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Smart Solution for Smart Factory

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Abstract: Modern Industry systems are mostly complex systems with a highly sophisticated level and with high potential for effectiveness and efficiency. To be part of the Industry 4.0 or so called the fourth Industrial Revolution, it needs a business transformation model through digitalization and smart solution. The Design and Management of such systems required Large (Big) Data Processing, Complex Models, Discreet Event Simulation, On Line Control, Multi criteria Optimization tools and also the appropriate knowledge and capacity building for it.

In this paper the integrative approach of modelling, simulation, control and optimization to create a smart solution for complex systems with INTSCHED is presented. Some action taken in UBT (University for Business and Technology) in order to generate knowledge and capacity buildings for Industry 4.0 and the relevant mentioned topics in transition countries like Kosova are shown.

Keywords: design of intelligent systems, control and scheduling, modelling and simulation, optimization, working scenarios, knowledge.

1. INTRODUCTION

Modern market requires a large variety of products/services with high quality and low prices at the same time.

Modern Industry systems are mostly complex systems with a highly sophisticated level and with high potential for efficiency. To be part of the Industry 4.0 (Smart Factory) or so called the fourth Industrial Revolution, we need to transform our business model through digitalization and smart solution. The Design and Management of such systems required Large Data Processing, Complex Modelling, Discreet Event Simulation, On Line Control and Multi criteria Optimization tools and also the appropriate knowledge for it.

Smart Factory is the result of three main developments: integration through digitalization, using flexible structures, strategies (scenarios) and also using the methods of artificial intelligence (smart solution). By connecting resources, materials and system control, it`s possible to create intelligent networks along the entire value chain that can increase the quality of decisions in real time and can control each other autonomously (Kopacek, 2015).

The efficiency of Smart Factory directly depends on the quality of the model and its respective tools which are implemented in the system. This model integrates all the operational functions and activities that are completed by different components of the system with limited resources and a lot of bottlenecks.

For it is necessary to design and implement intelligent tools for the optimization of working scenarios and to solve conflict situations and control such a system in an intelligent way. The optimization has to take three main parameters into consideration: the structure and functionality of the system, the actual state of the system and the scheduling.

The functionality of the system will be presented through the modeling. In this case we will deal with high complexity, different conditions complex systems. It is important that the model allows to integrate the customer requirements, operations requirements and also the actual state of the system. The model should represent the real situation of the system with the real sequences of the activities but in the same time give a grade of flexibility for different alternatives.

The large number of Data will be stored and processed in the system. A dynamic environment will be generated through data generation from the actual state of the system which can mainly be represented from discreet events and also the number of combinations in order to find the best solution. Internet of Thing with the suboptimal solution can support it. Industry 4.0 required the intelligent Control and Scheduling. Control and Scheduling problems for a complex system can pose extremely complex combinatorial optimization problems, because several different constraints may be relevant in realistic problem situations, such as alternative processing plans for the manufacturing of a product, specialized production structures, and so forth. For efficient scheduling of the system, the system operator as a user of the system has to make a lot of decisions in complex situations. Quality of decision and time needed directly influence the efficiency of the system. (Hajrizi and Co, 2001b).

2. INTSCHED – THE INTELLEGENT MODUL OF THE SMART FACTORY

INTSCHED is an intelligent module for control platform (Fig.1) (Hajrizi 2001a). This was developed to support the optimization of dynamic planning and control in Flexible

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Manufacturing Systems. This module, a simulation of the investigated manufacturing systems, consists of several input, output, communication and analyzing modules.

The module is designed as interactive support for the system's operator during: diagnostics of machine tools, equipment diagnostics, orders execution diagnostics, tool and system diagnostics, etc.; Projection of alternative virtual scenarios; Optimization during the scheduling and control; Finding solutions in complex conflicts and chaotic situations, etc.

