for each event (see [7] for the details). On the public administration side, the cost to a single agency for handling the inefficiency is no less than 10 million/year euros. Assuming that each business’s data appear in the data bases of at least 10 agencies, this brings the total cost to 100 million euros or more. A further consequence of the autonomy and heterogeneity among the agencies is an estimated 20 to 25 percent of misalignment between business records maintained in multiple registries.

In the following Section we detail the usefulness of the repository of services for businesses and we introduce the perspective used to associate services to business in the Government to Business interactions.

2.1 The value-chain perspective for the Business Processes/Services Association

Public administrations in their e-Government projects tend to develop administrative services, strictly related to their administrative procedures and laws to be enforced, disregarding the importance of value added services, that provide added value to business processes. An example of administrative service is the provision of a certification, while an example of value added service is a statistics or else territorial information that may be useful for marketing processes. In the repository both types of services, are included. In order to create utility for businesses, services have to be related to business processes using them.

In the repository G4B we provide a representation of business processes based on the Porter value chain. In [20] Porter addresses the interplay of cost and differentiation, as two major types of competitive advantage, with the scope of businesses’s activities. On that basis, Porter introduces in [20] the value chain as a tool for diagnosing and enhancing the competitive advantage of a business by its disaggregation into its most relevant activities. Value activities at an high level are classified in two types, the primary activities, that are involved in production, sales and assistance and support activities, that support the former. Taking that into account, an important issue in Porter’s model is related to the relationships or linkages [20] between cost and performances of the different value activities.

Referring to the conceptual organization of the repository (see again Figure 2), in order to enable a value-driven approach to business processes modelling, we have to introduce descriptive attributes of services and processes that support predictions in terms of usefulness of a service for a process (see [4]).

As a consequence of the above discussion, the repository, on the one hand, provides businesses with knowledge related to administrative services, namely prescriptive public administration obligations involved in processes; on the other hand, helps businesses in the discovery of value added services used in processes, not explicit related to norms. In their interaction with agencies, businesses, starting from a business process flow, need to discover all interaction events related to the process flow, both referring to administrative services and to value added services, in order to plan the choice of the best suite of services provided by administrations, also on the basis of the cost/effectiveness ratio.

In order to share a common knowledge, the supplier (agencies and private providers) and the requester (businesses) must refer to a shared representation of the service, this representation can be based on the service ontology shown on
In the following (Section 3) we detail the description of the ontology of services on the top of repository, that provides (i) a common representation of services and their properties on the basis of a common classification scheme, (ii) a value based model for the service provision in Government to Business interactions. In the Sections 3.1 and 4 we discuss how knowledge representation formalisms and tools effectively support the development and maintenance of the repository and the selection of value added services.

## 3. TOWARDS THE SEMANTIC REPOSITORY OF SERVICES

The main concepts of the ontology built on the top of the repository are **Actor** (e.g., Public Administrations and Firms), **Resource** (things that are necessary in the service provision, e.g., devices), and **Service**. The ontology includes a taxonomy of classes of services and other classification schema used in the repository in order to provide a structured representation of of services and of the other concepts involved in G2B interactions. The taxonomy of classes of services (see Figure 4) with their related properties is based on classification of Italian e-Government services to businesses. Besides, a second type of classification is introduced whose goal is to define classes of services on the basis of their functional characteristics (e.g. a service that produces as output a certificate is an instance of the class **certification**).

In functional terms, each class of services is described by three types of properties: (i) **requirements**, the events that activate the service provision, (ii) **preconditions**, the conditions needed to activate the service, and (iii) **effects**, the outcome of the service. A definition domain corresponds to each property, which refers to a set of concepts involved in the service provision. Moreover, each property value has a meta description that defines the role played in the service conceptual schema, the role can be, e.g. **Actor, Process, Resource, and Constraint**. As example, a service in the class **Procurement** has: (i) a **Requirement** property with value **Owner**, whose Role is **Actor**, (ii) a **Precondition** property with value **RequestDate**, whose Role is **Constraint**, (iii) an **Effects** property with value **Outcome**, whose Role is **Resource**.

