

Simulation of Mass Production Quality Control Line Optimization Using Symphony

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Abstract. Developing new solutions to solve projects problems is normal routine management process. Considering the tight competition in the marketing issue and the necessitate of quick production due to the market requirements forces owner to have a special notice on making the waiting time of the mass production line as less as possible as well as keep the quality of the product within the existence standards. To reach this target they need to test ideas and assign proper human resources to optimize the line compromising the investment and the profits of the company. This study is leading the owners to simulate ideas within possible limitations through using of Special Purpose Simulation in Symphony. Three scenarios have been developed and data were compared. Consequently, the result shows that which scenario is the optimum one for the assumed proposes with the highest productivity, satisfactory of the clients, employees, and the owner, and the least waiting time possible with the company constrains consideration.

Keywords: Special Purpose Simulation Symphony (SPSS), Simulation, Optimization, Mass Production

1. Introduction

Real world systems are so complex that some of these systems are virtually impossible to model. In these instances, numerical and computer-based simulation can be used to imitate the behaviour of the system. A model is defined as a representation of a system for the purpose of studying the system. Although many assimilationists stated that it is not necessary to consider all the details of a system because thereby a model is a substitute and a simplification of a system, the model should be sufficiently detailed to permit valid conclusions to be drawn for the real system. The simulation model building process involves many steps. Problem formulation, setting up of objectives, model design and building, data collection, programming, validation, and implementation are the major steps. The art of modelling is enhanced by an ability to abstract the essential features of a problem, to select and modify basic assumptions that characterize the system, enrich, and elaborate the model until a useful approximation results. However, the model complexity need not exceed that required to accomplish the purpose for which the model is intended.

2. Approach: Simulation using Symphony

Simulation has been adopted in the industry through the means of Special Purpose Simulation (SPS) methodology. Knowledgeable practitioners in any field are enabled to easy model a project while complexity of simulation methodologies and lack of deep simulation knowledge among industry personnel are among the main causes of weak utilization of simulation in construction management. Computer simulation effective use within the industry is best done through specialization and customization of the modeling, analysis and reporting components of the simulation systems (1), (2), (3), (4).

To increase the productivity of the Quality Control line in HPC¹ mass production, this simulation has been developed which can be used for any similar manufacturing company. Preventing long waiting time in this section and raising the outcome are the main purpose of this simulation.

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3. Structure of the Simulation Template and Its Logic Behind

This research has been performed based on the HPC statistics data gathered within one year operation and Figure 1 depicted the model of HPC Quality Control line.

A part or a unit is sent to service A or B section in the QC line. In the section A, there are two services of A-1 and A-2. HPC has always some A-1 and/or A-2 services such as inspection, repair and replacement. “False” in Figure 1 means service A-1 is not required and the part or unit are healthy. Units or parts may need service A-2 with the probability of 10% or they will exit from the QC line with the probability of 90% while they do not need to be rechecked. “True” in Figure 1 shows that faulty unites or parts, using service A-1 or A-2, must go to the quality checker section for quality double-check. In the section B, a unit or a part, passing quality section, may require service B-1 or B-2 with probability of 85% although they may not need any services with the probability of 15% and exit from this section, consequently.

Units or parts are labelled in the queue-machine section. So they should wait. When the quality checkers receive labelled units or parts, they will be sent to the QC section and then, their quality will be rechecked.

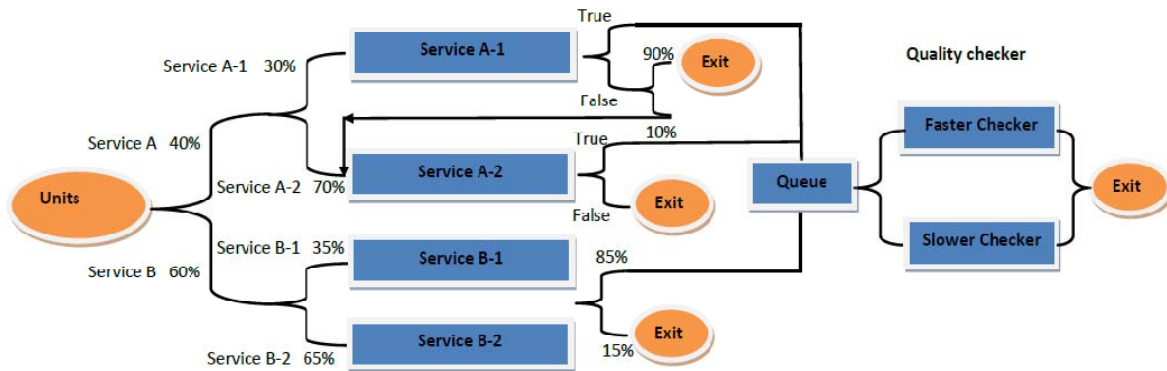


Figure 1: HPC Quality Control modeling

Two quality checkers are available as the HPC human resource restriction which one of them is faster than the other. HPC can only replace one of the resources in the A or B Services sections and also HPC is able to increase the number of quality checkers, while they cannot change the number of activities in QC line.

