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Simulation Based Design for Adaptive Multi Agent Systems: Extensions to the ADELFE methodology

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Abstract—ADELFE is a methodology proposed to help and guide the designer during the development of an Adaptive Multi-Agent System (AMAS). In this paper, we propose extensions to ADELFE in order to facilitate the task of the designer and help him to detect and correct the Non Cooperative Situations that the agent may encounter during its life.

Keywords—ADELFE, Adaptive Multi-Agent Systems, Simulation Based Design.

I. INTRODUCTION

Adaptive Multi Agent Systems (AMAS) [1] are complex systems that evolve in dynamic environments. The AMAS theory is based on the principle that if all agents of a system are cooperative, then the system is functionally adequate and therefore adapted to its environment. The overall function of AMAS, with emergent nature, is difficult to model and the empirical approach is certainly the only possible one in validation activities. Build such self-organizing systems is not an easy task, we need computer-aided design. The agent-oriented methodology ADELFE [2] was proposed to guide AMAS designers. Actually, ADELFE organizes the design of the two parts of the agent behaviour (nominal and cooperative) in two iterative complementary activities. The problem, lies in the composition of the cooperative behaviour executed by the agent which is not predictable and in the definition of the Non Cooperative Situations (NCS) which the agent may encounter during its life. To help designers during this step, we defined challenges in order to enrich ADELFE by engineering activities and tools to achieve the Simulation-Based Design in order to help the designer and guide him to produce a better quality of AMAS. These activities and tools aim to automate as possible the design of the agent behaviour. In this paper, we present the principal extensions made for ADELFE.

II. NEW ADELFE PROCESS

Figure 1 presents the new workflow proposed for ADELFE. We propose to use a classical workflow for simulation-based design which starts with a model that is defined according to the thematic requirements. Once it is validated according to properties which are required for the

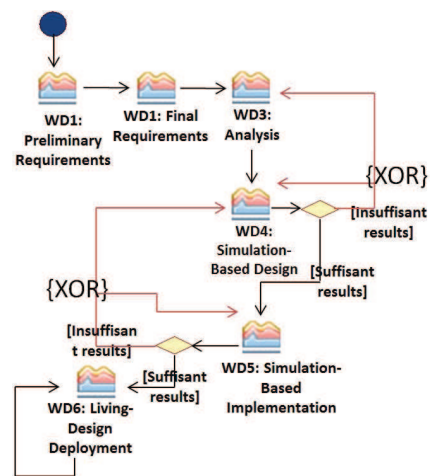


Figure 1. The Simulation-Based Workflow for ADELFE

model, the experiment is conducted with various parameters. Results are collected and an analysis is made in order to produce new conclusions. If these conclusions do not satisfy the thematic, a new simulation cycle is executed. Otherwise, the process is stopped. We use this generic view of a simulation process to introduce new improvements in the last three phases of the ADELFE process. Ultimately, our long term goal is to enable the designer to provide only a basic nominal behaviour for the agent which could adapt to the non cooperative situations encountered during runtime according to analysis and adaptation of its cooperative behaviour in a simulation-like cycle performed automatically by the agent. This "Self-Design" of the agent, as we call it, which takes place at the deployment phase would define the most efficient mechanisms of adaptation obtained so far. Before we reach this goal, and even we have a model-driven approach of the MAS design, we need to validate the implementation with respect to the design. In order to do that, simulation-based activities are introduced in the implementation phase. Their goal is to experiment the implementation and analyse the results in order to validate it or not. Initially, in the

design phase, we need to help the designer and to discharge him from the difficulty of searching for the cooperative behaviour of agents (search for non cooperative situations, anticipating and remain correcting problems). As well as from a quantitative point of view than from a qualitative point of view, the design has to be validated before going to the implementation phase. Thus, we define iterative activities that will enable the design of a cooperative agent that can be simulated and give information on what goes right and wrong. Then to be able to analyse the design and to start a new design cycle if necessary. This proposal validation steps contributes to improve the quality of the AMAS produced.

III. A SIMULATION-BASED DESIGN PHASE

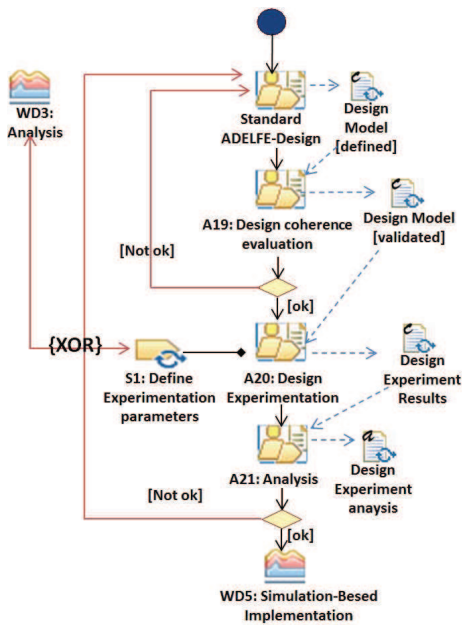


Figure 2. The Simulation-Based Design phase

Figure 2 presents the new design phase of ADELFE. Three new iterative activities are integrated:

- **A19: Design coherence evaluation.** the purpose of this activity is to eliminate the design errors that can be detected using a verification approach [3] before running experimentation. It is a preliminary validation of the design. If the model is validated, the designer executes the next activity (A20). Otherwise, he goes back to the previous design activities in order to make necessary changes.
- **A20: Design-experimentation.** The purpose of this activity is to simulate the result of the design by running many simulations using SeSAM simulation tool in order to observe the behaviours of the agents of the designed system. A Self-Design and Learning Cooperative Agent Model (S-DLACAM) [4] was proposed and developed

under SeSAM in order to automate as much as possible the detection and correction of the Non Cooperative Situations encountered by the AMAS agent. In addition, new plug-ins have been added to SeSAM to support the simulation of AMAS agents.

