ICT with Industry workshop 2015

1. Title

Towards a Method for a Formal Analysis of Law.

2. Composition of team

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3. Company information

- The IND implements policies on foreign nationals in the Netherlands and has a budget of € 375 million. The IND participated in the NWO Jacquard sponsored AGILE project (2008-2012). The NWO grant covered two AiO positions and one post-doc. This study case proposal is elaborating on the results of the AGILE project [12].
- DTCA implements tax and customs policies in the Netherlands. DTCA has a budget of € 3.200 million. DCTA invests constantly in innovation, especially in the field of ICT, including the Agile Law Implementation Project (Wendbare Wetsuitvoering).

4. Abstract

While service providing organizations are increasingly working within cross-organizational settings and consequently have to absorb and adapt to both internal and external rules. There is as yet no method that guarantees that rules incorporated in IT systems are compliant with sources of law and other normative frameworks. Building upon early work on rule governance and agile ways of defining rules in IT-systems (‘Rule-based or knowledge-based working’, ‘rule management’, ‘Knowledge as a Service’ (KaaS) a multi-disciplinary team worked in this workshop on further exploration of this problem and possible solutions to it.

In the workshop the researchers have focused on one of the components identified as core to the solution: the model of institutional reality. A first version of the formal language Flint (**F**ormal **L**anguage for expressing the **I**nterpretation of **N**ormative **T**heories) for expressing such institutional models was developed together with a first version of a reasoner supporting case assessment, i.e. applying such institutional model to cases. Also the language was formally characterized.

The outcomes of the workshop have lead to a first version of a future research roadmap that would allow for future cross-disciplinary collaboration on this interesting and challenging topic.

5. Description study case

Background

Every organization's behavior in some way or the other is impacted by rules. Rules being either set by the organization's policies, contractual agreements or externally imposed ones. This holds certainly for governmental agencies that have the responsibility for implementing law in various client-handling processes. Obviously these processes are bounded by rules, including legal rules set by law. Today service-providing organizations are increasingly working within cross-organizational settings. As a result these organizations are also confronted with rules of partner organizations. In addition the number of rules from sources of law has been growing over the last decades. Much work has been done in recent years on agile ways of defining rules in IT-systems ('Rule-based or knowledge-based working', 'rule management', 'Knowledge as a Service' (KaaS). However, there is as yet no method that guarantees that the rules incorporated in our IT systems are compliant with the sources of law and other norm frameworks.

Various approaches have been developed over the last decades, but thus far alignment between different approaches is lacking and various open issues still have kept us from large-scale application within industries and government. Researchers have been working on developing a method for formalizing rules for decades. Some promising results have been achieved, particularly within the artificial intelligence and law (AI&Law) community, a community that for some reasons is rather well represented in the Netherlands with an active Jurix community. Early research on building legal knowledge based systems [2][15][16] have showed that first order logic representation of norms is possible, but at the expense of sacrificing accuracy and reusability. Also modal logics have been applied to the field of law. Next to the computational unattractiveness modal logics share there is a problem with correctly expressing an essential normative concept, the concept 'legal ability'. A general problem for translating rules in logic is the disability to handle contrary positions and multiple contradictory interpretation models. Within the AI&Law community different conceptualizations have been developed, including formal models for argumentation [14] and factor analysis of cases [1]. Sileno et al. have reconceptualized norms and normative systems allowing us to model and analyze conflicting interpretations and allow for simulating multiple interpretations in agent-role model based representations of social reality [20].

We aim to develop a formal method for the interpretation of norms in order to enable organizations to design IT-systems that support their business processes in a systemic way that allows for maintenance and the implementation of changes. The specifications that are resulting from the application of the method should allow us to inspect whether systems comply with norms and support the internal and external communication on the interpretation of norms.

Currently many organizations recognize the huge economical potential that such method could have. This most certainly holds for governmental institutions responsible for the execution of the law and applying legal norms to a massive number of cases.

The challenge to develop such method not only requires inter-disciplinary collaboration between information science, artificial intelligence and law, but also between academic researchers and practitioners.

The Leibniz Center for Law works on this subject since the 1990's. From 1998 to 2001 in the CLIME program researchers of the Leibniz Center demonstrated techniques and solutions for a large normative domain: the classification of ships, and delivered a demonstrator called MILE (Maritime Information and Legal Explanation. The demonstrator showed logical violations, but did not give the reasons of these inconsistencies or gave suggestion on how to solve the conflicting norms [3][21]

The Leibniz Center and DCTA collaborated working on formal methods for the analysis of law in the ePOWER program in the early 2000's [8][9].