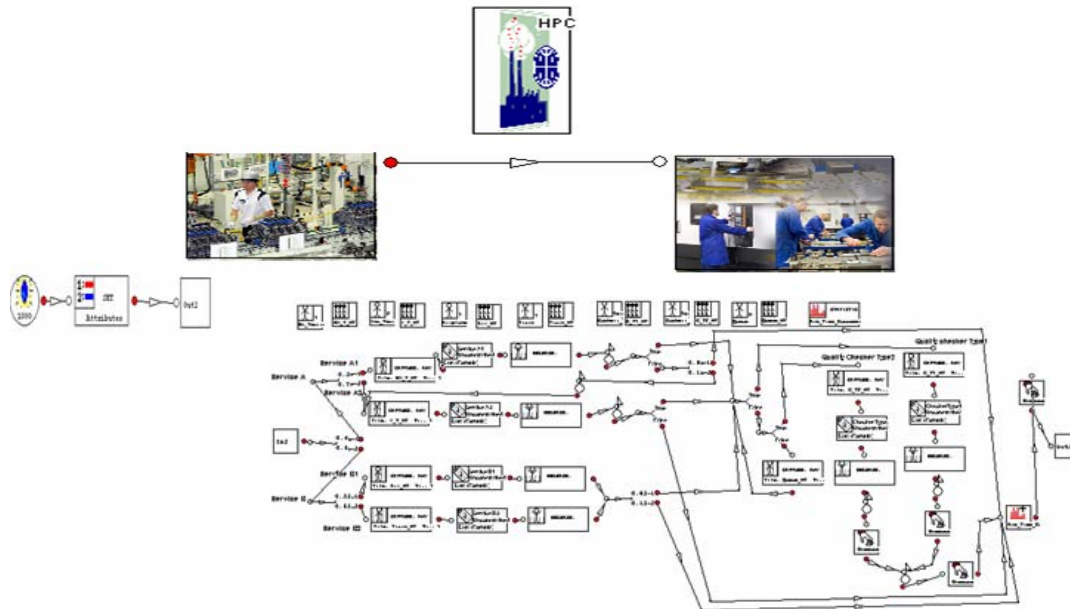


Figure 2: Summary of the Inputs and Output which are required for the Modeling of the “HPC_Factory” Real Life Project

¹ Homa Production Company (HPC) is an imaginary name for the Quality Control (QC) line of a car part manufacturing Company in Iran to keep the confidentiality of the information.

This program is developed in three levels, which are “Main-Root”, “Sub-Root” and “Common Template” named as “HPC_Factory”, “Unit_Section”, and “Service_Section”, in order. Each element and icons template was inserted to make the template ready to be programmed as it is shown in the Figure 2.

“HPC_Factory” element is defined to specify the template and relevant usage in addition to the future development to show all main outputs and statistics but not in detailed.

“Unit_Section” element is created to get input data such as “Number of Units”, “Time of First Create”, and “Time between Creations” and generate output data such as “Overall Number of Units per Day” and statistics data such as “Number of Units per Hour”, as well. All common elements, describing any kind of units or parts, should be used under this element child level.

“Service_Section” element is delineated for the input data of “Probability of Service A-1”, “Probability of Service A-2”, “Number of Service A-1”, “Number of Service A-2”, “Number of Quality Checker Type1 (Faster)”, and “Number of Quality Checker Type2 (Slower)”, and also the statistics data of “Average Spent Time by Units”, “Productivity of Quality Checker Type1”, and “Productivity of Quality Checker Type2. All common elements describing any kind of services should be used under this element child level same as “Unit-Section”.

Finally, “Execute elements” in child level of “Unit_Section” and “Service_Section” LEGO blocks has solved any issues in the link layers, input data, and results presentation.

4. Results and Discussion

4.1. Application of Simulation Template and Challenges

The parameters shown in Table 1 are summary of the inputs and output which are required for the modelling of the HPC_Factory real life project.

