TOWARDS INTEGRATED PUBLIC SERVICE DELIVERY BASED ON AN ONTOLOGICAL FRAMEWORK

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Abstract

Present-day governments are experiencing a shift towards supplying demand-driven and personalized electronic services. This often requires that government organizations collaborate with each other and their services and processes need to be integrated to act in a coherent manner. In this paper, we take the diversity of government agencies as a starting point and focus on the development of a shared ontology to enable interoperability among heterogeneous business process and services of public agencies. This framework contributes to understanding the key concepts and relations that form the basis for coordinating the activities necessary for integrated public service delivery. The ontology is aimed at capturing the main elements to enable communication among and integration of the activities of decentralized and autonomous agencies. The ontology has been interactively developed by studying organizational processes, by conducting interviews and literature study. The proposed ontology can provide a foundation for an architecture blueprint that can enable demand-driven integrated service delivery in practice without having to pose detailed requirements on organizations. As autonomy is fostered, this research can potentially enable the integration of private organizations.

Keywords: e-government, interoperability, service composition, integration, integrated service delivery, ontology, ORM

1 INTRODUCTION

Governments are experiencing a shift from supplying common, non-electronic services towards more demand-driven and personalized electronic service (e-service) delivery (Chen, 2002). To accomplish these goals, governments are becoming more externally oriented instead of focusing on internal functions. They are focusing more on their client's needs and less on their own functionality, organizational structure, and boundaries. Initially, public organizations focused on recurring client needs instead of on incidental needs. As such, assessing needs and reacting to needs do not provide the flexibility to react to new needs or even changes in laws and regulations. Government functions are fragmented due to constitutional, legal, and jurisdictional limitations. As a consequence, governments are often acting in silo structures, but nowadays are forced to cooperate with other government agencies and partners in the private sector.

Integrated Service Delivery (ISD) is a challenge and requires that the tasks of several types of actors need to be coordinated (Klievink et al., 2008). In this research, an actor is defined as an entity that is able to perform a task, such as a human or a computer. An example of an actor in the public domain is a civilian. The focus of the research reported in this paper is to determine relations and interdependencies between the main concepts that can be used for developing a distributed architecture for ISD. ISD requires that independent public organizations collaborate with each other, which in turn requires insight in the relationships among the functionalities and services provided by such organizations. This understanding contributes to distinguish the key concepts and relations that form the basis for coordinating the activities necessary for integrated public service delivery. This is realized by the development of an ontological knowledge framework for integrated public service delivery, which aligns and abstracts domain knowledge found in a case study in the public domain and by studying relevant literature.

Kraaijenbrink (2002) and Klievink, Janssen and Derks (2008) show that many problems arise when implementing integrated public service delivery. Public organizations have no experience in cooperating together. This cooperation requires process tuning, collective service supply, and mutual adaptation of computer-based applications. Furthermore, collaboration requires often that there is a need to change their processes and existing computer-based applications, and the way they offer services. The third problem discussed by Kraaijenbrink (2002) shows that public services are most often information services and that exchange of data and information is one of the crucial elements of ISD. Therefore, implementation of ISD in public organizations requires computer-based support in the integration and delivery of services that may not already be present in organizations wishing to offer integrated public services.

There are many initiatives aimed at ISD by creating interoperability in e-government. Peristeras et al. (2008) and (2009) provides an overview of the many interoperability initiatives for creating model domains. The idea is to create generic and reusable domain representations, which can be used as a reference for modeling the organizations under study. A related initiative is the development of interoperability Registries which can contain services in a predefined format by posing requirements on the infrastructure (Charalabis, Lampathaki & Psarras, 2009). These registries can be used for electronic services composition to create new services (Feenstra & Janssen, 2007). Chun and Atluri (2003) develos a portal facilitating ISD by customizing e-services at the design stage of the services, as well as through run-time adaptation of the services by reacting to changes in the environment during service execution. Given a change condition, the portal system of Chun & Atluri (2003) identifies migration rules that specify operations and tasks needed to achieve run-time adaptation and to generate a new workflow.