An attempt was made to relate analysis of law and the formal models that resulted from this analysis to sources of law. One of the results of the ePOWER project was an xml-standard for sources of law: CEN/Metalex (http://www.metalex.eu). So far, however, there is no proper support for the analysis and interpretation of legislation in a uniform and coherent manner. The lack of such a method results in deficient specifications and conflicts on the blame for the resulting errors in IT-products. An approach containing formal models that can be traced back to sources of law is essential in order to achieve integrated information, rules and process models with which the desired flexibility and agility in the provision of ICT solutions can be realized. Since 2012 DCTA and IND have been elaborating on this work in co-operation with the Leibniz Center and two private partners [11].

This work resulted in a preliminary version of a structured, inter-coder independent method for the extraction of rules from sources of law [5][6][10][13][14][18][19]. The method is at present being tested in a governmental setting. DCTA is experimenting with the development of software solutions supporting the method. IND focuses on the legal analytical aspects of the method.

Researchers of the Leibniz Center work on using models of sources of laws and other norms as components in agent-based models that are to be used to implement so-called embedded compliance models that are intended to monitor and enforce norm compliance in distributed networks [4].

The workshop offered the participating scientists yet another good opportunity for multi-disciplinary collaboration a way to exchange ideas and a possibility to work on some cross-sectional research issues that ultimately should lead to expanding experiments in other industries and involving other scientific disciplines.

Problem statement

The lack of a widely recognized method for modeling norms with connections to sources of norms is not only causing avoidable maintenance efforts and lack of adaptability of IT systems it also is keeping us from realizing a sustainable environment for open innovation. Cross-sector collaboration leading to standardization of the method and creating open standards for supporting ICT services will help us to overcome this problem. In order to achieve this we have to bring together business and scientific disciplines including artificial intelligence and law, business informatics, law, computational linguistics and ICT service design. Due to the current silos in academia as well as in business creating conditions for such collaboration allowing for real inter-disciplinary research and innovation is hard. This workshop provided us the opportunity to start such collaboration.

As for the outcomes of this workshop we expected some modest results:

- Broadening the connections with the scientific community;
- Taking steps towards a standardized method for other than just governmental use;
- Exploring the computational issues of using the representations created by using the method;
- Creating an initial research agenda for future cross-sectional research and innovation.

We knew upfront that developing the method depicted above would be hard. Norms and normative reasoning comes with issues such as open evaluative terms, qualification, argumentation, evidence and evidential reasoning, agency and compliance, all complex concepts that would have to be conceptualized in such way that we can fit them into a shared conceptual model. While all participants recognize that eventually all these elements have to be addressed we decided on an incremental approach starting from some recent research findings in this domain. By addressing bit by bit we then would develop our method and set the requirements for the representation formalism(s) and reasoning mechanism(s) that will allow for automated reasoning about a world governed by norms (rules).

Introduction to the case

Administrative Authorities are implementing sources of law. Sources of law consist of a combination of legal sources that contain a lot of implicit information. There is no such thing as an objective interpretation of sources of law, nor a general accepted one, thus interpretation is difficult for implementers and clients applying for public services. An explicit interpretation of sources of law, represented in a formal language, is a necessity for creating a single source specifications for public services.

Building IT-systems to support public services as described above is challenging. Due to a continuous stream of changes in sources of law the task gets even more compelling. Every year numerous articles in law and lower regulation are changed because of political decisions or changing circumstances. The fields of tax and immigration are examples of domains with a high frequency of changes of law.

The maintanence of IT systems in volatile environments is difficult. The IND uses rule based solutions in their primairy IT system to be adaptive to changes of law. Belastingdienst, being a ten times bigger organizations, also uses rule based systems, but their IT environment is far more complex then that of the IND, and consists of a mix of relatively new IT components interacting with legacy dating back to the 1970's.

Introducing rule based IT systems made Belastingdienst and IND potentially more adaptive to changes of law. At the same time a new bottleneck arose. Because the lack of a method for relating specifications of a public service and the sources of law that service is based on, the specification process is based on implicit interpretations of an expert. Legal experts interpret sources of law. The interpretation is explained to a knowledge modeler, who creates a model that has no direct relation to sources of law and is not validated by legal experts (see figure 1). As a consequence the validation of the knowledge model takes place after specification, making corrections more expensive. Furthermore impact analysis of consecutive changes are based upon expert opinions and are error prone. Generally speaking the lack of such a method decreases the potential life span of applications, it makes maintenance expensive, time consuming and does not guarantee correct application of the law.

