

# DISCRETE MATERIAL FLOW MANAGEMENT IN MULTIPOLAR MANUFACTURING NETWORKS

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**Abstract:** In the paper we will present a multipolar manufacturing network simulation using a new approach in discrete material flow management. We validate this approach using a case study of three partners network acting in a virtual enterprise architecture, analyzed in order to optimize the manufacturing design. Two of them represent product suppliers, and the third represents the enterprise where the assembling will take place, after which the final product will result. In order to evaluate the architecture of the system, we used simulation models of the material flow for the three FMS, using the Witness software. The purpose of the simulation is to introduce our new methodology for multipolar distributed simulation of the material flow in the manufacturing networks in order to optimise the activity between partners and to increase the profit.

**Key words:** manufacturing networks, multipolar simulation, Witness, FMS



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**This Publication has to be referred as:** Popa, C[icerone] L[aurentiu] & Cotet, C[ostel] E[mil] (2010). Discrete Material Flow Management in Multipolar Manufacturing Networks, Chapter 59 in DAAAM International Scientific Book 2010, pp. 679-686, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-901509-74-2, ISSN 1726-9687, Vienna, Austria  
DOI: 10.2507/daaam.scibook.2010.59

## 1. Introduction

Our new discrete material flow algorithm is meant to be used in virtual enterprises architectures. The virtual enterprise represents a temporary alliance of enterprises who wish to share resources and aptitudes for the purpose of making a product in the shortest time possible, at the smallest price possible, and with the maximum satisfaction of the client (Camarinha-Matos et al., 1997). It is based on a technical infrastructure, represented by the informational technologies and by the computer communication networks (Dragoi, 2005).

Also we can say that virtual enterprises could be defined as ephemeral organizations in which several companies collaborate to produce a single product during a project cycle time (Tichkiewitch & al., 2006).

Thus, the projection, planning of production and marketing, supplying, fabrication, services etc. can be realized anywhere in the country, the continent or the world, because of the facilities offered by the infrastructures which allow the change of information, goods and services.

## 2. Multipolar distributed simulation

The multipolar distributed simulation can be defined as an integrated system of monitoring more than two material flow simulations, interconnected inside the architecture of a virtual enterprise (Popa & Cotet, 2008).

In order to realize a simulation model of the material flow in the system, the first step is to define the necessary machine-tools, the work-pieces and the parts involved in the process on the level of each FMS (Flexible Manufacturing Systems). The inputs in the system are represented by the parameters of the machine-tools, of the work-pieces and of the parts involved, and the output of the system is represented by the optimized architecture of the system. The main limitations of the system are: the realization plans, the available realization stages, and the capacity of the CAD-CAM-CAE system to analyze the behaviour of the machine-tools, the work-pieces and the parts in the work regime (Lee, 1999).

The purpose of using this method is to achieve an optimum configuration for the system, regarding machines placement in the working place, the parts manufacturing order etc. In the following case study three partners are found, organized under the shape of a virtual organization. Two of them represent product suppliers, and the third represents the enterprise where the assembling will take place, after which the final product will result.

Using specific solutions, each partner can realize a simulation in order to check the capability of its own system to fulfil the function traced in the virtual enterprise. After this, all these simulations can be integrated in a model of multipolar simulation in order to optimize the material flow in the entire system.

In the following we will define the three partners implicated in the system as being the three flexible fabrication systems, and thus FMS1 and FMS2 will represent the components supplier partners and FMS3 will be the system that makes their assembly.

### 3. Case study

In order to evaluate the architecture of the system, we used simulation models of the material flow for the three FMS, using the Witness software. The simulation of this project was realized in order to demonstrate and confirm the productivity of a fabrication process, based on the presentation of the proposed design and the operational data. Another purpose of the simulation was the identification of the ways to improve the configuration of the system in order to raise productivity.

The improving of productivity means the identification of the material flow concentrators for each FMS and for the manufacturing network as a system, and the proposal of another manufacturing architecture that eliminates the concentrators.

