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Publication date

2013

Document Version

Final published version

Published in

BNAIC

[Link to publication](#)

Citation for published version (APA):

Sileno, G., Boer, A., & van Engers, T. (2013). Towards a computational model for institutional scenarios. *BNAIC*, 25, 183-190. http://bnaic2013.tudelft.nl/proceedings/papers/paper_44.pdf

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Towards a computational model for institutional scenarios

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Abstract

Focusing on descriptions of behaviours concerning the application of law, the paper presents elements of a methodology that supports story acquisition for a scenario-based modelling framework. It introduces practical reasoning patterns concerning action and power, which serve firstly as visual templates for the modeller, and secondly as building blocks of a story-model that can be analyzed and executed on a computational framework.

1 Background

Stories are “constituents of human memory, knowledge, and social communication” [14]: people continuously explain their own behaviour and the behaviour of other people, communities and organizations through the use of narratives, also in professional environments. They are fundamental instruments of knowledge transfer between humans. The legal domain provides many examples of *systemic* use of stories (e.g. case law), with the implicit purpose of conveying an interpretation of social behaviours not yet, or not sufficiently taken into account by the legal system. In administrative organizations, prototypical cases are used to explain legal services and serve as sources of requirements during design phases.

Despite such importance, they still remain an underutilized resource, in respect to computational tools. Scenarios, extracted from cases, correspond to environmental models, and, as such, they could be used in a design tool for policy makers/regulators, in order to test a new implementation, or as problem/solution space for monitoring/diagnosis tasks. The paper presents hereby elements of a methodology aiming to transform such stories in computationally exploitable models, connecting story acquisition with practices of scenario-based modelling and formal models of processes. Its main contribution is the identification and visualization of basic patterns that model the practical reasoning concerning *action* and *power*¹ in institutional scenarios. This work is part of a larger research, targeting the implementation of an *Agile methodology* specific to public administrations [2].

2 Methodology

The methodology consists of three steps. First, we identify all events described in the story and their sequence, extracting the *signal layer* (2.1). Second, we integrate the previous layer with an internal behavioural characterization, constructing an *intentional layer* (2.2). Third, we embed an *institutional layer* to consider normative aspects (2.3).

¹As observed in [3], the power component is often neglected in normative research, more focused on deontic aspects of norms.

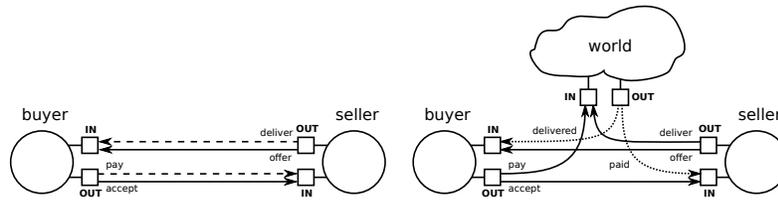


Figure 1: Topology of a sale story: direct and indirect communications.

2.1 Signal layer

Let us consider a simple story about a sale: «A seller offers a good for a certain amount of money. A buyer accepts this offer. The buyer pays the sum. The seller delivers the good.» In spite of its simplicity, this story provides a good overview on the complexities of the problem. We recognize four events (namely acts, performed by two agents), reported from the perspective of a narrator. The first two (offer, acceptance) are easily interpreted as *speech acts*. Generally speaking, however, all events in a story can be interpreted with a teleological perspective: they bring about some informational change in some agent (including the narrator). Then, for simplification, we assume that all acts are acts of communication, intentionally performed by some sender and directed to some intended receiver, possibly through intermediate actors.

Monitoring processes From an *ex-post* perspective, if the agent in the story has reacted to an event, we assume he perceived and processed it. This reactivity presupposes that the agent is provided with an adequate monitoring/listening process. Monitoring is important as well in emission, because an agent usually checks to some extent the outcome and the consequences of his performance.

Following control theory, we define an action as *closed-loop* if an adequate monitoring is placed as a suffix to the performance of an action, otherwise it is *open-loop* action. Taking the case of a speech act, we recognize two possible monitoring. The first concerns the transmission: we may need an acknowledgement of the reception of the message, e.g. a receipt. The second is related to the intended consequences of its content (the associated *perlocutionary act*).

Considering the sale story, monitoring processes are unveiled by the reactions to offer and to acceptance, but we cannot make any assumption about the existence of closed-loop actions. For instance, in case of a trusted partnership, the seller may overlook to check if the payment has been done. The story would instead unveil the existence of a closed-loop monitoring if one of the agents perceives some mismatch with his expectations and reacts to it.

