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EVALUATING WORKERS ALLOCATION POLICIES THROUGH THE SIMULATION OF A HIGH PRECISION MACHINING WORKSHOP

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ABSTRACT

Classic machining workshops assign one operator per machine. However, the production line we work with is highly connected and we now see the possibility to allocate more dynamically the tasks to the workers. A discrete-event simulation model of the metal parts manufacturing production line is built in order to test different allocation policies. We measure how more advanced policies lead to increased efficiency.

1 INTRODUCTION

APN Global is a manufacturing company that specializes into the production of complex and high-precision metal parts. They serve different industrial sectors, among them the aeronautic sector. The manufacturing process involves Computer Numerical Control (CNC) machines, automated measuring stations, manual measuring stations and collaborative robots. Humans are needed for different tasks (e.g. adding raw material, replacing a tool, removing shavings, quality control, etc.). APN collects an impressive amount of data and manufacturing activities and decision-making is highly automated. However, allocation of workers is still done as for classic machining workshops: simply assign one operator per CNC machine (although one operator can be in charge of multiple CNCs). APN's goal is to operate more machines with the same number of workers. Therefore, we developed a discrete-event simulation model in order to evaluate policies for the allocation of "micro-tasks" to the workers, instead of machines.

2 MODEL

We first developed a discrete-event simulation model using SIMIO. While most simulation models' focus is on products flow, our need was to model sequences of tasks: some performed by workers, some by workers and machines, others simply by machines. A conceptual representation of the model is given in Figure 1. The plant has 21 CNC machines (c), 31 workers with different expertise, (d) four measurement machines (f) including two coordinates measurement machines (CMM), one optic comparator and one manual optic comparator. From the APN production schedule (a) we can extrapolate a list of tasks: parts machining (blue), measurement (red) and others (yellow). Parts are machined on CNCs. At the same time, other tasks are accomplished by the workers on a worktable (b), although some may require the CNC to stop. After leaving the work center (e), some parts need to be measured for quality control. This is a complex process that involves many machines and workers. If a measure is out of specification, a corrective action task (e.g. tool change) is created and inserted first place into the waiting queue.

The different aspects of the system model were validated by interviews with experts working at APN in order to confirm that the model is representative of field reality. Expected duration distribution for the production tasks were extrapolated from the manufacturing execution system (MES) historical database. However, measurement and quality control come from "educated guess" by the process engineers.

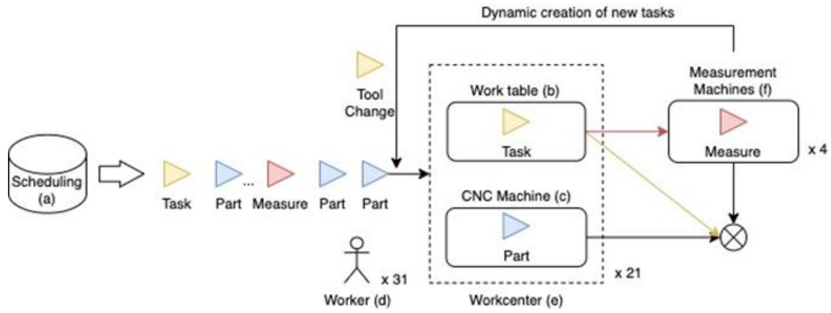
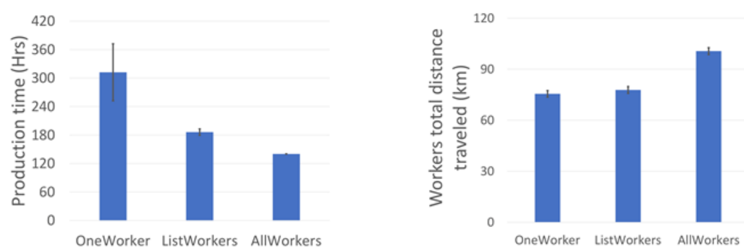


Figure 1: Conceptual representation of the simulation model.

3 EXPERIMENTS AND RESULTS

Different policies were compared regarding how they affect productivity (total time needed to carry on a production schedule) and the workers total traveled distance. The base case scenario is called *OneWorker*. One worker is allocated to one CNC. Once his shift is over, another worker takes over. Under the *ListWorkers* scenario, we are aware each worker is trained for which types of machines and tasks. For each task, we dynamically allocate it the closest free and compatible worker. As an upper bound, we also simulated the utopic *AllWorkers* scenario, where each worker would be trained for all machines and tasks. The following are the average results from 100 replications (95 % confidence intervals) of a single given production schedule (data extraction was very time consuming).



(a) (b)

Figure 2: (a) Production time (in Hours) and (b) Workers total distance traveled (km).

On average, dynamic allocation (*ListWorkers*) reduces total production time by 40.4 % (see Figure 2). What is even more surprising (and explains the previous) is by how much the confidence interval shrink too. Indeed, under the *ListWorkers* scenario we are much less affected by the stochastic nature of the processing times. The *AllWorkers* scenario leads to additional improvements, but it supposes important training costs. As for the walking distance (Figure 3), it is very similar for *OneWorker* and *ListWorkers*. *AllWorkers* greatly impacts walking distance.

4 CONCLUSION

A discrete-event simulation was developed in order to simulate task allocation in a high precision metal parts machining workshop. The main goal was to measure how well productivity is improved when more workers are allowed to process a given task. The next step is to run additional experiments for much more production schedules (that is, to get additional data). We will also test more advanced task dispatching rules and evaluate them regarding to other criteria (ex: fairness). Following this the company will need to develop a system in order to assign the tasks to the workers in real life.