According to the previous statements, FMS1 and FMS2 are diffused systems, and FMS3 is a concentrated system (Cotet & Dragoi, 2003). Therefore, a concentrated FMS can be defined as a manufacturing architecture based on a single work point surrounded & assisted by transport, transfer & deposit facilities. A diffused FMS system can be defined as a manufacturing architecture with more than two work points connected by transport & transfer systems and using deposits at local or system level.

First we defined the parameters for each machine and conveyor and, after running the simulation we will determine the place of the concentrators. Thus for the first system according to reports we have indentified the blockages at machine M1\_2; the activity for this machine is blocked 50% of the time, 47% of the time is working, and 3% of the time is waiting for parts.

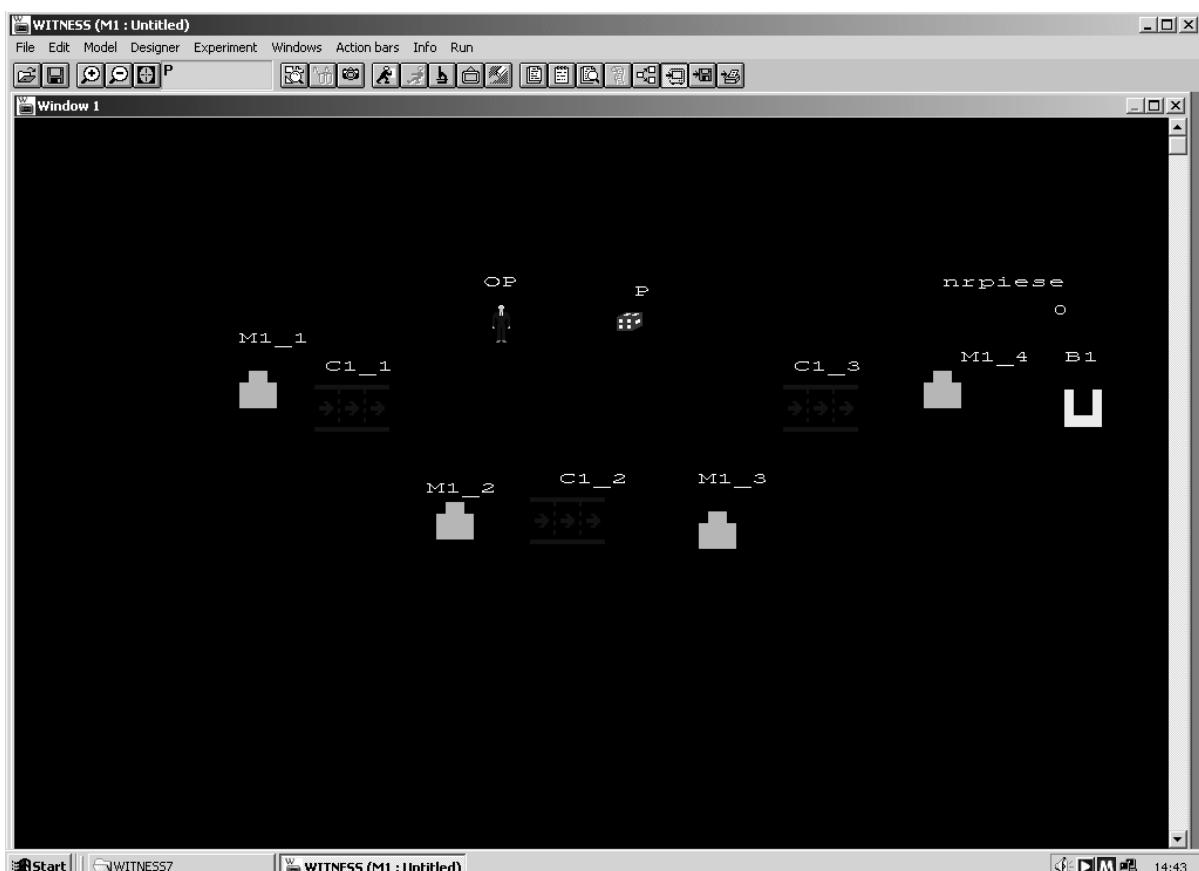


Fig. 1. Witness modelling for FMS1

The activity reports show blockages in C1\_2, its activity is blocked for 45% of the time, 45 % of the time is working, and 10% of the time is waiting for parts. Due to the blockages from the other machines M1\_4 is working just 11% of the total time, 89% of the time is waiting for parts.

