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# A Meta-ontology to Design Sustainable Project in a Competitive Stakeholder's Context

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## Abstract

Any sustainable land settlement project should consider social and environmental issues along with usual technico-economic issues. That complexity prompts us to propose a metamodel framework (Roth et al., 2017), and support it with a generic core meta-ontology shown in this work. It is further instantiated into four issues, stakeholders, layers and behaviour conceptual layers for land settlement project. Then we describe how it can be used to define an activity diagram supporting the development process and how it would be monitored with a mediation information system. We further specify it for the

Sivens' dam project case study. Comparison of the ideal activity diagram with Sivens' project one show how important is the systematic involvement of stakeholders at all scales for the project to be successful.

**Keywords:** model driven engineering, meta-ontology, development process.

## 1. Introduction

In the context of sustainable growth, any land settlement project must meet requirements relative to social and environmental issues in addition to usual technico-economic issues. Many well-engineered solution have been rejected because an opponent court action had delayed the process enough to impede its economic viability.

Development projects can be described as a scenario / sequence of activities within a decision-support frame. These kinds of projects last for months or years, require careful planning of activities, and most of all they also need a suitable knowledge management. They are also prone to face events that may disrupt the process and at least require some decision and scenario adjustment.

In this context, a Process System Engineering (PSE) approach aims at formulating a development project as a multi-objective, multi-constraint, multi-period optimization problem embedded into a decision support framework. Then, most of the knowledge and occurring events should be anticipated in alternative prospective scenarios. An even more systemic model driven engineering (MDE) approach could manage unanticipated events as the project goes on. MDE prescribes to distinguish metamodel and model layers of abstraction and confront them to the real system through a case-specific implementation layer. That multilayer frame allows focusing on knowledge management and information integration between tools. Activities requiring assessment of a technico-economic solution could use usual design, simulation and optimisation tools from the PSE domain. MDE help designing ontologies that promote and facilitate interoperability among systems and tools, like the CAPE domain ontology OntoCAPE (Morbach et al., 2009).

Roth et al. (2017) have proposed a metamodel framework to describe land settlement development project and assess their sustainability. Bénaben's team have used MDE to design a mediation information system (MIS) (Bénaben et al., 2013) that has been specified with artificial intelligence tools in the context of developing a crisis management scenario (Barthe-Delanoë et al., 2014). It is built around a core collaboration metamodel supported by a meta-ontology describing together how information and knowledge is shared by collaborative partners (Lauras et al., 2015; Bénaben et al., 2016). Event-related incoming data from the crisis field are collected and classified according to the architecture and structure of the metamodel. They are further interpreted with an inference engine into adaptations of the ongoing scenario.

We present here a core ontology based on the descriptive metamodel framework of Roth et al. (2017). It aims at gathering the knowledge around a development project and at elaborating upgradeable scenarios of the development process. Section 2.1 describes the core and the first model layers needed to instantiate the metamodel for land settlement projects. Section 2.2 shows how it could be used to design scenarios of development processes. In section 3, we imagine an idyllic development process scenario and confront it to the French Sivens' dam project that ended tragically in 2014.

## **2. Proposal**

### *2.1. Metamodel and Meta-ontology*

Bénaben's collaborative meta-ontology (Lauras et al., 2016, Bénaben et al., 2016) and Roth's metamodel framework (Roth et al., 2017) are used to develop a core ontology that aims at managing the knowledge around development project. Figure 1 describes the core model that is made of key concepts linked with semantic rules, common to all collaborative situations. Then, the model layers are packages inheriting from the concepts of the core. They are needed to instantiate the metamodel for land settlement development projects.

An asterisk labels concepts added to the metamodel of Bénaben. Overall, Bénaben's core is entirely reusable but some of his concepts have been omitted for the sake of conciseness. Our unique addition to the core information metamodel is the concept of "Stakeholders". Unlike Bénaben not all actors involved are partners and some are opponents acting against the project, which installs a competitive context.

