A Simulation Environment for Testing CIM-Elements

Johannes Krauth, Jens Klußmann, Markus Vöge

Bremen Institute of Industrial Technology
and Applied Work Science at the University of Bremen (BIBA)
D-28335 Bremen
GERMANY

Abstract: This contribution describes a new, participative way of selecting CA-applications using simulation. This approach will be explained by the testing and selecting of shop floor monitoring and control systems (SMC-systems) by future users. Current practice confines potential users to a passive participation in decision finding and the evaluation of alternative systems is confined to system demonstrations or visits at reference users. In contrast, the proposed procedure enables testing of SMC-systems by means of a simulation model provided with respective company specific data and environmental information. The simulation model portrays exactly the area which is to be controlled by the SMC-system and thus to allow for the verification of suitability of the SMC-system for any specific task required. This contribution describes the set up for evaluation and first experiences with application in practice.

Dr. - Techn. Johannes Krauth studied mathematics, social sciences, and informatics at the FU Berlin. After finishing his studies he worked on the development of simulation software and optimisation of assembly systems. Since 1990 he has been head of the „Computer Supported Design, Planning, and Production Processes" Department at BIBA.

Dipl. -Inform. Jens Klußmann has been busy with the practical application of simulation technologies. He works at BIBA as research scientist, responsible for the area of simulation in production.

Dipl. -Ing. Markus Vöge has been with BIBA as research scientist since 1990. He is responsible for the area of shop floor monitoring and control and the SMC-laboratory. He is mainly concerned with the planning and realisation of re-organisational measures in such areas as EDP introduction and production organisation.

Introduction

Simulation in connection with production system planning and control systems is mainly facilitated in the phase of installations planning. It is used to check to what extent the projected installation will be able to meet expected performance, how it will react to disturbances, etc. The major part of the available simulation software has been developed for this task.

For some years it has been realised that, once developed, simulation models can also be sensibly applied to subsequent phases in the life cycle of a production installation. The devoted research is brought about by the reflection that despite the increasing power of simulation tools the development of a correct model still requires considerable effort and therefore the result - the model - would, if possible, be further utilised. For instance the model can be used in production planning and control [1], or in development and verification of software [2, 3, 4]. Sometimes the simulation models are also facilitated as unproblematic and accessible training environment for users of company specific data processing systems [5, 6].

On the other hand, the term "simulation" has for a long time now been used in the domain of production planning and control (PPC) in connection with capacity planning. Simulation here aims at a somewhat different target though. Instead of verifying the functioning of an installation, the scheduling of production orders by a PPC system is to be checked and optimised. Accordingly, the tools look different [7, 8].

A new kind of application of simulation technique, a coupling of both kinds, will be described in the following. The aim is to select by means of simulation of a decentral production area, a shop floor monitoring and control system which is suitable for the control of the respective area.

Participative Selection and Testing of Shop Floor Monitoring and Control Systems

Many projects which aim at promoting new technologies fail, because potential users of these technologies do not at all or insufficiently participate in the design, testing, and selection of the systems. Particularly, electronic SMC-systems are instruments which, due to their application area, cannot be developed, tested, and introduced without the future users' involvement.

Traditional approaches to selection and introduction of SMC-systems often miss the target as future users only marginally take part in the selection process. Generally they are only given a short demonstration of the final selection of systems. Therefore, at the Bremen Institute of Industrial Engineering and Applied Work Science (BIBA) a selection method has been developed which may be called "participative Benchmarking". This method comprises comparative and activity oriented tests of SMC-systems by future users, based on company specific data. It builds on their empirical knowledge and supports the decision making as to selection and acquisition.

In the BMFT-funded co-operative project "PLANLEIT - Monitoring Systems for Shop Floor Control" BIBA, together with employees from seven companies in the areas of mechanical engineering, tool production, engine production, installation production, and heavy machine production, comparatively tested SMC-systems on a benchmark. Jointly, three systems were selected which seemed, due to their functionality, philosophy, market presence, and to their producers' readiness in realising the testing results, best suited (AHP-CIM, PIUSS-0 SMC-system, and OPS-Powerstation). On these systems a scenario was implemented based on the actual company situations of seven test-user companies. It became obvious that the users found it very convenient to compare the systems, to define specific system requirements, and to select a system on this basis [compare 9, 10].

The results of participative Benchmarking of a SMC-systems show that traditional ways of designing and selecting systems do not always meet practical requirements. Evaluation catalogues of a SMC-system based on extensive questionnaires and company independent system presentations do not, in the users' opinion, sufficiently support future users in the selection of a system for their company.

