

Chapter 10-7 – EXAMPLE APPLICATIONS: AGENT-BASED MODELLING, EXAMPLE INSTANTIATION WITH PAX

SUBJECT

This chapter presents the results of an example instantiation of the Conceptual Model using the German agent-based model PAX.

APPROACH

Based on the variables and relations in the CM, a scenario was developed for the German ABM PAX for testing the NCW hypothesis that “Shared Situation Awareness/ Understanding enables Synergistic Actions/ Self Synchronization.” As illustrated by Figure 10-7.1, the objectives of this activity were to assess:

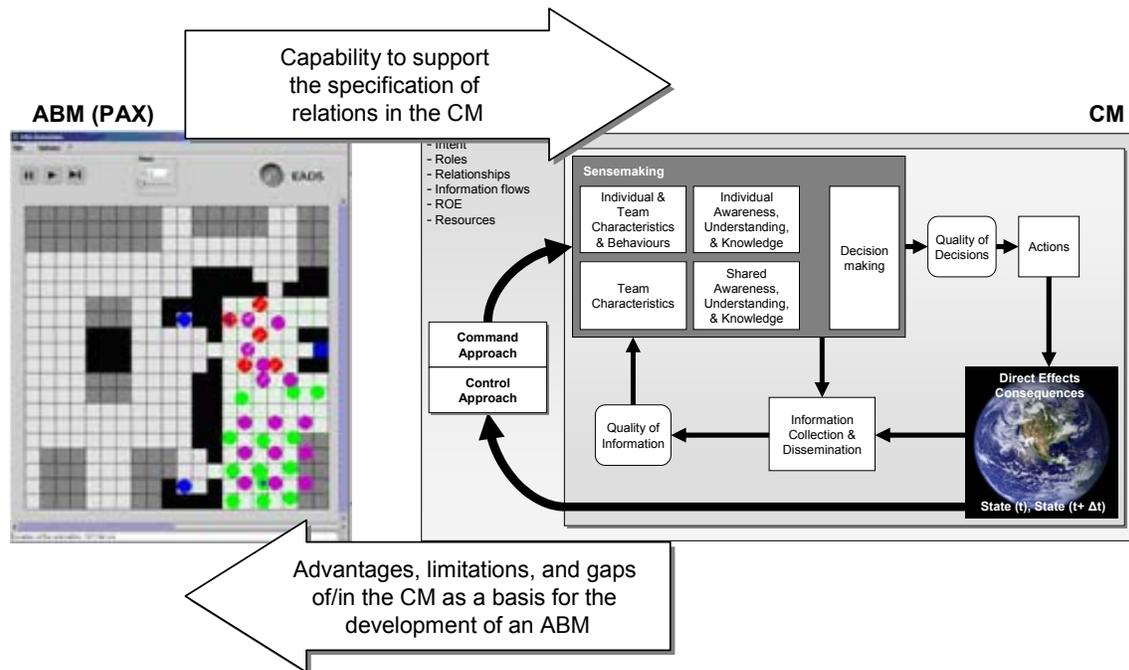


Figure 10-7.1: Objectives of CM Instantiation in Form of an ABM.

- The benefits of the CM for its instantiation in terms of an ABM; and
- The potential of ABMs for refinements of the CM.

The scenario featured a situation where Blue forces were tasked to provide security for Green voters in a soccer stadium during an election campaign event in Afghanistan that Red troublemakers might attempt to break up. In particular, the Blue security was to quell any attempts by troublemakers to disrupt the election campaign.

Individual Awareness and Understanding underlying the decisions of agents was modelled in terms of a map describing a local part of the whole situation (see Figure 6-4a). Shared Awareness and Understanding meant sharing of these local maps between agents of the same party (see Figures 6-4b-d). Based on the situation, a certain combination of behaviours of the security forces was defined to be synergistic. Different information sharing processes were implemented to measure how the occurrence of the synergistic behaviour changes.

THE BENEFITS OF THE CM FOR ITS INSTANTIATION IN TERMS OF AN ABM

The CM provides an extensive list of variables relevant for C2 analysis, especially in the area of the individual and team characteristics and behaviours, from which to select those for modelling attributes and behaviours of agents. Characteristics and state variables present a set of attributes to describe the state, which may change over time.

Similarly, the CM provides a set of dependencies from which those to be instantiated in an ABM may be selected. These might be direct dependencies such as, for example, “alertness depends directly on the state of physical health.”

The CM supports the developer of a model by assisting him to determine which variables need to be considered in modelling the variables of interest. The CM contains references to and definitions in the scientific literature where background and possible instantiations of these variables are described.

The CM also helps to find references to relationships between variables that have been empirically tested and thus may be directly instantiated in the form of rules for interactions between agents.

It should be pointed out, however, that variables in terms of which the NCW tenets are defined (Situational Awareness/Understanding and Synergistic Actions) represent composite variables representing vectors specifying the attributes, or basic variables, by which these (composite) variables are described. Thus, they may not be immediately instantiated. However, the CM provides a list of variables that may influence awareness and understanding that supports the developer in instantiating relevant variables.

THE POTENTIAL OF ABM FOR REFINEMENTS OF THE CM

Agent-based models are mostly based on a large set of very simple rules that are plausible and easy to understand. They describe the response of individual actors in specific situations. The interaction of actors leads to a dynamic combination of these simple rules leading to unpredictable or often surprising behaviour of the (modelled) system comprising the actors. Thus, relationships may emerge that are not modelled explicitly in the ABM but generated through the interaction of agents, or rather the interaction of their simple behavioural rules.

The relationships emerging in the course of ABM experiments may help to specify relationships between variables postulated, or not covered at all, by the CM.

Data Farming, a method to support experimentation with ABM, determines the degree of dependency between variables. Data Farming is a kind of sensitivity analysis for the relationships between variables. It helps to identify the variables that have a significant impact on a specific variable of interest and to establish the relationships that are important in a specific context. Using ABM experiments, it is possible to assess the degree of influence of one variable on another in a given context.

WHAT WE LEARNED

- Because most of the variables in ABM are very basic, a direct matching to the CM variables often fails. However, using aggregation and de-aggregation, the variables and relations within the CM provide a valuable basis for the development of an ABM. Relations in the CM provide a basis for interdependencies between variables from which to select those modelling behaviours of agents.
- ABM models have a high potential for further refinements of the CM. The variables and behavioural rules in ABM provide indicators for CM variables and relations. In the course of ABM experiments, often surprising relations emerge that are not explicitly modelled but arise from the dynamic combination of a large set of simple rules. Further investigations of these emerging relations will have to provide the evidence that such relations are worthy to be part of the CM.

REFERENCES

- [1] Roemer, Jens. "Agent Based Models and the Conceptual Model – Mutual Benefits." Presented at the Peer-to-Peer Workshop. Virginia Beach, VA, USA. 4-6 October 2005.