### 3.1 Ontological Representation and Inference

Recently research on ontologies developed a number of knowledge representation formalisms and tools supporting ontology development and maintenance and different reasoning tasks. The exploitation of such formalisms and tools allows to provide a deeper semantic representation of the domain ontology, with greater expressiveness and the possibility to perform inference.

In particular, with standard formalisms such as OWL-DL [9] (generally preferred because it offers a good balance between expressivity and complexity with respect to reasoning) and basic reasoning services (e.g. offered by widespread reasoners such as Racer [14], Pellet [23] and Fact++ [26]) it has been possible to add to the repository a deeper semantic and to exploit it for the management and the navigation of the repository in order to enhance the service provision from the business perspective. In order to present the advantages offered by this richer ontology we present just a little subsection of our domain ontology, and in particular a part that allows to elicit how inferences enabled by the additional semantics affect the way in which the repository can be managed and used. In particular, Figure 7 represents (i) the linkages between the process ontology and the service ontology, and (ii) the specification (used for reasoning in the next paragraphs) of the relationships between class of services that aggregates other classes. The Ontology has been represented in OWL-DL with a rich T-Box; the following are some of the more salient description logic axioms that characterize it:

\[
\text{AggregateService} \equiv \quad \text{Service} \sqcap \exists\text{hasAggregate.Service}
\]
\[
\text{UpdateBusinessAddress} \sqsubseteq \quad \text{isAssociatedTo} \circ \text{changeBusinessAddress}
\]
\[
\text{aggregates} \equiv \quad \text{providesPartsOf}^-
\]

When the ontology has been represented in OWL-DL, it...
is possible to exploit different kinds of reasoning on it by exploiting only the OWL-DL syntax and state of the art reasoners. Let us outline the advantages provided by the semantic enrichment of the repository’s ontology through the discussion of four kinds of basic reasoning task, with some examples of their application to our domain.

1. **Inheritance.** A first - pretty trivial indeed - class of inferences supporting maintenance and updating of the repository is based on inheritance. An example of exploitation of this kind of inference taken from the unified service/process ontology is the inheritance of the association to the process `ChangeBusinessAddress` for all the subclasses of `UpdateBusinessAddress` and for instances as well (see Figure 5). From the repository maintenance perspective this means that if a new instance or a new subclass of this type of service is added to the repository, the association to business process is performed automatically.

2. **Inferences based on semantics of relations.** A second fairly simple kind of inference concerns the possibility of exploiting the richer semantics of the relations (i.e. of roles in OWL-DL), such as the specification of transitivity, symmetry, functionality and the definition of inverse properties in order to enrich the information extensionally contained in the repository. As an example the two roles `providesPartsOf` and `aggregates` are defined one the inverse of the other one. This means that it is sufficient to fill in one relation and the other is automatically inferred (e.g. if one specifies that a new class of services aggregates other already existent classes).

3. **Classifications based on definitions and type inference.** State of the art reasoners provide the possibility to exploit definitions of equivalent concepts and relations in order to infer that an instance is member of a certain class or that a concept is subsumed by a second one. This reasoning service, although not extremely powerful, yet offers some useful inferential power. With respect to our purposes let us present just two examples. First of all value of processes according to Porter’s value chain can be automatically inherited from higher level processes (e.g. a mega processes) to all the subunits by which it is composed (e.g. an activity - observe that this is not a pure inheritance because the semantic of a mereological, and therefore non “IS-A”, relation needs to be recalled); moreover, exploiting an analogous solution mechanism it is possible to associate also a Porter’s value to services according to the value of the processes they are associated to. A second example is related to the case study about value based service selection discussed in the next section and concerns the recognition of a service as a service that aggregates the effects of other services: defining an `AggregateService` as a service which has at least a filler of the role `aggregates` allows to automatically infer e.g. that the service `UpdateAddress` is an aggregate service, given that (i) `providesPartsOf` has been specified for `UpdateAddressA` and `UpdateAddressC`, and (ii) that `aggregate` is inverse of `providesPartsOf` (see Figure 6).