Most initiatives take a top-down approach and focus on standardization as the main strategy to deal with the complexity and heterogeneity. In this way neglecting the autonomy of public organization and heterogeneity of applications and processes that have been developed over time. In this paper we focus on fostering the autonomy of agencies and develop an ontology that can be used to describe a wide variety of activities and services of organizations. By creating such a shared understanding, the

foundation for a distributed architecture which can integrate the heterogeneous activities and services of decentralized organizations is created.

This paper is structured as follows. Section 2 clarifies background knowledge necessary to develop an ontological framework for ISD. From an organization-centric view, domain knowledge is acquired from the case material by applying a bottom-up approach which consists of meticulously studying organizational processes that include information on the supply of public services during process fulfillment. Several process models have been created as a result of this study. Besides studying existing organizational processes in the public domain, we have analyzed how actors participating in such processes would fulfill their part of a process in a public organization. This has been realized by conducting interviews with participants in public processes. Thus, we have applied an organizational view and an actor-centric view when studying processes in public organizations. These views have been extended by incorporating other views on public processes from current literature. Furthermore, the resulting process models are structured and abstracted in a process reference house before proceeding to the realization of an ontological knowledge framework in section 3. Finally, section 5 concludes this paper and gives an overview of future work.

2 BACKGROUND

Ontologies are becoming increasingly essential for organizations, because they are looking towards them as vital machine-processable semantic resources for many application areas (Jarrar & Meersman, 2008). An ontology is an agreed understanding of a certain domain, formally represented as logical theory in the form of a computer-based resource. By sharing an ontology, autonomous and distributed software applications, such as e-services for the public domain, can meaningfully communicate to exchange data and thus make such data transactions interoperate independently of their internal technologies. Relating the notion of ontology to the research described in this paper, it can be noticed that organizations sharing an ontology which includes semantics related to the public domain create a starting point for realizing ISD. To understand the relations and interdependencies between main concepts for ISD we have studied processes involved in the so-called expat case in detail. Actor involvement in those processes has been studied by interviewing expats who search and request public services. Expats are, in this case, persons who live in another country and want to come over to The Netherlands for their work. For this purpose they will at least need a (temporary) residence permit, a registration in the citizens' registry, a bank account, a job, a health insurance, and housing. Process models have been developed for each of these scenarios. The expat case contains typical problems of ISD and involves public organizations that need to collaborate together. An example of a problem related to ISD is to bridge the digital divide among citizens (Ke & Wei, 2004). Citizens lacking Internet access at home should still be able to use e-services by other means, such as community self-service terminals. Another example of a problem that needs to be overcome for successful ISD is already mentioned in section 1, namely the observation that governments are often acting in silos. Nowadays they are forced to cooperate with other government agencies as well as partners in the private sector.

2.1 Process models from the expat case

A high-level process model containing composite processes that are required to fulfill when requesting a residence permit for expats has been developed during our research and is shown in figure 1.

Figure 1: High-level process model for requesting and receiving a residence permit.

This model is based on the Business Process Modeling Notation (BPMN) (OMG, 2006), which is an industry standard graphic notation for representing organizational processes. The model is based on information concerning the processes related to the acquisition of a residence permit provided by the Dutch Immigration and Naturalization Service (INS). Figure 1 shows that there are three composite processes involved when obtaining a residence permit. First, a temporary residence permit has to be requested by an expat followed by the request of a permanent residence permit before registering at the municipality. To comprehend what the composite processes exist of, detailed process models for the composite processes shown in figure 1 have been developed. For example, a low-level process model for requesting a residence permit is shown in figure 2. It can be noticed that several parties are involved in the process to let an expat obtain a temporary residence permit. The process starts by the expat requesting to obtain a residence permit from the INS. The remaining process steps can then be fulfilled until the expat collects the residence permit from the INS. Note that the process for requesting a residence permit can be represented in various ways and that the representation shown in figure 2 is but one of the possible ways. An ontology that is shared by public organizations is an agreed understanding of the public domain and as such enables to identify essential concepts and relations between concepts in such processes. Studying public processes in which multiple parties interact is but one of the ways to achieve a better understanding of ISD. This can be regarded as an organization-centric view on ISD, because public processes are arranged by public organizations such as the INS, municipalities, and embassies. As part of the expat case, eleven interviews have been conducted with expats to understand how they participated in process fulfillment during their attempts to acquire a residence permit, a registration in the citizens' registry, and so on. Lessons learned from this actor-centric view can not only be used to improve current governmental processes and public service delivery, but they are for the purpose of this paper used to understand ISD from an actor's point of view also. In the case of the interviews the intended actors can be equated to the interviewed expats.

