Using Simulation Based on Agents (ABS) and DES in Enterprise Integration Modelling Concepts

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Abstract. The aim of this paper is to share the dilemma about approach to simulation tool selection. The paper presents the results of the authors researches using methodologies of enterprises architectures (CIMOSA and GRAI) where agent approach is used to solve planning and managing problems. Processes are performed in enterprise manufacturing and supply chains. To verify new proposed solutions, simulation experiments are necessary. The problem is which simulation tool is appropriate to use for verification. Selected tools based on ABS and DES are presented. Some tools combining DES and ABS approaches are described. The process of choice and recommendation is also presented.

Keywords: Multi-agent systems, DES, simulation, Process modelling, Enterprise Architecture.

1 Introduction

The different economic and financial crises existing today have increased the necessity of enterprises to be prepared and well-organised. Enterprise modelling is one way for restructuring them in order to improve their performance and being more efficient. Three methodologies are mainly used for modelling enterprises: PERA, CIMOSA and GRAI. Enterprise modelling involves not only global enterprise performance improvement but also local improvements. Authors use in

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their researches CIMOSA and GRAI methodologies. For both multiagent systems was elaborated. In the case of CIMOSA it was agent system for planning process. For GRAI the research concerns a new tool based on agent system. The general structure of the tool is based on Case Based Reasoning (CBR). The CBR concepts are combined with Multi-agent systems for developing the new tool. Case Based Reasoning (CBR) remains widely used for the definition of the needs for the design and development of expert systems. The originality of this part is that it shows how the reasoning is combined with the theory of Multi-Agent systems and Artificial Intelligence and Metaphors of Mind.

In both case the verification of developed methods is necessary. Actually simulation is widely used and practically only one tool which can enable verification of complex systems.

The both presented cases are regarding manufacturing and supply chain processes. The logic of the planning and design of expert tool allows the use of agent technology but the simulation of the processes of manufacturing and supply chain is not so obvious. In authors' opinion in order to continue the further research, it is necessary to use simulators that take into account both the requirements of the agent approach and the requirements of classical DES (Discrete Event Systems). In this paper both approaches are discussed. The authors present available commercial simulation tools and define the requirements from point of view of the potential users- engineers dealing with operations management and supply chain processes.

The paper presents brief theoretical introduction to the studies (Section 2). Section 3 describes the management using MAS and model ling of manufacturing and supply chain processes. The overview of tools for Discrete Event Simulation DES is provided in Section 4. Discussion on the selected tools is presented in Chapter 5 and final conclusions are stated in Section 6.

2 VLPrograph and GraiMOD

CIMOSA is used for improving enterprises locally. The results of the previous studies are presented in paper [4]. These results consisted in planning the process taking place in an enterprise characterized by the manufacture of complex products (machine building). The idea is based on the so-called domains of the CIMOSA concept which has been used for the modelling. A planning process based on the multi-agent architecture called VLPRO-GRAPH. Agent-based system is defined in the present section as a multi-agent system that acts as a support tool and utilizes the databases of main system (ERP system). Multi-agent system is a collection of heterogeneous, encapsulated applications (agents) that participate in the decision making process [3]. The architecture of the tool (VLPRO-GRAPH – Very Long Process Graph) is based on the assumption that the system will support the MPS creation in ERP system and will be plugged in to ERP system database by for example java connector. This architecture was introduced in [5] and extended by a new agent, i.e. MR agent (movable resource agent). The task of this agent is integrated with the planning process which is described at three layers reflecting to [4]: A – the whole process perspective, the

so-called whole process planning; B – the entity level where the whole process plan is divided into sub-plans which are executed by each sub- process and being transformed for individual production schedule at the domain level and where local re-planning activities takes place; C - domain sub-layer where production control activities are executed and information about disturbances is gathered and passed to upper levels.

GRAI Methodology is used for global performance improvements. GRAI Methodology is designed and defined for managing of this modelling. This method is used for example to choose and implement a computer tool (Supply Chain management and ERP) which meets the real market needs (globalisation, relocation, capacity to be proactive, cost optimisation, lead time, quality, flexibility, etc….). GRAIMOD is a tool being developed for supporting the methodology [1]. The general structure of the tool is based on Case Based Reasoning (CBR). According to CBR concepts the new case studied could be capitalized, but the parameters would also improve the reference model of the enterprise domain. Java is chosen for developing GRAIMOD. The Jade platform is being used in relation with FIPA-ACL for developing the different modules of GRAIMOD (GRAIQUAL for managing quality approach, GRAISUC for choosing and implementing an ERP or SCM tool in an enterprise and GRAIXPERT for managing reference models and rules used to improve enterprise performance).