- **A21: Analysis.** The purpose of this activity is to analyse the design experimentation results in order to decide either to go to the implementation or go back to the previous design activities or to the analysis phase in order to make necessary changes. SeSAM offers a lot of tools for analysing simulation results. The designer can export different formats for external processing using the integrated functions for visualization of model results. New plug-ins have been added to SeSAM to support the analysis of the simulated AMAS-model. The effective validation of the design takes place at the end of this activity.

IV. A SIMULATION-BASED IMPLEMENTATION PHASE

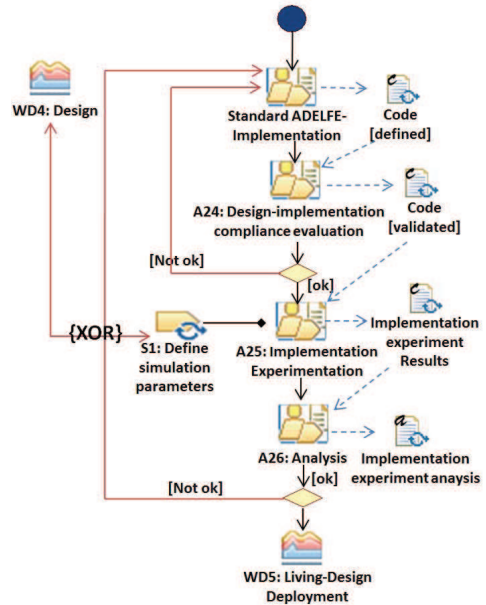


Figure 3. Iterative activities added to the ADELFE implementation phase

Figure 3 presents the new implementation phase of ADELFE. Three activities are added:

- **A24: Evaluate the design/implementation compliance.** The purpose is to report problems that are related to the non-compliance between the design and implementation. It is a preliminary validation of the implementation before running experimentation. If the code is validated, the developer executes to the next activity (A25). Otherwise, he goes back to the previous implementation activities or to the design phase in order to make necessary changes.

- **A25: Implementation experimentation.** The purpose of this activity is to experiment the implemented agents. It consists in running many execution scenarios of the implemented system.
- **A26: Analysis.** The purpose of this activity is to analyse the implementation experimentation results. To do this an analysis tool (AMAS-Analysis) was proposed to help the developer to analyse the behaviour of the implemented agents and the system to see if they are able to correctly detect the Non Cooperative Situations and to converge towards the good behaviour as simulated in the design phase. The effective validation of the produced system takes place at the end of this activity. Based on the analysis results, the AMAS developer can decide either to deploy the system or go back to the previous implementation activities or to the design phase in order to make necessary changes.

V. A LIVING-DESIGN DEPLOYMENT PHASE

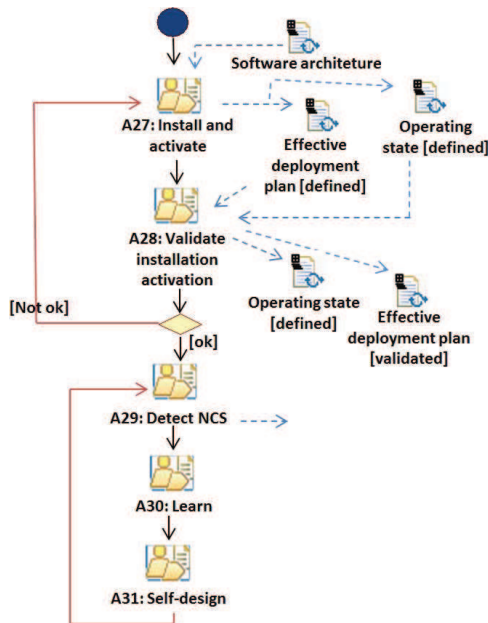


Figure 4. Living-Design Deployment phase.

Figure 4 presents the deployment phase proposed for ADELFE. At this stage, the system should have the self-adaptation qualities to ensure the emergence of the right behaviour in any environment. This Living-Design, as we call it, is the result of the new Self-Design and Learning Cooperative Agent Model proposed in (reference) and of the iterative activities defined in the design and the implementation phases. This deployment phase is composed of six activities:

- **A27: Install and activate.** The purpose of this activity is to install the system and activate it.

- **A28: Validate installation and activation.** The purpose of this activity is to validate the installation and the activation of the system.
- **A29: Detect NCS.** The agent auto-detect the NCS that it encounter during its life.
- **A30: Learn.** The agent learn from the encountered NCS.
- **A31: Self-design.** The agent change its behaviour And/or its relationships with the other agents of the system in order to avoid next time the detected NCS.

VI. CONCLUSION

The SBD was applied in several areas[5]. However, to date few MAS development processes based on simulation have been proposed in the literature and few approaches take into account some of the principle concepts of our systems. Simulation play a strategic role in the development of Adaptive Multi Agent Systems because it helps to support the modelling of agents that dynamically adapt their interactions and behaviours. For the most part of related works, they are not interested in the construction of the agent behaviour but rather to the performance of the system. Our objective is to focus on the building of the agent behaviour because improving the agent behaviour will certainly improve the cooperation between agents. We proposed a Simulation-Based Design approach for Adaptive Multi Agent Systems and we integrated it with the ADELFE methodology by the definition of new iterative simulation-based activities. In this paper, we presented the improvements added to ADELFE. The objective was to make the task of the designer more easier by helping and guiding him in his task and specially the detection and correction of the Non Cooperative Situations that the agent may encounter during its life-cycle.

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