Central issues related to the residence permit process that were experienced by the interviewed expats are concerned with: Information that is presented in Dutch only, governmental Web sites that are not functioning properly, contradictory information presented by multiple public organizations, and serious human mistakes during service delivery. The latter is related with loss of documents and failing / forgetting to inform other parties in the process. These issues obviously appeal to improve ISD, of which the ontological framework presented in section 3 can act as a step in the right direction. Our research contributes to at least partly resolve the aforementioned issues as follows. The issue of presenting contradictory information can be resolved by letting public organizations share an ontology such as is presented in the next section, so that an agreed understanding is realized concerning the public domain. Based on the ontology, integrated public e-services can communicate to exchange data and thus make such data transactions interoperate independently of technology. This can at least partly resolve the issue of malfunctioning governmental Web sites. Serious human mistakes during service delivery can be diminished when more insight is provided how services can be offered and integrated for repeatable service requests. Next, a hierarchical public domain process reference is described to structure processes that are part of public organizations and are involved in the expat case.

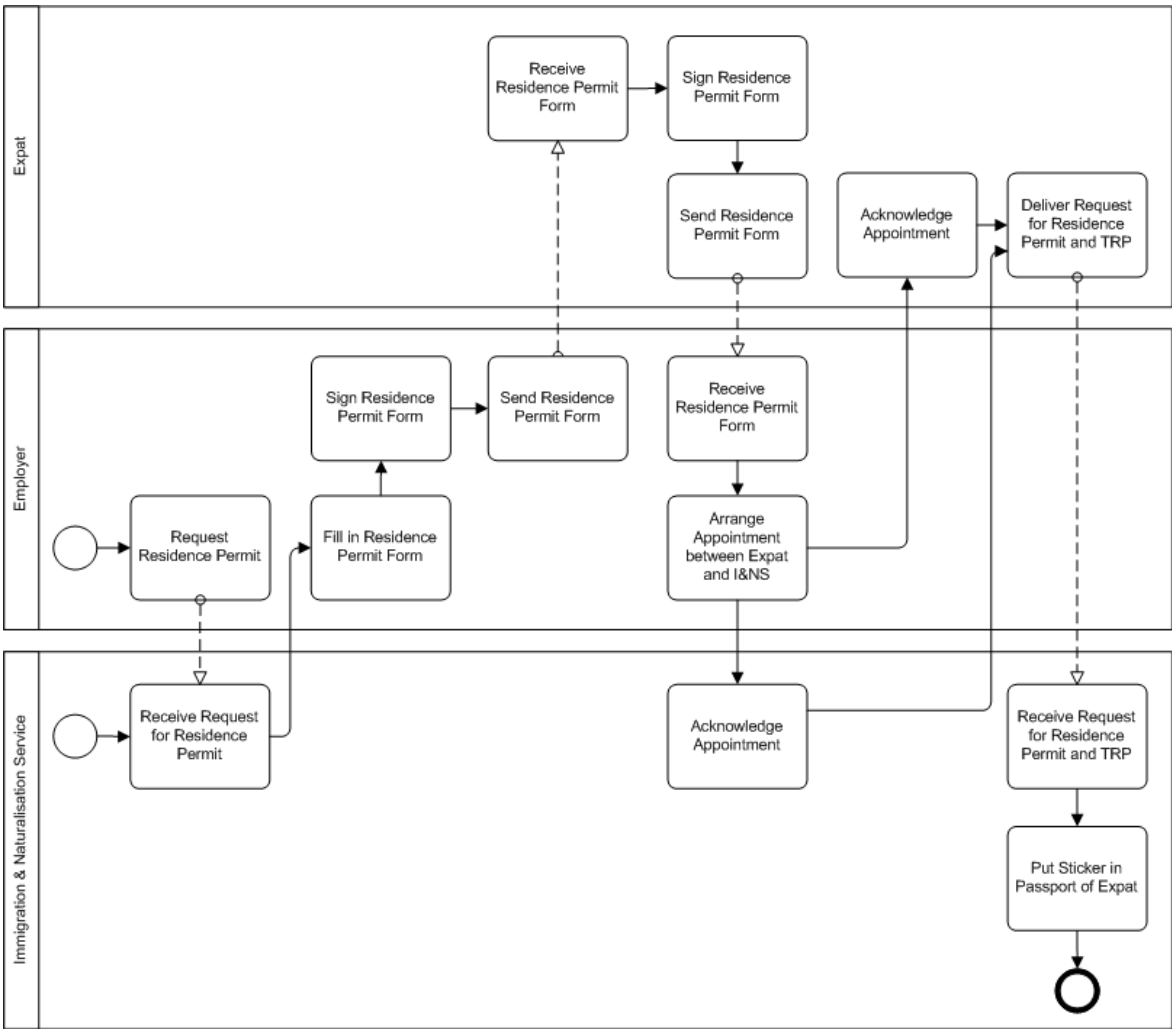

Figure 2: Low-level process model for requesting a residence permit.

2.2 Hierarchical public domain process reference