Thus, the system appears to be inefficient. We must do a remodelling of the system, a new parameterisation of the system's components and eventually we can run a new simulation. After running the simulation the material flow concentrator from M1\_2 machine is eliminated.

In this new configuration M1\_2 machine is working 75% of the total time and 25% of the time is waiting for parts. An important improvement can be noticed for M1\_4 machine, the machine is functioning 98% of the time, a big difference from the first case when it functioned only 11% of the time.

In figure 2 the FMS2 is presented during simulation. The parameters for each machine and conveyor were defined, and following the simulation, the place where the concentrators of the respective systems were identified.

The report regarding the activity of conveyor C2\_1 is found in figure 3. We can observe the blocking of activity at this unit for 45% of the time, the conveyor is stopped for the intervention of the operator 5% of the time, and the machine works normally just 50% of the total time.

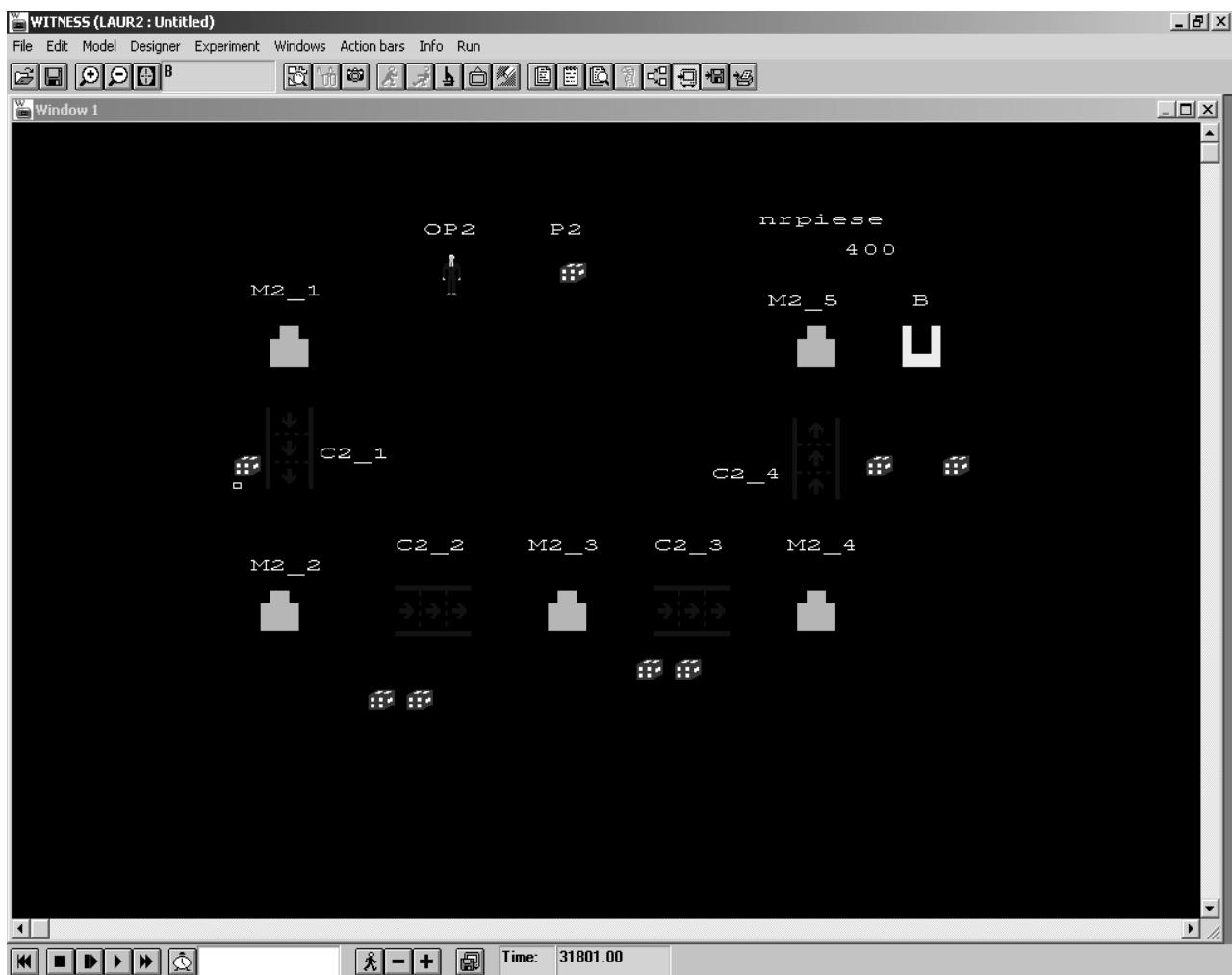


Fig. 2. The FMS2 during simulation

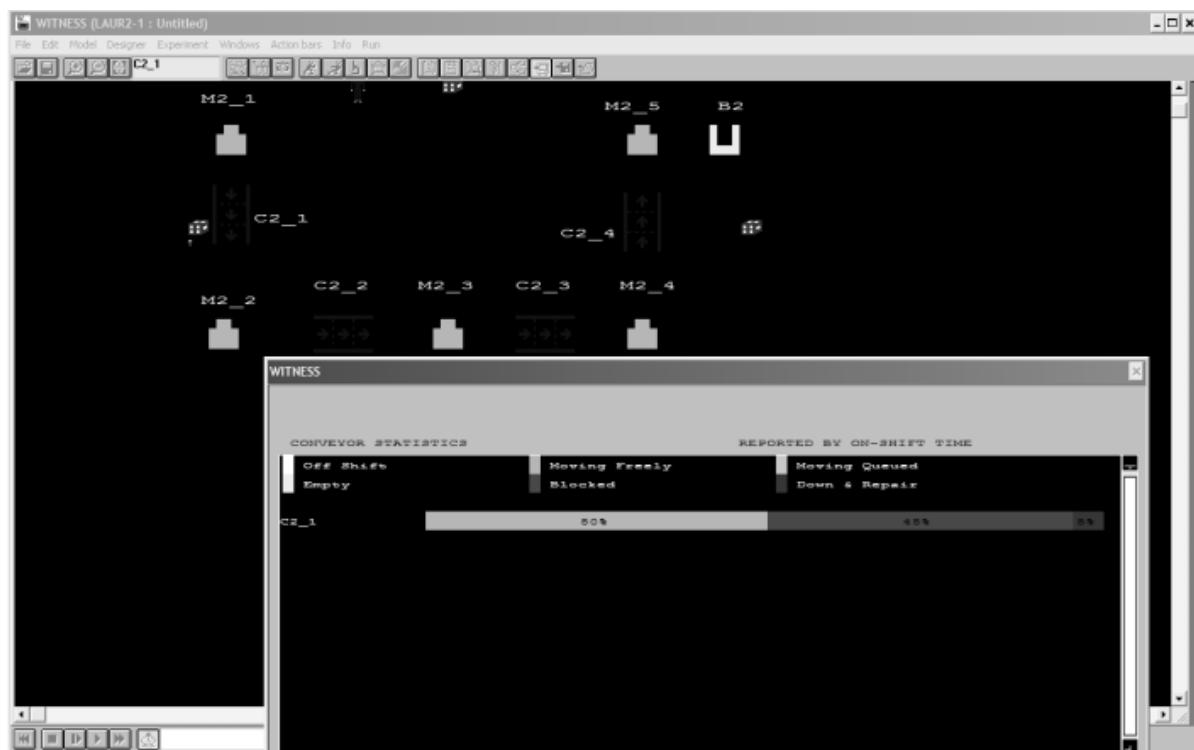