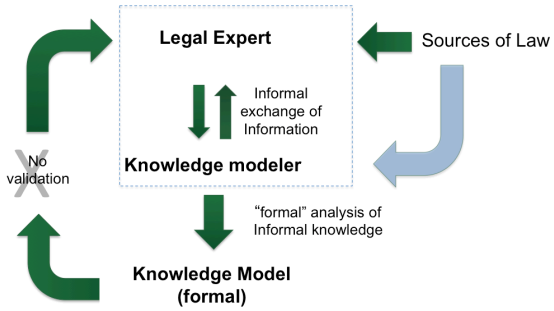


Figure 1: Expert based modeling

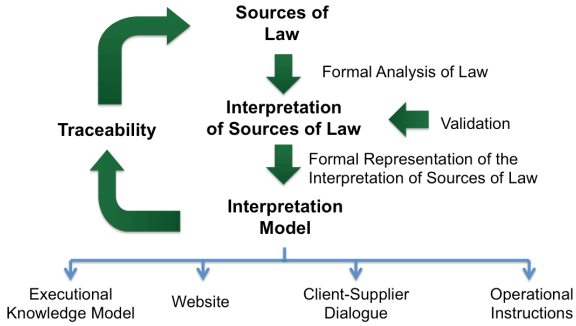


Figure 2: Formal Interpretation of sources of norms

The aim of a formal interpretation of normative texts in natural language is to be able to make an interpretation that (see figure 2):

1. can be traced to constituents of a sentence in natural language
2. can be interpreted by legal experts
3. contains all information to create a formal interpretation model that can be used as a single point of truth.

The first step towards this method was finding a framework that describes legal conceptions in a formal way. The method we developed for modeling the institutional content of normative sources is based upon earlier work of Wesley Newcomb Hohfeld who in 1913 introduced a set of fundamental legal conceptions, see Hohfeld and Cook [13]. His conceptualization of norms was meant to provide a solution for the ambiguity of the concepts 'right' and 'duty'. Hohfeld introduced a smallest set of legal conceptions to which according to him any and all 'legal quantities' could be reduced (see figure 3).

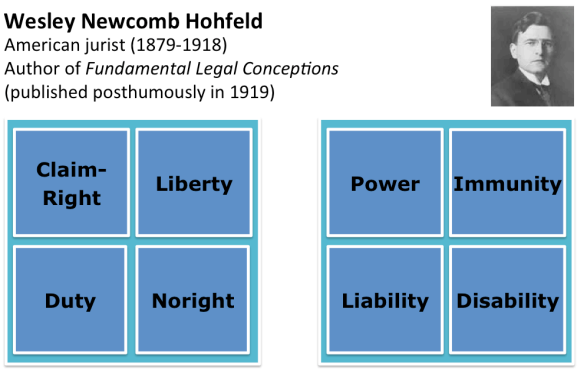


Figure 3: Hohfelds fundamental normative relations

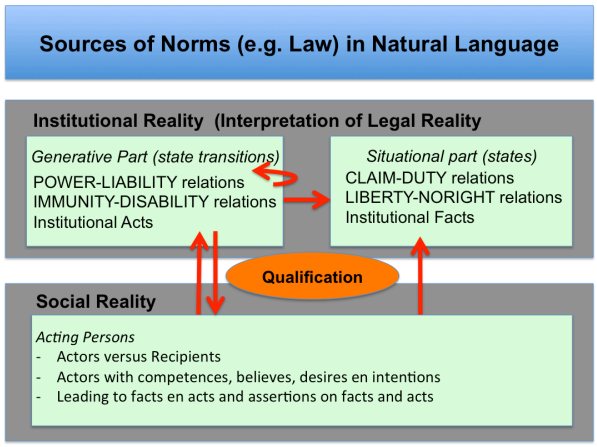


Figure 4: Institutional Reality based on sources of norms [7]

To be able to use this approach for making traceable interpretation models we separate three levels of reality that are interconnected, see figure 4:

1. The sources of Norms
   This layer describes the components; structure and referential mechanisms that allow us to refer at the sources describing the norms we want to 'translate' into formal computational models. The way we represent the normative sources is completely according to the state of the art standards (see CEN/Metalex: http://www.metalex.eu)
2. The Institutional Reality
   This layer describes the meaning of the content of the sources of norms of the previous layer, more specifically the norms, the states representing situations, legal positions, and acts regulated by these norms. This paper is focused on this layer.
3. The Social Reality
   The social reality layer describes the agents, their agent-roles, their collaboration, coordination, message passing, and behavior amongst others. This layer is used to describe and simulate behavior in societies regulated by norms. We can use it for example to test (non-) compliance scenarios, to predict effectiveness.

