A BRIEF INTRODUCTION TO EM_{ONT}

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EM_{ont} is a so called upper or foundation ontology that lays a basis for capturing domain-specific models of human knowledge in the form of conceptual knowledge and human activities. EM_{ont} is not restricted to human knowledge only. It can also be used for modeling system behavior and the interactions amongst them using the same principles. So it is better to speak of actors, which may be humans but also non-human subsystems such as machinery and physical systems.

Conceptual knowledge, also known as *knowing-that* knowledge, is modeled in terms of propositions. A proposition relates a subject by means of a predicate with an object. An example of a proposition is: a *fire worker* (subject) *drives* (predicate) a *fire truck* (object). Propositions give meaning to a subject by relating it to objects. An object in its turn may fulfill the role of subject in another proposition, and vice versa. In this way, networks of propositions are formed and as such they provide a knowledge base. As a matter of fact, the semantic web (a.k.a. web 3.0) is constructed using subject-predicate-object triples.

In the remainder of this introduction we focus on the *knowing-how* knowledge, in particular on modeling EMM/SSM worldviews. EM_{ont} is a relatively small ontology with only a few concepts. Its power stems from the recursive appliance of the concepts. This allows us to model human behavior at all abstraction levels, ranging from social networks comprised of interacting humans to the nitty-gritty detail of an individual. Knowing-how knowledge is situational defined, that is, what may be effective in one situation does not necessarily has to be in another situation. Also, humans look at a situation differently. The concept of context is used to alienate the situations in which knowledge is applicable. Using the concept of context recursively, we can construct a system in terms of interacting actors, modeled as subcontexts.

1 HUMAN BEHAVIOR (PQR FORMULA)

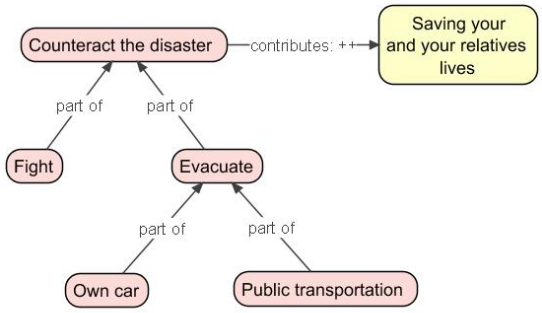
Human behavior is seen in EMM/SSM as a human activity system. Human activity system as well as other kind of actors (e.g., machinery) are modeled using the PQR formula. The formula stems from the Soft Sytems Methodology (SSM) in which it is used as an aid to express a root definition: a statement written in a few sentences capturing the intention of someone's worldview. The PQR formula is given the central role in EM_{ont} because it captures the notion of nested cognitive patterns of human behavior concisely.

The letters P, Q and R do not stand for anything, except that they are subsequent letters in the alphabet, but they do have a special meaning:

- P - what?
- Q - how?
- R - why?

The PQR formula should read as a sentence: Do P by a Q in order to achieve R.

For example, if a disaster strikes, then you should counteract (P - what) to save your and your relatives lives (R - why). But the question is: how do we save lives? Usually, there are several options, that is, particular ways (Q's - how's) to achieve the desired goal. One option is to fight the disaster (Q_1), another one is to evacuate the endangered area (Q_2). Which one to choose depends on the circumstances, but both can contribute positively to achieving the desired goal of saving lives. By setting up this PQR formula, we are actually describing behavioral patterns that humans use in order to deal with particular circumstances. We are touching on expertise or know-how knowledge in the sense that an expert can apply the right patterns almost without consciously thinking. By experience, an expert knows intuitively what to do in specific situations.