Fig. 3. The report regarding the activity of conveyor C2\_1

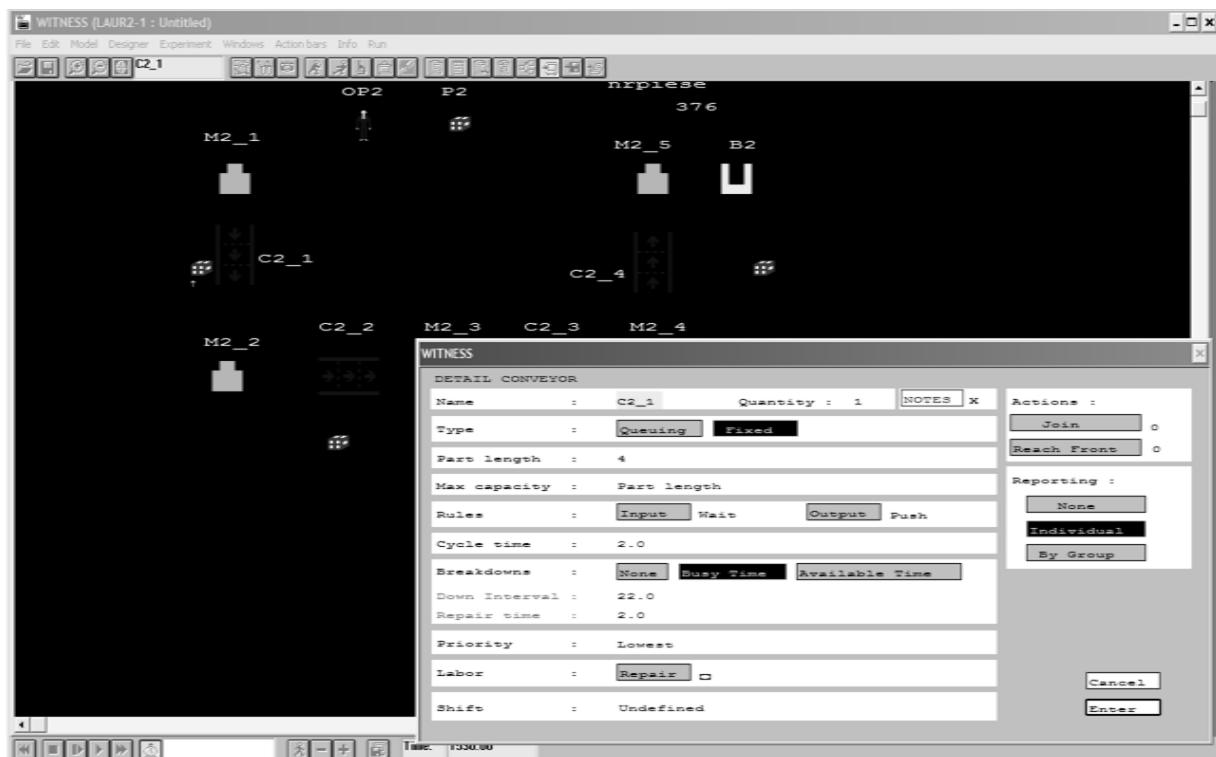


Fig. 4. Definition of parameters for conveyor C2\_1

The FMS2 system was remodelled and a new simulation of the material flow in the system was made. In figure 5 the report regarding the activity of conveyor C2\_1 after the remodelling is presented and we can observe the total disappearance of blockages found in the previous simulation. Thus, the conveyor is in function 55% of the time, 34% of the time it waits for parts arrival, and the time necessary for the intervention of the human resource is of 11%.