Table 1: Input and Output Parameters Required for Modelling

Element/LEGO Block	Parameters/Inputs	Outputs	Statistics
HPC_Factory	HOMA Production Company	---	---
Unit_Section	Number of Units Time of First Create Time between Creation	Overall Number of Units per Day	Number of Unit per Hour
Service_Section	Probability of Service A-1 Probability of Service A-2 Number of Service A-1 Number of Service A-2 Number of Quality Checker Type1 (Faster) Number of Quality Checker Type2 (Slower)	---	Productivity of Quality Checker Type1 Average Spent Time by Units Productivity of Quality Checker Type2
Queue	---	---	Waiting_Time Waiting_Length
Resources	---	---	Waiting_Time Waiting_Length
Resources	---	---	Resource Utilization

Furthermore, the statistics gathered from one year operation of HPC are shown in Table 2.

Table 2: Activities, Resources Identification in the Defined HPC_Factory Project

Activities/Resourcing	Description	Duration (min)	Number
Service-A1	Service A-1	Uniform(7,15)	One
Service-A2	Service A-2	Uniform(5,10)	One
Service-B1	Service B-1	Triangular(1,2,3)	One
Service-B2	Service B-2	Triangular(1,2,3)	One
Quality Checker Type1	Faster Quality Checker	Uniform(2,5)	One
Quality Checker Type2	Slower Quality Checker	Uniform(4,10)	One
Unit_Section (Entity) Parameters	Value	Service_Section Parameters	Number
		Probability of Service A-1	30%
		Probability of Service A-2	70%
Number of Unit_Sections	1000	Number of Service A-1	50
Time of First Create	5 min	Number of Service A-2	100
Time between Creation	Triangular(1,2,3)	Number of Quality Checker Type1	1
		Number of Quality Checker Type2	1

In the scenario 1, the waiting time of the “ServiceA-2” is high and it may cause dissatisfaction of the line productivity. On the other hand, resource utilization of “Service A-2 Resource” is also more than other sections. Therefore, the employee is displeased in this section. Base on the owner constrains of changing the number of resource of “Service A or B”, one resource will be added to “Service A-2 Resource”. Results of 480 times simulation in the scenario1 in 10 run times are shown Table 3.

Table 3: Results Comparison

Item		Before senario1	After Senario1
Service A-2	Waiting Length	4.07	0.1
	Waiting Time	27.81	0.7
	Resource Utilization	92.06	49.38
Quality Checker Type1	Productivity (Average)	12.96	13.05
Quality Checker Type2	Productivity (average)	6.9	6.95
Unit	Number	168	173

Data of Table 4 indicate satisfaction of the “Service A-2” by decreasing waiting time/length. Employees and the owner are pleased by decreasing utilization and increasing the HPC outcome, respectively while the line productivity is not still satisfactory because of spending time in the quality section and the waiting period would be high in the queue. Also resource utilization of “Quality Checker Type1 and Type2” is high; so the employee unhappy in this section.

In the scenario 2, bases on constrain that owner can change of number of “Quality Checkers”, one resource will be added to “Quality Checker type 1” that is faster than the other one. Results of the comparison between scenarios with the 480 simulation unit and 10 number of run 10 are shown Table 4.

Table 4: Scenarios 1 & 2 Results Comparison

		Before Senario1	After Senario1	After Senario2
Quality Checker Type1	Waiting Length	0.29	0.29	0.02
	Waiting Time	1.24	1.22	0.06
	Resource Utilization	81.33	80.79	63.95
Quality Checker Type2	Waiting Length	0.32	0.34	0.03
	Waiting Time	2.44	2.6	0.034
	Resource Utilization	86.81	89.13	54.96
Queue	Waiting Length	17.27	19.25	0.17
	Waiting Time	39.36	43.29	1.12
Unit	Average Spend Time by Unit	45.27	43.15	9.5
Quality Checker Type1	Productivity (Average)	12.96	13.05	20.73
Quality Checker Type2	Productivity (average)	6.9	6.95	4.38
Unit	Number	168	173	211

Data in the Figure 3 and Figure 4 shows that the “Average Spend Time” and “Waiting queue Time” in the line are decreasing “waiting time/length” of the “Quality Checker” section.

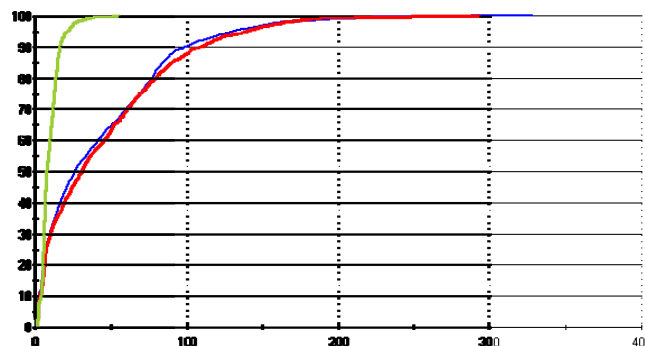


Figure 3: Average Spent Time by Units CDF (Scenario 0, Red, Scenario 1, Blue, and Scenario 2, Green)

“Quality Checkers” and the owner are happy by decreasing utilization and increasing the HPC outcome and “Productivity Quality Checkers Type1”, respectively.

