

# MULTI-AGENT METHODOLOGICAL APPROACH FOR DISTRIBUTED SIMULATION

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## KEYWORDS

Methodological approach, Distributed simulation, Physical system and knowledge distribution, Multi-agent systems.

## ABSTRACT

We work in complex industrial system simulation on geographical, decisional and informational distribution terms. We postulate that existing methodologies and simulation tools seldom take account of these three distribution aspects. Our goal is to conceive a modeling and simulation solution that is able to utilize these aspects to resolve problems.

This paper is divided into 4 parts. The first is a brief introduction. The second is a short resume of the state of the art in the distributed simulation and the multi-agent system fields. There, we present the bases used for our reasoning. The second part describes the industrial system distribution modeling problems. In this section, we also develop the methodological multi-agent approach. Thus the use of distributed simulation, economical and multi-agent works enable us to consider a model on which is based our approach. Throughout in this section, we present an iterative construction approach of our methodology and simulation environment. Finally, we conclude.

## 1 INTRODUCTION

Simulation is regarded as one of the rare techniques taking into account the dynamism of the industrial systems. But the evolution of the industry towards decentralization imposes the technological development of industrial system modeling. Hence simulation must support the physical, informational and decisional flow distribution. Although the distribution of physical flows can be carried out by the current tools, the two others are still difficult to model. Moreover simulation softwares are seldom associated with precise methodologies.

To answer these dilemmas, we decided to conceive a methodological approach with an simulation environment taking into account the three aspects of the company distribution. Indeed, in the resume of the state of the art is illustrated that company distribution is not completely managed by existing methodologies and tools. Moreover concepts attached to multi-agent systems are adapted to model and simulate the behaviour of industrial systems.

In section 2, we present a short state of the art in the fields of distributed simulation and the multi-agent systems. Section 3 describes the problems and the our approach. Finally we conclude and unveil our perspectives.

## 2 STATE OF THE ART

In this section, we briefly present distributed simulation and the multi-agent systems.

### 2.1 Distributed simulation

The advent of the simulation techniques brought to the industrialists the possibility to model the behav-

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\*SIC : Cooperative Industrial Systems.

ior of their systems in much more realistic ways. Indeed other existing techniques *e.g.*, the arithmetic approach, operational research or the computer-assisted production control; make it difficult to support all the behavioral aspects of an industrial system. Simulation is one of the rare approaches integrating the dynamics of a system and usable in an industrial context. This permits the utilization of different techniques to create a simulation model.

However we would like to concentrate on the following problems: the integration of distribution in the first stage of the model's construction, the fact that accompaniment of tools for simulation by a methodology is still rare and the need for modularity and the reutilisability of the aforementioned models.

To partly solve the problems of the decentralization of information and knowledge like those of times in modeling and simulation, the scientific community has considered the implementation of distributed simulations according to two major approaches: data-processing model and knowledge distributions. In the first case, the distributed data-processing problems were tackled and especially the model synchronization (Filloque 1992). In the second, economical works allow to represent the companies in a world context (Burlat 1996).

Distributed simulation, which is composed of these two axes, makes it possible to take the international characteristics of companies into account *i.e.*, the problems of technical culture, knowledge and geographical distributions can be supported by a distributed simulation model. However this field has not become fully developed yet. Indeed no methodology is truly adapted to these aspects. Moreover existing tools are specific *e.g.*, ARÉVI<sup>1</sup> concentrates on the virtual representation of the systems (Chevaillier et al. 1997) and SWARM is an simulation environment adapted to the artificial life (Burkhart 1994). We ourselves interested more particularly in the second axis of the distributed simulation while use works belonging to the first. Indeed, the data-processing model is not sufficient to resolve the knowledge distribution problems.

## 2.2 Multi-Agent Systems

In this section, we explain the concepts which make up the definition of a multi-agent system. However

we will tackle the reasons of our choice of this technology in section 3.

According to (Ferber 1995), an agent is a physical or abstract entity equipped with a precise degree of intelligence and able to have an influence on its own behavior, on the other agents as on the Environment<sup>2</sup> in which they will evolve. A multi-agent system is composed of the whole of the agents and the Environment. If we take for example a multi-agent system intended to model an ants' nest, the agents will be the ants and the Environment will be composed of rooms, food and cocoons.

Within the framework of the *Systèmes Multi-Agents* team research, we consider a structuring in a multi-agent system construction. This approach, named Vowels (Demazeau 1995), makes it possible to identify a multi-agent system according to four axes: **A**gents, **E**nvironment, **I**nteractions and **O**rganization.

The first axis defines a model of agent. There are two opposing schools of thought. The first considers that agents are equipped with cognitive capacities *i.e.*, they implement a rational algorithm in order to choose the next action to be realized (Boissier and Demazeau 1997). The second school considers that agents are reactive *i.e.*, they react to stimuli by generating an action without directly using a cognitive mechanism (Ferber 1996).

The axis Environment is based on the modeling of the space in which are the agents, and of actions and observations that are possible in the Environment.

The third axis allows the study of the interactions existing in the modeled system. The interactions are only messages made by the agents. These communications can have a complexity from simple messages, to protocols of interaction based on communication languages (Carron et al. 1999).

The last axis is the implementation of an organizational model of the agents. Here the concepts of hierarchy, market or community allow the placement of a mechanism making it possible to create an organization within the agent society (Hannoun et al. 1998).

Modeling and design containing multi-agent systems make it possible to be partially abstracted from problems involved in the communication between

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<sup>2</sup>We define the Environment as the space in which agents exist, the environment of said agents which is composed of the Environment and other agents

data-processing processes.