Topology of the story The collection of messages constitutes the *topology* of the story. The topology serves as a still picture of the whole story-system, and show how signals are distributed between the *agent-roles* [2]. In our approach, we consider it also from a complementary perspective: the first identification of an agent in a certain agent-role is given by the topology of known exchanged messages.

Inspired by the Actor model [10], we illustrate two possible representations of the topology in Fig. 1 (the little boxes are *messages queues*, the lines are *communication channels*, all messages have a specific *propositional content*). On the left figure, the dashed lines refer to actions that have relevant outcomes besides the direct communication. On the right figure, we introduce an explicit world/environment actor and the potential closed-loop component of the communication, visualized with dotted lines². The world would play an intermediary role also in case of broadcast offer³.

Flow of the story The signal layer, constrained by the strict linear order suggested by the discourse, reproduces only one specific story. We need some abstraction, if we want to compare similar stories. We

²In a general case, monitoring may occur in two ways: (a) the observed entity autonomously sends the targeted message when available, as the world actor does in this case; (b) the agent has to produce an explicit request in order to receive it.

³With a similar spirit, acts performed autonomously by the world can model natural events.

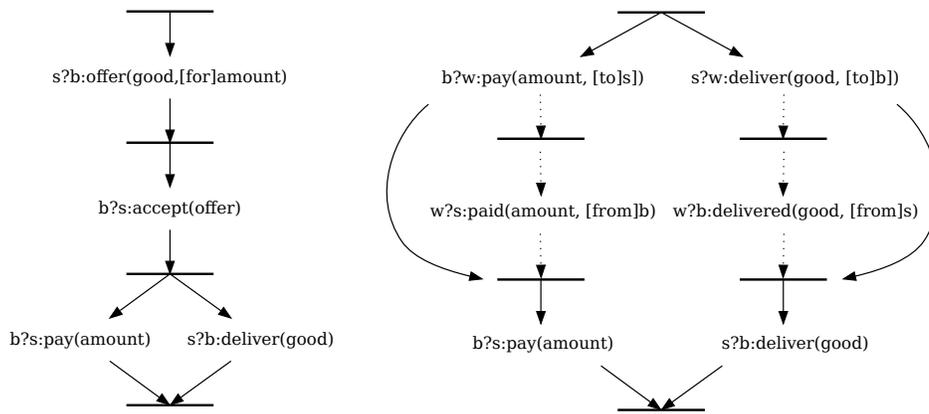


Figure 2: Flow of a sale story: the whole process and a detailed excerpt.

need to acquire more semantic information. The first step is analyze the “syntactic” necessity between events, in order to scope possible concurrent sub-processes. For instance, in a sale, a buyer accepts only if there is an offer, and the payment and delivery usually occur after the acceptance⁴. Without contextual specifications, however, we do not have any clue if the payment occurs before the delivery, or vice versa. The story presents in this respect a partial ordering.

The *flow* of the story - the order in which events occur - is a description orthogonal to the topology. It can be visualized using Petri nets, with a practical naming of places (given a message going from *sender* to *receiver* and transporting *content*, the associated place is labelled `sender?receiver:content`). At this point, places represent only acts, i.e. the results of the performance of actions, while actions are “compact” into transitions (left of Fig. 2). Similarly to what is done in the topology paragraph, we may disjoint the emission from the reception in payment and delivery, introducing an intermediate environment/world. Obviously, emission necessarily occurs before the reception. The result is shown on the right of Fig. 2 and provides an example of how a place can be decomposed maintaining the initial story synchronization (in the same spirit of *hierarchical Petri nets* [7]).

The topology and the flow of the story described so far concur to construct the **signal layer**: a bare scheme of the story, with points of synchronization. Losing some granularity, it can also be represented on a UML-like diagram, for instance in a *Message Sequence Chart* (MSC). From an application perspective, this is a hint for a simple user interface. The MSC would serve as a first description, while refinements would occur switching to the topology and flow views.

2.2 Intentional layer

Once we have constrained the *external* behaviour, we integrate the previous layer with an *internal* behavioural characterization of the participants in the story. Because we are considering intentional agents, we know that each action presupposes an intention, persisting at least throughout its performance. In addition, intents may be nested: in order to achieve a goal, the agent can start to bring about an associate sub-goal. An *ex-post* intentional interpretation of the story results in a hierarchical decomposition of plans of the agents. In the sale story, we identify the agents as buyer and seller since the beginning, so that we know from the start which are their intents. Nevertheless, in other stories, the real intents may be unveiled only at the end of the narrative.