A process reference enables to structure and provide more insight in processes to serve as a foundation for an ontology. Such a reference house can provide a basis for describing the semantics of processes in the public domain, and to make the content and relationships between process parts more explicit. This way to structure processes has been previously applied in the healthcare domain (Dang et al., 2008). In that case, the healthcare process reference house formed the basis of an adaptive workflow system for hospitals. Figure 3 shows four levels of how processes as part of public organizations can be hierarchically structured. Insights from the organization-centric and actor-centric views on public processes as part of the expat case have initiated the development of the reference house. Level one contains a set of processes as part of a case in the public domain, such as the expat case. Level two contains the core processes as part of such a case. It can be noticed that an expat requires to be involved in these processes in the public domain as has been discussed earlier in this section. Recall that a high-level model of the residence permit core process as depicted in level two is shown in figure 1. The actors that play a role in such core processes are shown in level three. The process actor categories shown are actually possible actors in the public domain that can perform tasks as part of core processes. These tasks are part of the fourth level and form the most decomposed parts of a process. The process actor categories and the tasks depicted in figure 3 are also shown in the low-level process model of figure 2. Note that the residence permit process part is shown to illustrate how insight has been provided in the

four levels of public domain processes as part of the expat case. Now that we have gathered both organization-centric and actor-centric insights on processes in the public domain with respect to a case in which typical problems for ISD are surfaced, it is possible to develop an ontology that contributes to distinguish the key concepts and relations that form the basis for coordinating the activities necessary for ISD.

