Institution Aware Conceptual Modelling

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Abstract. Conceptual modelling for information systems design is to a large extent about describing and prescribing the actions and interactions of agents in organizations. Thus, rules, regulations, organizational roles and other institutional aspects become key notions for conceptual modelling. While modellers may intuitively take these notions into account when creating conceptual models, it would be valuable also to take a more systematic and methodical approach to institutional aspects in the modelling activity. As a first step to such a method, this paper proposes a set of guidelines that support a modeller in identifying classes in a domain model starting from an analysis of the institutional aspects of the domain. The guidelines build on an institutional ontology that describes key notions of institutions, including actors, rules, rights, contracts, and processes.

1 Introduction

Conceptual modelling can be viewed as the activity of analysing, describing and representing some existing domain, typically an organizational one. The goal is to create a correct representation of the domain that can be used as the basis for the design of an information system supporting the activities of the organization. However, this view is often too limited in its focus on the purely descriptive aspects of conceptual modelling. When creating a model for an organization, it is generally required to take a future-oriented perspective, meaning that the model to be produced should not only be descriptive but also prescriptive. It should be able to specify how people are enabled, allowed and constrained to act and interact in the domain. For this purpose, the model needs to represent processes, rules and regulations that determine how people can interact. In other words, institutional concerns come to the foreground when designing prescriptive models for organizational domains.

Institutions have been defined as "systems of established and prevalent social rules that structure social interactions" [1]. Institutional theory defines institutions as regulative, normative and cultural-cognitive structures, also called institutional pillars, that provide stability and meaning to social life [2]. In the

following, we focus on the formal aspects of institutions, in particular formal rule systems.

Institutions are created and maintained through communication between people. In line with a communicative view on institutions, John Searle [3, 4] has investigated how institutional reality is constructed by means of communication acts (speech acts). Searle acknowledges that there is a material world that exists independently of human beings and their beliefs, and asks "how can we account for social facts within that ontology?", [4, p. 7]. This question can partially be answered by the fact that humans have a capacity for collective intentionality, where they share intentions, [5]. Through collective intentionality, they are able to assign functions to things, in particular functions that have little to do with the physical properties of the tool or medium that mediate the function. Such functions are called status functions by Searle. For example, people can assign the function of being money to pieces of paper or the function of being American president to a person. According to Searle, [6], status functions mark the difference between material and institutional reality, where the latter is a matter of status functions and institutional facts, not physical things. Furthermore, institutional facts such as money, property, government and marriage cannot exist without the use of language, which means that communication is constitutive for institutional reality.

Recently, researchers have investigated how an understanding of institutions and communicative action can help in the design of conceptual models, [7–9]. The present paper has the same goal, as it intends to describe and characterize how institutional aspects should inform conceptual modelling in the context of information systems design. In order to achieve this goal, we propose an ontology and a set of guidelines for designing a domain model based on institutional aspects of a domain. Using general, top-level, ontologies to create domain models is not a straight-forward process in the sense that there exists a simple mapping between top-level concepts and domain specific ones [10, 11]. Moreover, the complexity and abstraction level of top-level ontologies constitutes a learning barrier that is hard to overcome in the absence of guidelines and examples of use. We introduce an institutional ontology in Section 2 that describes key notions of institutions, including actors, rules, rights, contracts, and processes; this ontology is a revision and extension of previous work, [9, 12]. Being familiar with the ontology can itself help modellers to construct conceptual models that take institutional aspects into account. But doing this requires a "creative leap", as there is a gap between the notions of the ontology and domain model notions. In order to bridge this gap, the paper introduces a number of guidelines in Section 3 that support a modeller in identifying classes in a domain model starting from an analysis of the institutional aspects of the domain. This can be viewed as making the conceptual modelling activity explicitly aware of institutions.

2 The Institutional Ontology

The proposed institutional ontology is divided into three levels, see Figure 1. The bottom level (white in the figure) is the material level that represents material entities, such as human beings and other physical entities, as well as physical actions. The middle level (yellow in the figure) is the institutional facts level that represents institutional phenomena. The top level (blue in the figure) is the rule level that includes rules, as well as groupings of rules, that govern how entities are created and can interact at the institutional facts level. The ontology is depicted as a UML class diagram (multiplicities are 0..* if not otherwise indicated).

Institutional Rights

Institutions are used to enable, regulate, and constrain human interaction. In order to do so, rights are created and allocated among people, thereby setting up relationships of power and obligations between them. Rights are always relational involving at least two agents, e.g., an obligation of one agent to deliver some goods to another agent. Additionally, a right can include other entities that are the objects of the right, such as the goods in the above example.

One of the most well-known classifications of rights is the one proposed by [13], who distinguishes between four kinds of rights: claims, privileges, powers and immunities. A *claim* means that one agent is required to act in a certain way for the benefit of another agent, e.g., a person can have a claim on a company to deliver a product. An agent has a *privilege* to perform an action if she is free to carry it out without interference from other agents, e.g., a privilege to enter a premise. A *power* is the ability of an agent to create or modify claims, privileges or powers, e.g., the ability to transfer ownership. *Immunities* are about restricting the power of agents to create rights for other agents. In the institutional ontology, rights are modeled by the classes Right Kind and Institutional Right.