Critical conditions In order to trigger the performance of the reported acts, there may be other conditions or hidden acts to be taken into account. For example, a buyer usually accepts an offer only after positively

⁴The offer may be broadcast. In this case the identity of the buyer is not known until the acceptance.

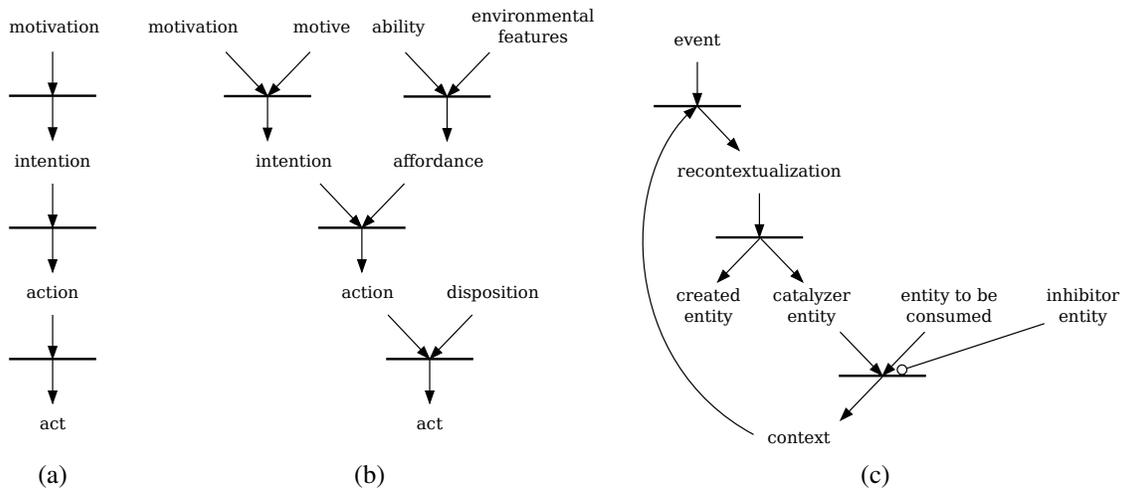


Figure 3: (a) basic and (b) extended action patterns, (c) prototype model for recontextualizations.

evaluating it⁵ and should own at least the requested amount of money⁶. Analyzing these conditions in detail, we observe that the *acceptability* condition reflects the possibility of the buyer to close what he considers an acceptable deal. It imposes a refinement to a generic buyer script, and it depends on the economic skills of the buyer in assigning and handling attributes and features of the market (average price, scarcity, competitiveness, compliance, ...). The *ownership* condition is instead a precondition to successfully perform the payment. They are both examples of conditions *critical* for the story to occur.

Such critical conditions are in general associated to the *ability* or, more in general, to the *power* of the agent, in a specific *context* agent+environment. They identify which propositions should be true in the story-system, so that the agent is successful in the performance of the associated action. The subjective evaluation of each of these conditions gives the *affordance* [9] of that behaviour, as perceived by the agent. However, if the affordance is a sufficient condition for the performance of the action, it is only necessary for the intended outcome, where the contextual *disposition* plays a role (cfr. [5]).

Action patterns In section 2.1 each place of the Petri net was labelled with a message, i.e. a reified expression of the *act*. We extend that representation adding, before each act, a place referring to the performance, expressing the ongoing state of the *action*. When the token passes through the input (output) arrows, the action is starting (ending); the whole passage corresponds to the occurrence of the event. Similarly, we add an anticipatory place for the *intention* associated to the action. If intentions are nested we report them respecting their hierarchy. To complete the view, we add the *motivation* place, for the mental entity that makes the agent sensible to a certain fact, which is the *motive* for action. The resulting template is in Fig. 3a.⁷

At this point, we integrate on each level the places for critical conditions, in terms of *affordance* and *disposition*, and places for motives, according to the pattern on Fig. 3b. In respect to a specific action, the *motive* is a fact acknowledged by a agent, starting the cycle of practical reasoning which brought to the performance of that action. The affordance may be seen as an expression of the *contextual perceived power* of the agent, while the disposition synthesizes the *contextual actual power*, where the context agglomerates the agent and the environment. If affordance and disposition are equal, this means the agent has a perfect knowledge-of and control-on the relevant properties of the context.⁸

⁵The absence of evaluation is symptomatic of a *combine* scheme: the buyer performs mechanically the acceptance in order to advance the interests of another element of his social network.