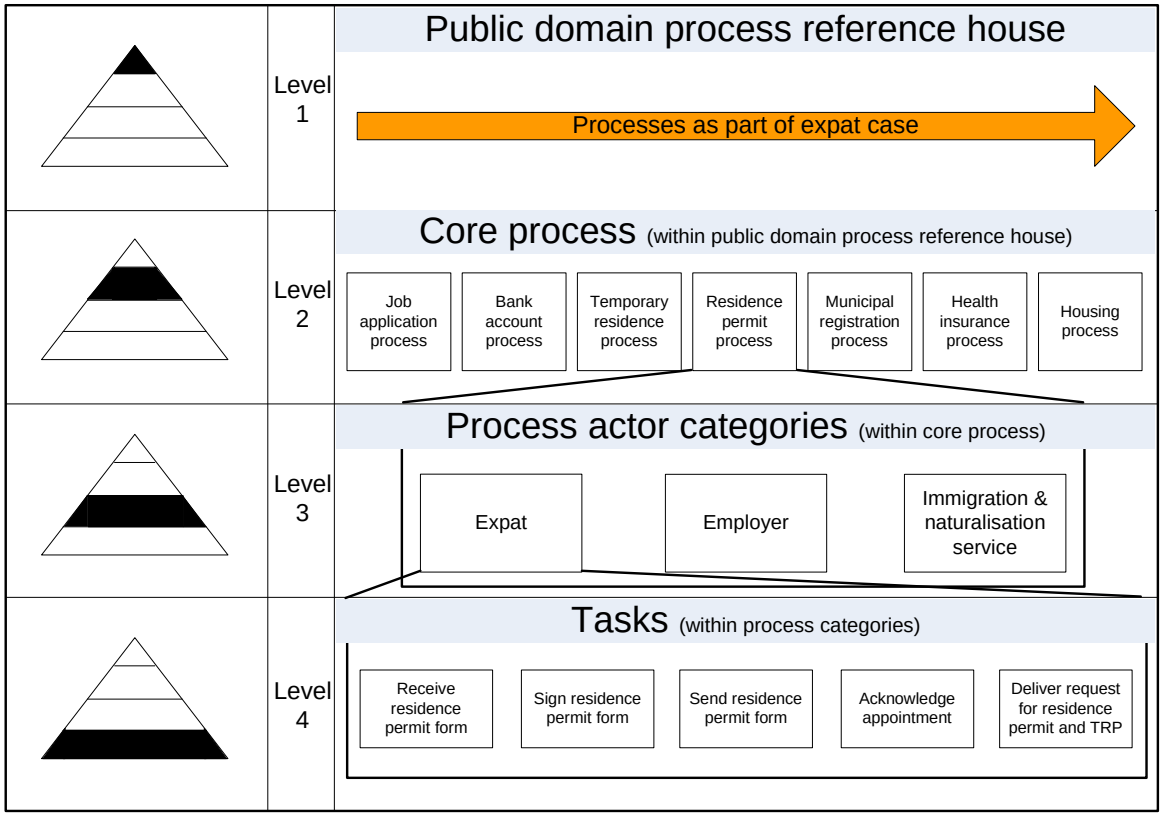

Figure 3: Public domain process reference house, adapted from (Dang et al., 2008).

3 ONTOLOGICAL FRAMEWORK FOR INTEGRATED PUBLIC SERVICE DELIVERY

To accurately describe key concepts and relations between such concepts in the public domain, the domain knowledge that we have aggregated in the previous section is used as a basis for the creation. of an ontological knowledge framework. Besides these insights the ARIS EPC (Event-Driven Process Chains) model (Wikipedia, 2006) can be used for ontology creation, because it provides a description of a public process that extends our organization-centric and actor-centric views with service-centric, resource-centric, and event-centric views. The service-centric view describes concrete services offered by organizations that are required by actors for successful process fulfillment. The resource-centric view describes resources belonging to an organization and which processes consume which resources. To understand the event-centric view an explanation of this view is provided in the next section. First, an ORM representation of the ontological framework for ISD is presented in section 3.1. Second, the different types of ontological constraints are introduced in section 3.2. Third, an OWL specification of the ORM model is presented in section 3.3.

3.1 ORM representation of the ontological knowledge framework

Figure 4 shows an Object-Role Modeling (ORM) model of the proposed ontological framework for integrated public service delivery (Verbeek, Klievink, Janssen, 2009). ORM is a conceptual data modeling technique, which can not only be used for the conceptual modeling of database models, but for a variety of modeling purposes such as the modeling of ontologies.