Institutional Entities

Institutional entities are entities that are created by an institution through communicative action. An *institutional entity* is either a right, an entity that can have rights, an entity that is the object of a right, or a grouping of rights. Institutional entities are often based on some other pre-existing entity. The institutional entity is said to be grounded in that other entity [14], e.g., a student (an institutional entity) can be grounded in a human being (a physical entity). A number of different kinds of institutional entities can be distinguished.

Institutional Subject An *institutional subject* is an institutional entity that can have claims and is directly or indirectly grounded in a human being.

Institutional Thing An *institutional thing* is an institutional entity that cannot have claims and is grounded in a physical entity or another institutional thing.

Institutional Information *Institutional information* is an institutional entity
that cannot have claims and is grounded in informational content, e.g., a
text or an image.

Institutional Right An *institutional right* is an institutional entity that represents a claim, a privilege or a power.

Institutional Contract An *institutional contract* is an institutional entity that
groups together a number of rights, e.g., a sales contract.
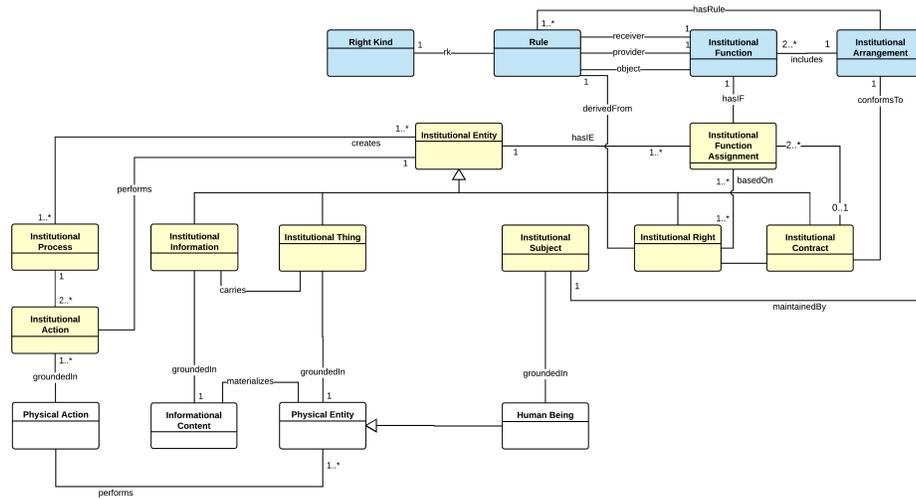
Fig. 1. A UML diagram of The institutional ontology. Cardinalities 0..* if nothing else
stated.

Rules and Institutional Functions

Rules express how institutional entities can and should interact. An example of a
rule is "the *seller* has to deliver *goods* to the *buyer* before the deadline". A rule
includes institutional functions that specify the institutional entities to which
the rule should be applied. Institutional functions are similar to roles as they
are used for defining bundles of rights that can be bestowed upon institutional
entities. Examples of institutional functions are *seller*, *buyer*, and *goods*.

Institutional functions always come together, since their meanings are dependent on each other. For example, the meanings of the institutional functions
tenant and *landlord* depend on each other, as the one can only be defined by
referring to the other. A tenant is someone who is obliged to pay rental to a landlord. A set of interdependent institutional functions together with a set of rules

is called an *institutional arrangement*. Intuitively, an institutional arrangement can be viewed as a contract template.

Rules are closely related to rights, as they can be seen as generic rights. If the institutional functions in a rule are assigned to institutional entities, the rule will result in a right between these. For example, the rule above could result in "IKEA has to deliver the shelf Billy to John Doe".

Institutional Processes

Institutional entities are created by means of communicative actions that form institutional processes, i.e., an *institutional process* consists of a sequence of institutional actions. And these institutional actions are grounded in physical actions, e.g., displaying a badge or writing a signature on a piece of paper.

3 Guidelines for Institution Aware Conceptual Modelling

While knowledge of and familiarity with the notions of the institutional ontology can help modellers in developing conceptual models that take institutional aspects into account, there is still a gap between the ontology and a domain model, i.e. a model for a specific domain. In order to close this gap, we suggest a number of guidelines for applying the ontology. These guidelines are not to be viewed as definite or exhaustive, but rather as preliminary examples of the kind of support required for building conceptual models that are aware of institutional aspects.

As a running example for illustrating the guidelines, we use the notion of warrant in the context of law enforcement. As defined by [15], ""Warrant" refers to a specific type of authorization: a writ issued by a competent officer, usually a judge or magistrate, which permits an otherwise illegal act that would violate individual rights and affords the person executing the writ protection from damages if the act is performed." There are three main kinds of warrants. A search warrant allows a police office to search the premises (or another object) of a subject; an arrest warrant authorizes a police office to arrest a subject; and a bench warrant orders a police office to ensure that a subject appears at court.

