Towards a Model of Multilevel Adaptive Collaboration

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Abstract

Rules and regulations grow into complex webs that are difficult even for experts to overview and comprehend. Particularly in cross-organisational collaborations in heavily regulated practices, e.g. health information exchange, rules and actors may form multilevel, adaptive, organisational rule systems. One potential way to analyse these complex structures is by utilising enterprise modelling and visualisations. This paper proposes a conceptual model for the description of rules in multilevel adaptive collaborations. The model is demonstrated with a case of collaboration for health data exchange, representing how actors at different levels adapt their rules according to their goals and how these goals must be balanced against the goals of the collaboration.

Keywords

enterprise modelling, health information exchange, complex adaptive system, legal design, multi-level governance

1. Introduction

In the realm of healthcare, Cyber-Physical-Social Systems (CPSS) are being increasingly employed to facilitate remote patient monitoring, the early identification of health risks, and the delivery of personalised medical interventions by merging cyber technologies with physical infrastructure and human social interactions [1]. These CPSS rely significantly on Health Information Exchange (HIE) for health data accessibility. Nevertheless, acquiring access to such health data necessitates interoperability across various layers: technical, semantic, organisational, and legal [2]. This study primarily concentrates on the organisational layer.

As argued by Sobb et al. [1], understanding CPSS requires a complex system perspective, recognising the non-linear, emergent behaviours that arise from interactions between technological components, organisational actors, and regulatory environments. According to Complex Adaptive System (CAS) theory [3], a system is composed by agents that interact according to the rules that constrain their behaviour. Feedback channels allow agents to evaluate the behaviour and adapt their rules to perform better. Some of the rules that constrain an agent are set by the agent itself, while others are imposed by other agents in the surrounding system. CAS theory overlaps with complexity theory and emphasises the non-deterministic, fuzzy, and messy nature of reality. It also focusses on emergence, how a larger system can suddenly have properties that are hard or impossible to predict by studying its parts.

When studying how CAS evolve, it is vital to understand that there are often conflicts between levels in multi-level systems. Wilson emphasises that a principle for rule evolution is the two-level selection, meaning that rules must be functional on more than one level in the system [4]. Rules that work for one level in the system, say a care unit, but undermine the goals of a hospital, are unlikely to survive in the long run.

In an earlier study [5], Wilson, Ostrom and Cox explore how the core design principles managing common pool natural resources [6] that gained Ostrom the Nobel Prize in Economics can be generalised into design principles for collaboration. The common denominator between resource management and other forms of collaboration is that it requires a rule system that, in short, with a light but firm hand, makes the participants collectively balance their own needs with those of the collaborative system.

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The insights of Wilson and Ostrom are crucial in the context of intra- and inter-organisational collaboration. The inevitable tensions between the goals of the wider system (the collaboration) and its components (the collaborators) must be managed. Rules and goals must be understood and, probably, constantly redesigned.

A vehicle for understanding and designing that we explore in this paper is Enterprise Modelling (EM) [7]. EM may be used to establish an overview and common understanding among the many stakeholders in an organisation. In addition to developing IT systems, EM is helpful in designing sociotechnical systems, especially those that are computationally independent, such as organisational rules. The concrete output of EM is usually a visual model. A model shows an organisation, or collaboration, from certain perspectives. Two common perspectives, which are also the fundamental concepts in a CAS, are actors and rules [8].

This study is part of a PhD Design Science Research (DSR) [9] project, aiming to design a modelling language of organisational rule systems as complex adaptive systems. Earlier contributions include for example a systematic mapping study [10] of enterprise modelling of organisational rules in collaborations, leading to a minimum viable model [11] of organisational rule systems.

The research aim of this paper is to contribute to the understanding and design of rules in organisational collaboration. The research question is: Which concepts are needed to model a multi-level, adaptive, organisational rule system?

The remainder of this paper is structured as follows: Section 2 situates the study in a wider research project and presents the methodology. Section 3 presents the proposed model. Section 4 demonstrates the model. Section 5 discusses the results and concludes.

2. Research Context and Methodology

This study is part of a larger PhD Design Science Research (DSR) project aiming to create a modelling language for organisational rules in complex adaptive systems. Previous works include i.e. a systematic mapping study [10], in which we analysed existing modelling languages that have been used for modelling organisational rules in the complex setting of organisational collaboration. The study found several research gaps. In this study, we are addressing one of them.

In another study [11], we viewed organisational rules in the setting of complex adaptive systems and outlined the main concepts needed for their description. We reused parts of this larger model as a base and adapted them for the specific purposes of this paper. We expect that the patterns in the model proposed in this paper will later be useful for improving the larger model.

