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The Role of Computer Simulation Tools in Improving the Quality of Life in Small Settlements of the Czech Republic

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Abstract

This chapter presents the computer-aided organisational modelling and simulation of relevant socio-technical processes with regards to the new housing and building law and regional management trends in the European Union. We present an example related to the processes and agendas of the urban planning of the landscape areas and small settlements. Our models were simulated, verified and validated to help the officials (especially from the smallest settlements) to improve their knowledge to allow them to participate more in the future. As one of the dimensions of quality of life is the self-realisation and participation of local people, we expect an improvement in the quality of life in general. Our approach uses the novel type of process maps, which describe the legislation, visualise it and simulate it. These models consist of the original combination of FSM and object-orientation. It gets local people a better understanding of their life situations without the need for thorough prior training. It also causes the effect of better participation and subsequent improvement of the quality of life, because of the actual and specific problem in the Czech local government of small settlements in the low level of participation of citizens in these small villages caused by the complexity and also time-varying form of law and statutory regulations.

Keywords: BORM, FSM, object-orientation, business process simulator, EU legislation, regional management, building law, e-democracy, participation of citizens, quality of life

1. Introduction

We have to answer problems related to the small settlement development and enlargement, landscape care and overall efforts to improve the quality of life and the level of democracy while

preserving the conditions of the sustainable development (addressing living standard, cultural and historic value, agricultural and industrial production, transport infrastructure construction, tourism potential, etc.). Technophobia of local people significantly increases this problem because the low-level knowledge of local people is strongly contrasting with high knowledge of external people and (owners and investors for example) penetrating the rural area, who use good information and communication technologies (ICT) (especially geographical information systems and project management) and process management knowledge.

Business process models show the collaboration of more participants within the solved system. They also can be visually animated in case of need to teach participating people their roles. We need this approach for simulation, validation and verification of the real world problems from the area of agriculture, landscape management and country planning. A fundamental purpose of such a business model is to create and simulate a complex interconnected system, where local actors, citizens, regional government, various interested organisations and partners and other participants mutually communicate. In addition to that, business process models are also the foundation of subsequent system modelling activities of software engineering, organisational design and management consulting. The typical method of performing these activities is to start directly by drawing process maps without performing the initial interviews. However, we present the idea, which for better modelling, we need to use a specific textual technique, which helps us to recognise, define and refine our initial set of business process participants and their properties before performing any graphical modelling activity.

In our experience, any modelling and simulation diagramming technique or instrument aimed for some real and practical projects should be intelligible to the stakeholders who are not typically well educated in ICT. Furthermore, these models must not inadequately simplify or distort requirement information. We recognised that the correct visualisation of the problem into the model and subsequent optional simulation is a challenging but essential task for standard diagramming techniques. We believe that the business community still lacks a powerful yet easy-learned tool for process modelling; capable of performing a comparable function to that operated by Flow-Charts, Entity-Relation Diagrams or Data-Flows Diagrams over the past decades. One of the strengths of these old techniques and tools was that they included only a restricted set of concepts (about 5) and were understandable by problem domain professionals after few minutes of learning. Regrettably, Unified Modelling Language (UML) and Business Process Model and Notation (BPMN) approach lost this advantage of clearness and simplicity.

2. Motivation

Czech landscape development suffers from the low level of inhabitants' participation in small settlements of rural areas. We examined to model and visually simulate process-based knowledge about legislation about the urban planning and building development to obtain visual simulation an instrument for increasing the participation of local people in activities related to their real-life situations.

We have recognised that there is a low level of knowledge about participation possibilities in business and workflow processes of territorial planning and development. According to several political declarations by the European Union like Spatial Planning Charter and Aarhus agreement by the European Council, we have to accept that ICT has potential to resolve the low level of local people participation, which decreases their quality of life.

The expected result of modelling and simulation activities is represented by structured data (tables, lists, forms...) that can be directly used as an instrument for knowledge improvement or implementation of some systems or an organisational change in the way of management consulting services. This is why there are the following main dangers described by [1, 2]:

1. *inability*—some important details cannot be expressed due to the deficiency of used method.
2. *oversimplification*—we are forced to simplify the modelled subject while trying to finish its visualisation.

3. Organisation modelling

The organisation modelling is a necessary ingredient for the start of the whole system development life cycle. Darnton [3] and Taylor [4] say that the main obstacle (defined from the perspective of the software application development) with this step of the requirement analysis of socio-technical systems stands in the early steps of the whole system life cycle. The first step of any modern approach should contain two steps. The first one is the designation of the requirements in the form of business processes and their participants. The second one is the formation of a model, often called an essential object model or business object model, developed as a set of domain-specific subjects and participants known as essential elements. These two steps should be completed with the active participation of the domain experts, because they are able to guarantee that the accurate model will be made. Obviously, every modelling tool used at these early stages should be intelligible to the domain experts, because they are typically not skilled in ICT. Furthermore, these instruments must not damage or badly simplify requirement information.

The most used approach for business-process modelling in current object-oriented methodologies is use case modelling as the origin of the documentation process in UML. Jacobson founded the concept of use cases in the early 1990s [5]. The principal information source on UML is the website [6]. Ambler [7] says, use cases are usually the basis of most object-oriented development methods. Use case modelling consists of the identification of actors, which are external subjects communicating with the software section of the modelled system.