4. **Consistency Check.** Consistency check allows updating the repository soundly with respect to the service/process top level ontology and provides better control also when changes on the T-Box are needed.

These kinds of inferences, on the one hand, provide help for the maintenance and enrichment of the repository. On the other hand, according to the concerns outlined in the previous sections, it is also possible to exploit the semantic repository in order to improve navigation through the offered service and the selection according to the value they have for businesses and their processes.

4. **VALUE-DRIVEN SEMANTIC SELECTION OF SERVICES**

The effort in providing methods to support the value-driven selection of services is a relevant topic, and, in particular, in the context of the development of SOA applications for automating the discovery and delivery activities.

In particular, the ontology presented above developed and the gained inferential power should enable to move toward a more intelligent selection and navigation of the available services on the basis of the value they have for businesses and their processes. On the one hand, the service/process association should in fact lead to an integration of the business perspective based on process models with the perspective on service of the repository (through value models); this integration may range from the improvement of navigation (navigating through the services starting from business processes) to the development of application s that provide a proactive suggestion of the services according to running or particularly relevant processes (that requires an integration of ERP systems with the application managing service provision). On the other hand, the desired integration aims at improving the selection of services (web services - if the services are delivered on the web) on the basis of the value that a service have for businesses and their processes.

From this perspective the association between processes and services, endowed with semantics for further reasoning, provides a way to explore the repository from the business perspective; as an example consider the retrieval of all the services associated to a business process that has specific prop-
Figure 7: Detail of ontology of services - The broken-narrowed line represents the hierarchy of generalization for the class Service

properties. As pointed out in Section 3.1, it is possible to infer the value of services by inheriting it from the processes to which they are associated; it is therefore possible to have an evaluation of the service value, retrieving services that have been inferred to be, e.g. support services, and enhance navigation through this information. Nevertheless, this criterion of evaluation of the service value is quite poor and should be developed and/or integrated with other models and techniques.

Indeed, one development direction concerns the adoption of other value configuration models [24] for business processes, in order to project the computed value of processes to service associated to them (the investigation along this direction is object of our current work). The approach developed here allows to provide some support to value based service selection though; this can be achieved by enhancing computational techniques with the semantic view on the domain ontology, as discussed through an example in the next Section.

4.1 A Case Study: Selection of the best Address Updating Service

The semantic based approach proposed can be exploited, as a matter of fact, to support service selection, if coupled with other quality composition techniques according to some parameters for service evaluation. We will discuss this issue presenting a case study with services taken from our repository.

A business moved to other offices (the process change office location is running) and is obliged to update its address. Three concrete services respond to this need: services A and B update the business address respectively in the Social Security (INPS) and in the Chambers of Commerce (UNION-CAMERE) registries; service C provides the updating of the business address both in the INPS and the UNION-CAMERE (UC) registries. A, B and C are concrete services represented in the semantic repository as UpdateAddressA, UpdateAddressB and UpdateAddressC which are members respectively of the three abstract service classes UA_INPS\(^1\), UA_UC and UA_INPSUC: the class UA_INPSUC aggregates the classes UA_INPS and UA_UC according to the semantic of the aggregate relation as defined in the previous section.

The problem on which we focus here concerns mainly the value attribution to services in order to select the most valuable service from the business perspective. There are two aspects that need to be considered here: first of all it is necessary to develop metrics to compute the service value according to suitable quality parameters; the following three quality parameters are relevant to service value and can be considered in value computation:

- time spent by the business for requesting the service (RT)
- time spent by the provider to deliver the service (DT)
- price of the service (P)

Secondly, for the comparison of the different values is necessary to take into account the fact that the third class of services aggregates the other two ones. This means that the value of UpdateAddressC must be compared with an aggregation of the value ratings computable for UpdateAddressA and UpdateAddressB.