The use of multi-agent systems will allow to facilitate the development of GRAIMOD. Some changes could be integrated according to the opinion of Jade specialists. Then CBR needs to be related to Multi-agents systems in order to satisfy user requirements. The reactive agents are not appropriate to our problem because they react only for the environment changes.

The global objective of this research is to be more efficient in the improvement of enterprises. The supply chain of each enterprise could be reorganized by using the concepts elaborated. The reorganization takes into account both the production typology and the supply chain in the modelling.

For each enterprise, the supply chain is decomposed into different parts (sourcing, procurement, purchasing, production, distribution, sales, transport and logistics management). For each part GRAIQUAL is used and a quality approach is defined in order to improve this part. Indeed, the optimizing of each part is coherent with the other parts.

For instance, the implementation of SQA in enterprise needs the use of knowledge relating to this enterprise domain, but the system will also evolve during this implementation. The system both provides the new case with data and takes into account the particularity of this new case. The multi-agent system defined is well-suited to this kind of work: use and capitalization of knowledge.

Multi-agent systems architecture also facilitates the communication between each different module of GRAIMOD by defining connections from each module to the others. The improvement of quality in the whole enterprise has a positive impact on cost and on delivery date.

3 Process Simulation – DES and ABS

For manufacturing and supply chain process simulation DES (Discrete-Event Simulation) has been mainstay for over 40 years. DES is useful for problems that consist of queuing simulations or complex network of queues, in which the processes can be well defined and their emphasis is on representing uncertainty through stochastic distributions [7]. Many of these applications occur in manufacturing, supply chain and service industries as well as queuing situations.

DES models are characterized by [7] process oriented approach (focus is on modelling the system in detail, not the entities). They are base on top down modelling approach and have one thread of control (centralised). They contains passive entities (i.e. something is done to the entities while they move through the system) and intelligence (e.g. decision making) is modelled as a part in the system. In DES queues are a key element; a flow of entities through a system is defined; macro behaviour is modelled and input distributions are often based on collect/measured (objective) data. These attributes describe manufacturing and supply chain processes too.

ABS (Agent Based Simulation) help to better understand real-world systems in which the representation or modelling of many individuals is important and for which the individuals have autonomous behaviours. ABS offers something novel, interesting and potentially highly applicable to manufacturing and supply chain. However, there is relatively little evidence that ABS is much used in the Operational Research community, there being few publications relating to its use in OR and OR-related simulation journal. Much greater volume of ABS papers is in journals from disciplines such as Computer Science, the Social Sciences and Economics.

Summarized ABS models are characterized by [7]:

- Individual based (bottom up modelling approach); focus is on modelling the entities and interactions between them;
- Bottom up modelling approach;
- Each agent has its own thread of control (decentralised);
- Active entities, i.e. the entities themselves can take on the initiative to do something; intelligence is represented within each individual entity;
- No concept of queues;
- No concept of flows; macro behaviour is not modelled, it emerges from the micro decisions of the individual agents;
- Input distributions are often based on theories or subjective data;

These attributes doesn't describe manufacturing and supply chain processes but describe many aspect of management.

The emergence of ABS as a technique in Operational Research is timely. Globalised business is a highly complex management process, and making decisions in this environment is not well supported by the current set of tools, including DES [1].

4 Available Agent Systems

In table 1 is presented list of selected agent systems. This list includes systems which originate really from agent based approach.

Apart from presented list there are available many systems based on Java like: iGen, ICARO-T, JABM, JAMEL, JANUS, JAS, JASA , JCA-Sim, Madkit, Mason, Moduleco, Sugarscape, VSEit. There is a number of excellent academically developed tools, the commercially available software is limited to AnyLogic (but Anylogic origins are from DES so we classified it as DES system which included ABS approach), and all of these products expect knowledge of object oriented programming techniques and the modeller needs to be comfortable with Java. It is difficult to find an agent system which has possibilities to combine agent based and DES.