⁶Ownership, or more in general, *control*, may be translated in certain contexts as having physical possession. In other cases, it may involve communication with third parties, like banks, warehouses, etc.

⁷cfr. the general story scheme *Motive* → *Goal* → *Action* → *Consequences* used in [1], synthesizing, in turn, what proposed in [12].

⁸Generally speaking, an affordance has components expressed in an *analytic* form (e.g. we cannot drink from a glass if there is

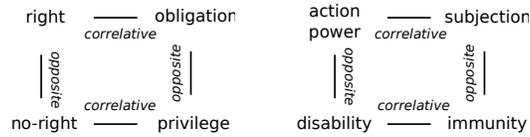
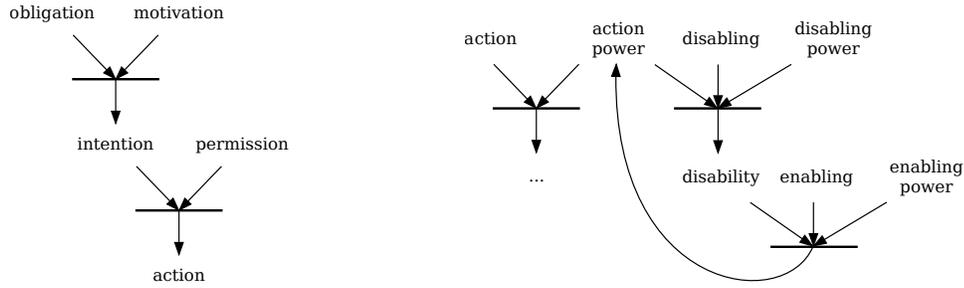


Figure 4: The Hohfeldian squares: directed obligations and power



(a) Obligations as motives catalyzed by motivations. Permissions as part of affordance evaluation.

(b) Power enabling and power disabling actions.

Figure 5: Institutional reasoning patterns.

Recontextualization The picture provided by these patterns is not yet complete. For instance, an action may produce side-effects, an intention is usually maintained until the intended objective is reached, etc. For each event in the story, we need a *recontextualization* pattern to model the emergence of a difference in structures or relations between contextual elements (belonging to ontological and epistemic realms). This mechanism is a technical solution to allow the representation of the dynamics of concurrent processes and of persistent states. In Fig. 3c we provide some elements about how recontextualization may be represented using Petri nets. We exploit some of the intuitions introduced with STRIPS, and in biological modelling [4]: catalyzers are necessary entities, but not affected by the transformation, inhibitor arcs have to be connected to empty places in order to enable the firing of the transition.

2.3 Institutional layer

What occurs when conditions are not satisfied? For instance, if the buyer does not own the agreed amount of money, he won't be able to pay. The incomplete fulfillment of an agreement normally entails some social consequences. On the contrary, the "acceptable offer" condition, although critical to the story, can plausibly be false, without creating any failure according to social norms (in terms of contract). The difference between these conditions can be expressed integrating an institutional layer. In particular, we refer to the fundamental legal concepts that compose the Hohfeldian squares [11], shown on Fig. 4.

The seller promises to deliver a certain good to a buyer, if the buyer will in turn promise to pay a certain amount of money. Offering is a conditional promise, while acceptance is a direct promise. With the offer, the seller declares to be *subjected* to the buyer's power to accept, whose action would trigger an *obligation* to deliver. On the other side, with the acceptance, the buyer also creates his own *obligation* of paying.⁹ In order to be able to promise, however, the seller and the buyer need to have the *power* to make these promises, i.e. to have the power, in respect to a social (sub)system, of changing the associated normative positions.

no water), but it mostly refers to *synthetic* propositions (e.g. the "drinkability" of a container is a *feature* recognized via heuristics learned by experience), which overcome non-systemic and non-deterministic aspects of reality. In this respect, narratives act as bridge to symbolic expressions, passing over the synthetic act; the relevant factors are reported, if they are critical to the explanation of the story.

⁹A natural strategy to avoid failures is that the agent performs a check on (expected future) affordances before acquiring obligations. In doing that, all critical conditions of potential obligatory actions are inherited up to commitments. In the sale story, the buyer should check if he owns the money before accepting.