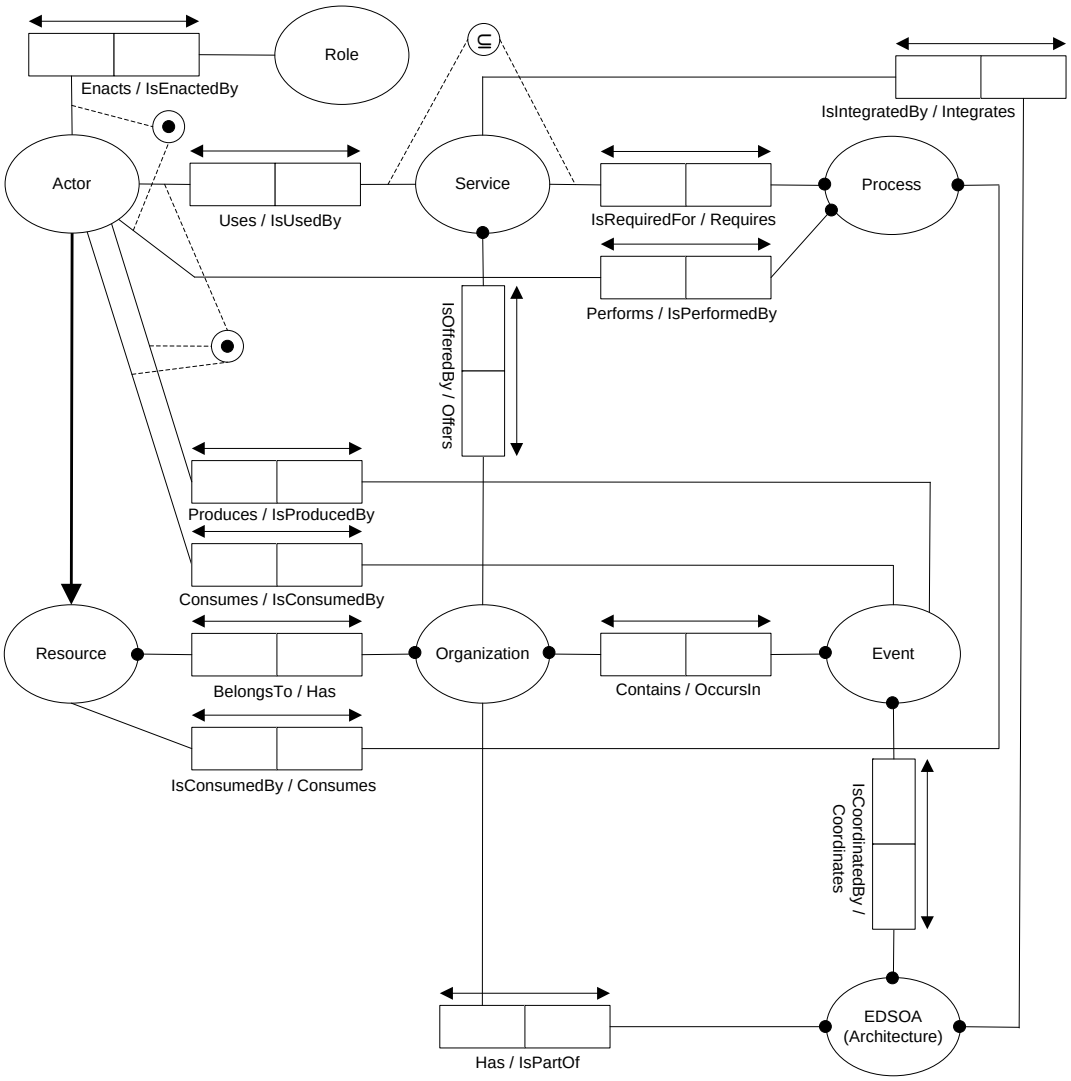

Figure 4: An ontological framework for integrated public service delivery (Verbeek, Klievink, Janssen, 2009).

In an ORM model, ovals represent object types (which are counterparts of classes), whereas boxes represent relations between object types. These relations are dubbed as fact types. For more details on Object-Role Modeling, see e.g. (Halpin, 2001; Hofstede & Weide, 1993).

There are eight central concepts that are part of the ontology. These are the concepts of role, actor, service, process, resource, organization, event, and an Event-Driven Service-Oriented Architecture (EDSOA) concept. A description of a public process from an organization-centric view, such as shown in figure 2, forms the basis of introducing the 'organization' concept in the ontology. The actor and process concepts are explicated in the process reference shown in figure 3. The concepts of service, resource, and