Table 1 List of selected available agent systems.

Name	Description	www
Altreva Adaptive Modeler	software application for creating market simulation models for price forecasting of real-world stocks and other securities.	www.altreva.com
AgentBuilder	an integrated software toolkit to quickly develop intelligent software agents and agent-based applications	www.agentbuilder.com
AOR Simulation	AB discrete event sim.; special extensions for modelling cognitive agents (with beliefs and speech-act-based information exchange communication).	oxygen.informatik.tu-cottbus.de/aor/
Ascape	General-purpose agent-based models.	ascape.sourceforge.net
Brahms	Multi-agent env. for sim. organizational processes	www.agentisolutions.com
Construct	Multi-agent model of group and organizational behavior.	www.casos.cs.cmu.edu/projects/construct/index.php
FAMOJA	Resource flow management, theoretical systems science, applied systems, environmental analysis	www.usf.uos.de/projects/famoja/
JADE	Distrib applications composed of autonomous entities	jade.tilab.com/
NetLogo	Social and natural sciences; Help beginning users get started authoring models	ccl.northwestern.edu/netlogo/

5 DES Systems on the Market

Table 2 presents the list of selected DES systems. This list includes systems which really originate from discrete events approach.

Table 2 List of selected DES systems available on market (O – Open Source, C – Commercial).

Name	Description	O/C	www
PowerDEVS	an integrated tool for hybrid systems modeling and simulation based on the DEVS formalism.	O	www.fceia.unr.edu.ar/lsd/powerdevs/index.html
SimPy	an open source process-oriented discrete event simulation package implemented in Python.	O	simpy.sourceforge.net/

Table 2 (*continued*)

Tortuga	an open source software framework for discrete-event simulation in Java.	O	www.ohloh.net/p/tortugades
Facsimile	discrete-event simulation/emulation library	O	www.facsim.org/
Galatea	the product of two lines of research: simulation languages based on Zeigler's theory of simulation and logic-based agents.	O	galatea.sourceforge.net
MASON	fast discrete-event multiagent simulation library core in Java	O	cs.gmu.edu/~eclab/projects/mason/
AnyLogic	graphical general purpose simulation tool which supports discrete event (process-centric), system dynamics and agent-based modeling approaches	C	www.xjtek.com/
Arena	simulation and automation software developed by Rockwell Automation. It uses the SIMAN procesor and simulation language.	C	www.arenasimulation.com
Enterprise Dynamics	simulation platform developed by INCONTROL Simulation Software. Features include drag-and-drop modeling and instant 2D and 3D Animation	C	www.incontrolsim.com
ExtendSim	general purpose simulation software package	C	www.extendsim.com
Flexsim	discrete event simulation software which includes the basic and three product lines: distributed simulation system (DS), container terminal library (CT) and Healthcare Simulation (HC)	C	www.flexsim.com
Witness	A discrete event simulation environment, with graphical 2D & 3D and scripting interfaces, for modelling processes and experimentation	C	www.lanner.com
Plant Simulation	by Siemens PLM Software enables the simulation and optimization of production systems and processes	C	www.plm.automation.siemens.com
ProModel	discrete event simulation tools	C	www.promodel.com
Simio	tool for rapid modeling of discrete-event systems to give rapidly an accurate 3D animated models.	C	www.si mio.com

Some systems offer possibilities to combine DES with ABS. the first is AnyLogic. AnyLogic supports agents in a continuous or discrete environment and also supports sophisticated animation capabilities to visualize agent behaviours. It contains a graphical modelling language and also allows the user to extend simulation models with Java code. The Java nature of AnyLogic allows model extensions via Java coding as well as the creation of Java applets which can be opened with any standard browser. The second system is Simio. The Simio framework is a graphical object-oriented modelling framework as opposed to simply a set of classes in an object-oriented programming language that are useful for simulation modelling. The graphical modelling framework of Simio fully supports the core principles of object oriented modelling without requiring programming skills to add new objects to the system. Simio framework is domain neutral, and allows objects to be built that support many different application areas. The Simio framework supports multiple modelling paradigms. The framework supports the modelling of both discrete and continuous systems, and supports an event, process, object, and agent modelling view. The third system is Flexsim. The Flexsim Simulation Software is a new generation of simulation software. The from the scratch own developed simulation kernel, the seamless