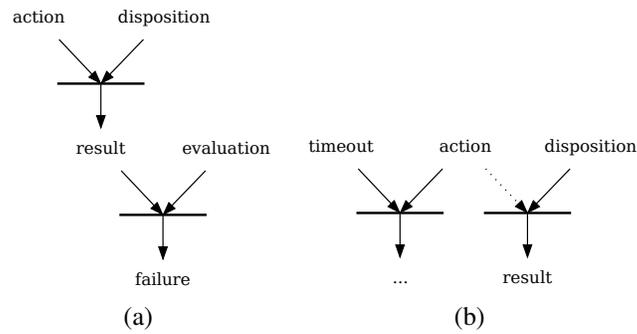


Figure 7: Failure patterns.

= **prevent disability** can be achieved in three ways: (i) inhibiting the disabling power of other agents, (ii) preventing others' intentions to perform a disabling action or (iii) preventing a positive evaluation of the affordance associated to the disabling action; **keep immunity = prevent subjection** is dual with the previous case.

Let us consider some example of its application. A group of people, including the owner of a confiscated real estate and someone internal to the public administration, wants to take advantage of a public auction to gain the property back. Considering the power to acquire the property, they are in a position of immunity in respect to other competitors, because they are the only ones to know about the auction. In order to keep this immunity, they may: hide the publication of the auction, provide people with false information (influencing their affordance), or threaten/bribe them so that they prefer to renounce to take part in the auction (inhibiting their intention). A fraudulent seller that uses an identity outside the legal jurisdiction is instead keeping immunity by inhibiting the disposition factor.

2.4 Failures

In consequence to the introduction of the institutional layer, we are able to model the occurrence of a social failure. Any action, however, may produce results that differ from expectations. Considering for instance a physical action, if it is performed in a wrong disposition, we observe a misalignment with the *immediate intent* related to that action. This failure may be due to an incorrect evaluation of affordance, or, outside the narrative world, to non-deterministic factors. It is perfectly plausible that an ability taken for granted may sometimes fail. For example, even if we are able to drink, we may let the water go down the wrong way.

Non-deterministic factors can be modelled as *free* events, in the sense that their occurrence is not explained by a causal reconstruction. A related Petri net model is shown on Fig. 7a. It is similar to the normal action pattern. The wrong result is made explicit in the net, as it is statically settled in the story.

A slightly different case of failure is the one occurring because of *timeout* (Fig. 7b). Because we know that the transition on the right will never be fired, we may omit to report it in the Petri net. The timeout place is a synchronization place, defined in relation to other events in the story.

3 Discussion

Although there are interesting overlaps between our research and the current research on normative multi-agent systems, there is an intrinsic and important difference of perspective. With the latter, researchers design, create and study properties of artefact systems, which are (or aim to be) largely under control, trusted, and highly predictable (for example, electronic institutions). We focus instead on aspects involved *within* a human social system (e.g. which messages, how and why they are observed, interpreted, generated). For these reasons, we share more common interests with traditional AI research in story understanding. For example, our patterns may be interpreted as a kind of *conceptual dependencies* or compared with *plot unities*.

However, while these concepts were introduced for automatized understanding, our purpose is to represent and acquire subjective interpretations of social reality, given by a narrator. We assume the narrator has a systemic model of the story (and of the world in which the story occurred) and we aim to elicit that knowledge using adequately simple but descriptive templates. This paper is the result of a reflection on this exercise, conducted on a primitive form of economic transaction.

As all practical methodologies, diagrams do not represent a solution, but a tool. And tools acquire sense only with their use. If they are adequate to a certain field of application, the more we use them, the more they boost our abilities and the more we acquire useful experience to improve them. Although we framed our research in the legal context, we think that our approach is generic enough to be used to elicit scenarios of social systems characterized by informal social rules (targeted in sociology and economics), and business rules (in management sciences and information systems). What we propose in this paper is a starting point for *story acquisition* in a exploitable form. In this, Petri nets were chosen in the first place because of their visualization power, adequate to illustrate the flow, their rigorous concurrency model (actually a reduction to parallelism), and their wide-spread use, giving access to a great number of techniques and tools. However, it may turn out not to be the best choice when we will extend the framework with other perspectives.

Concerning the cognitive aspects of the paper, i.e. framing power in a intentional and ecological perspective, they are part of a larger theory of *social affordance*, which will be further investigated in our future work.

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