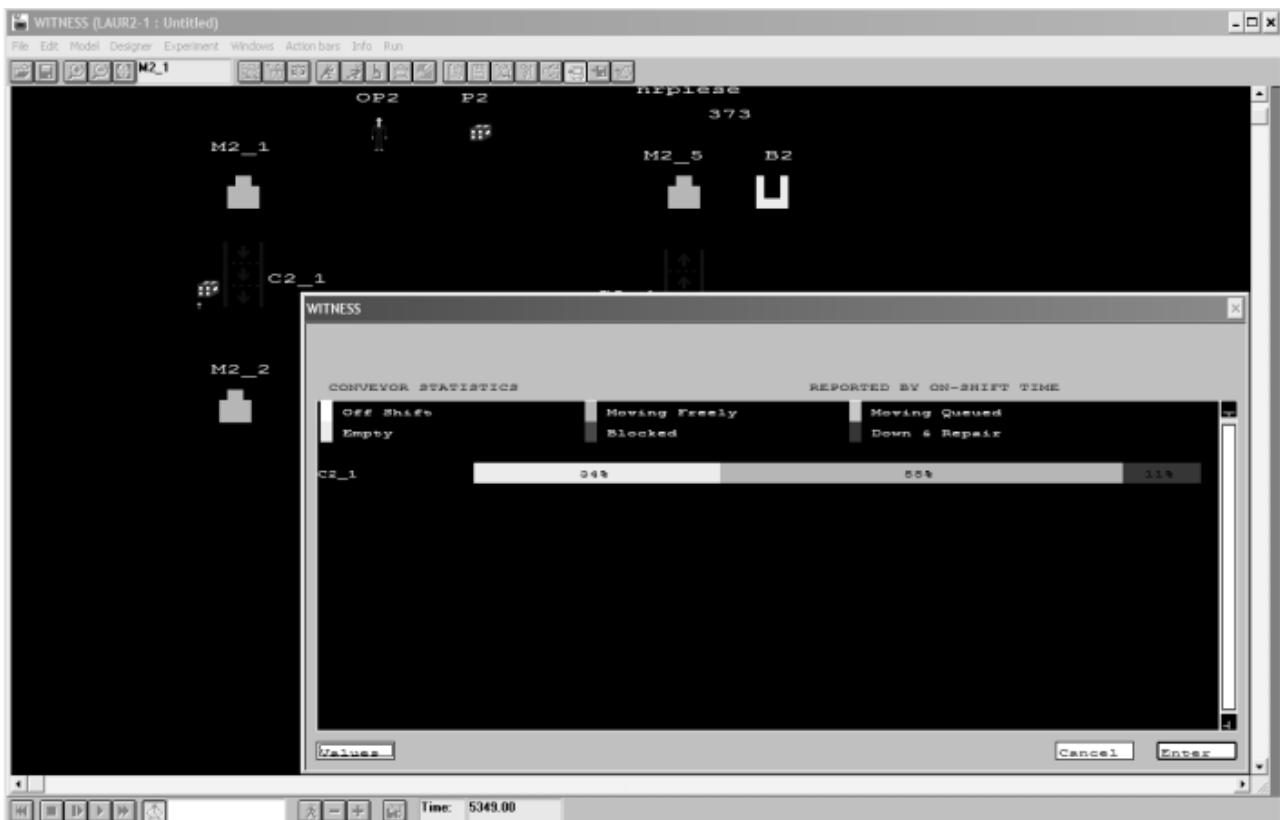


Fig. 5. The report regarding the activity of conveyor C2\_1 after system remodelling