The starting point for the guidelines are the rules of the domain. In the running example, there are three main rules, one for each kind of warrant:

Search warrant A Police Office is allowed to search a Search Object belonging to a Subject
Arrest warrant A Police Office is authorized to arrest a Subject
Bench warrant A Police Office is obliged to make a Subject to appear at court

These rules include three institutional functions: Police Office, Subject and Search Object. They also represent three different kinds of rights: a privilege, a duty and a power, respectively.

Guideline 1 Every Institutional Function becomes a class stereotyped as Institutional Entity

Institutional functions can be assigned to institutional entities, thereby bestowing a number of rights on them. Thus, institutional entities that have been assigned the same institutional function become similar to each other, in terms of the rights in which they are involved. And this similarity is a reason for categorizing them into a class of their own, meaning that to each institutional function there is a corresponding class in the domain model. This guideline may not be applicable to an institutional function that is dependent on another institutional function in the sense that if it is assigned to an entity, then the other institutional function must also be assigned to it. For example, an institutional function *course participant* can be dependent on another institutional function *student*, and in this case it may be sufficient that only student becomes a class in the domain model. In the running example, this guideline will give rise to three classes stereotyped as Institutional Entity: Police Office, Subject and Search Object.

Guideline 2 Every Rule becomes a class stereotyped as Institutional Right

When the institutional functions in a rule are assigned to institutional entities, there will be a right between these entities. Thus, different assignments to institutional entities will give rise to a number of rights that are similar to each other, as they are all derived from the same rule. The similarity between these rights is a reason for grouping them into a class of their own, which corresponds to the rule. In the running example, this guideline will give rise to three classes: Search warrant, Arrest warrant, and Bench warrant.

Guideline 3 Every Institutional Arrangement becomes a class stereotyped as Institutional Contract

An institutional arrangement groups together a number of interdependent institutional functions as well as a number of rules that refer to them. These rules function as a contract template for the involved institutional functions. When the institutional functions of one institutional arrangement are assigned to institutional entities, the result will be a set of rights that are grouped together into a contract. In the running example, we assume that there exists a Warrant contract that can group together several warrants.

Guideline 4 Every Institutional Arrangement gives rise to associations between classes stereotyped as Institutional Entity and Institutional Contract

An institutional arrangement groups a number of institutional functions. In the domain model, these will be captured through associations between the class corresponding to the institutional arrangement and the classes corresponding to the institutional functions.

Guideline 5 Every Rule gives rise to associations between classes stereotyped as Institutional Entity and Institutional Right

A rule includes a number of institutional functions. In the domain model, these will be captured through associations between the class corresponding to the rule and the classes corresponding to the institutional functions. Depending on cardinality constraints, these associations can sometimes be omitted as they can be derived from those of the institutional contract that contains the institutional rights.

Figure 2 depicts a fragment of the resulting domain model of the running example. The domain model is created with the Institutional Ontology as point of departure to identify relevant classes and associations.The guidelines described above are used to aid the modeller in this process.
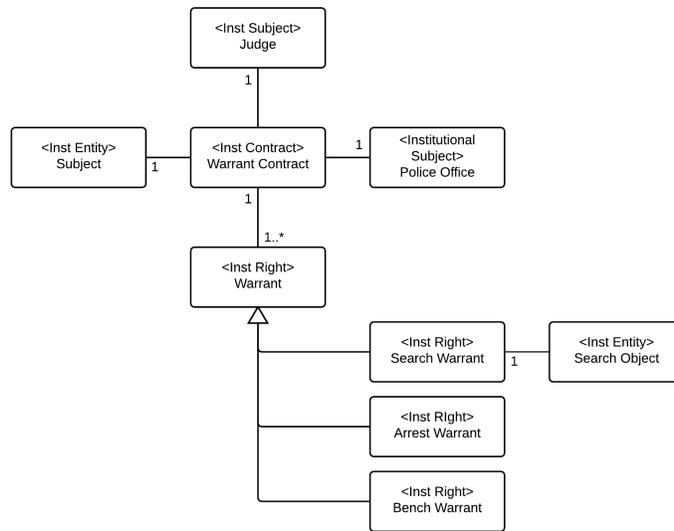
Fig. 2. A UML diagram of a domain model of the running case. Cardinalities 0..* if nothing else stated.

4   Discussion and Conclusion

In this paper, we have proposed an institutional ontology as well as a set of guidelines to use the ontology in order to support developers to design conceptual models for institutional domains. The use of the guidelines are illustrated through an application on law enforcement. Although the guidelines are aimed to be used in conjunction with the proposed ontology, they are built on general institutional concepts such as right, right assignment, contract, institutional function, etc. Hence the proposed guidelines may also be used to explain how

to create domain models not only based on the Institutional ontology but also other ontologies that focus on institutional concepts. Examples of similar ontologies are the REA ontology, [16] and the service ontology, [17]. In contrast to these ontologies, our institutional ontology does not only include commitments (duties) as rights but also privileges and powers.

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