It is our experience that the accurate description of the system boundary is a troublesome duty, which usually needs deep knowledge of the proposed system, which must be included in the phase of system requirements specification. Some insufficiencies in this

approach are stressed in Barjis [8]. There are miscellaneous opinions on the reasonability of use cases and similar instruments in the first phase of system modelling. Simons and Graham [9] very well explained examples where use case modelling could destroy the true logic and system behaviour. Unfortunately, standard UML-based tools are too oriented at the software engineering and programming logic, but there are yet another approaches for business modelling:

1. Many other process modelling tools are based on Petri Nets. The advantage of this method is that it is both graphical and has a solid mathematical basis. The best implementation of Petri Nets is the event-process chain (EPC) diagram from Aris methodology [10].
2. Other approaches use diverse species of flowcharting. This method is the oldest graphical technique practised in computer science. It was originally used for visualising the sequences and control of computer program instructions. Nowadays, flowcharts are often used to express details of business logic. A very good application of flowcharts is workflow diagram applied in Proforma Workbench or FirstStep Business CASE Tools. Of course, it is also a sort of the activity diagram of UML [11] and a quickly expanding standard Business Process Model and Notation (BPMN, <http://www.bpmn.org/>).
3. The third approach used here is the use of automata finite-state machine (FSM). FSM has a solid theoretical background ([12] for example), as well as Petri Nets. A practical implementation of state machines is the state-chart diagram in UML, for example. Certainly, the sequence diagram of UML also includes some behaviour of FSM.

The overview of all approaches for simulation business processes described here is presented in **Table 1**.

Approach	Theory behind	Advantages	Disadvantages
EPC–Aris	Petri Nets	Very popular in Europe, has Aris CASE Tool, easy and clear method for domain experts.	Little link to possible subsequent software development techniques, slow analysis, low expressiveness of large models.
UML activity diagram or BPMN	Flowchart	Industry standard, has many CASE tools with Unified Modelling Language (UML) or Business Process Modelling Notation (BPMN).	Too much computer based, difficult to understand by domain stakeholders.
UML Sequence Diagram and State Diagram	Finite State Machines	Industry standard, has many CASE tools with Unified Modelling Language (UML).	Too much computer-based, difficult to understand by domain stakeholders.
Workflow Diagrams	Flowchart	Easy and clear method for domain experts, perfectly has many business CASE Tools.	Little link to possible subsequent software development techniques, obsolete method.

Table 1. Most used simulation approaches.

4. Our Solution—BORM as the FSM and OOP combination

Our expertise in system modelling recommends that classical UML is not proper for the initial steps of analysis, where business processes must be identified. UML diagrams are too complicated for the users from the problems domain community as they oftentimes include extreme detail concerning possible software implementation. This involves classes, inheritance, public/private methods, attributes, link classes, etc. Nearly the same practice we have is written in Simone and Graham [9].

We conclude that the business community requires an easy but powerful tool for business process modelling and simulation; capable to perform an equivalent function to that performed by Entity-Relation Diagrams, Data-Flows Diagrams or Flow-Charts known in the past. One of the advantages of these timeworn tools was that they included only a little set of concepts (typically not more than seven), which caused them intelligible by business experts after a very short learning time. Regrettably, UML and BPMN method missed this power.

That is why we developed our own Business-Object Relation Modelling (BORM) process diagram and our own way to start business system analysis. The initial work on Business-Object Relation Modelling (BORM) was carried out in 1993 under the support of the Czech Academic Link Programme (CZALP) of the British Council, as part of the *Visual Application Programming Paradigms for Integrated ENvironmentS* (VAPPIENS) research project; further development and recent practical projects in the last decade has been supported by the Craft.CASE Ltd.—the British software consulting company supporting innovative technologies. *(VAPPIENS was financed by the British Governments CZALP, managed by the British Council. The authors acknowledge the support they received from this source, which enabled them to meet and carry out the initial work, out of which BORM grew.)*

Our approach is founded on the reclaim of old thoughts from the early 1990s concerning the modelling of object features and behaviour by automata (FSM). The first book articulating the potential blend of the Object-Oriented Approach and Finite-State Automata was the Shaler's and Mellor's [12]. Taylor [4] wrote one of the best books speaking about the applicability of OOP to the business modelling. These early works together with our practical experience is the reason why we believe that the business requirement modelling and simulation and software modelling could be unified on the background of object-oriented approach and automata theory.

Figure 1 shows an example of a model of a book in a library characterised in a form of an automaton having three phases: a book on a shelf, a book on loan and a returned book to be put back on a shelf. These phases are easily recognisable through an interview with domain experts. When these phases are recognised, it is possible to identify behaviours required for transferring books between the states. Of course, other entities in the system can be also modelled as another automata, which mutually communicate to each other. Let us have a borrower as an example. Even they have their own phases, which can be related to the time-related situations of the book; and analogically, the borrower's behaviour can be related to the book's behaviour, see **Figure 2**. This figure shows that a satisfied borrower is associated