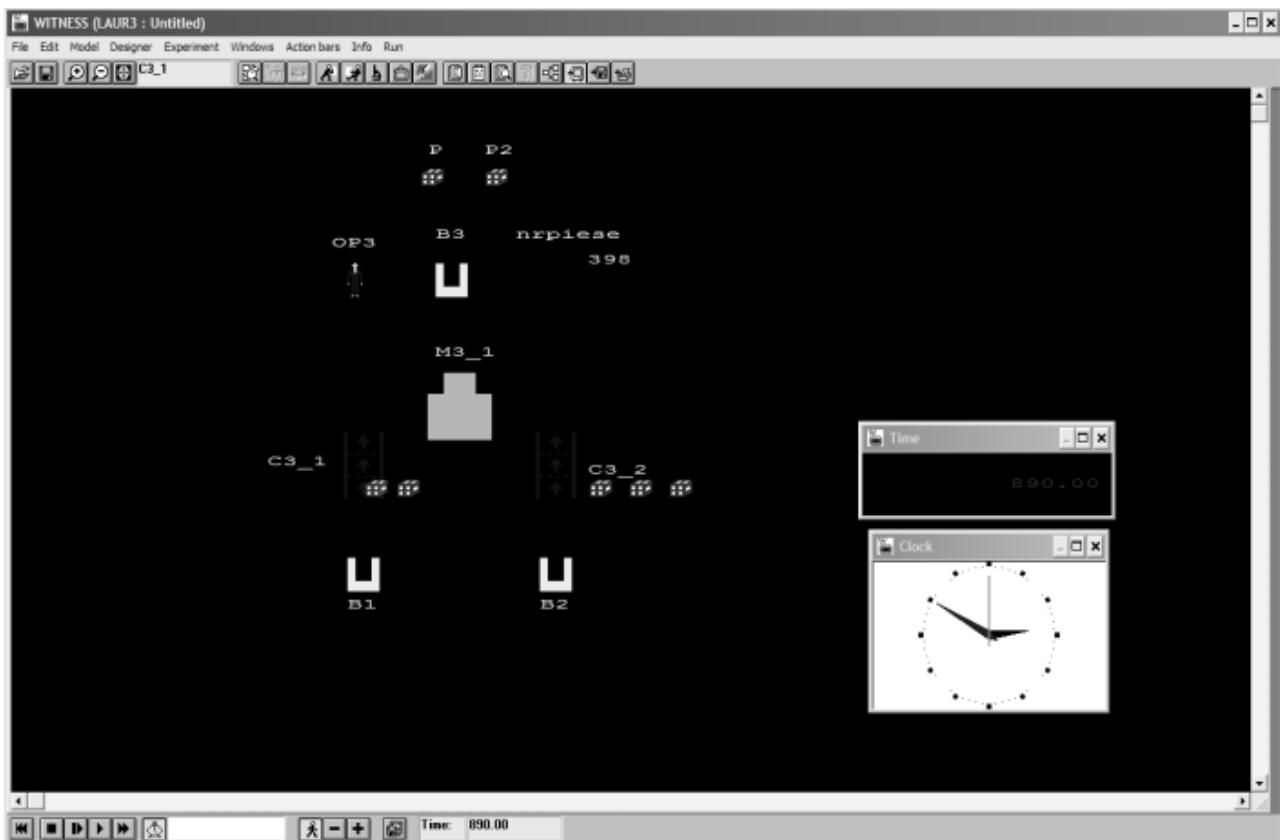


Fig. 6. The FMS3 during simulation

In figure 6 the third manufacturing system is presented during the simulation. We can observe: the B1 and B2 buffers that are the inputs in system 3 and also the

outputs of system 1 and 2; the two conveyors and the machine on which the final assembly is done (M3\_1).

Also, the two parts (P and P2) can be found, which come from the previous systems FMS1 and FMS2, the operator and the number of pieces being worked at the time of reporting. From the study of the rapports and from the localization of the concentrators, especially in conveyor C3\_2, results the necessity of remodelling the system for eliminating the concentrators.

This will be done for system 3, and if concentrators will be maintained it results the necessity of intervention over the inputs in the system, and therefore over systems 1 and 2, which through the results of their own outputs determine the two inputs of system 3.

In the case of conveyor C3\_2, according to the report presented in figure 7, the existing blockage is reduced from 84% to 19% of time. Thus, it results that it works normally 80% of the time, which indicates a major improvement of its activity and implicitly of that of the system.

After analysing the remodelled system 3 we noticed an increasing of productivity for system 3 and for the whole manufacturing network obtained by optimising the material flow from the three systems separately, but as a general system.

By eliminating the concentrator from conveyor C3\_2 we decreased the transfer and transport times for parts on M3\_1 machine. The two components were delivered faster so the machine was reprogrammed to assembly faster. So the manufacturing cycle was significantly reduced.

