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THE ROLE OF SIMULATION OPTIMIZATION IN PROCESS AUTOMATION FOR DISCRETE MANUFACTURING EXCELLENCE

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ABSTRACT

We discuss the application of simulation to estimate a nominal, or target, processing times for work stations on a serial assembly line. The expectation is that having different processing times per station per product will increase the throughput of the line, compared to having a constant time for all stations. A demonstration case at ABB Robotics in Sweden will be presented. This is a small part in the "*Process Automation for Discrete Manufacturing Excellence*" project (PADME) involving five manufacturing industry partners and four research organizations, that aim at adapting Industrie 4.0 strategies and existing state-of-the-art technologies into new configurations, serving as a framework that can be used by similar industries.

1 INTRODUCTION

With increased global competition, shorter product life cycle, and diminishing market boarders, companies are turning to data to better utilize their resources and speed up decision making, while keeping a wholistic view of the effects of real-time reactions. Industrie 4.0 is concerned with how to securely collect information from various sources, and the methods needed to utilize such information to create a Smart Factory that provides competitive advantage.

The goal of PADME is to investigate and demonstrate how the highly-digitalized and proven systems of the process industry, like collaborative process automation systems (Hollandar 2010), can be used in discrete manufacturing to reduce cycle time, increase throughput, and optimize work-in-process levels. One partner in the project, ABB Robotics, is interested in creating a digital twin of its robot manufacturing plant to investigate questions like: which product mixes achieve the highest profit, how does the layout affect the cycle time, what resource allocation removes bottlenecks, and how can we quote better delivery dates given the system variability.

Addressing such questions required a wholistic view of the operations at the shop floor, and simulation was chosen as a tool to help us understand the connections between the various operations. The work is ongoing and we will focus here on the first part of the project involving the assembly line. In specific, we like to know if the current target processing times, set for the operators, can be lowered and/or made different for each workstation, such that the current throughput is *significantly* increased while keeping the average queue length per workstation less than or equal to one.

2 SIMULATION MODEL DEVELOPMENT

The AnyLogic multimethod simulation software (Grigoryev 2015) was used to model the assembly line. The challenge was in collecting the required data from the various control systems available, and to manually sample those that are not. In specific, we collected data on: processing time per product per station, the resources needed to assemble a product at each workstation (operators, tools, etc.), & the information, or instructions, guiding the operators at the stations. A schematic of the line is shown in Fig 1.

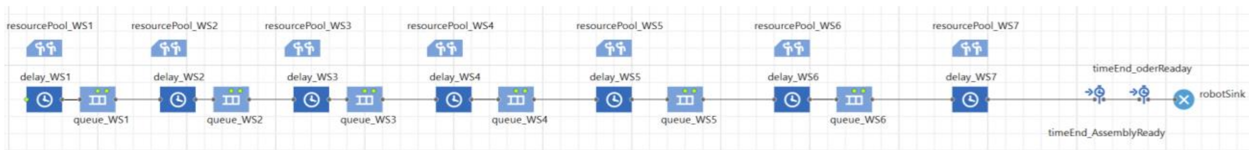

Figure 1: Schematic of the simulation model of the assembly line developed in AnyLogic.

Each workstation was modeled as a delay, a queue (with a size limit of 1), and a resource pool. Resource pools are not identical, nor do they include the same type of resources. The remaining part of the plant is treated here as a blackbox feeding orders into the line, and taking semi-finished products from it. Needless to say that such a simplification has a large effect on the recommended nominal processing times, so it was made clear to the stakeholders that this is just an initial estimate that should be revisited once the remainder of the plant is simulated. There are seven continuous decision variables representing the processing time for each workstation, and seven binary variables representing the queue length per station. The processing times have current recommended values, and follow empirical distributions identified from past data. Assuming that the centrality parameters of these distributions are close enough to the nominal processing times set forth to the operators, we will use the simulation model to evaluate the systematic reduction of the centrality parameters, while maintaining the same probability distribution and adhering to the queue size limit.

3 EXPERIMENTAL SETUP AND RESULTS

The performance measure of interest is the throughput rate of the assembly line. The current, baseline, throughput rate TH_{bl} is measured by running the simulation model with the processing times currently occurring; that is, resulting from having a constant processing time for all workstations. The new, hopefully improved, throughput rate TH_{new} is measured by running the simulation model with "optimized" processing times obtained by searching for new, feasible, values for each workstation. Feasible values were defined in the previous section. The search for improved processing times is done using an evolutionary algorithm, with tuned parameters, that evaluates each generation by running several replications of the simulation model. The algorithm did find better values for the processing times and they did differ from one workstation to the next. However, these new values are not yet implemented to see if the system will actually preform as anticipated by the simulation model or not. It is likely that there will be a difference due to the stationary distribution assumption made while searching for feasible solutions.

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