event are part of the ARIS EPC model. The role concept is introduced in the ontology to be able to denote a specification of an actor enactment. An actor is a resource of an organization that enacts a role during process performance or, on a more granular level, task performance. An employee enacting the role of registrar at a municipality is an example of such an actor at a public organization. A civilian is also an example of an actor in the public domain. These actors can use services that are offered by organizations. Services are on their turn required by actors during process performance to assist actors in process fulfillment. For example, an expat that performs the process to acquire a residence permit is provided with a Web service to request a permit online and to provide those digital documents to government agencies that are necessary for the permit request. Finally, the concepts of event and event-driven service-oriented architecture need to be introduced. An EDSOA or simply architecture in the context of this research defines a methodology for designing and implementing computer-based applications and systems in which events are transmitted between a set of integrated and interacting services (Yuan & Lu, 2009). Such events are consumed or produced by actors in organizations. An actor that consumes an event can subscribe to an architecture that manages such events, and an actor that produces an event publishes to this architecture. When an event is broadcasted by an actor, the architecture facilitates that this event is forwarded to a demanding actor. If a demanding actor is unavailable, the architecture can facilitate the storage of the event and try to forward it later. This architecture-based coordination of events can be dubbed as event orchestration (Klievink et al., 2008). An example of an event in the residence permit process shown in figure 2 can be the event 'residence permit form received'. A subsequent event that can be produced by the receiving expat is the 'residence permit signed' event. Building applications and systems based on an EDSOA allows these applications and systems to be more responsive, since such systems are more oriented to unpredictable and asynchronous environments. Eventually, implementation of an EDSOA based on the ontological framework shown in figure 4 can enable ISD and orchestration of events between services in practice. Regarding the ontological knowledge framework for ISD shown in figure 4, it can be noticed that three different constraints can be distinguished. These are the mandatory, uniqueness, and subset constraints. These constraints are discussed in the following section to understand the relations between concepts in the ontology.

3.2 Ontological constraints

The mandatory constraint is sometimes referred to as the total role constraint. It expresses that each instance of an object type has to play the role to which the total role constraint is related. For example, figure 4 shows that every process is performed by an actor. The population of elements in an ORM model, such as instances of object types, fact types (i.e. relations between object types), and roles (one of the two parts that constitute a relation between object types) can be found by applying the population function as introduced by Bommel, Hofstede and Weide (1991). By means of the population function it is possible to reason about the constraints in an ORM model in a precise way. This function can be referred to as Pop and can be modeled as follows:

$$\mathrm{Pop} : \mathrm{OT} \rightarrow \wp(\Omega)$$

The set OT contains object types. Note that roles and fact types are subsets of object types. The set Ω can be referred to as the Universe of Instances, abbreviated to UoI. The Universe of Instances contains all possible instances of types found in an ORM model. Mandatory or total role constraints found in the ORM model of the ontological knowledge framework for ISD can now be expressed by applying the population function. For example, the total role constraint connected to the role '*OccursIn*' can be expressed as follows:

$$\mathrm{Pop}(\mathit{Event}) = \mathrm{Pop}(\mathit{OccursIn})$$

It is now trivial to express each total role constraint that spans one role by using the population function such as above. However, two total role constraints spanning multiple roles can be identified in the ORM model of the ontological framework. First, note that if an actor uses a service, that actor also produces and consumes an event. This is expressed by the total role constraint spanning over the roles 'Uses', 'Produces', and 'Consumes'. Formally, this can be expressed as follows:

$$\text{Pop(Actor)} = \text{Pop(Uses)} \cup \text{Pop(Produces)} \cup \text{Pop(Consumes)}$$

Another complex total role constraint that can be found in the ORM model spans the roles 'Enacts' and 'Performs'. This is to make sure that an actor enacting a role should also perform a process and vice versa. Uniqueness constraints are used to express that instances of object types may play a certain combination of roles at most once (Bommel, Hofstede, & Weide, 1991). This restriction can be generalized as follows: if a certain combination of object type instances occurs in a set RO of roles, then this combination should occur at least n and at most m times in this set. Note that $\text{RO} \subseteq \text{OT}$. The uniqueness constraint can be expressed by using the following frequency function:

$$\textbf{Frequency} : \text{RO} \times \text{N} \times \text{N} \rightarrow \wp(\Omega)$$