In our conceptualization *institutional acts* play a pivotal role as these acts connect the *worlds* in which certain *institutional facts* hold and certain *legal relations* exist. Our representation allows for a functional interpretation relating complex objects (i.e. some world) to another. In fact two types of legal relations, *power-liability* and *disability-immunity* are expressed in a functional way, having pre- and post-conditions.

Figure 5 is an example of the representation of the precondition, institutional act and postcondition of the POWER to reject an application to grant a temporary residence permit as it was presented in the workshop.

Combining the work done within the IND on the interpretation of legal norms with the modeling of social reality was one of the aims of the workshop.

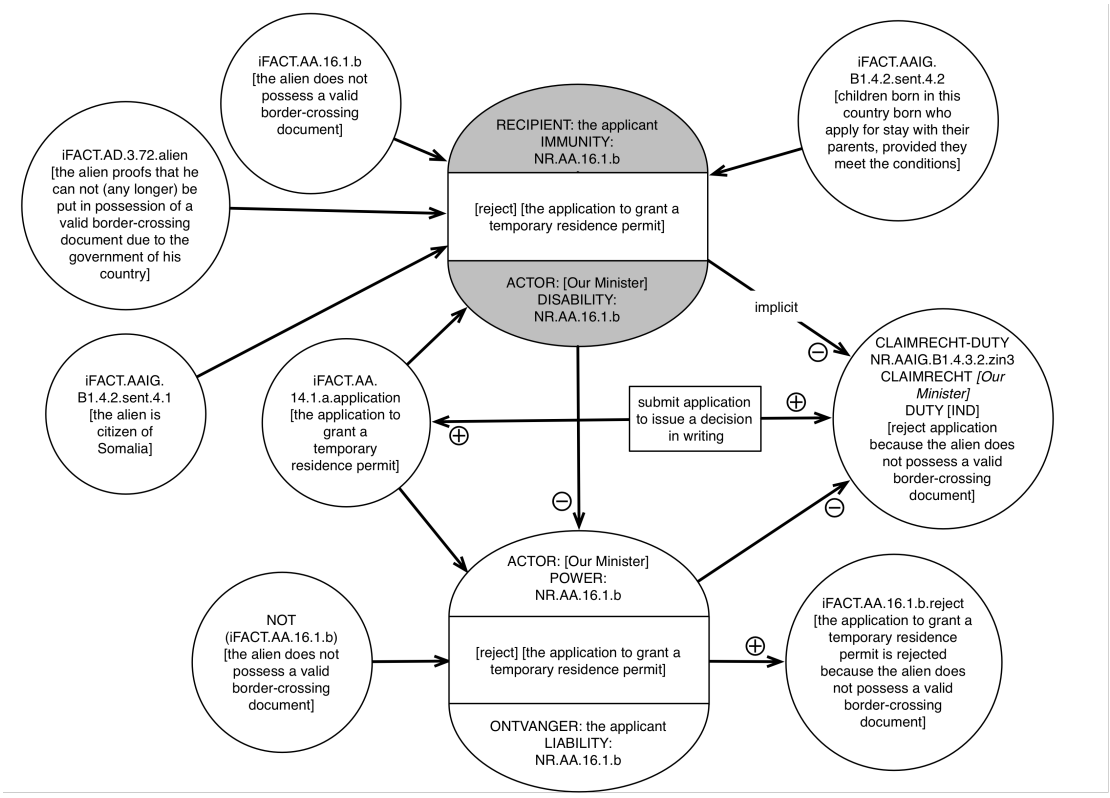


Figure 5: Representation of the Normative Relation described in article 16, paragraph 1, point b, Aliens Act (Robert van Doesburg)

6. Findings

Strategy to solve the case

In order to explore the problem space, develop some common vocabulary, which shouldn't be taken lightly in inter-disciplinary research setting like this, and to pave the grounds for setting the requirements for the method we were to develop we had the participants present the current state of the art from their specific perspectives. On the first day of the workshop the IND and the Tax Administration reported on the status of the method for a Formal Analysis of Law they have been working on and they showed some results of applying the method on some concrete and actual examples of law which implementation is the responsibility of these organizations. The next day experts from the field Artificial Intelligence and Law gave additional input by explaining the issue of different layers of reality and mapping issues between them and we discussed institutionalism, qualification, constitutive and regulative rules (see figure 6), agency and social aspects relevant to normative behavior (see figure 7) thus giving some more context to the institutional model that was presented during the first day of the workshop.