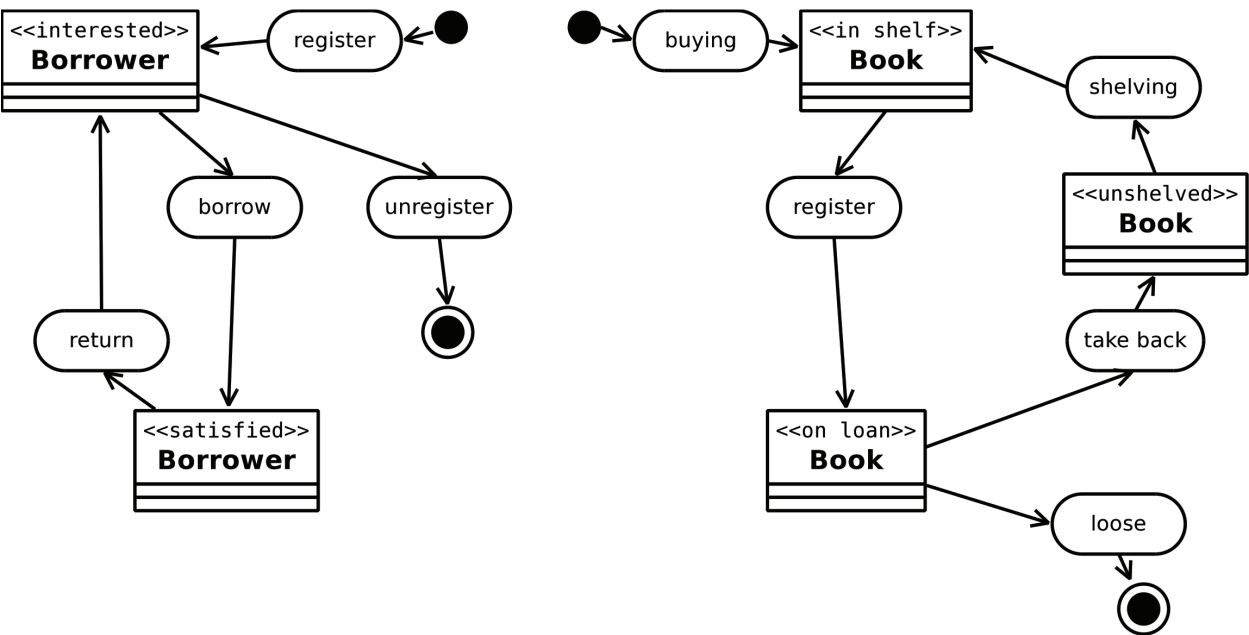


Figure 1. A book and a borrower as two FSM.

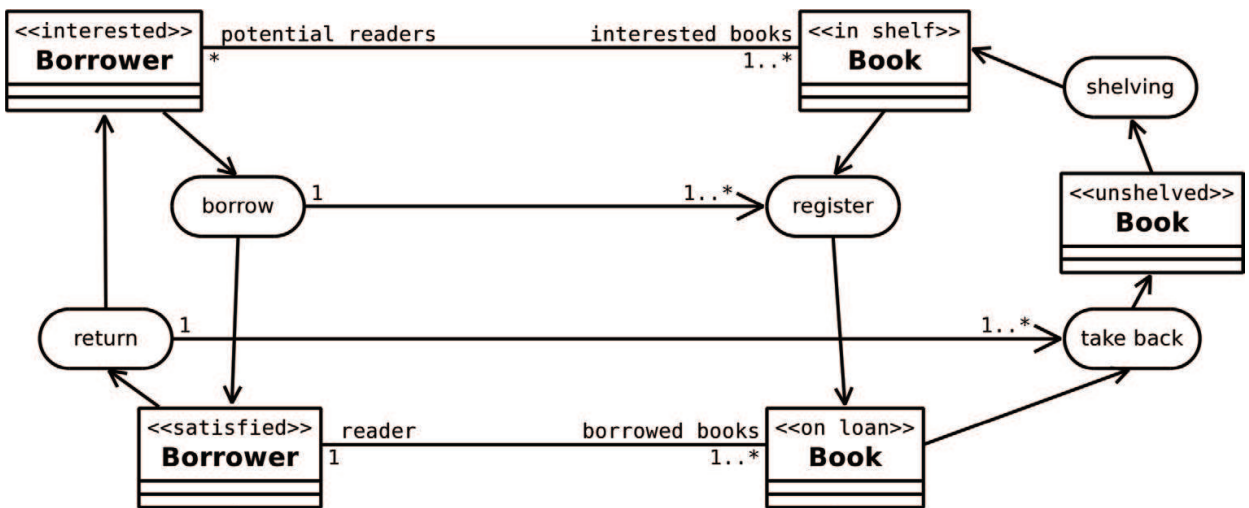


Figure 2. Two FSM mutually connected.

with an object of a book on loan in a relationship with cardinality of a 1 to many. That means, that every book on loan has to have its borrower and every satisfied borrower is satisfied if and only if he has at least one book borrowed. This is the possible business situation of our model. Similarly, we can identify the associations between borrower interested in borrowing a book and available books in the shelves. This association can be another possible business situation of our model.

Our given modelling approach unifies UML-manner of object modelling and business process modelling manner. Models like UML, BPMN and other can be easily derived from this BORM model. The proposed unified method unifies and simplifies object modelling. **Figure 3** presents the mapping of our model to the regular BPMN and **Figure 4** presents the same model represented by the state-chart of the regular UML.