By means of comparative testing within a scenario defined by future users they could, in contrast, get a good impression of what possibilities systems currently offered. They gathered ideas for the specification of their company specific SMC-system and they could professionally discuss about the three systems with the system producers.

It becomes clear that users from different companies state differing company specific demands which ask for an individual adaptation of the systems, i. e. no SMC-system can automatically meet all requirements.

When testing the systems along an especially written script, some of the participants became aware of the problem that only a static situation or task could be processed (re-planning of a certain order by a defined machine). The accidental events of real life, i. e. the unexpected breakdown of a machine, missing material, or rejects could not be portrayed. Therefore the project started by aiming at the portrayal of real and accidental events within routine order processing in production and assembly.

The Simulated Production Plant As Test Environment for SMC-Systems

The demand made by the participants to test a SMC-system in a "realistic" environment can most easily and cheaply be realised by linking the SMC-system with a simulation model of the production system which the participant works daily on.

The basic idea is as follows: Using the SMC-system the participant works out a finite scheduling for the supposed order and transfers this finite scheduling to the simulation model. There orders are processed according to scheduling, and the respective status information for the SMC-system is generated. The simulator further generates accidental disruptions in production and sends specific information to the SMC-system. The participant now has the possibility - just as in real production - to check which effects the reported disruption will expectedly have on the SMC-system and on how best it will react. He can test re-scheduling of the system and when he has found an adequate reaction to the disruption, he can transmit the updated finite scheduling to the simulation system. During this procedure two kinds of simulations are to be distinguished:

First a model of the production area to be controlled is derived by means of a simulation tool. In order to run the model with the simulator, the respective result of each re-planning is passed on to the SMC-system. Within this model, work progress is simulated and accidental disruptions are generated, i. e. the model portrays the current situation in production and the respective information is then constantly passed on to the SMC-system.

Within the SMC-software a second simulation now takes place: the current situation, i. e. the state of the first model, is taken over by the SMC-system and further orders are planned and different reactions to cases of disruption are simulated and evaluated according to their consequences. This kind of a simulation is offered by almost every SMC-system.

The two models - one in the simulation system, the second in the SMC-system itself - can vary in graphic portrayal and accuracy. The model in the simulation system can contain considerably more details (e. g. about transportation means) than the SMC-system which generally only contains information about the available resources (machines, human resources). The models also differ with respect to their utilisation: whereas the first one has to be generated and validated by a simulation expert and then it is not further directly used, the second one is defined by the input potential of the SMC-system and is therefore directly available to the user for planning. With the first model the user is concerned only in so far as he transfers his scheduling to this model and receives feedback.

The described coupling of SMC-system and simulation software allows that the user works with the SMC-system the same way as he did in his usual working environment. In so far the coupling is an excellent means for selection of a suitable SMC-system as well as for training of future users.

One has, however, to take into account that - as always when modelling on a computer - the model cannot completely portray reality. Special attention is to be given to the fact that the operator can interact with the simulated production process only through the SMC-system, whereas in real life other ways of communication do exist. Daily, very important especially in decentral areas, informal communication among colleagues cannot be taken into account in computer simulation. Within the range of possibilities of a simulation system, the company reality can, however, be copied at any desired level of detail and accuracy.

A similar coupling between SMC-system and simulation was carried out by Scholtissek (1993) [11], with a different aim though: the suitability of priority rules for finite scheduling in different production systems was to be tested in simulation. In this constellation no operations by the user were required, the SMC-system reacting to each reported disruption according to set rules. In contrast to the works of Scholtissek, our approach is concerned with solving a new problem: in order to be able to compare different SMC-systems, it has to be possible to couple the simulator with different SMC-systems without much effort. This task is burdened by the fact that standardised interfaces currently exist for neither SMC-systems nor simulation systems. Therefore we are also working on standardised interfaces for simulation systems.

At BIBA marketable simulation systems were examined as to whether they offer the possibility of communicating with one of the SMC-systems available at BIBA as "virtual production". The result was positive so that it could be done without the developing of a simulator of their own. When selecting a system and designing an interface there has to be taken into account that communication with SMC-systems of different producers keeps possible without much extra effort. Finally, the prototype of a combined system was developed based on which a company specific order and production scenario could be simulated realistically.

Concept and Structure of the Testing Scenario

Within a project concerned with the introduction of group work in a partly autonomous production isle it became necessary to find a suitable SMC-system for this organisational structure. When testing and selecting systems, especially the SMC-system PIUSS-0 from the company PSI was examined. At BIBA this SMC-system can be coupled with the simulator WITNESS from AT&T ISTEL. Both systems can be run under DOS/Windows. The coupling is done by using the existing interfaces offered by the systems. This way of proceeding guarantees a far reaching independence of the systems used and makes next interfacing of other SMC-systems a lot easier. In the following the preparational generation of the simulation model and the course of testing the SMC-systems are mentioned.