Then, we develop the abstract model layer with four specific packages to land settlement development projects. "Stakeholders", "Scales" and "Issues" are used for knowledge management, and the fourth "Behaviour" package is useful to design the best scenario fitting the development process. Once additional case-specific layers, not shown, are instantiated to explicit a case study issues and stakeholders, the first three packages can be used alone for the purpose of describing case studies. This was done by Roth et al. (2017) for the El Hierro's island or Sivens' dam projects. Sivens' project is briefly discussed in Section 3. The packages in details are:

- The "Stakeholders" package shows that stakeholders can be pro or against the project. They establish a network where links between them can be either cooperative or conflicting. Each bear an attribute acceptability which strength is proportional to his degree of approbation of "events" or "decisions" in the development process. By taking position, groups of stakeholder establish common patrimonies linked to issues.

Indeed, each position taken by a stakeholder usually aims at preserving their patrimony or improve it.

- The “Issues” package aggregates the political, social, economic, territorial and technical context of the project. “Issues” and “Stakeholders” are linked since all stakeholders’ appreciations refer to a context issue and their patrimony alike.

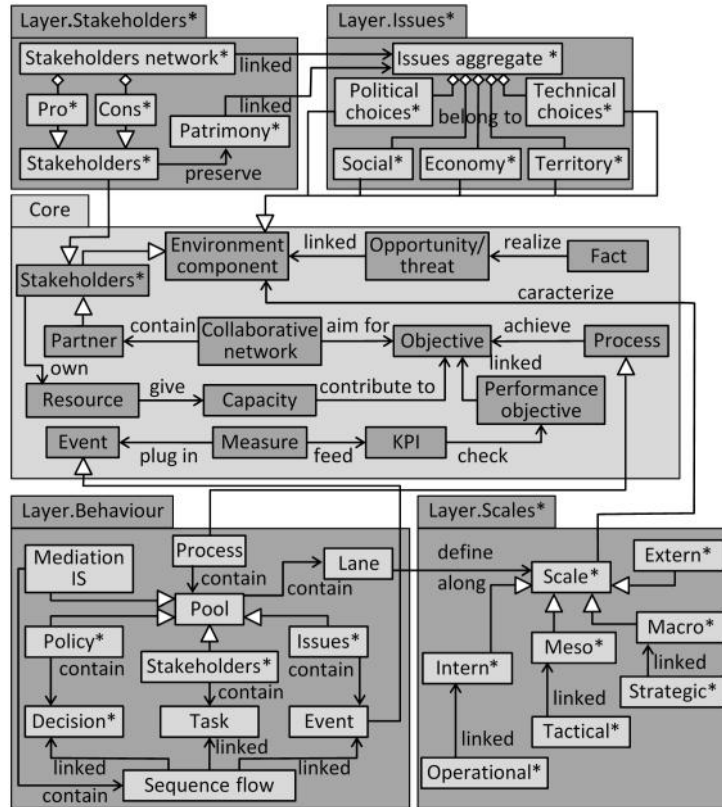


Figure 1: Core metamodel and first layer oriented land settlement projects

- The “Scales” package features the multiscale modelling usual in the PSE domain. It distinguishes external, macro, meso and internal level. Those hierarchical levels are linked with the strategic, tactical and operational decisions levels respectively. For a land settlement project, the internal level is related to the project developer, the meso level concerns the ground neighbourhood (local actors and suppliers, end-users, ...), the macro level concerns the nearby area (county or state level). The external level deals with the world-wide concerns and decisions.
- The “Behaviour” package is close to the one of Bénaben (see Lauras et al., 2015) but we have omitted in figure 1 many classes for the sake of conciseness. We have kept the Mediation information system (IS) that will act as the development process conductor and will monitor the scenario underlying it. The MIS contains a sequence flow that is a sequence of decisions, tasks and events. As seen by the inheritance links and association links towards the “Scales” package, decisions, tasks and events can occur at or affect various scale levels. Together they form the process.

## 2.2. Implementation for conducting development process

Bénaben et al. (2016) used his metamodel to instantiate a model for managing a crisis. They deduced the best process and thanks to the MIS, they orchestrated the stakeholders' coordination. The real-time process monitoring in response to events allows updating the model with the new knowledge and deducing a new process and coordination sequence. Following those authors' work, we sketch an analogous implementation in Figure 2.