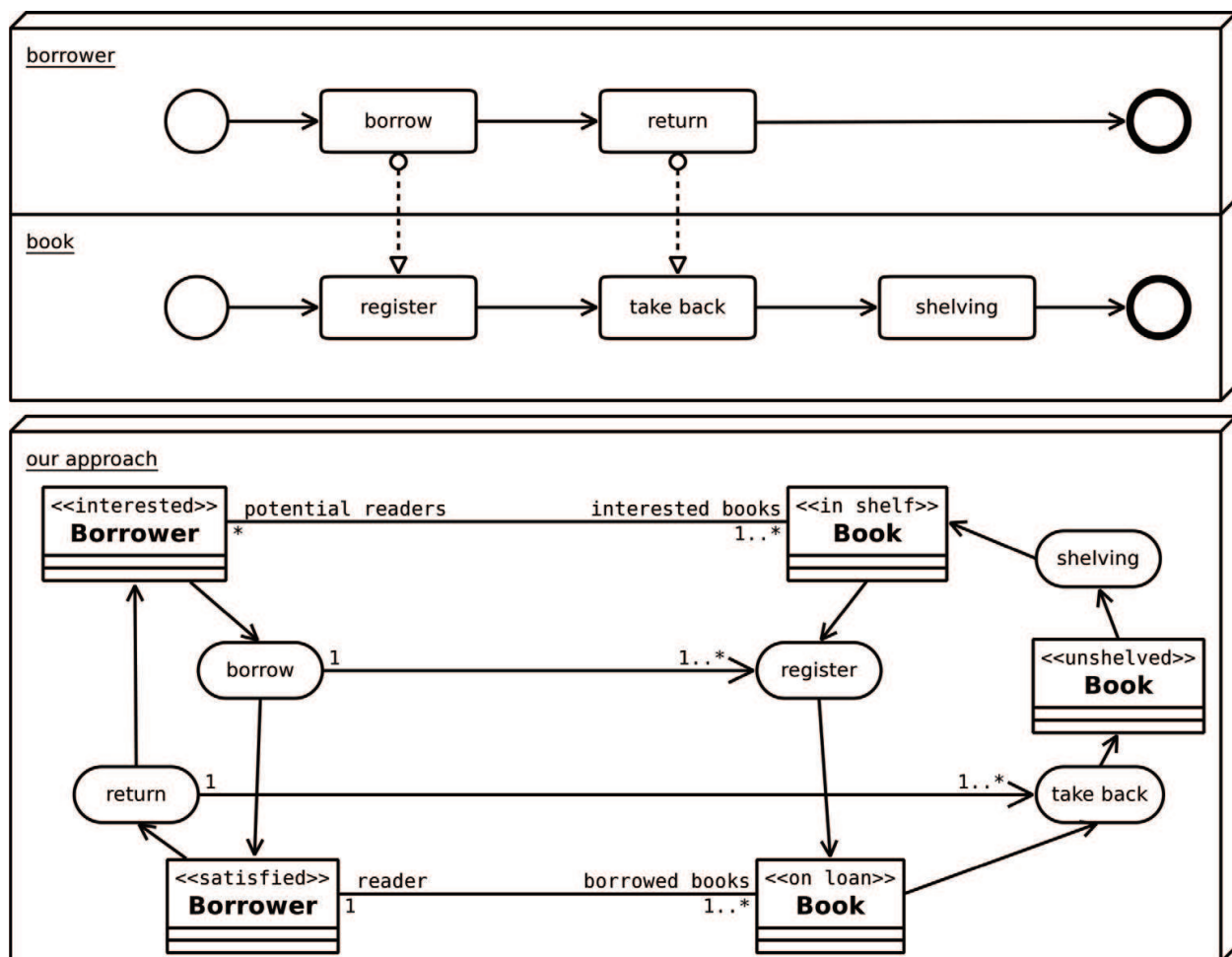


Figure 3. BORM and BPMN.

In our method, the states of objects are the most important elements. Behaviours denote only the necessary linkage between them. Both business processes and software components should be consequently modelled by starting with their states—situations of participating objects in the requested system in some moment. Modelling can be simpler, more correct and less behavioural imperative than it is now. Moreover, our focus on situations matches the conventional description of life situations, as is known above all from descriptions of the implementing regulations and the various guidelines, decrees and laws.

Likewise [3], we think that activities are key elements of business process modelling. Eeeles and Sims [13] describe a business process having a number of elements; activities, transitions, states and decisions. They assert that the UML activity diagrams can be a helpful modelling instrument in recording business processes.

In the organisation modelling, subsequent simulation is important that every participating object should be described as an automaton (FSM) with states and transitions dependent on the behaviour of other objects. Each state is defined by its semantic rule over object data associations and each transition is defined by its behaviour, necessary to transform the object from its initial to its terminal state. All organisational and business process models should be able to be simulated in this way. Hence, it should accent the mutual relationships (communications and associations) of states and transitions of objects in the modelled system.

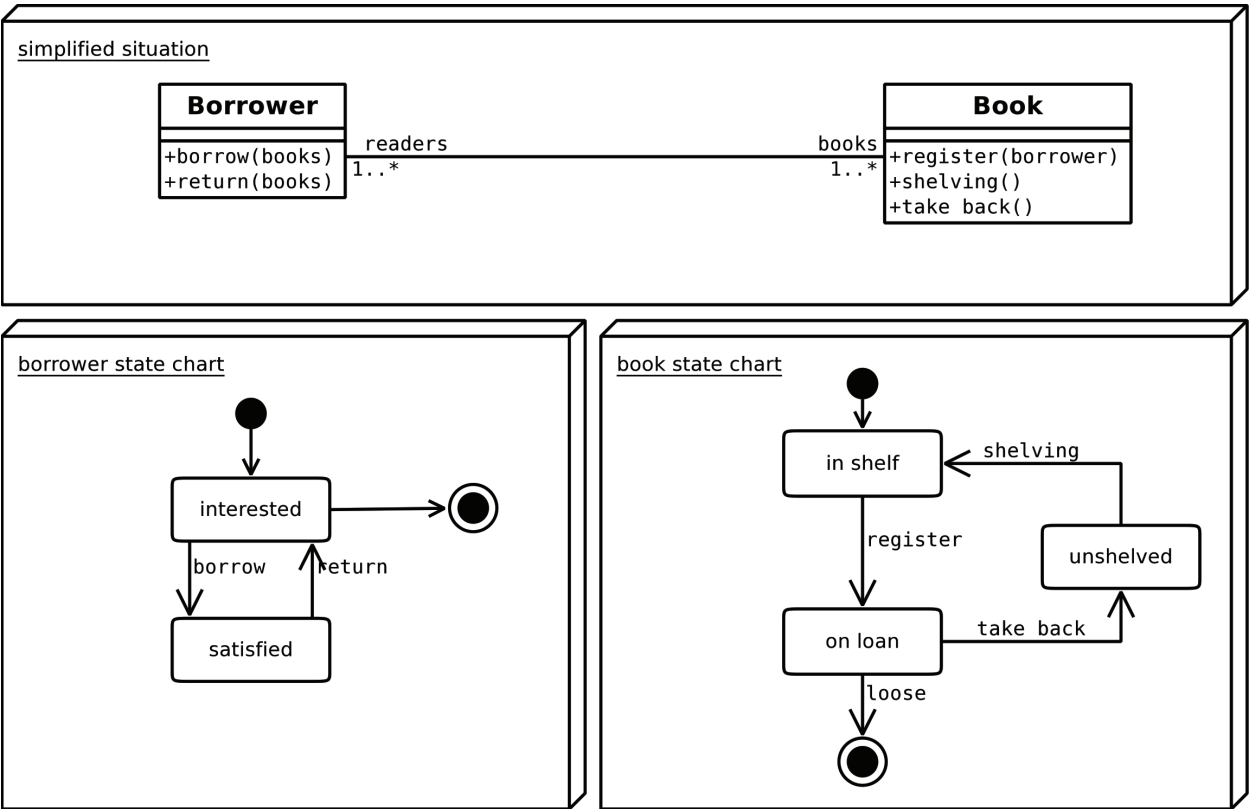


Figure 4. BORM model decomposed into standard UML models.