First an abstract model is generated in the simulator which is furnished with the main characteristics of the production isle. It is made up of a number of workstations which are all interconnected by simulation. At each workstation there exists a data capturing terminal (order buffer) which has ready a list of the work steps to be taken and their sequence. Additionally, in front of each workstation there is a physical buffer which during simulation collects the "real" orders to be produced (in order of their arrival). Special rules in the simulator make sure that the sequence of processed orders corresponds with the planned sequence according to the SMC-system list. The model structure is kept so general that an increase in the number of workstations or an alteration of the course of interfacing should be obtained without having to adapt the model.

To the general simulation model company specific data are now added. These encompass next to shift plans mainly statistical distributions for occurring disruptions which can influence real production (e. g. workstation disruptions, illness of staff, variations in processing times, or rejects). Values for these distributions are derived from production control evaluations which are based on the production of the last twelve months (in the traditional organisational structure). The input of distributions into the simulation model is generally not carried out by the user, but by experienced personnel.

Subsequent to the preparation of the simulation model, the required data are fed into the SMC-system. The workstations and the corresponding shift plans and orders are drawn up. For testing the SMC-system to be used in the production isle, 18 different workstations with 39 workplaces were planned which during a week 45 orders with varying tasks and throughput times had to be processed at. Depending on these data the SMC-system generated a loading plan.

For dynamic simulation of production the SMC-system first of all generates a list of all planned but not yet started operations - together with the required information - in form of an ASCII file. These data which are originally intended for a data capturing system, are instead processed for the simulator. Special transformation programs generate the data and data formats which the simulator asks for. Facilitating an ASCII interface, the data are taken over by the simulation model.

Now virtual production starts. The orders are processed in the sequence planned by the SMC-system. They pass through the simulation model according to the real course of operations. At each workstation SMC-system relevant reports are generated (start of operation, end of operation). At the end of the day, or after having processed all orders, the simulation ends. Special possibilities of the utilisation of a virtual production plant in connection with a SMC-system, however, are particularly sustained by the generation of accidental disruptions of the course of production. The simulator generates at random events, as for instance disruptions of machines, processing times deviating from the planned scheduling, or rejects. The occurrence of such events leads to the generation of proper reports (begin of disruption, end of disruption, number of parts, number of rejects), and to the interruption of simulation. In such a case, reports on the state of completion are generated for all started operations. All reports gathered during the run are transmitted to the SMC-system in form of data capturing data.

The back flow of the data again depends on the systems' standard interfaces. The simulator generates an ASCII file with the necessary information. The file is processed by a transformation program and read into the SMC-system via a data capturing system interface. Beside the information on why the simulation was stopped, the system clock which accesses the SMC-system is additionally re-set (the new time results from the moment of beginning the simulation plus the duration of simulation). After having read the data into the SMC-system, the system displays the current order situation in the production plant.

The user sees the new situation on the SMC-system. In case unexpected events have occurred (e. g. disruptions), he can decide on whether he wants to replan the orders which have so far been planned for the disrupted machine or not. In case of re-scheduling or additional new scheduling the course starts as described above. If the user does not desire an alteration of the planned order volume, the simulation is continued from the point at which it was stopped.

Results and Suitability of Testing

Due to the possibility of including real accidental disruptions in the simulation, the testing of SMC-systems has become very close to reality. Given the company specific environment on the computer, the user of the system can adequately evaluate the respective SMC-systems. During testing the members of staff who were to be the future users learned about how to operate SMC-systems, they got informed about possible functionalities of SMC-systems in the SMC-laboratory, and they processed a number of company specific orders. When carrying out routine tasks, as for instance the modification of routing plans, they were interrupted by disruptions randomly generated by the simulator (machine breakdown, rejects, etc.) and had to react to these. Thus the participants could make first estimates of the individual stress caused by the system and the usefulness of the system to real life production. They could for instance check what feedback from production was suited for their work, which effects the disruption had on deadlines and personnel capacities, how often operations on the SMC-system were necessary, which functionalities the SMC-system had, or which requirements the system could not meet.

Benchmarking of SMC-systems in dynamic company scenarios gives to future users the possibility of actively and cheaply knowing about the effects and consequences of SMC-systems in their company.

Future Research

The approach presented here is not limited to the selection of SMC-systems. In principle, it can be applied to the selection of other CIM components as well. Currently, BIBA is exploring its applicability to MRP systems, especially for SME`s.

Other exciting extensions of the approach would be its use to test the co-ordination of various production islands, each one controlled by an SMC-system, or the communication between MRP and SMC-systems.

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