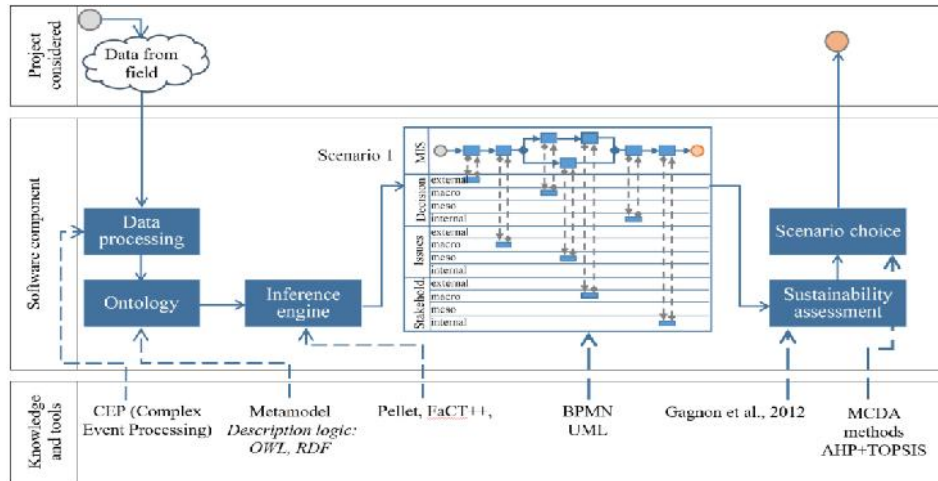


Figure 2 : Software implementation

Data are collected from the field and processed into the information systems. The resulting information is structured by the case-specific instantiations of the ontology (see figure 1) derived from the core metamodel proposed in section 2.1. Then, an inference engine, previously set with logical rules, thinks the ontology over, creates new concepts, links, and produces different scenario to be monitored in the MIS. It can be described in BPMN or UML language. Then a sustainability assessment is needed to select the best scenario. The assessment can use Gagnon's shades of sustainability (Gagnon et al., 2012) and on Multiple Criteria Decision Analysis (MCDA). Gagnon proposed to assess a posteriori the sustainability of the design process with different shades of sustainability. They covered six dimensions that deal with the design process itself, the indicator relevance, the sustainability issue covered, the analysis tool accuracy, the alternative performance and the decision-making process itself.

## 3. Case study

Since we are dealing with development projects that we would like to be sustainable, it is worth to consider another of Gagnon's proposal (Gagnon et al., 2012): after a review of design processes, he identified 12 critical tasks and 10 other tasks in his so-called integrated sustainable engineering design process (ISED). This constitutes the basis of the generic activity sequence in our knowledge database. We now use them to define the ideal scenario for a development processes. We compared it to the development scenario of the Sivens' dam project in Tarn's county, France which ended up tragically, and to the successful El Hierro's island hydro-wind project. That later is not presented for conciseness.

The Sivens' dam project was initiated by state-backed elected institutions to overcome drought impacting intensive water demanding crops. It lasted 10 years, acquired a nationwide audience and ended sadly with an activist death. It was based on a 1969 needs assessments. Local and nationwide opponents demonstrated and were not involved in the decision process.

Figure 3 shows a superimposition of the UML activity diagram representing the ideal process sequence flow (dotted lines and boxes) and of the Sivens' dam sequence flow in light dark. A more complete sequence flow of Sivens' project was built manually by Roth et al. (2017) from literature analysis (news, newspaper, reports...).

