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Towards a holonic multiple aspect analysis and modeling approach for complex systems: Application to the simulation of industrial plants

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Abstract

In complex systems, multiple aspects interact and influence each other. A vast number of entities are present in the system. Traditional modeling and simulation techniques fail to capture interactions between loosely coupled aspects of a complex system. In this work, we describe a generic framework for modeling and analysis of naturally distributed and complex systems based on Holonic Multi-Agent paradigm. We illustrate the suitability of our generic model by applying it to the modeling and simulation of an important industrial plant in the east of france.
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Keywords: Simulation methodology; Holonic multi-agent systems; Views

1. Introduction

In the past years researchers have deployed a considerable effort in the analysis, modeling and simulation of complex systems. Their work has improved our understanding and methodologies to design software capable of simulating such systems.

In order to simulate its behavior, we need first a model of the real world. However, to obtain a reliable model, we cannot analyze a complex system with only one dimension. In complex systems multiple aspects interact and influence each other. It is essentially this characteristic that attracts the interests of researchers and where lies the difficulty of this type of systems.

One possible way to reduce complexity is to divide the analysis objectives in perspectives or views of the system. Indeed, the modeling and analysis of complex systems involve various professionals which may have different views or requirements. Tackling the study of several views at once makes the modeling process difficult [23]. Dividing the system in perspectives enforces the separation of concerns, reduces the number of enti-

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ties involved [33,32] and decreases the complexity of the process. Indeed, each objective acts as a filter through which we identify a set of important entities. This approach lets us concentrate on those important entities while making abstraction of less meaningful components. We call these filters *Views* of the system.

In this paper we present this approach applied to the analysis and modeling of an important industrial plant of the east of France. The plant of PSA Sochaux is greater than 250 hectares, and, as most industrial plants, is in perpetual evolution. The plant, that produces over a 1700 automobiles per day, requires constants improvements and expansions in order to handle the increasing demand of vehicles world wide. As the production grows new buildings need to be implanted and production units relocated.

The production chains are located inside buildings that exchange their products using trucks. These trucks have predefined tours inside the plant. Buildings with an exchange on a regular basis are called a Building Family. Identifying these families can be a useful tool when redefining the trucks' routes and, even more important, when planing an infrastructure modification. Any change could, in return, generate perturbations on the traffic flow and, thus, in the smooth functioning of the plant as a whole. Moreover, it allows the identification of functional dependencies in the plant and to estimate the impact of relocating production unit could have on traffic.

This plant, containing even an internal railway, can be seen as a small town with a high density of traffic. The plant counts with over 19,000 employees working in different shifts to ensure the plant produces 24 h a day. Last year over 1600 trucks entered the plant every day. Geographically, the plant is enclosed by three cities and a highway. Such a configuration, shown in Fig. 1, makes impossible to simply increase the plant's size to accommodate new buildings, forcing to redesign the infrastructure.

Due to the great number of constraints and interrelated dependencies between traffic and production, a simulation tool could prove to be of great help when evaluating different designs. Even the smallest modification in a plant of this size often requires a significant budget to be invested. A reliable simulator offers the possibility of detecting "side-effects" prior to the project's validation. Our system aims to provide a set of tools to help the decision maker when preparing infrastructural modifications, such as new buildings, parkings, relocation of production units, road planification, etc. or when changing functional elements, like trucks' schedules and routes.

In our study of the plant, we used two views of the system, see Fig. 2. The first one, *Traffic View*, concentrates on the traffic inside the plant. In this view, the modeler will identify and look at "traffic related" components, like roads, vehicles, traffic lights, etc. It also concerns the identification of parameters that will provide meaningful information to estimate the congestion, possible jam, etc.

The second view, *Building Families View*, tries to identify groups of buildings with important product exchange. This information is of great importance in order to optimize the production chain. It also has an important impact on traffic since an important product exchange implies a significant traffic flow between the concerned buildings.

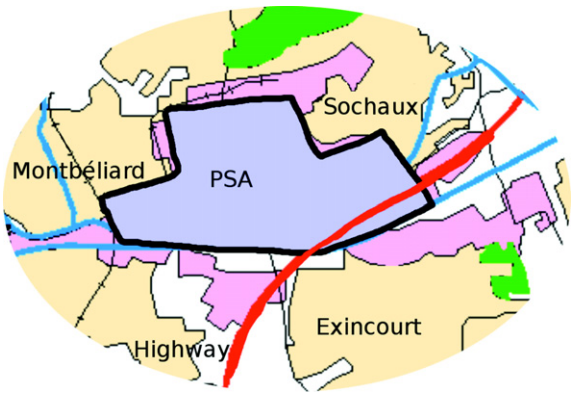

Fig. 1. Geographical location of PSA Sochaux.

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