The adaption was grounded on the theoretical contributions by Wilson et al. [4, 5], and demonstrated in the form of an instantiation on a fictitious case, presented in Section 4, based on our knowledge of the Swedish health data domain. (This is so far the only instantiation of this conceptual model.) The process was iterative, moving back and forth between the conceptual model and its instantiation.

3. Proposed Conceptual Model

To be able to describe the rules, actors and their interactions in an organisational rule system, a number of concepts are needed. The proposed model for these concepts is shown in Figure 1 and explained below.

The primary classes in the model are Rule, Agent, Behaviour, and Action. The rules controls agents and their behaviour, and the agents evaluate their behaviour in light of their rules (in particular higher-level goals) and change their rules accordingly. Agents can be part of other agents, forming multi-level systems.

Starting from above in Figure 1, an Actor can be either an Agent or a more abstract Role. While an Agent has an identity, a Role does not. In the example case, Care Inc. is an Agent, and ”member of The Data Hub” is an institutional role, created by the statutes of The Data Hub. When Care Inc. assumes

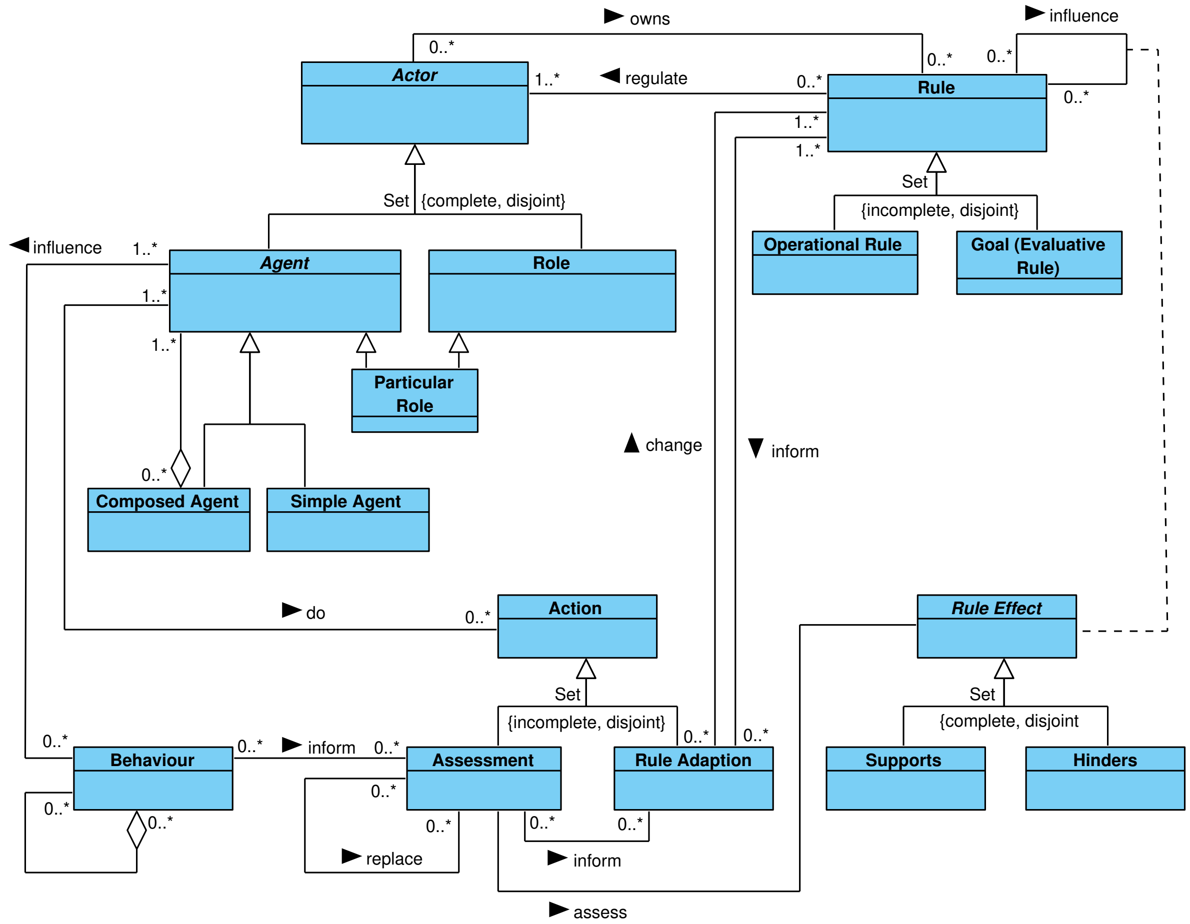

Figure 1: Conceptual model of multi-level, adaptive, collaboration. All classes have start time and end time attributes that are not shown in the diagram.

this Role, it instantiates it into a Particular Role. In this Particular Role, Care Inc. has the same rights and duties as any member, as stipulated by the Rules that apply to them.