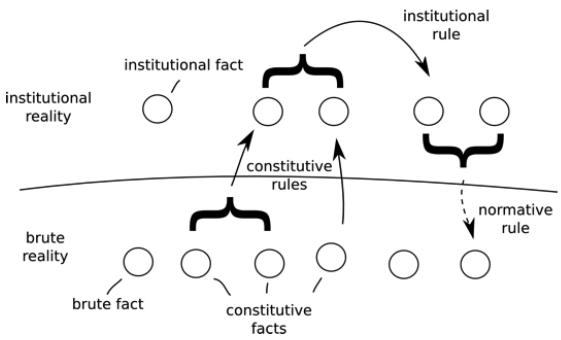


Figure 6: The institutional stance [17]

We also discussed the role of narratives and other mechanisms that are used to produce the evidence that fuels the institutional inference engine. Obviously all of these mechanisms can be subjected to arguments pro and con. Therefore we also discussed formal approaches to argumentation.

We observed that the different approaches the presenters were sharing all had in common that the representation formalisms they were using all had in common that they could be abstracted as graphs, an observation that smoothly fitted with the graph theory discussion and model-driven software engineering discussion we held on the third day.

We decided to try two different graph oriented approaches to represent the initial model presented at the first day of the workshop. While the graph transformation method was showing that we could too some extend come with a representation that would allow us to reason about cases (see figure 7 to 10), the representation lacked the isomorphic features the initial representation model had and which we considered essential parts of the referential mechanisms linking our models and systems components to sources of norms.

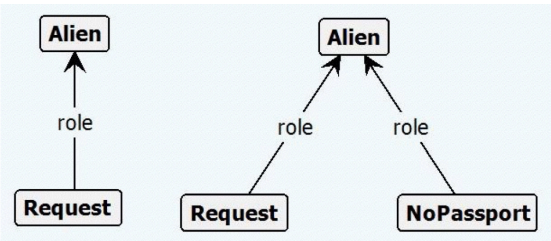


Figure 7: Graph transformations for alien applying for residence permit (Arend Rensink)

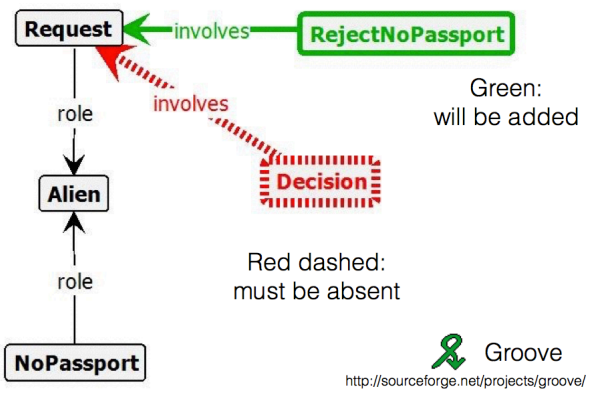


Figure 8: Graph transformations for decision on application for residence permit (Arend Rensink)

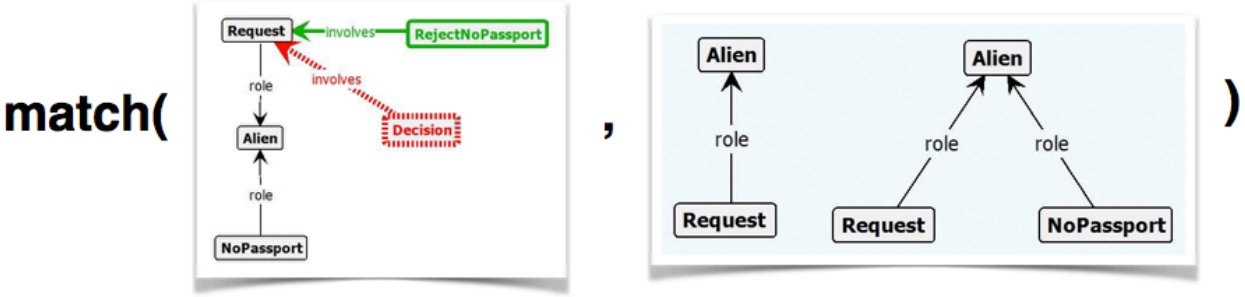


Figure 9: Graph transformations for match alien, application and decision (Arend Rensink)