### 3 MULTI-AGENT METHODOLOGICAL APPROACH

We suggest working on a methodological approach of modeling and simulation in term of distribution of various flows (physical, decisional and informational). This approach is completed by the implementation of a simulation platform integrating the concepts of distribution, which will be released by methodology. We can locate our work within the framework of the distributed methodologies and placed along an axis corresponding to the distribution level of simulation. We carry out a methodology integrating the geographical, decisional and informational distributions by associating it with simulation environments that are able to be distributed.

Our methodological approach, which is made up of the four traditional phases (analyze, specification, conception and implementation) and of AEIO approach, is based on UML (Muller 1997). The latter can be extended with the concept of stereotypes. Thus we can create a UML package, which is specialized in the simulation model construction.

The suggested methodological approach is strongly influenced by the multi-agent systems. They make achievable the three aspects of the industrial system distribution :

**Physical Distribution** The autonomy and the interaction capacities of the agents make it possible to carry out at the same time the distribution within a data-processing network, and the distribution of the various industrial system parts by associating each agent with the one of them;

**Informational Distribution** The cognitive and interactional agent capacities make it possible to distribute information;

**Decisional Distribution** The cognitive mechanisms composing the agents allows to set up the decision-making processes (Burlat 1996).

Moreover the modularity generated by the use of a multi-agent system permits the use of existing simulation tools. Indeed, the industrialist has at his disposal a significant number of software. This can

be mono-site and mono-platform *e.g.*, ARENA® or SIMPLE++®, or may simulate models not specifically belonging to the industrial system class, *e.g.*, SWARM.

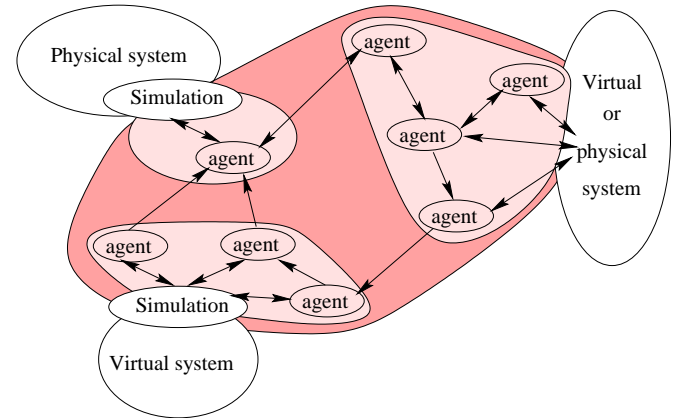


Figure 1: Multi-agent system allowing distributed simulation

These various points led us to propose the representation of figure 1. We want to carry out a model of distributed simulation using at the same time existing tools but also, following the SWARM example, systems only made up by agents able carrying out a simulation.

In order to allow us a progressive resolution of the problems involved in the design of our methodological approach and our simulation environment, we decided to use an iterative approach. Figure 2 illustrates our vision of a working progression. We start from a traditional object approach made up of a series of successive refinements. They move according to a progress axis corresponding to the refinement of the Vowel or AEIO multi-agent approach. We consider that synchronization is a necessary technique to pass from design to implementation stages. This step will enable us to gradually merge our methodological approach and our simulation environment. The progress of the evolution on each direction is parallel *i.e.*, we will make develop our work in a precise direction according to our needs.

This spiral vision of our work enables us to release the first stages, which will especially touch on specification, design and implementation with the Vowel approach :

- analyze of a system made up of two machines functioning like a flow-shop, and independent of a simulation tool;
- analyze of a system always made up of two ma-

chines but in which cycles are authorized (always independent of a tool for simulation);

- generalization to a system with  $n$  machines.

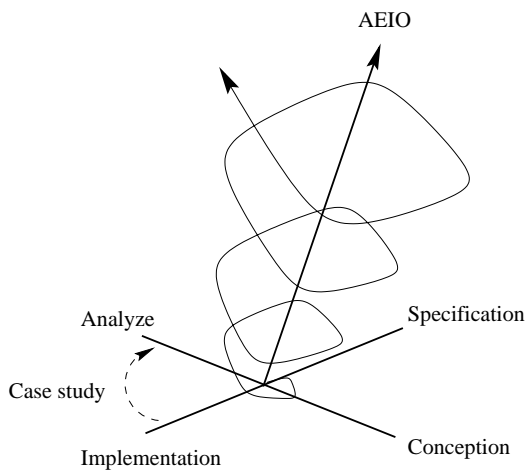


Figure 2: Evolution of the Problem Analysis

## 4 CONCLUSION AND PERSPECTIVES

Simulation is a recognized by the industrial world for its ability to highlight industrial system behavior. But with the modern company progress, which tends to distribute physical devices as well as that of knowledge, this tool shows its limits. Even if techniques such as distributed simulation take into account the geographical distribution of a system, the decisional and informational areas are still not easily managed. This last problem was studied by scientific community during economical works on the company modeling. This knowledge was seldom used within the framework of the creation of simulation tools.

In this context, we offer a methodological approach integrating the geographical, decisional and informational distributions; and a simulation environment based on a multi-agent system. The problems concerning the distribution of physical flows having already been studied within the framework of work on Distributed Data processing, we centered our research on the knowledge distribution modeling by the intermediary of the multi-agent system cognitive capacities. Thus with our iterative approach, we gradually conceive the various stages composing our “distributed” methodology.

Our first work will be to study an application with

some students who will use our method on several fictitious companies. It will be only based on a generalized flowshop modeling and will be composed by physical and decisional models. The physical models physical flows of the simulated system and decisional allows a dynamic strategical management. Each model managed by students are placed in a situation that allowing the illustration of the dynamic behaviors generated by the interactions between the different model parts.

Thereafter we will work in parallel on the methodology design and on the simulation environment update.

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