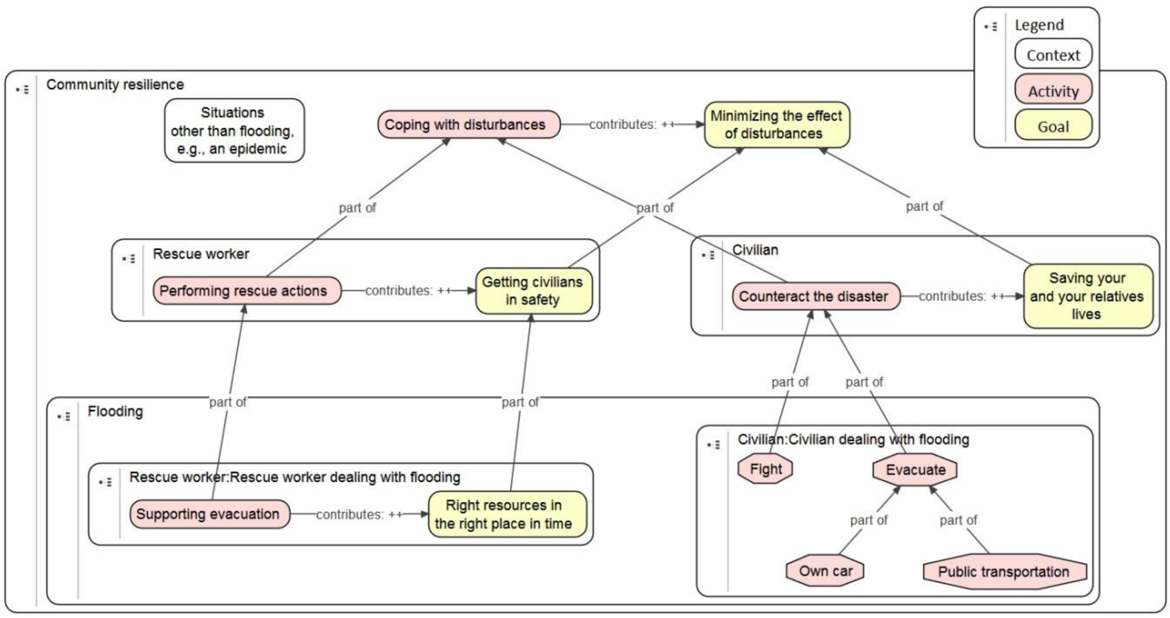


But don't stop here, the PQR formula can be applied recursively. A Q (a how) can be decomposed in deeper Q's (how's). To continue the disaster example, the evacuation activity can be subdivided in evacuation by car (Q_{21}) or by public transportation (Q_{22}). By doing so, the evacuation activity (Q_2) becomes a P (a what) for its constituents. Generalizing from this example, by applying the PQR formula recursively, we can model the expert's knowledge, that is, his patterns, at any desired level of detail. Not only activities can be decomposed, the same holds for goals, which can be decomposed in sub-goals.

Many practitioners find it hard to remember where the letters P, Q and R stand for. To reassure those practitioners, the way we are using the PQR formula, PQR could be remembered as the idea of recursively decomposing activities in what and how in order to be specific in how to achieve goals. In EM_{ont}, we make no distinction between what and how activities. The context makes clear the intention of a particular activity. So, it is really not important to remember where PQR stand for. The idea behind PQR, however, is key in modeling the behavior of actors. We refer to this idea by using PQR as a mnemonic.

2 SITUATIONS (PQRS IN CONTEXT)

The next step is to introduce the concept of a situation. A situation can be seen as a network of actors, whether they are human or not, brought together to accomplish goals, shared or not. Technically, a situation is modeled as a context and the actors in the situation as subcontexts. This idea is illustrated in the figure below.



The main context, i.e. situation, is community resilience. Within that situation, the community as a whole try to minimize the effect of disturbances. This is the overall goal form which subgoals such as “Saving your and your relatives lives” are derived. The overall goal can be seen as a hook to which more specific subgoals can be attached. The same holds for the activity “Coping with disturbances” that is also a hook for attaching more specific activities that ultimately contribute positively to the main goal.

The main activity and main goal are only addressing what should be done, not how it can be done. To probe deeper, a few subcontexts have been added to the community resilience situation. First of all, two subcontexts are included that represent roles: the civilian and the rescue worker. These two roles may be engaged in specific subsituations, in this particular case, the situation of flooding.