BORM has been used for a number of large projects by Deloitte consulting company, Central Europe office in Prague, including

- the identification of business processes in Czech health care system,
- the modelling of characteristic features of the Central European general agricultural commodities wholesale sector,
- business-process reengineering approach of the electricity supply industry,
- business-process reengineering approach of the Central-European telecommunication network management, and
- at last but not least, the project on improving the quality of life in small settlements of the Czech Republic which this text is about.

5. BORM in detail

5.1. Object-orientation

The object-oriented paradigm comes from the 1970s, when started the research of new species of user-friendly operation systems, graphical user interfaces and consequently in related programming techniques necessary for their software implementation. It changed software engineering

paradigm by incorporating non-traditional ways of thinking into the field of applied computer science. On OOP, the software system is modelled as an abstraction of the real world in the very similar way as it is in classical philosophy (e.g. models, meta-models, ontologies, objects...). The basic building concept is an object that incorporates both data structures and their functionality. Another modelling approaches handle data and behaviour independently, but OOP is based on their mutual dependency. OOP has been and still is explained in many books, but we consider that this early work [14] written by OOP pioneers is still the best.

5.2. Finite-state machines

In the field of theoretical informatics, the finite-state machines (FSM) theory is a study of abstract automatons and the problems they can solve. An automaton is a mathematical model for an entity that responds to its external environments, receives data and produces another data. Automata can be constructed in a way that the output from one of them becomes input for another. Finite-state machine activity is determined not only by receiving data but also by an internal status of given machine. The output is created as the combination of an input and internal status. For example, the FSM theory is essential not only for the computer science and engineering, but also for a human language translation theory. It has been explained in

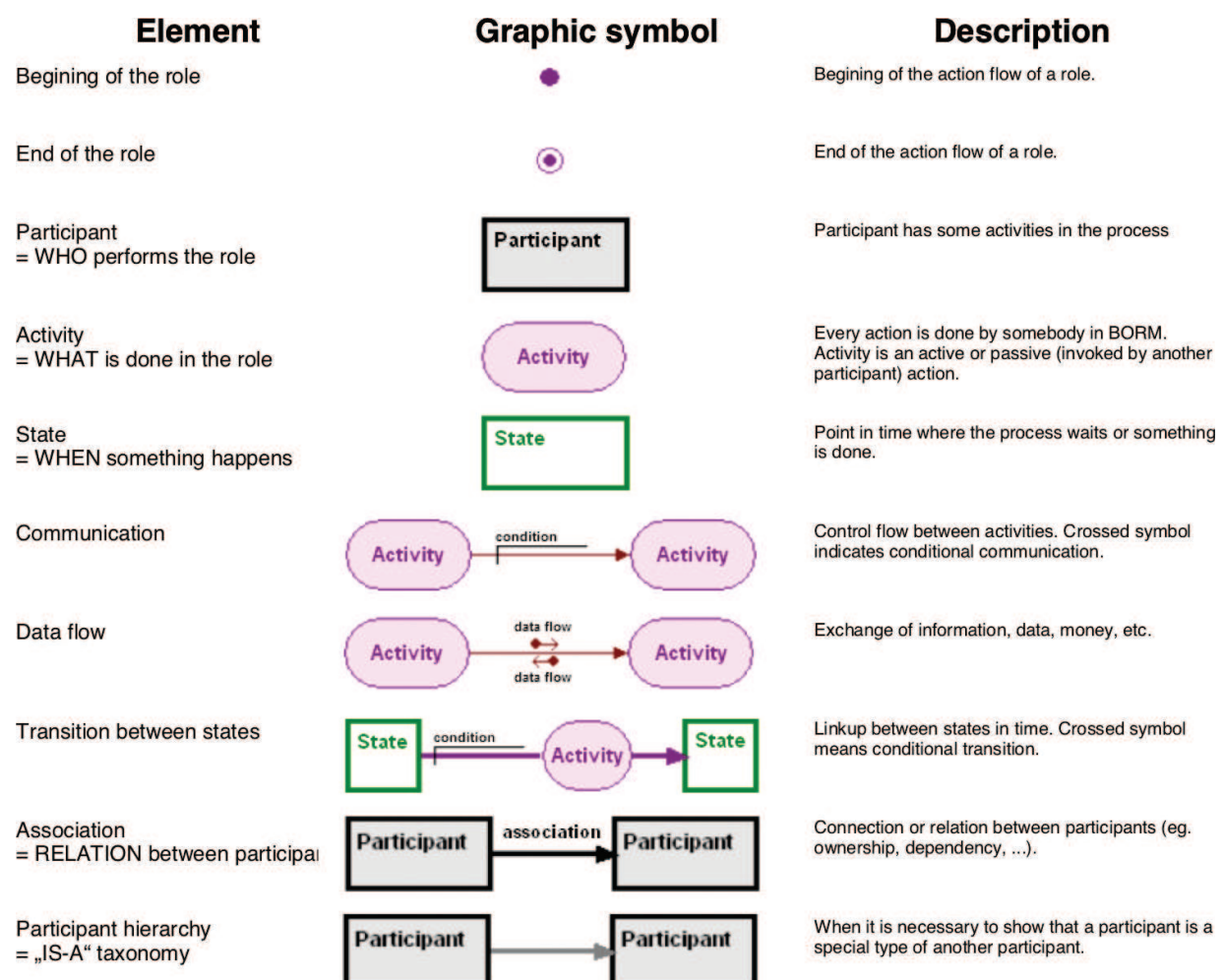


Figure 5. BORM business diagram symbols.