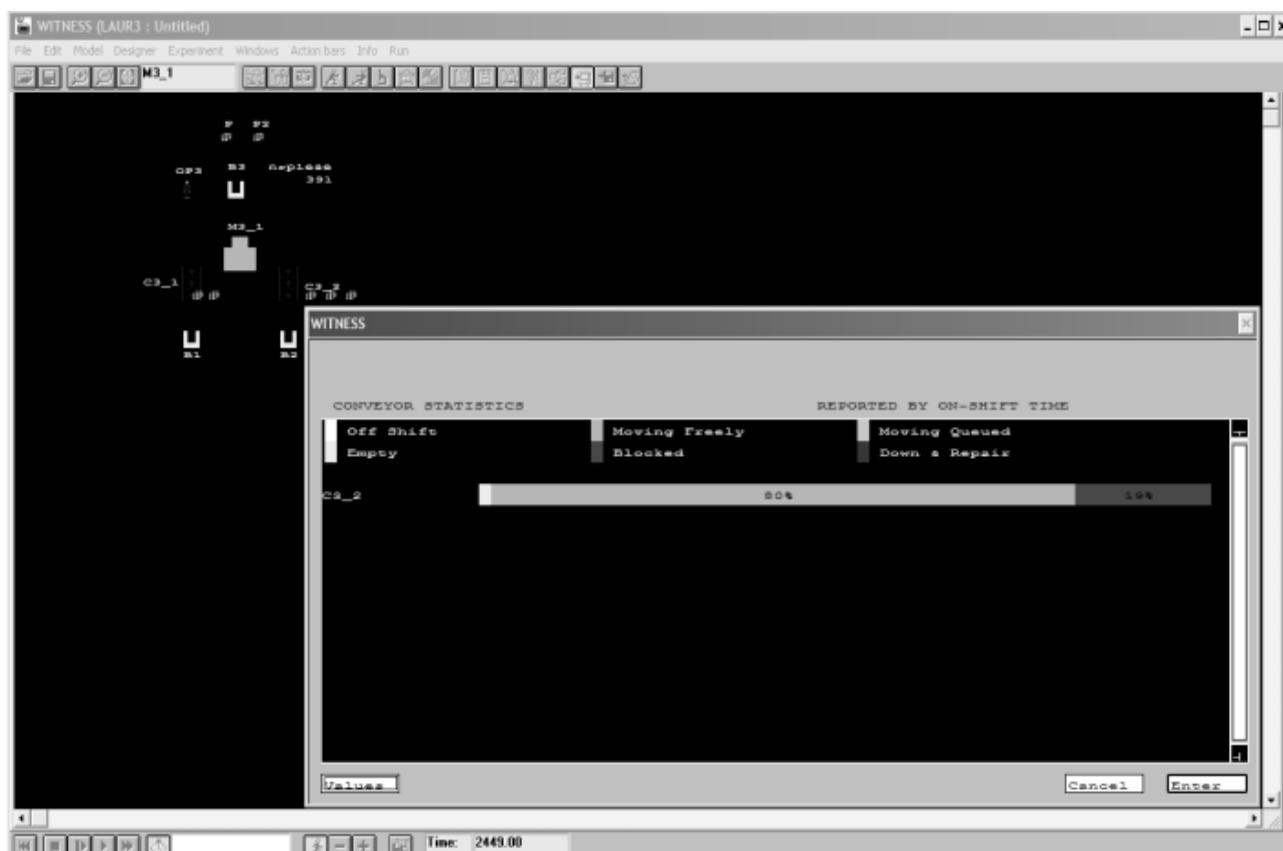


Fig. 7. The report regarding the activity of conveyor C3\_2 after system remodelling

## 4. Conclusion

If we want to optimize the material flow inside a manufacturing network, a simple simulation is not enough. This is the reason why we proposed as a solution, the multipolar simulation, capable of evaluating the performances on a manufacturing network as an integrated system. The analysis of the multipolar simulation does much more than just concatenates the results of isolated simulations. The flow concentrator which results from the multipolar simulation can be any of the concentrators of isolated simulations, but it can also be a totally different one. Some of the main causes of this particularity are the difference in algorithms for diffuse, isolated algorithms. For our case study, eliminating the material flow concentrator of FMS3 improves the production at the level of the entire virtual enterprise, but the most influent concentrator of the entire system is localized in FMS2.

When calculating the necessary transportation time between the two supplier units and the enterprise where the assembly takes place because the working points are geographically de-located, the distances can be extremely large and it's hard to estimate a medium transportation time. Medium times were used for our case study, because the results are relevant, opposed to cases of parts transportation between systems were medium times can't be used because it varies from hours to weeks, depending on problems occurred on roads and distances. However, in our future research we intent to calculate the transportation times using specific distribution laws in order to develop our algorithm and cover more complex case studies.

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