Being this an administrative service and not a value added service, quality properties of the service are only little interesting and the main concern can be assumed to be getting the service with minor waste of resources (money and time). A strategy to define the service value is to calculate a general cost, taking both RT and DT as costs to be summed to the service’s price; although a number of computing methods can be exploited (e.g. multi-objective optimization with, for instance, Pareto’s front [10]), in this context we can simply adopt a normalized weighted average. Normalization is needed here, being the parameters heterogeneous, and as normalization range percentage can be chosen. Observe that since the normalization of RT, DT and P to percentages needs the selection of reference parameters, suitable normalization criteria need to be associated to each parameter; ontologies can be recalled again here since these reference parameters can be defined for classes of services, represented in the ontology, and retrieved when needed. Assuming therefore \(c^RT\), \(c^DT\) and \(c^P\) as the three normalized costs, the total cost \(c^s\) for a service \(s\) can be then computed by the following weighted average:

\[
c^s = \sum_{i=1}^{n} w_i c_i, \text{ where } \sum_{i=1}^{n} w_i = 1
\]

Weights here play a major role and allow to modify the relevance given to each parameters according e.g. to classes of services. An example that assumes \(w_0 = 20\%\), \(w_1 = 20\%\) and \(w_2 = 60\%\) is given in Table 1. In this example it is clear that UpdateAddressC is the most “expensive one” with respect to price. Nevertheless, being known that one of the

\(^1\)For readability reasons “UA” is used here as short form for “UpdateAddress”
three services compared is an AggregateService (notice that this has been inferred by reasoning on the ontology as shown in Section 3.1), it is possible to compare its value with the sum of the other two, and choose the one that minimize costs. Pseudocode reported in Program1 describes a sample procedure to carry out the task2:

```
Object: findAndCompareAggregate (search, C)::

begin
for all $x \in (C \cap \text{AggregateService})$ do

$L = 0$;
$\text{sum} = 0$;
for all $y \in (C \cap \text{providesPartOf} \ni x)$ do

$L = L \cup \{y\}$;
$\text{sum} = \text{sum} + \text{cost}(y)$
end for

write $x$ “aggregate” $L$;
show comparisonTable($x$, $L$);
if $\text{cost}(x) < \text{cost}(\text{sum})$
then
suggest($x$)
else
suggest($L$)
end if
end for
end
```

Program 1: This pseudocode implements a function that given as argument a function search and a OWL-DL concept C, support the choice among an aggregate service and the services it aggregates providing: a comparison table and a suggestion for the choice.

With respect to the sample values given in Table 1, although price has been heavily weighted and the aggregate service UpdateAddressC’s price is higher then the sum of the other two ones, this service is to prefer to the composition of UpdateAddressA and UpdateAddressB; this is inspired by the consideration that aggregation of services has an added value based on saving time, up to a certain balance in the weight association. It is easy to check that if saving money is the main concern (e.g. assuming weights such as $w_0 = 5\%$, $w_1 = 5\%$ and $w_2 = 90\%$) the choice of composing the two services can be preferred to the aggregation of the two. Weight attribution is another interesting issue in this context and different solution are currently under evaluation (from the association of weights to class of services within the ontology, and the human dynamic association through interaction, to the exploitation of hystory of choices and user profiling).

5. RELATED WORK

The problem of matching user’s goals with service description is out of the scope of this paper. This is a major issue though, and it basically consists in understanding that user goals are accomplished by the composition of the effects of the two simpler services, which are as a matter of fact given alternatively by the aggregate service. In the context of application based on semantic web services different strategies have been proposed and the integration of these strategies with our approach to the value based service comparison and selection is object of ongoing research carried out in the NeP4B project.

