Representation

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1.0 INTRODUCTION

The notion "representation" is used in many different contexts (politics, arts, lobbying, …). In context with simulation it is to be interpreted as an image or an idea substituting a piece of reality of interest in conjunction with a certain problem or question. It implies an iterative process or trade off between the simulation user and the simulation developer in choosing suitable and acceptable abstractions of the piece of the real world of interest.

This trade-off is captured in the "Conceptual Model of the Problem Space" or – in a military context – in the "Conceptual Model of the Mission Space (CMMS)".

2.0 BASIS FOR REPRESENTATION: THE CONCEPTUAL MODEL

The Conceptual Model can be seen as the bridge between the simulation developer and the simulation user. It serves as a primary mechanism for clear communication among simulation development personnel (e.g. software designers, system engineers, system analysts) and members of the user community (e.g. users, functional area subject matter experts) and is the basis for the design of a simulation.

The Conceptual Model documents the decomposition and abstraction of the "piece of the real world" of concern as described in the mission space in military terminology by mutual consent between the simulation developer and the simulation user. It should capture this "piece of the real-world" at the right level of resolution and fidelity for the purpose of the simulation. It should identify all topics and issues that need to be addressed in order to meet the requirements of the simulation.

3.0 THE ROLE OF THE APPLICATION DOMAIN

The first step regarding representation in context with simulation applications is answering the question: "For which purpose is the simulation supposed to be used?"

To facilitate and formalize the handling of this question in connection with military simulation applications the "Military Operational Requirements Subgroup (MORS)" of the "NATO Modelling and Simulation Group (NMSG)" endorsed a structured approach for a clear definition of military simulation application domains, the "simulation application space" extended by the "dimensions"

- Military activity to be supported (defence analysis/planning, operational analysis/planning, conducting operations)
- Simulation application mode (training, exercise, rehearsal, experimentation, real execution support)

Neugebauer, E.; Steinkamp, D. (2007) Representation. In *Integration of Modelling and Simulation* (pp. 2-1 – 2-4). Educational Notes RTO-EN-MSG-067, Paper 2. Neuilly-sur-Seine, France: RTO. Available from: http://www.rto.nato.int.

- Military level (technical, tactical, operational, strategic)
- Kind of Mission (Article 5 (war operations), Non-Article 5 (Operations other than war (OOTW), Crisis Response Operations (CRO) like peace building, peace keeping, humanitarian support,...))
- Staff involved (who is supposed to utilize the simulation; CJ1…CJ9)

Consideration of these "dimensions" may result in different and very specific requirements for a simulation. It could lead to the necessity to address peculiar design topics and issues and could therefore influence the Mission Space and the Conceptual Model.

4.0 THE ROLE OF THE MISSION SPACE AND THE UNDERLYING MILITARY SCENARIOS

The next step is answering the question: "What is to be represented by the simulation?", or in other words: "What is the problem space?" or – in military terms – "What is the mission space?".

To answer this question, we have to understand how military operational requirements are derived. Basis for the derivation of military operational requirements is the analysis and planning of required capabilities of military forces. This starts with guidance documents on the political level. E.g., in Germany we have the "Auftrag der Bundeswehr" (Mission of the Bundeswehr). These guidance documents are implicitly based on specific existing or anticipated political situations reflecting certain states of parts of the real world of interest.

Such situations embrace

- the involved entities (humans, systems) with their characteristics (values of relevant attributes describing their states), their relations, and their behaviours (change of attributes with time) depending on their relations, missions, orders, functions and interactions,
- the environment surrounding the involved entities, including events with potential feedback on these entities,
- at a certain point in time.

One could see a situation as an instance of a scenario, therefore we can see immediately the paramount importance of readily available military scenarios as basis for the definition of the mission space of military simulation applications or – more specifically – for the derivation of the operational requirements for a military simulation application.

But how can this – the establishment of scenarios, the derivation of needed capabilities and of the operational requirements – actually be done?

Ideally we would start on the highest level, the political level. We are looking at a specific piece of the real world of interest (let's say, as an example: Afghanistan).

What we need first, is the general description of the (political) scenario. This could be done using an operational planning guide, e.g. the NATO Guide for Operational Planning (GOP). Once we have the general scenario description, we can now look for specific instances of the scenario, describing a specific political situation.