An Agent can be either a Composed Agent (by other Agents) or a Simple Agent. In the example case, Care Inc. is a Simple Agent, and The Data Hub is a Composed Agent.

An Agent influences a Behaviour, either alone or jointly with other Agents. A Behaviour can also be part of other Behaviours. In the example, the data sharing behaviour of Care Inc. (and the behaviour of other members) is part of the aggregated data-sharing of the whole collaboration.

A Rule regulates how Actors behave. A Rule can be either Operational or a Goal (evaluative rule). In short, an operational rule tells you what you should or should not do, and a Goal tells you what outcomes are good and bad.

A Rule influences other Rules. Often they are means to an end in multi-level supporting structures. However, Rules can also Hinder each other. These relations can be both complex and debatable and, therefore, need an Assessment that, like any Action, is done by an Agent. An Assessment can, but does not have to be, based on a Behaviour; An assessment can also be done before the Rule starts affecting a Behaviour, in other words an ex-ante evaluation [9] of the rule. An Assessment can replace an earlier Assessment by the same Actor.

An Assessment can inform another type of Decision, a Rule Adaption, that can create, modify, or terminate Rules. A Rule Adaptation is normally informed by the relevant existing Rules as well as an Assessment of their impact.

A final note about the conceptual model is that the multiplicities are representing what can be expected to have registered in a database rather than what is ontologically true. This mostly results in many-to-many (0..* at each end) relations.

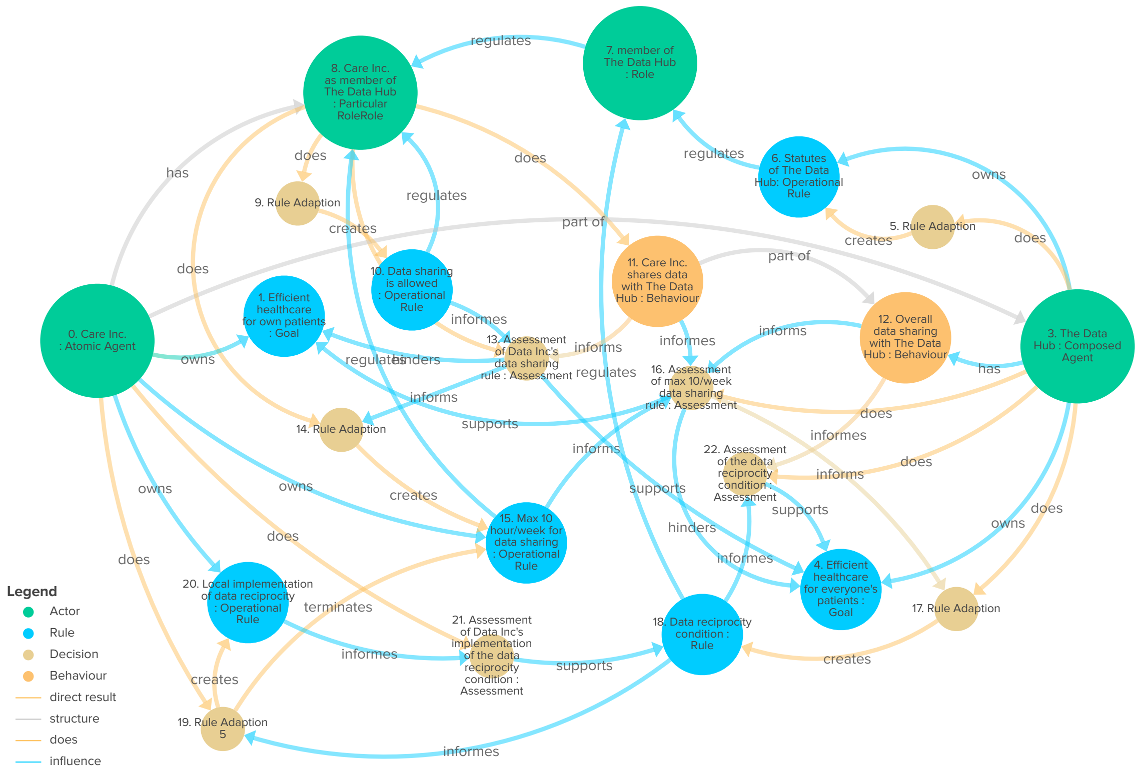

Figure 2: The instantiation of the fictitious case, done with Kumu.io. The numbering of the elements represents the order of events. The figure shows how Actors (green circles) are regulated by Rules (blue circles), influencing their behaviour (large orange circle). The Actors makes assessments of how the rules work, leading to rule adaptions (i.e. Decisions, small beige circles). This figure only presents an overview; A more understandable map is available online in the footnote referred to in the body text. (When viewing the interactive map, start by changing "Untitled view" to "time point 00" in the upper drop-down menu.)