[12] and many latest publications. The idea of FSM also inspired behavioural features of the Unified Modelling Language [6].

5.3. BORM business diagram

BORM uses an original diagram for business process modelling and subsequent simulation (see **Figure 5**). It conveys together information from three separate UML diagrams: state, communication and sequence.

The BORM group has found that it is clearly understood by business stakeholders. Main principles of the BORM process diagram are:

1. Each subject participating in a process is displayed in its states and transitions.
2. This diagram expresses all the possible process interactions between process participants. The business process itself consists of a sequence of particular communications and data flows among participating subjects.

Officially, BORM process diagrams are graphical representations of interconnected Mealy-type automata, where each automaton represents some participating entity of the entire business process. The idea of modelling participating entities as FSM automata was firstly discussed in [12]. Visual simulation of a business process is based on market-graph Petri net. It is a very similar method, which is fully explained in [15]. Hence, we can model states, transitions and operations of all entities involved in a given business process in a very powerful but still relatively simple and intelligible graphics for domain experts who typically are not educated in detailed computed science.

6. BORM simulation models in regional management

Latest BORM application of organisational modelling and simulation was the project of enhancing the decision-making of mayors and people from local administration. It offered the possibility to model and simulate real-life situations in small settlements. The project activities were for modelling; simulation and reengineering processes related to the regional government processes of small towns and villages, and the subsequent development of supporting information systems addressing life situations of local people.

Today, we have to deal with many troubles related to the settlement expansion into the open landscape. We need to improve the quality of life and the level of democracy of these people while preserving the conditions of the sustainable development (attending living standard, historic and cultural values, agronomic production, building and maintenance of transport network, touristic value, etc.).

Urban sprawl described by Frumklin in [16] is an issue that our method can also resolve. The root of the urban sprawl in the small settlement development is the circumstance that the elected local people (e.g. clerks, politicians, mayors...) cannot be completely knowledgeable

in every part of law and local government itinerary and their practical impacts on their settlements and their citizens. They do not know how to fully use the legislation in favour of the settlements and usually depend on a misleading interpretation provided by their governing bodies and more often by another subjects, who are frequently privately involved in the process in question and thus biased.

Urban sprawl an uncontrolled expansion of certain kind of urban build-up into the free landscape caused by favourable land prices, demand for cheap but modern estates, etc. Dualny and others wrote [17] about harmful absorption of original small settlement structures, which causes many negative effects. It is a wrong experience that arose in the second half of twentieth century in the advanced industrial countries (USA, France and Great Britain) and lately also in our country. At the beginning, citizens of affected settlements typically perceive the urban sprawl optimistically, mostly because of the lobbying.

We examined the legislation and local officials' experience related to the processes and agendas of the urban planning of the landscape areas and small settlements with regards to the new housing and building law and regional management trends in the European Union. It consisted of a series of simulation sessions with four business process models correlated to the building development and territorial planning. One of them is also our example of the process of building permission in **Figure 6**.

Our method handling business process models of EU-legislative and their visual simulation encourages the officials (particularly in the smallest villages) to explain this legislation and shows the possible alternatives of its use. Our models and their visual simulations explain how the BORM can be applied to improve the process of decision-making on the level of mayors and local officials. It allows the opportunity to model and simulate real-life situations in small villages. The example at **Figure 6** presents the BORM business object diagram of a process of acquiring building permits. **Figure 7** presents the particular step of Craft.CASE simulation software [18], where the BORM model can be visually step-by-step animated.

Our method is based on business-process models and their visual simulation. This helps the participating subjects (especially in the smallest villages) to explain the legislation and designates the optional ways of its performing. Our models and their visual simulation illustrate how it can be practised to improve the decision-making process on the level of mayors and local authorities. It makes the opportunity to model and simulate real-life situations in small villages. Our modelling software allows analysing particular simulation steps. Our diagram is a visual representation of object associations and communications within given business-process. Our notation is the re-used UML notation from the state diagram, activity diagram and sequence diagram UML but combined and simplified in an original way into a new diagram that shows the process in the manner of mutually interacting automata (FSM). Furthermore, we can use a visual simulator for animating these business processes. Our visual simulation software has incorporated the user group communication component inspired by Facebook chatting (see **Figure 8**).

Sure, when presenting our method, the target staffs are typically not educated in any ICT-related skill (Yet if they are people from small villages). On the other hand, the process-mapping stage must be fast accomplished. This is why the analysis team does not have much