In our example, Afghanistan, we have a situation characterized by political instability, power of war lords, high poppy production, destroyed infrastructure, poverty of population, attacks by the Taliban, and this can be described concretely by the values of the attributes of the entities involved and by specific behaviour patterns. So this is the given political situation (initial state). Of course the desired end state is quite a different situation described in corresponding political guidance documents: a stable and self-sustained democracy.

To accomplish the transition from the initial state to the desired end state, certain effects are to be reached. To accomplish a specific effect, certain tasks are to be conducted. To enable a specific task, certain capabilities are required. To acquire a specific capability, certain force packages are needed. All this is essential information for the definition of the mission space needed for the establishment of the conceptual model of a simulation to be developed.

Since the requirements for a certain military level are always depending on the tasks of the level on top of it, it is clear that a consistent hierarchy of scenarios, effects, tasks, capabilities and force packages has to be derived top down from the political level via the operational and tactical level down to the technical level. Depending on the intended application domain of a simulation the right elements of this hierarchy are to be selected for the development of the mission space as the indispensable pre-requisite for the development of a suitable conceptual model. The lack of a well defined mission space and the underlying scenarios will inevitably lead to never ending disputes and quarrels between military simulation users and simulation developers regarding the determination of the conceptual model and proper representation of the military needs.

5.0 ESTABLISHMENT OF THE CONCEPTUAL MODEL

The intended application domain and the mission space for a simulation (which is normally covering a spectrum of similar or related scenarios, e.g. tactical level Crisis Response Scenarios, with a certain bandwidth of possible instantiations) determine the entirety of simulation requirements. The Conceptual Model should address all these requirements. It is supposed to give (with exceptions, see later) the answers regarding questions in context with representation: what is to be represented and how is it to be represented.

The establishment of a Conceptual Model embraces four steps. In a first step authoritative information about the simulation context (intended application domain) is gathered and a "high level" conceptual analysis is performed, in which the areas of concern and their relations are determined in a coarse way. In a second step the entities and processes which must be represented for the simulation to accomplish its objectives are identified (mission space decomposition). Basic decisions about the level of detail (level of aggregation) are made. In a third step the representational abstraction of the entities is determined. Decisions are made regarding the level of accuracy, precision, resolution, and fidelity needed in the representation of an entity or process. The simulation requirements are reviewed thoroughly by checking each entity regarding the following questions:

- Is this entity to be represented to satisfy at least one of the requirements?
- Is this attribute of the entity under consideration to be represented and why?

In a fourth step all relationships among the entities are identified. It is ensured, that all constraints and boundary conditions imposed by the simulation context and all operational and functional requirements are taken into consideration.

In the first place a Simulation Conceptual Model is a simulation developer's approach of translating user requirements specified on the basis of the application domain and the mission space into an abstracted and decomposed representation of the piece of the real world of interest. However, it has to be established iteratively in close cooperation with the user (e.g. Subject Matter Experts (SMEs) involved in conceptual model review and validation). Therefore it is important to make use of a descriptive format assuring a mutual understanding of the Conceptual Model for simulation developers and users.

Class diagrams and sequence diagrams as used in the industry standard “Unified Modelling Language (UML)” allow a delineation of both static aspects of the Conceptual Model and dynamic requirements for the system comprehensible for both sides.

In order to further simplify the understanding of the Conceptual Model, and to facilitate the allocation of parts of the Conceptual Model to different federates in a networked simulation (e.g. in an HLA federation), there should be a structured hierarchy of diagrams: a high level diagram highlighting main entities and relationship and several low level (child-)diagrams each focusing on specific aspects and with a higher level of detail.

6.0 CONSTRAINTS

Certain aspects of representation can not be covered by the Conceptual Model. For example compliance in the dynamic behaviour of entities is of course dependent on the algorithm that is used for a certain method of a certain class representing a certain entity. In networks of simulations this can be a serious problem which can at the worst result in logical inconsistencies. For this reason the “Federation Development and Execution Process (FEDEP)” under the HLA standard specifies beside the Conceptual Model and its reflection, the “Federation Object Model (FOM)”, additionally needed documents containing representation-relevant information (e.g. the “Federation Agreement Document (FAD)”).

7.0 CONCLUSION

Suitable representation is of paramount importance for each simulation application. Therefore a simulation development should always rigorously be based on a proved process model like the FEDEP including a deliberated and user-agreed Conceptual Model. Unfortunately – because of cost reasons – we often see a sloppy backwards “tailoring” of representation based on the capabilities of existing simulations neglecting essential steps of meticulous simulation development. This often results in discontent users and discrediting of simulation application.