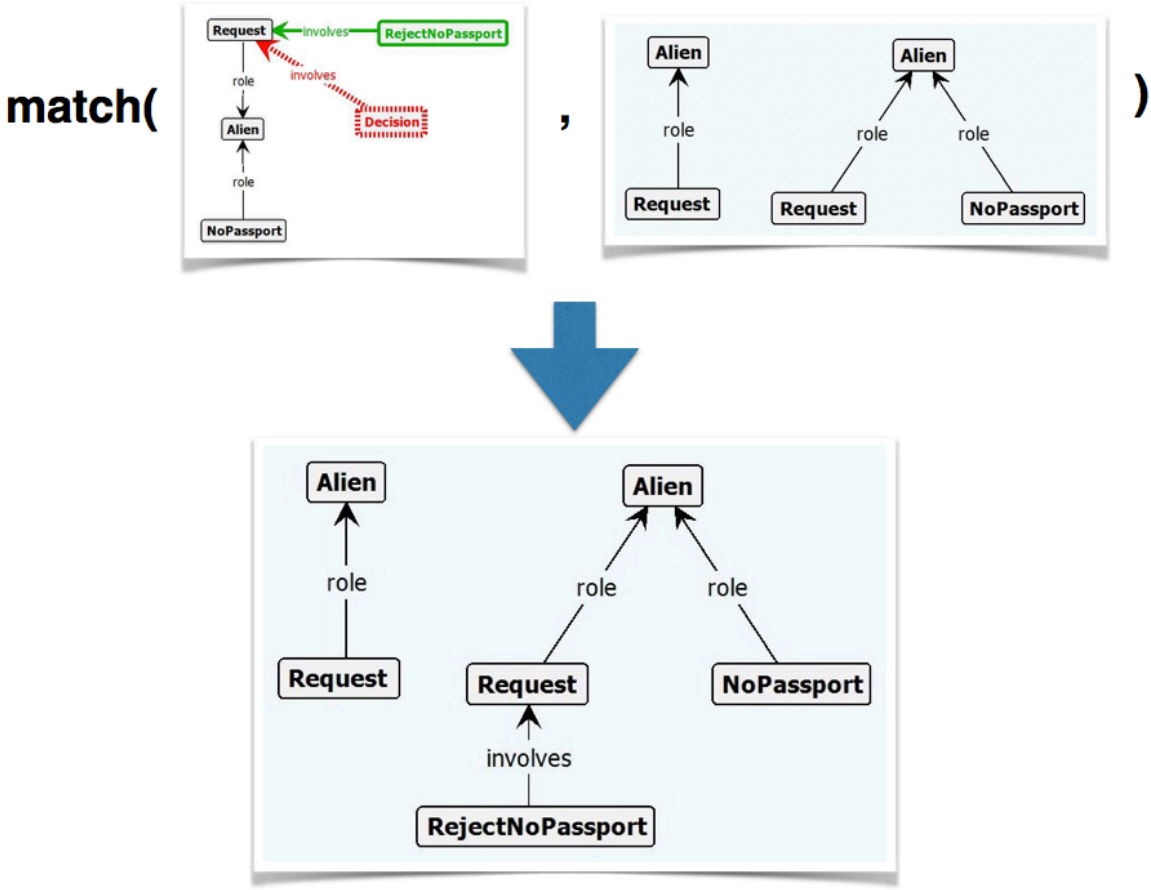


Figure 10: Graph transformations for functional transition decision on application for residence permit (Arend Rensink)

The second approach, see figure 12 and 13, resulted in an almost identical structure to the original one figure 11, with the advantage that the latter could be run in execution mode.

This graphical visualization was automatically generated from a prototype implementation of Flint, entirely built during the workshop, using Rascal (http://www.rascal-mpl.org), a meta programming language for source code analysis and transformation. The prototype consists of an integrated development environment (IDE) for textually describing rules, whose behavior can then be simulated in concrete situations.

As a result, the semantics of rules being developed during the workshop could be directly tested and evaluated.

