DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING - 34TH CYCLE

Title of the research activity:	**Design and management of industrial systems through Parametric Simulation models in the Industry 4.0 era.**
State of the Art:	The majority of today's real-world production systems are complex, stochastic, and dynamic in their very nature. This results in difficulties in representing their actual behaviour and in optimizing and planning their performance. Such difficulties exist in a great number of applications in the areas of product development, manufacturing, and production planning. Hence, simulation modeling has been used extensively to mimic the behaviour of production systems and to provide a flexible platform for parameter design (PD) and system improvement (for example, see [1,2,3,4]). While utilizing Discrete Event Simulation (DES) models in PD problems provides close-to-reality system representation (structure, logic, data, and performance), it lacks the optimization capability. Hence, simulation applications are often combined with methods of mathematical optimization, experimental design, and direct optimization search (see, for example, [5,6]). A number of so-called simulation optimization approaches have been published, which turn out to be of great interest for various types of applications [8,9,10]. Typically, they aim at determining the best possible values of a vector of input variables to a simulation model, so as to optimize a function (e.g., expectation) of an output variable that generally represents a performance criterion. The related literature shows that most of these approaches are actually limited to the search of a vector of input parameters (generally numerical). However, such approaches cannot handle more complex, but often encountered situations, where the decisions to be made to obtain good system performances do not consists only in finding good parameters, but also in determining a good way to ''configure'' the system. What is called configuration here refers to the manner in which the different system's components (sub-systems), will be chosen and put together. It is clear that we are interested here only in the options or in the parameters that can have an effect on the system performances. We will globally refer to these as design options [11,12]; each design option can in turn necessitate the choice between sub-options and/or numerical parameters. The limitations of traditional simulation optimization methods, which only aim at ''tuning'' parameters, would be overcome: we are now closer to an automatic optimal configuration of systems, which opens many perspectives. Several solutions for the efficient design of a system can be provided using this approach. Meanwhile, the theoretical advances in optimization are now limited by simulation model development. As a matter of fact, in certain cases it may appear fastidious to program a simulation model capable of switching from one option to another, so that the optimization module can change the current configurations in accordance with the solutions that need to be evaluated. Pierreval and Paris [7] argue that several research directions seem therefore to merit further investigation of advances in ''automatic'' configuration of systems. In particular, approaches using generic objects [13], hierarchical

	Petri nets, and multi-agents models could be considered, keeping in mind the major difficulties that we have just mentioned.
Short description and objectives of the research activity:	In the perspective of the revolution consisting in the paradigm of the industry 4.0, the ability to model complex systems that can be optimized thanks to the large quantity and variety of available data, represents a fundamental objective. Simulation models play a fundamental role, provided they are able to parametrically represent changing systems, and provided that they allow real-time simulation. The research activity aims to make a significant step forward with respect to traditional approaches. This objective can be achieved through the development of object-oriented parametric discrete events simulation models able to take advantage of the enabling technologies provided by industry 4.0.
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