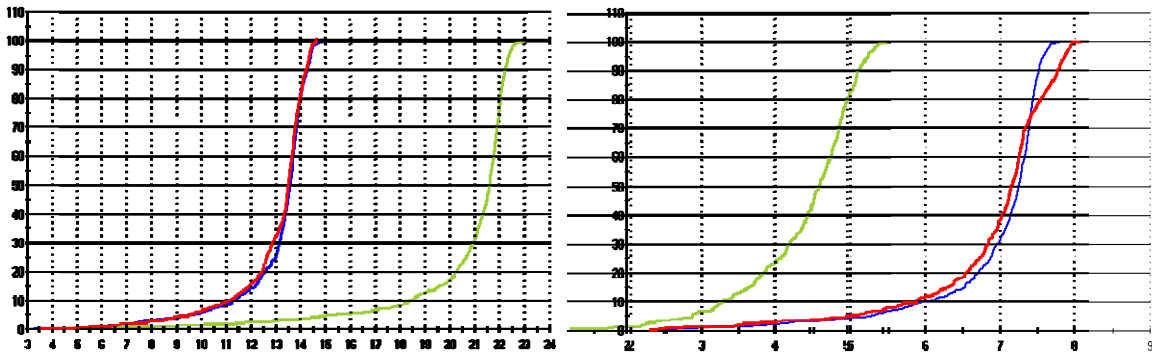


Figure 4: Productivity CDF (Scenario 0, Scenario 1, and Scenario 2 are Red, Blue, and Green accordingly, which are the Number of Units/Parts Which Served by Fast -Left curve- and Slow -Right Curve- Quality Checker per Hour)

4.2. Limitation of the simulation Template

There are strengths for the usage of such simulation, although accessible data history of the company is vital where documentation is very important and also simulating complicated processes would not be very precise when all real elements are not substitution. Always, there are the probability of a error percentage that should be find out with more real case studies in the future investigations, while it is obvious that less data and using less element will grow up this error percentage.

5. Conclusion

Ultimately, one the advantages of this simulation is establishing economical mass production Quality Control line, though there is no need to change the production procedure through simulating various possible scenarios and finding the least possible spending time to execute. Highly flexible simulation tools implementation, which support graphical, hierarchical, modular, and integrated modelling, using Symphony can be used by tool developers very easy and without spending any additional execution cost (5), (6). Another benefit of this optimization is reducing the production cost, increase of productivity, decreasing of fuel consumption which is an environmental issue, developing competitive marketing, on-time goods with high quality, and finally satisfactory of the client as well as the employees considering the working load.

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7. References

- [1] *A Framework for Applying Simulation in the Construction Industry*. **S. AbouRizk, D. Hajjar**. 3, s.l. : Canadian Journal of Civil Engineering (CSCE), 1998, Vol. 25, pp. 604-617.
- [2] *Building a Special Purpose Simulation Tool for Earth Moving Operations*. **D. Hajjar, S. AbouRizk**. s.l. : Proceedings of the Winter Simulation Conference, 1996.
- [3] *Simphony: An Integrated Environment for Construction Simulation*. **S. AbouRizk, y. Mohamed**. Phoenix, Arizona : Proceeding of the Winter Simulation Conference, ed. J.A. Joines, R. R. Barton, K. Kang, and P.A. Fiahwick, 2002. pp. 1907 - 1914.
- [4] *Simulation of Production Homebuilding Using Simphony*. **Anil Sawhney, Howard Bashford, Howard Bashford, André Mund**. s.l. : Proceedings of the Winter Simulation Conference, eds. B. A. Peters, J. S. Smith, D. J. Medeiros, and M. W. Rohrer, 2001. pp. 1521-1527.
- [5] *Simphony: An Environment for Building Special Purpose Construction Simulation Tools*. **D. Hajjar, S. AbouRizk**. Piscataway, New Jersey, USA : Proceedings of the Winter Simulation Conference, ed. P.A.Farrington, H.B.Nembhard, D.T.Sturrock, G.W.Evans, 1999. Institute of Electrical and Electronics Engineers. pp. 998-1006.
- [6] *Simphony: An Integrated Environment for Construction Simulation*. **Anil Sawhney, Howard Bashford, Kenneth Walsh, André Mund**. s.l. : Proceedings of the Winter Simulation Conference B. A. Peters, J. S. Smith, D. J. Medeiros, M. W. Rohrer, eds., 2001.