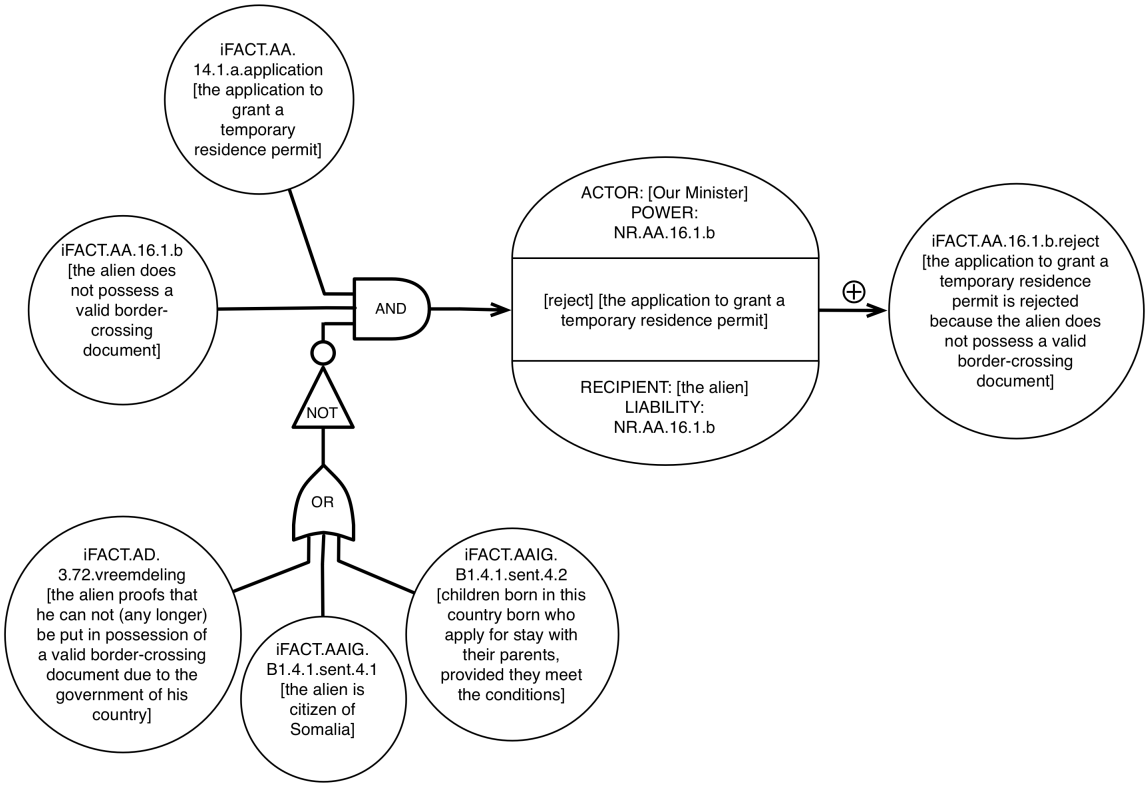
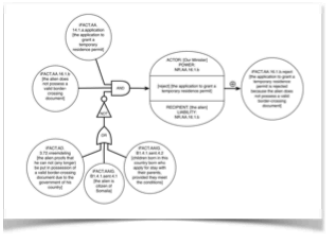


Figure 11: Original representation of the Normative Relation described in article 16, paragraph 1, point b, Aliens Act (updated conform results workshop) [7]



```
document Application

rol Alien
rol Minister

feit AA.14.1.a.application(v: Alien, x: Application) {
  the application to grant a temporary residence permit
}

feit AA.16.1.b(a: Alien) {
  the alien does not possess a valid border crossing document.
}

feit AD.3.72.vreemdeling(a: Alien) {
  the alien proves that he can not (any longer) be put in possession
  of a valid border-crossing document due to the government of his
  country.
}

feit AAIG.B1.4.sent.4.1(a: Alien) {
  the alien is citizen of Somalia
}

feit AAIG.B1.4.sent.4.3(a: Alien) {
  children born in this country who apply for stay with their parents,
  provided they meet the conditions.
}

feit AA.16.1.b.reject(a: Application) {
  the application is rejected.
}

actie reject(a: Application)
 + AA.16.1.b.reject(a)

relatie NR.AA.16.1.b(m: Minister, v: Alien, a: Application)
  m is bevoegd jegens v omtrent reject(a)
wanneer
  AA.14.1.a.application(a)
  en AA.16.1.b(v)
  en niet (
    AD.3.72.vreemdeling(v)
    of AAIG.B1.4.sent.4.1(v)
    of AAIG.B1.4.sent.4.3(v)
  )
```

Figure 12: Translating original representation NR.AA.16.1.b to code (Tijs van der Storm)

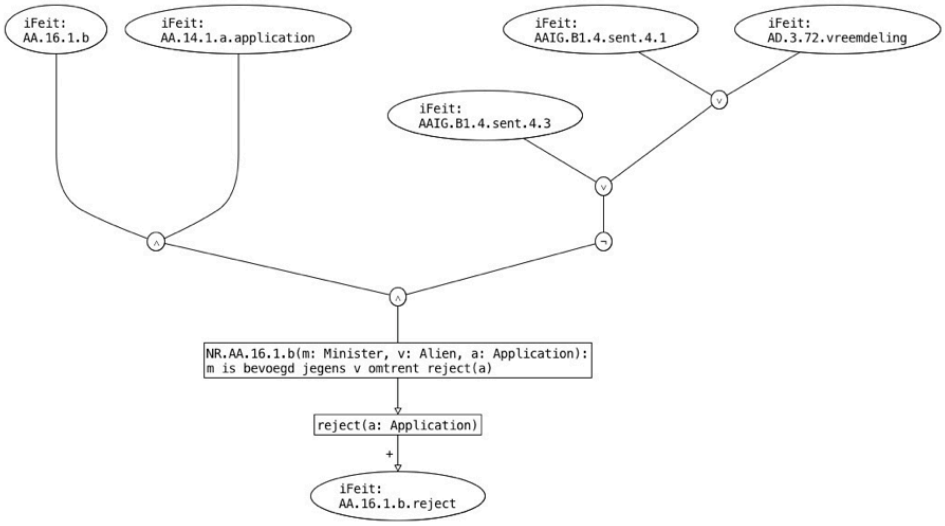


Figure 13: Generated representation of Normative Relation NR.AA.16.1.b (Tijs van der Storm)

