# Chapter XXXVI
# Application of RAP/AOR to the Modeling and Simulation of a Ceramics Factory

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## ABSTRACT

*This chapter describes the application of the RAP/AOR methodology proposed by Taveter and Wagner (2005, 2006) to the modeling and simulation of a real ceramics factory. The chapter addresses the modeling of the ceramics factory from the interaction, information, and behavior aspects of the methodology. The chapter also discusses the simulation of the manufacturing processes of the ceramics factory by executing the process models developed using the RAP/AOR methodology. The method is aimed at the creation of simulation environments and automation systems of distributed manufacturing.*

## INTRODUCTION

According to Tamm, Puusepp, and Tavast (1987), the so-called "modeling by simulation" is one of the most practical means of conceptual analysis of a problem domain, because it enables learning of and experimenting on the target system with complex internal dependencies, and trying out the influences of decisions of informational, technological, and organizational nature.

On the other hand, new business models emerge. The importance of subcontracting is emphasized by, for example, Zeng and Sycara (1999): "In manufacturing, managers face 'make or buy' decisions, i.e., the choice of making components/products in house or subcontracting them to outside sources ... These decisions are critical in today's highly competitive and dynamic business environment." On the European scale, subcontracting is often the only way how the countries newly admitted to the European Union, as well as the other candidate countries from Central and Eastern Europe, are able to participate in the European division of labor. Primarily for this reason the case study of the current chapter deals with the Tallinn Ceramics Factory Ltd. (http://www.keraamikatehas.ee) located in Tallinn, Estonia. Introducing new business models is already acute at the Tallinn Ceramics Factory because a remarkable portion of the orders received by it are sub-contractual orders for mug handles and stove tiles for fireplaces from Sweden and other countries.

In this chapter, the *Radical Agent-Oriented Process* (RAP) methodology of agent-oriented modeling is employed. The RAP methodology was proposed by Taveter and Wagner (2005, 2006), and it is based on the agent-object-relationship (AOR) Modeling Language (AORML, http://aor.rezearch.info). In AORML, the agents in a problem domain are distinguished from the (non-agentive) objects. The agents' actions, event perceptions, commitments, and claims are explicitly included in the models.

It was demonstrated earlier by Wagner and Tulba (2003) that agent-oriented modeling by AORML lends itself easily to simulation. In this chapter, we first show how business and manufacturing processes of the ceramics factory can be modeled by making use of the RAP/AOR methodology. Thereafter we address the actual simulation of the manufacturing processes by means of the simulation environment described by Taveter and Wagner (2006).

## MODELING OF THE CERAMICS FACTORY

In this section, the modeling methodology proposed by Taveter and Wagner (2005, 2006) is applied to the case study of the Tallinn Ceramics Factory. We decided to model the factory in an agent-oriented manner for two reasons. Firstly, since there are communicating and interacting agents (actors[1]) everywhere, it is the most natural way and in a sense truly nature-inspired. Secondly, an agent-oriented modeling approach lends itself easily to simulation. As has been shown by Taveter and Wagner (2006), the models of the problem domain worked out by following the RAP/AOR methodology can thus be quite straightforwardly turned into the implementation constructs of the simulation environment. It is important to emphasize here that agent-oriented modeling and simulation of a problem domain does not imply an automation solution based on software agents.

### Principles of Reactive Scheduling

The core of manufacturing processes of any factory lies in the scheduling of production operations. In real life, scheduling is reactive as much as predictive. A general scheduling solution utilized in the modeling and simulation effort described in this chapter is based on the works by Ow, Smith, and Howie (1988), Smith, Ow, Muscettola, Potvin, and Matthys (1990), and Smith (1995) because the method proposed in them can be easily transformed into an agent-oriented one. Note that applying the scheduling method described in the works referenced effectively means re-engineering, that is, improving the existing manufacturing processes of the factory.

According to Smith et al. (1990), the factory scheduling problem can be defined as one of coordinating sequences of manufacturing operations for multiple orders so as to:

- obey the temporal restrictions of production processes and the capacity limitations of a set of shared resources (i.e., machines); and
- achieve a satisfactory compromise with respect to a myriad of conflicting preferential constraints (i.e., meeting due dates, minimizing work-in-progress, etc.).