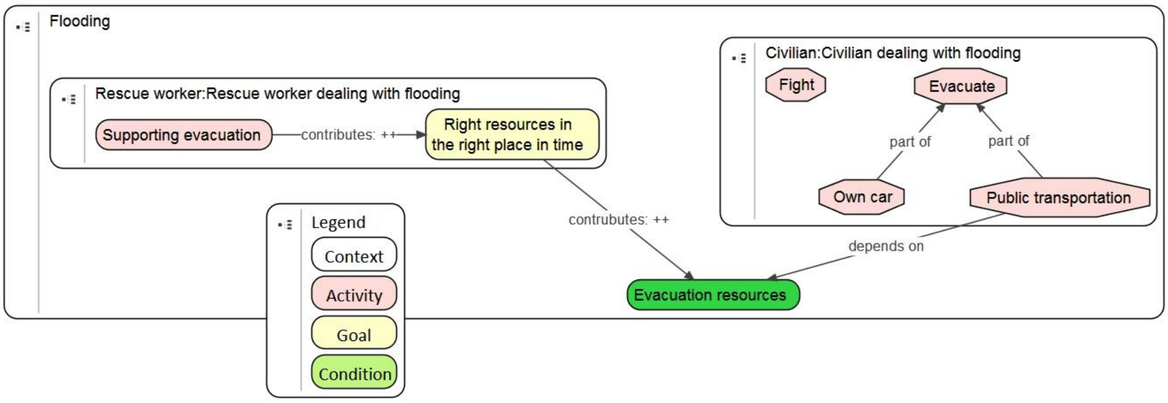
Depending on the situation, humans perform specific actions to achieve the required goals. This notion is modeled as subroles in the flooding situation. For instance, in the flooding situation, a civilian has to deal with flooding. This may sound obvious, and it is, but something interesting is going on. This is reflected in the notation “Civilian:Civilian dealing with flooding”, which means that “Civilian dealing with flooding” is a subcontext of “Civilian”. But at the same time, the subcontext “Civilian dealing with flooding” is also a subcontext of “Flooding”, just because in the diagram the former is contained in the latter. Thus, a subcontext may be included in more than one context. This captures the idea that humans play specific roles in specific situations.

To conclude this section, we observe that the concept of context is used to model situations comprised of subsituations and roles. A role in its turn may be a situation for its constituents. That is, a role can be seen as a situation made up of subroles and subsituations. A typical example is an organization which has employees engaged in specific activities. For an employee, the organization may appear as a situation rather than a role. So it is all a matter of perspective from which we can abstract away by using the general concept of nested contexts.

3 INTERDEPENDENCIES (CONDITIONS)

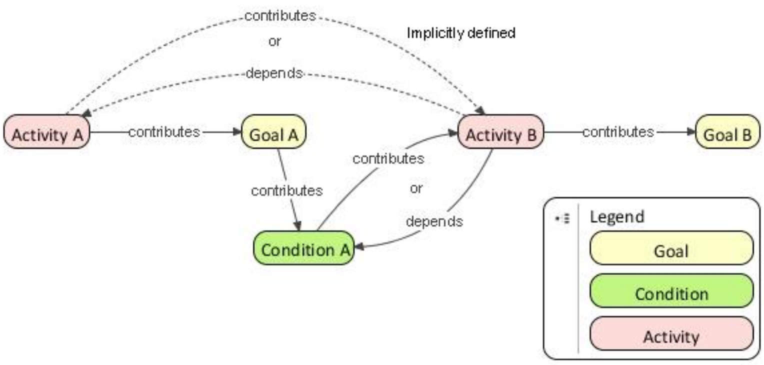
Actors are not islands, they interact with each other. How and how well they interact is abstracted in conditions. A condition describes a state of a system, which may be influenced by the behavior of an actor. A condition is often defined as a qualifiable expression, e.g., the availability of rescue workers, or a sufficient supply of evacuation resources. A condition can also be regarded as an internal system indicator. A collection of conditions characterizes a system.

The usage of a condition is shown in the figure below. Typically, a goal is connected to a condition using a contributes relation. In the example, the goal “Right resources in the right place in time” contributes positively to the condition “Evacuation resources”. In this way, a condition is an indication of the extent a goal has been achieved. A goal and a condition have been deliberated been modeled as separate concepts. It is quite possible, and in real situations frequently the case, that the achievement of one goal reflected in a condition is undermined by the achievement of another goal.



Other activities may depend on a condition, as is the case of evacuation with public transport. A dependency relation between an activity states that the way an activity can be performed depends on how well the activity is facilitated by another activity expressed in terms of one or more conditions. Alternatively, the dependency relation can be expressed as a contributes relation to model situations in which the connection between an activity and a condition is less strongly defined.