**Table 1: An example of comparison table according to the weighted average (values are percentages).**

<table>
<thead>
<tr>
<th></th>
<th>$c^{RT}$</th>
<th>$c^{DT}$</th>
<th>$c^{P}$</th>
<th>$c^{s}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>UpdateAddressA</td>
<td>60</td>
<td>10</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>UpdateAddressB</td>
<td>30</td>
<td>10</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>UpdateAddressC</td>
<td>30</td>
<td>15</td>
<td>35</td>
<td>34</td>
</tr>
</tbody>
</table>

At the state of art, a definition of Semantic E-business is introduced in [22] as an approach to manage knowledge for the coordination of e-business processes through the systematic application of Semantic Web technologies. Semantic E-business is founded upon three streams of research: (i) Semantic Web technologies (ontologies, knowledge representation, and intelligent software agents); (ii) knowledge management, by focusing on the creation, storage, retrieval, and exchange of machine interpretable useful information in order to support decision for action that can be taken or advised; (iii) secure e-business processes, including process automation, enterprise systems integration, and the coordination of work flows and activities within and across organizations. Value based approaches to Semantic Web Services [2] point out to the issue of modelling services that have a grounding in the real world, beyond their Web elements and references alone. This kind of approaches are supported by a value based perspective on requirements and engineering to exploiting eBusiness [12]. Furthermore, an example of business domain ontology with a discussion of the state of the art is introduced in [11]. Besides, to the best of our knowledge our contribution is at the crossroads of these research topics, by focusing on providing an integrated view on the linkages of services to business processes through a value-chain perspective. This concern, on the one hand, is related to deepen the capabilities offered by such a value configuration for service selection and composition; on the other hand, to investigate how semantic repositories make effective the knowledge sharing on services and support business interactions (focusing first on C2B interactions). A proposal for repository technology appears in [6]. Repositories of conceptual schemas are proposed in several application areas; e.g. in biosciences [25]. A data repository is used in [17] as the core structure of a mediator-like module. In the database area, the conception of repository as dictionary has a tradition in model management (see [3]). In the area of Semantic Web and Web Services, the need of semantics in service descriptions [18] leads to a large number of repositories of ontologies distributed through the Web [16]. Moreover, in the area of distributed computing and in particular in Peer-to-Peer approaches, the need of scalability and flexibility improves the building of repositories that contain semantic information upon data and services provided by each provider (e.g., RDFPeers Repository [8]). Focusing on the application of ICT technologies in e-Government, in [15] a conceptual framework is proposed, identifying the importance, categorisation and presentation of the strategies for overcoming technical and organizational challenges facing a transactional e-Government system. With regard to the technological architecture, [5] compares architectures that can be adopted in Government applications. The role of a service repository in platforms for one-stop Government is discussed in [27].
6. FUTURE WORK
Value-chain model offers a business perspective that supports selection and composition of services with competitive advantage, but represents a quite static configuration despite other available for networked interactions [24] (with higher degree of dynamics in the configuration of actors' roles, services' resources and requesters' needs). Indeed, a first future work direction is to investigate the adoption of other value configuration models for business processes, in order to project the value of processes determined on the basis of such models to services associated to such processes.

Besides, that of “AggregateService” seems to be a crucial notion for reasoning tasks. By now, membership of service to the AggregateService class is automated but is based on the assumption that at least one direction of the aggregation association (aggregates and providesPartOf in the ontology) is known. Much more helpful should be if it could be possible to derive that a service \( A \) (or a class of services \( CA \)) aggregate two services \( B \) (or \( CB \)) and \( C \) (or \( CC \)) reasoning on their effects, through a refinement of the ontology. Here different formalisms and reasoning tools are needed, and to analyze them represents a second research stream in future work.

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8. REFERENCES