Related to figure 4, the expression **Frequency**{has, IsPartOf},0,1) shows that a combination of instances in the set of roles 'Has' and 'IsPartOf' should occur at least 0 and at most 1 times in this set. Instances of the object type 'Organization' play the role of 'Has' and instances of the object type 'Architecture' play the role of 'IsPartOf'. A combination of an architecture instance playing the role of 'IsPartOf' and an organization instance playing the role of 'Has' cannot occur more than once. Subset constraints can be used to indicate that instances of an object type that play a certain role are also part of a set of instances that play another role. In figure 5, a subset constraint is used to indicate that each service that is used by an actor should be required for some process. Formally, this can be described as follows:

$$\text{Pop(IsUsedBy)} \subseteq \text{Pop(IsRequiredFor)}$$

A graphical representation of the three types of constraints that are used in the ORM model of the ontological knowledge framework for ISD is shown in figure 5.

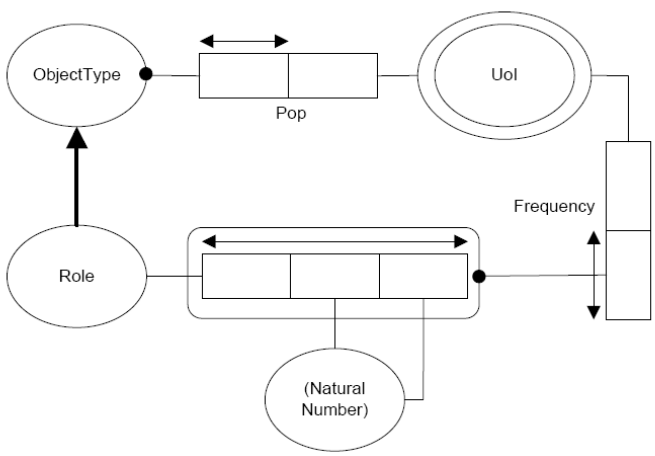

Figure 5: A meta model of the mandatory, uniqueness, and subset constraints.

To increase usability for public organizations that wish to adopt the ontological framework shown in figure 4, the ontology might be specified in multiple specification languages, such as XML, RDF, RDF-S, OWL, etc. See e.g. Jarrar and Meersman (2008). These languages are specifically designed for use by computer-based applications that need to process the content of information instead of just presenting information to human actors. However, the Web Ontology Language OWL facilitates greater machine interpretability of Web content than that supported by e.g. XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics (Jarrar & Meersman, 2008). To increase successful adaptation and machine interpretability of our ontological framework, an OWL specification of the ontological framework that has been visualized in ORM so far is presented in the next section.

4 CONCLUSIONS & FUTURE WORK

Governments are experiencing a shift from supplying common, non-electronic services towards more demand-driven and personalized electronic service (e-service) delivery. This requires the integration of the activities performed by semi-autonomous government agencies. To enable the integration of these activities an ontological framework for integrated public service delivery is described in this paper. The key concepts and relations that form the basis for coordinating the activities necessary for integrated public service delivery can be distinguished by means of this ontology. It is also a foundation for an EDSOA that can integrate services and orchestrate events between services in practice. Knowledge to develop the ontology is acquired by studying a case in which expats search and request public services, and by studying relevant literature. Expats are persons who live in another country and want to come over to The Netherlands for their work. Public processes have been studied from an organizational viewpoint resulting in detailed process models. This has been illustrated by a process for requesting a residence permit. Furthermore, several expats have been interviewed to understand how actors participating in such processes would fulfill their part of the process resulting in an actor-centric view on public processes. Next, the studied processes in the expat case have been hierarchically structured by identifying the core processes, the actors that participate in each core process, and the tasks those actors fulfill as part of a core process. Finally, an ontological framework for ISD is realized by extending the results from the expat case with findings from related literature. The resulting ontology is represented as an ORM model and described in OWL.

Future work consists of the development of an EDSOA that is based on the ontological framework for ISD. The ontology will provide the concepts for describing the heterogonous services and activities of the independent public organizations. The EDSOA architecture will be based on the ontology and defines a methodology for designing and implementing computer-based applications and systems in which events are transmitted between a set of integrated and interacting services (Yuan & Lu, 2009). Implementation of an architecture based on the ontological framework can enable ISD and orchestration of events between services in practice. In subsequent work these architecture needs to be evaluated and generalized to a diversity of cases.

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