integration of Microsoft C++ and the use of the newest OpenGL technology for unrivalled 3D animation in combination with the just as compact as practice-oriented library are the highlights of Flexsim. Flexsim is offered in following versions: GP (General Purpose Simulation), CT (Container Terminal Simulation), DS (Distributed Simulation) and HC (Healthcare Simulation). Flexsim DS is an object oriented simulation tool. Thereby is naturally well suited to ABS. It also possesses special features for modelling large volume systems, either through it's built in modelling constructs, or c++ for especially demanding agent based models.

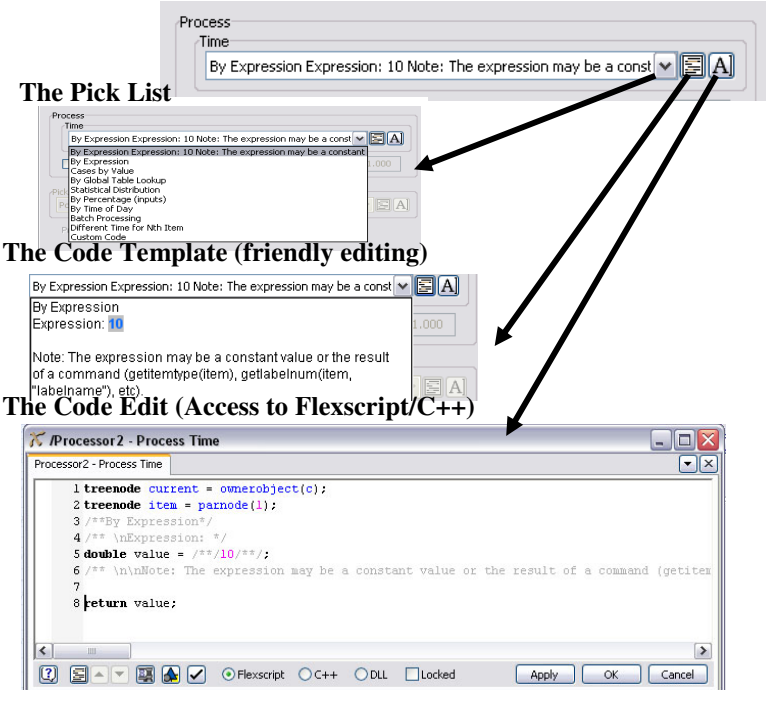

Fig. 1 Different level of user possibilities in Flexsim.

6 Conclusions

We identify two main barriers for ABS implementation in area of manufacturing and supply chain. These barriers are on the different levels:

- features of manufacturing and supply chain processes - queuing simulations or complex network of queues, in which the processes can be well defined and their emphasis is on representing uncertainty through stochastic distributions,

- all of ABS products expect knowledge of object oriented programming techniques and the modeller needs to be comfortable with Java. These are not skills that the average manager has developed during his career. For this reason, ABS remains the domain of a relatively few skilled experts and academic researchers.

The first challenge is therefore for the software development community, working in collaboration with current users from manufacturing and supply chain areas to establish how and where software can simplify the more technical aspects of ABS and reduces this barrier to entry. Reducing the amount of java code to be written is a must [7].

Based on our researches we decided to choose Flexsim (figure 1) as our main simulation tool for two reasons.

The first one is that in Flexsim DS the ability to combine any number of models together provides unlimited scalability, such that in principle, any size of agent model can be constructed. This can be especially important when agent based models have the possibility to become computationally intensive. Flexsim is able to represent agents with objects and can describe the state models of each agent object in it's own modelling language or c++. The 3D virtual reality environment of Flexsim allows the agents to operate in a detailed high fidelity world where geometry, shapes and motion exist. Rapid development of agent models is facilitated through the built in flexscript language engine which does not require compilation steps, and if more simulation execution power is required, the same code can be promoted seamlessly to c++ for optimal performance.

The second is that Flexsim offers possibilities to work through the three levels of users: occasional, intermediate and advanced. According to these levels Flexsim propose to work using (see figure 4):

- the pick list,
- the code template (user friendly),

the code edit (access to Flexsript/C++).

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