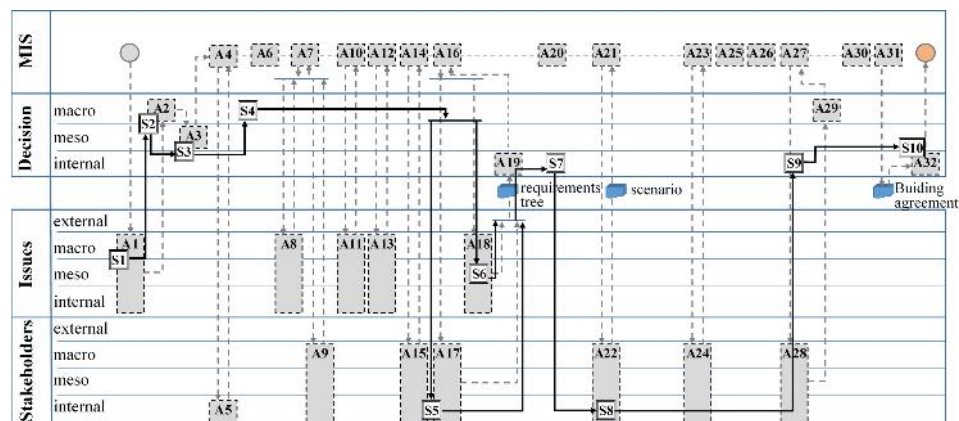


Figure 3: Ideal (A1 to A32) and Sivens' dam project (S1 to S10) activity diagram

For the reader's understanding of the "stakeholders" pool, the internal lane regroups the project developer CACG. CACG was also one of the original project prescribers after the local water agency commanded a study of opportunity to build a dam in response to the request made by the Tarn county elected assembly. The meso lane regroups local inhabitants and mayor and opponents, but also farmers that hope to use the dam water for intensive irrigation. The macro lane regroups national offices in charge of project evaluation (two offices disapproved the project impact on nature and aquatic media with not enough compensation measures) and the government representative who decided to send riot squad but also ultimately stopped the project.

The project was initiated because during the most severe drought ever recorded in 2003, farmers requested to secure water to maintain intensive water crops (activity n°1, A1, S1). County water agency decided to rejuvenate a 1969 project and to build a dam in Sivens Area (A2, S2, A3, S3). Then, the process begins. The ideal process is under the supervision of the MIS, the real one under the developer's supervision. Notice that the MIS activities n°A4, A6, A7, A10, A12, A14, A16, A20, A21, A23, A25, A26, A27, A30 and A31 correspond respectively to Gagnon's generic ISEDP tasks 1-7, 10-12, 14-16, 19, 22 (Gagnon et al., 2012) and include all the critical activities that Gagnon identified.

Figure 1 and 3 highlights the importance of the "issues" and "stakeholders" pools which multiscale architecture and structure are elsewhere (Roth et al., 2017). Hence, the ideal process shows activities A8 and A9 to create the structure of both pools, A11 and A15 to fill in the pools' elements, and A13 and A15 to decode the pool elements' network.

Activity 19 corresponds to the start of the design phase itself, once the requirement tree has been built, ending the so-called intelligence phase. Project alternatives are thought up

and analysed (A19). Finally, the chosen alternative (A29) is characterized in detail (A30), monitoring indicators are defined (A31) before its implementation (A32).

All along the ideal process, a systematic involvement of the stakeholders is prescribed (A5, A17, A22, A24 and A28). They span actors over the internal, meso and macro scales together. On the contrary, the real Sivens' dam process chose exclusively the CACG (S4). It marginally involved stakeholders and did so mostly at the internal scale (S5, S8) and with some connivance between the actors that led to disdain the disapproval of several French offices (ONEMA and CNPN) and to scorn opponents. Besides only the dam building alternative was evaluated (S6), proposed (S7) and chosen (S9) in answer to the farmer's demand. Not a single heterodox alternative, like shifting to less water intensive crops was considered.

#### 4. Conclusion

In support of a framework for land settlement development project in Roth et al. (2017), we have presented a generic meta-ontology for describing development processes. We have instantiated four issues, stakeholders, layers and behaviour conceptual layers for land settlement project. Following Bénaben (Bénaben et al., 2016) we have briefly described a future software implementation aiming at defining an ideal activity diagram supporting the development process and monitored with a mediation information system. The activity diagram is compliant with Gagnon's Integration Sustainable Engineering Design Process. Finally, we showed how it can be specified for the Sivens' dam project case study. Comparison of the ideal activity diagram with Sivens' project one show how important is the systematic involvement of stakeholders at all scales for the project to be successful, especially in the current context where many activities are weighted with respect to the three pillars sustainable growth.

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