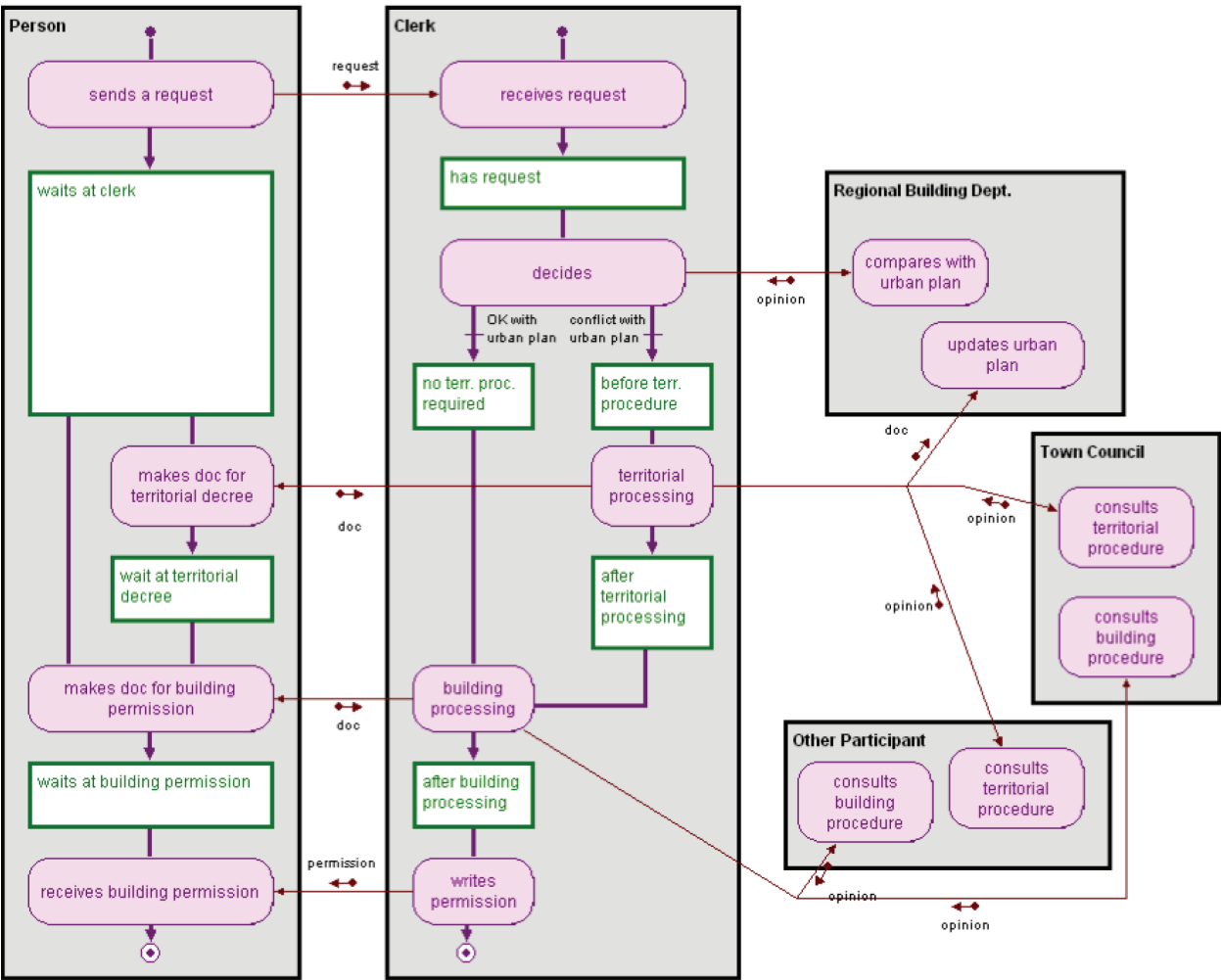


Figure 6. Building permission process.

time for detailed modelling training such as the explanation of all aspects of the used method with outcomes into the computer programming. Long-time education with a modelling software is also inapplicable. We typically have time only for a very short opening session on how to read our computer models. Here, we consider the big advantage of our method because this very introductory session typically takes only 20 minutes of a showing of how it works. Most people were ready to start their work after this primer.

Consequently, we identified that the ICT equipment is not a big barrier to use our method as we expected on the assumption that the people were from small villages.

We prepared our models in the professional modelling software Craft.CASE and then transported them to the environment of a freeware simulator, which is fully available via the fast Internet. The network was not a problem, because the Central Bohemian region, where we did our project, due to the vicinity of Prague (capital city of the Czech Republic) is adequately equipped with high-speed Internet.

Finally, we asked 57 people from the local government of several Central-Bohemian small settlements about the increase of their knowledge and about their evaluation of their past

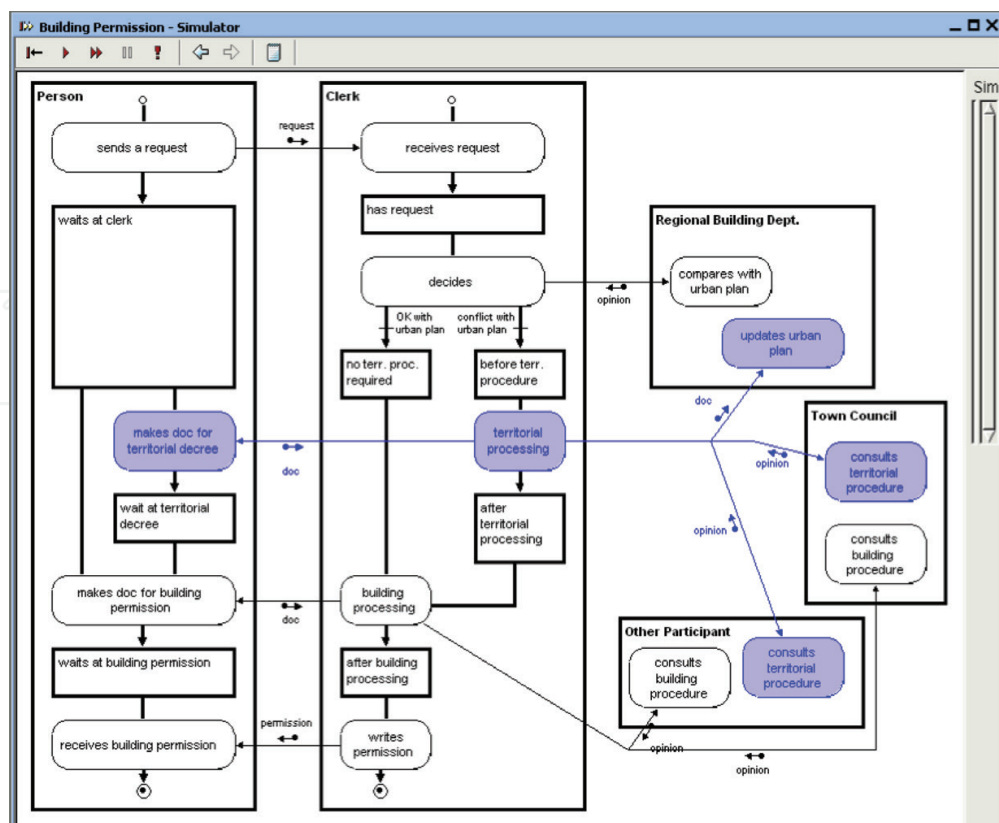


Figure 7. Step-by-step simulation in Craft.CASE tool.