The implementation of INTSCHED has the following advantages: (1) it can determine a high-quality scheduling, because of several optimizations techniques (insertion of genetic algorithms and some other heuristic methods are implemented), (2) it is very flexible to be connected with another software like SAP or ERP Solutions, (3) it can be directly connected to external databases, so planning with scheduling can be integrated, and (4) it can directly get the real state of each subsystem over special interfaces in real time, so it can be used as a real-time optimizer of complex dynamic scheduling. This module is most suitable for application over a wide range of industry systems.

Especially now where the hardware components (Internet of Thing) are more and more in place INTSCHED can be integrated more successfully.

The result of optimization by INTSCHED is an (sub) optimal order. This order will be built in a virtual scenario in case of simulation (off-line) or in a working scenario in case of scheduling planning (on-line). The results obtained from scheduling give information on how to build up the queues. The queues determine the operation sequences on for example machine tools, the flow of pieces, tool flow and sequence of set-up activities. The necessary data containing the information on the state of the system can be transferred directly over the information-flow structure of the system. Specific data can be given to the module via an interactive dialogue with the operator or over an intelligent sensor system (Fig.1).

This module offers the possibility to use different working scenarios and to solve conflict situations in an intelligent way. The model is based on priority structures and queues of orders and activities. This module is implemented and verified on different complex flexible systems as a part of smart solution.

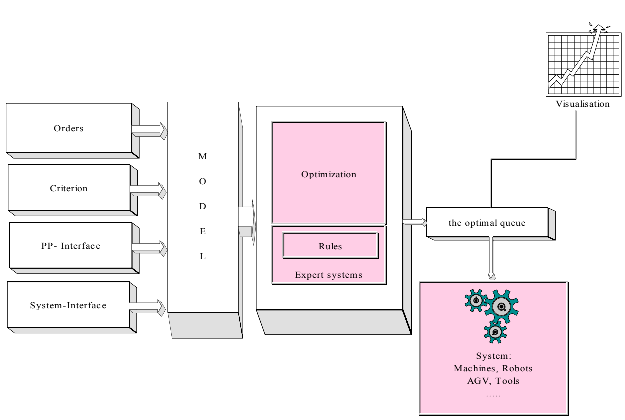

Figure 1. The structure of INTSCHED

3. OPTMIZATION PROCESS

The operator of the control platform initializes a population of orders and gives a time interval as stopping criteria. During this interval the module chooses an optimization method (enumerative, branch and bound, genetic algorithm) and in combination with multi - criteria (heuristic's) generates and optimizes a plan of the system.

The fitness function for the optimizing of the scheduling is a complex function which considers diverse criteria.

For example, for flexible manufacturing systems two kinds of fitness functions are used (Hajrizi, E., 2001b).

The first fitness function is a weighted total evaluation (1) where a lot of simple criteria (priority, setup time, process time, start date, due date, actual state of System, minimizing flow tools, minimizing transportation routes, etc.) are included. There are about 50 different criteria implemented. The criteria can be applied singularly or in combination; depending on the state of the system, the expert - operator will design the best strategy for scheduling.

SUM ((Kij / Gi) * 100) (1) (1)

with:

Kij – weighted total evaluation of criteria **i** for order **j,**

Gi - weighted total evaluation of criteria **i** for all orders.

The algorithm is given as follows:

1. Provide orders,
2. Select the criteria (all together 50 criteria)
3. Initialization of population (randomly)
4. Calculate the weighted function for each order
5. Sort the orders in a queue by weighted function
6. Calculate the object function (example make span)
7. Evaluation of population
8. Selection of chromosomes in new population
9. Repeat the steps 5 to 9 until time = stopping criteria
10. Visualization of order sequences

This scenario is very suitable for on-line optimization. Here it is possible to include all important criteria (including also the actual state of the System) into the fitness function.

The second fitness function can be used as an objective function. There are a lot of objective functions which can be used as fitness functions: balancing machines, minimizing flow times, minimizing total number of rejects, minimizing make span (completion time for the last job), minimizing total processing cost, etc.

The algorithm is given as follows:

1. Provide orders
2. Select the criteria (all together are 50 criteria)