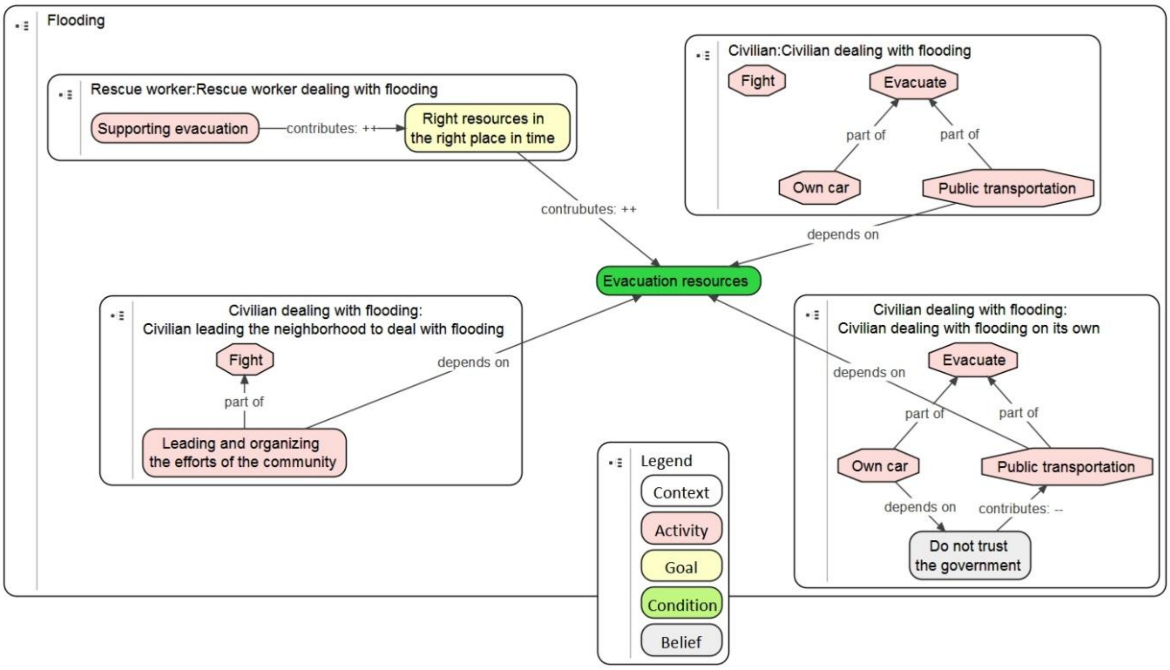
The general pattern is shown below. By using a condition, a connection is actually established implicitly between Activity A and Activity B. So there is no need to make this connection explicit, it is already there. Not shown in the figure, Activity B could on its turn facilitate yet another activity, and so on. This could very well lead to circular chain of dependencies. By modeling these chains, we get insight in the interdependencies between activities.



4 Refinements (removing and adding information)

So far we have dealt with one kind of human that depending on the situation perform some actions. However, not all humans will act in the same way. We have to account for different behavior depending on different worldviews. We have already seen how contexts are used to model roles in specific situations. Now we take this construct a step further by removing and adding information in derived subcontexts to cater for differences in worldviews.

The general idea is shown in the figure below. Specialized roles, such as “Civilian dealing with flooding on its own” and “Civilian leading the neighborhood to deal with flooding” are derived from the “Civilian dealing with flooding” role. The octogram (8-corner shape) notation means that a certain element, e.g., “Evacuate”, is used also elsewhere. That is, it is the same element which happens to be used in different contexts.