4. Demonstration

The demonstration of the proposed conceptual model was done in the form of an instantiation representing the fictitious case of Care Inc. The used tool was Kumu.io, which is a general-purpose mapping tool. The full instantiation is available in Figure 2. However, this figure only serves to give a general idea of what was produced. The reader is advised to consult the interactive visualisation available online [1] (and start by changing "Untitled view" to "time point 00" in the upper drop-down menu).

The demonstration is built on a fictitious but realistic case of a data hub which member organisations collaborate to pool health data. An example of such a hub is The Swedish National Diabetes Register, which collects data for research and quality control purposes. Being a member of a health data hub provides access to more data but also demands dedicating time to gathering and preparing the data sent to the hub, while also managing different legal and ethical challenges related to patient privacy [12]. The rules and actors of the case form an organisational rule system.

When creating and evolving the hub, rules concerning the collaboration of participants adapt and evolve as well. In the beginning of the case (time point 00 in the interactive Kumu map), a company named Care Inc., decides to join (time point 01) a nascent, still not formalised, collaboration of caregivers and other health data creators. The main goal of the company is to provide efficient care for its patients. The collaboration formalises into The Data Hub, and produces (time point 02) its first set of rules in its statutes. Among other things, the statutes define the rights and duties of a member organisation. Care Inc., being a member, assumes (time point 03) this roles and changes its internal rules to allow sharing

[1] https://kumu.io/joran/multilevel-adpative-collaboration-cpss4sus2025

data (time point 04) with The Data Hub. After some time, Care Inc. makes an assessment (time point 05) of how this new routine affects its main goal and other rules. Sadly, it concludes that even if the data sharing does contribute somewhat to the goals of the collaboration, it has become a burden on Care Inc.'s staff, leading to less time with patients. In other words, the data sharing has become a net burden for Care Inc.'s own goals. Care Inc. also has the impression that not many other hub members are sharing much data anyway. Therefore, Care Inc. makes a new rule (time point 06), reducing the work time that can be spent on the data sharing collaboration to maximum 10 hours a week.

Now, The Data Hub secretariat reacts and assess (time point 07) that Care Inc. (and some other members) have become free-riders, excessively putting their own goals before the common goal. A meeting with the members is summoned, resulting in a consensus decision (time point 08) to add a new rule to the collaboration: a reciprocity-based data-access model [12], which means that the more you share, the more access you gain. Care Inc. now has to choose between leaving the collaboration or complying. The choice is not obvious, but it decides to stay and implements (time point 09) the reciprocity-based data-access model in its own routines, resulting in spending more than 10 hours a week on data sharing. On the other hand, other members have increased their sharing as well, so Care Inc. does not regret its course of action (time point 10). The Data Hub, too, makes a new assessment (time point 11) and is satisfied with the new situation.

5. Discussion and Conclusion

The research aim of this study was to model the multi-level and adaptive aspects of an organisational rule system. As shown by the demonstration, the proposed model can represent several of the crucial relations identified by Wilson [5]. First, it shows that agents start collaborating and how this collaboration formalises into an agent itself. Second, it also expresses how both individual members and the collaboration learn and adapt according to assessments informed by how existing rules affect behaviour. Third, it represents how this adaption creates an interplay between system levels.

Several of Ostrom's core design rules [5] can be observed in the instantiation: Collective-choice arrangements (the consensus decision-making); Proportional equivalence between benefits and costs (solved by the data reciprocity condition); Monitoring (the assessments); Graduated sanctions (the data reciprocity condition). For more information about each of the design rules, we refer to Ostrom's work [5].

Some of the design choices in the proposed conceptual model were not obvious. As can be seen in Figure 1, Particular Role has a double inheritance, which is in general something to avoid since it can make a model harder to instantiate. On the other hand, for the purpose of this paper, we did not see any concrete problems arise. Another option would have been to use an association that represents that a Particular Role instantiates a Role.

A second design choice was to abstain from going deeper into the Behaviour concept. We could have represented how Behaviours relate to each other in time or added classes for events (that form Behaviours), or situations (in which behaviours occur). However, it is questionable if trying to disentangle this complexity would make the model more useful or rather just make it more complex.

A third design choice was to not include an association between a Behaviour and the Rules that affect it. This was for two reasons. First, a Rule does not affect a Behaviour directly, but indirectly through Actors, which is represented in the model. Second, in case of doubt, it is probably best to avoid adding more constructs to a model.

In conclusion, the proposed model can be used for analysing how a collaboration evolves and continuously adapts its rules in order to make its members gain enough to want to stay while also contributing enough for the collective goals.

6. Declaration on Generative AI

The authors have not employed any Generative AI tools.

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