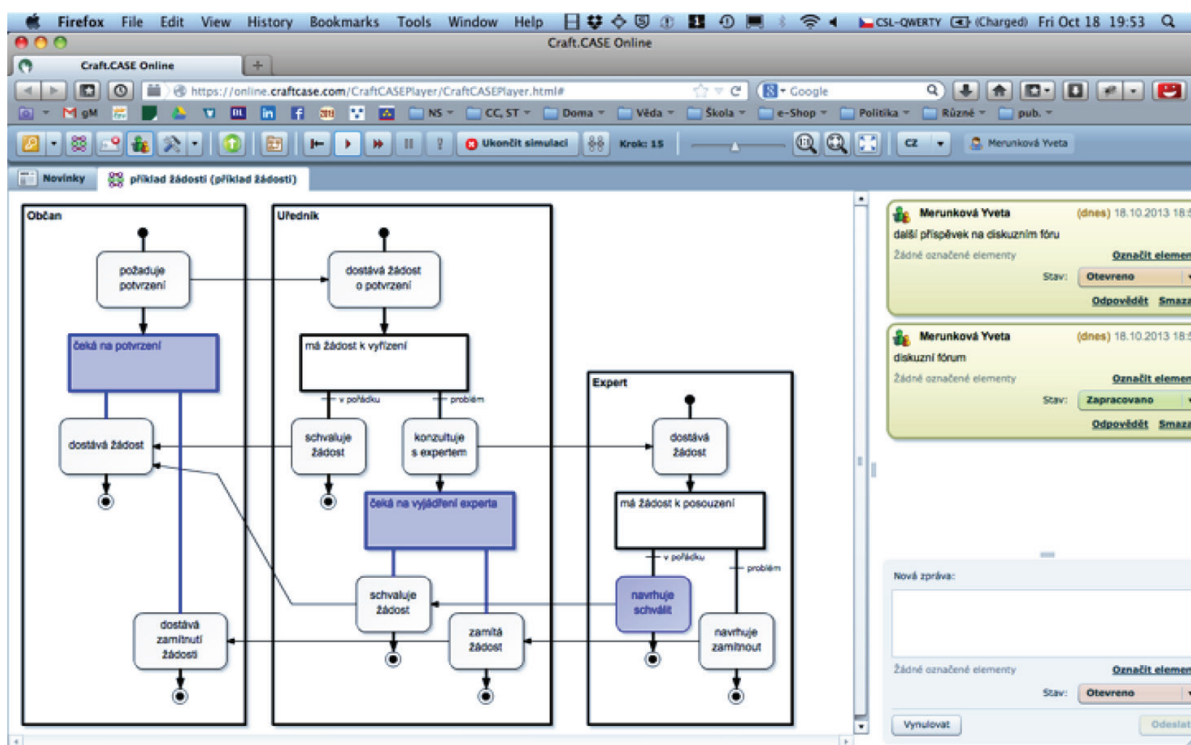


Figure 8. On-line BORM business process simulation of Internet user group.

projects from the attitude of the newly obtained information. The probability between the answer about the efficiency of our new method and the estimated better participation was 64%. Furthermore, based on the new information, 67% of tested people stated the evidence, that external investors and lobbyists manipulated them in the past due to their former low level of business-process knowledge.

Our conclusions are also worthy of the possible subsequent software development of information systems addressing better life situations of local participants.

7. Conclusion

The BORM method is built on the blend of the object-oriented approach with automata (FSM) and our working experience with the business modelling projects, which were intended to support the teams composed by business experts and software developers from various areas of socio-technical systems. We conclude that this method can improve the expected possible convergence of BPMN and UML models and support problem domain specialists in the area of organisation structures simulation as it is prognosticated by Scheldebauer in [19].

BORM is an object-oriented and process-based analysis and design method, which is proven to be effective in the construction of business systems. The effectiveness of BORM is based on its ability to record and display the fundamental features of the relevant business model, which can be simulated, verified and validated for subsequent software implementation. Furthermore, many partners in our projects work with diverse legacy Process Modelling Systems (e.g. EPC-based ARIS, for example). Nevertheless, these partners favour to analyse and design business processes using BORM and then rewrites these processes into their legacy method.

Our BORM innovation is based on the reuse of old ideas from the beginning of the 1990s concerning the representation of object-oriented subjects and their behaviour by automata (FSM) and displaying the process-based knowledge as the automata communication where each process participant is represented by own automaton. In the BORM method, states and situations are emphasised in distinction to activities as it is in standard process diagrams. We assume, based on our practical experience, that the business requirement modelling and simulation and software modelling could be unified on the platform of OOP and FSM, where objects (e.g. process participants described as Mealy-type FSMs) are interconnected via passing messages to achieve necessary behaviour.

We consider that the best value of BORM is caused by the specific way of modelling, which covers two different worlds: business engineering and software engineering. Moreover, BORM is an intelligible instrument for mutual communication between system architects and problem domain experts via organisation structures modelling and subsequent simulation.

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