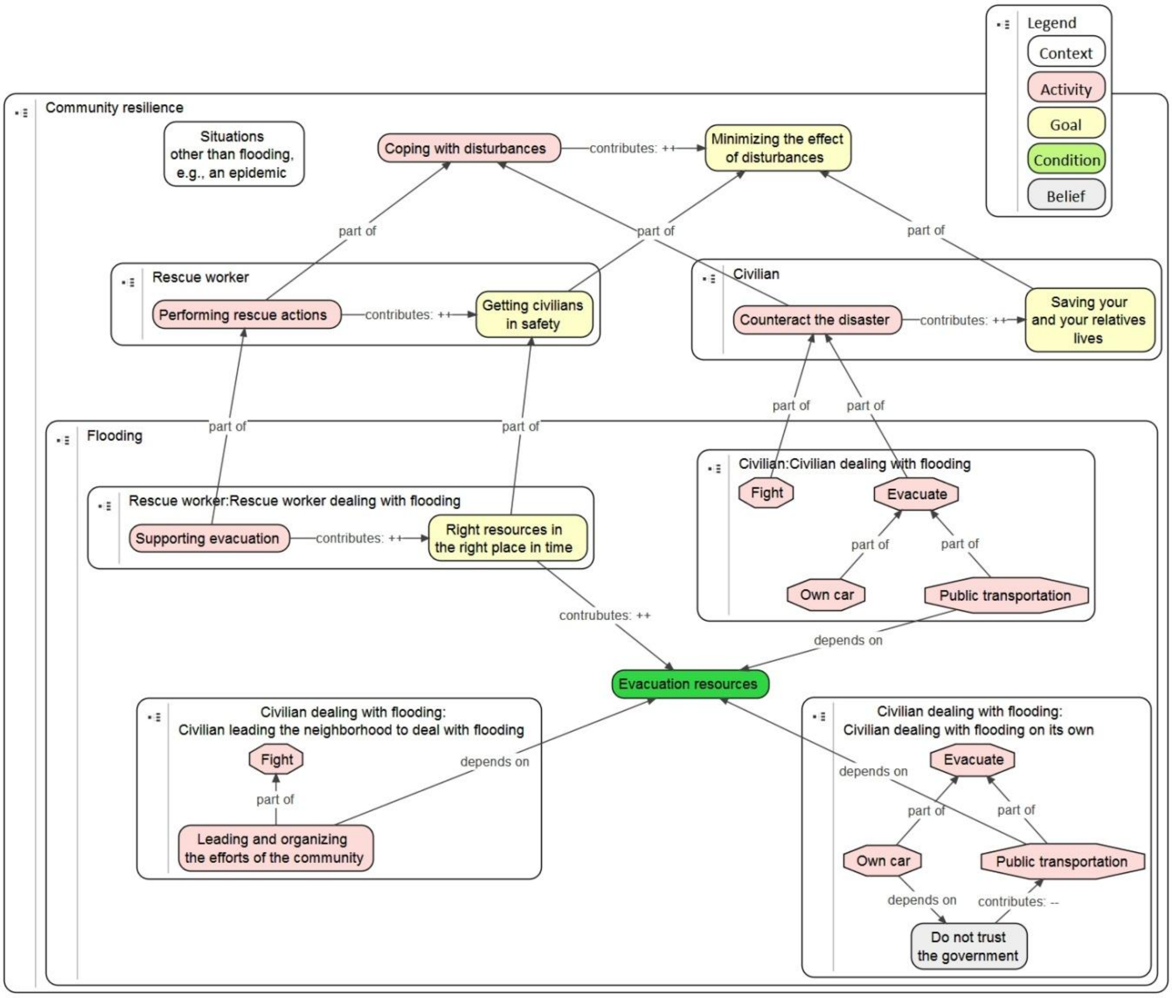


In the context "Civilian dealing with flooding on its own", a new modeling element has been added: a belief. A belief can be regarded as a fixed idea. It is similar to a condition, but in contrast with a condition, a belief cannot be changed within the system itself. In this case, the belief "Do not trust the government" reflects that this particular civilian does not expect anything good coming from the government, no matter how hard the government tries.

An important idea is that more information can be added in a derived context. In this way, we can define in broad strokes behavior within a context to be refined in derived contexts. It is a kind of under specification by just providing hooks. Equally important is that elements can be discarded if they has no use in a derived context. For instance, in the "Civilian dealing with flooding on its own" context, the activity "Fight" has been removed.

5 ALL TOGETHER NOW

All the pieces discussed in the previous sections are brought together in one model shown below. In this brief introduction, we have not addressed all aspects of EM_{ont}, but only the most important ones to get the flavor of modeling with EM_{ont}. Topics not discussed include documenting good and bad practices, sequencing of activities, and conceptual knowledge modeling and its connection to PQRs in context. However, these topics do not introduce significant new elements into EM_{ont}, rather they make it more comprehensive.



As said before, EM_{ont} is a relatively small ontology, its power stems from putting PQRs in context and applying this concept recursively. The main goal of this introduction was to show that having a versatile concept of context with which situations as well as roles can be modeled, lead to models of interacting actors in context.

The example that was used was only a toy example. It is far from being complete. Real models tend to grow large. An important issue is to separate the forest form the trees. Again, contexts come to a rescue. Not all contexts need to go in a single diagram. In this way, models can be constructed in separate diagrams starting with the big picture and gradually go into more detail. In addition, information can be added in a derived context, but more importantly, information can also be discarded if it has no added value in a particular context. In short, we do not need to tell it all, we may underspecify. In this way, we can tame the complexity of modeling complex situations.

To come to a conclusion that summarizes it all, context is key in modeling interacting actors with varying worldviews. Even for a single actor, its worldviews may vary depending on the situations it is engaged in.