The discussion on the formalization of normative interpretations lead to improvements of representations used by the case owners: compare figure 5 and 13. Boolean expressions are now used to be able to make a formal graphical representation of the relations between the institutional facts that constitute the precondition. Also the institutional acts based on a POWER-LIABILITY relation are separated from institutional acts based on an IMMUNITY-DISABILITY relation. The POWER-LIABILITY relation is used by [Our Minister] to reject an application to grant a temporary residence permit based on article 16, paragraph 1, point b, Aliens Act. The IMMUNITY-DISABILITY relation is used by the applicant to appeal a decision the alien considers to be wrong.

After showing how we could use the tools that have been developed for supporting this way of creating model driven software we created a working prototype of a first version of a formal language Flint (**F**ormal **L**anguage for expressing the **I**nterpretation of **N**ormative **T**heories). What was still lacking however was the semantics of that language.

So we worked on defining the formal semantics of FLINT, by defining the Schema, Ontology rules, Transition rules, Dynamic rules etc. This formal description can be found in a separate document (to be published). This language was designed in connection with the other formalisms such as the one based on graph transformations, and we expect that a well-defined relationship can be established. Moreover, the language was designed such that it is likely to be powerful enough to represent the rules from the use-cases, but at the same time simple enough to allow for not only execution but also formal analysis of the processes that it can define such that important properties such as invariants (constraints that always need to be satisfied at each stage of the process) and (un)reachability of certain states in the process can be algorithmically checked. An interesting innovation in the language is that it provides a semantics for uncertainty and allows the modeling of a process where in a certain state it is neither certain that proposition $P(x, y)$ is true, but also not certain whether its negation is true. This is something that turned up in the use cases, but is usually very hard to model and reason about in a way that is understandable for the users. Therefore this was given special attention in FLINT.

Research questions

How to achieve executable specifications for organizations, bounded by rules, who want to act 'rational' in a complex environment?

The workshop resulted in a research agenda for a formal language for normative theories. First we determined what is already possible. Based on the material discussed in the workshop we can:

- A formal definition of rules based on the semantics of legal sources in natural language
- Describing fragments of actions of people and organizations in design patterns
- Describing argumentation structures in combination with statistics

To establish a method for the Formal Analysis of Norms we need:

- Representations of argumentation in factor-based domains including evaluation models

- A complete language to describe acts of people (agents adapting agent-roles) and organizations (multi-agent) in design patterns
- A mapping of the semantics of rules (norms) on design patterns describing acts of people and organization

What is possible when we achieve what is missing?

- The ability check and use formal expressions of rules and apply them to calculate consequences on real world or fictive situations
- Agile implementation in case of changing sources of norms (e.g. of law)
- Making a structured analysis of intentional and unintentional effects of new norms
- Deriving relevant scenarios from a set of cases.

Identification research topics

The following research topics were identified:

- The language: scope, adequacy, completeness, decidability, error detection, language design, modularity, & other domains?
- Rule design: norm planning, mapping institutional reality and social reality (qualification), logical units of work
- Operation: simulation, planning, impact analysis, comparing alternative interpretations, forward/ backward reasoning

Scientific papers

The suggestions made for adjustments of the method for the interpretation of normative sources is described in the paper "Modeling the Interpretation of sources of Norms" by Tom van Engers and Robert van Doesburg (to be published) [7].

8. Follow up/outlook

- During the workshop two places for further co-operation have been started (https://github.com/cwi-swat/flint and normware.org).
- During the workshop the lay-out for a paper on syntax and semantics of the method was made by Jan Hidders. This layout is to be elaborated to a paper. A separate paper will be written on generating representations of normative relations using the Rascal prototype made by Tijs van der Storm.
- Based on the results of the workshop a proposal for the Lorentz Workshop on the modeling and execution of norms was submitted.
- Results of the workshop will be presented at the next conference of the Expertise Group Business Rules Management on March 10, 2016. The Expertise Group is a co-operation of governmental administrative authorities exchanging knowledge and experiences related to the use of rule based IT systems.
- Besides the general presentation of the results of the ICT with Industry Workshop at the ICT.Open of March 22-23, 2016, a proposal for a research presentation was accepted.

9. References

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