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Simulation in Wood Industry. Part I

Simulacija u drvnoj industriji. Dio I.

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ABSTRACT • *The aim of our project was to answer the question of our multinational window and door hardware manufacturing company as to whether it was worth building a new hall and increase the output or not. Of course there were also other important questions to answer, such as what kind of array of manufacturing machines should be, what is the minimum number of employees (including employee redundancy), what is the right timing for incoming parts and outgoing products, etc. Such questions are usually hard to answer with classical methods. Therefore we have choosen other ways to solve the problem: the solution was to create a simulation model and simulate all processes in order to get the required results and answers. For this project we used the program SIMUL8 Company's SIMUL8 Professional.*

Key words: *simulation, flow-simulation, utilization, throughput*

SAŽETAK • *Cilj projekta bio je odgovoriti na upit multinacionalne tvrtke za proizvodnju prozora i vrata o isplativosti izgradnje novoga proizvodnog pogona i povećanja opsega proizvodnje. Usto je trebalo odgovoriti i na još niz pitanja, npr. koji je najbolji raspored strojeva, koliki je najmanji potrebni broj zaposlenika, koje je pravo vrijeme ulaska materijala u proizvodnju i izlaska gotovih proizvoda i sl. Na takva pitanja obično je teško odgovoriti uz pomoć klasičnih metoda. Stoga smo izabrali drugu metodu rješavanja postavljenih problema. Izradili smo simulacijski model i simulirali sve procese u proizvodnji kako bismo dobili tražene rezultate i odgovore. Za realizaciju simulacije primijenjen je program SIMUL8 Company's SIMUL8 Professional.*

Ključne riječi: *simulacija, simulacija toka, primjena simulacije, protok podataka*

1. UVOD
1 INTRODUCTION

1.1 What is simulation
1.1. Što je simulacija

Simulation is the imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviours of a selected physical or abstract system. Of course there are many different definitions of simulation, but we mostly deel with the software SIMUL8, that specializes in discrete event simulation as described below.

1.2 Discrete event simulation
1.2. Simulacija diskretnih događaja

A simulation is a computer model that mimics the operation of a real or proposed system, such as the day-to-day operation of a bank, or the running of an assembly line in a factory, or the staff assignment of a hospital or call center.

The model is time based, and takes into account all the resources and constraints involved, and the way these things interact with each other as time passes. Simulation also builds in the randomness you would see in real life. For example it does not always take exactly 5 minutes for a customer to be served and a customer

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does not always arrive every 15 minutes. This means that the model can really match reality - so something you try in the model will behave the same way as it would in real life.

With simulation you can quickly try out your ideas at a fraction of the cost of trying them in the real organization. And, since you can try ideas quickly, you can have many more ideas, and gain many insights, into how to run the organization more effectively.

1.3 Working of simulation
1.3. Provedba simulacije

When you click the run button in a simulation model you see the work you do (products, patients, paper work, etc.) move around the organization. The clock in the corner of the screen tells you what the equivalent time would be in the real system.

Simulation is animated. This enables visualization of a new facility and a greater ability to visualize the impact of experiments in an existing facility. You can see key bottlenecks, over-utilized resources and under resourced elements of a system.

The software automatically collects performance measures as the model runs so that you can not only see visually what will happen, you can also get accurate numerical results to prove your case.

Typical outputs include:
- Inventory
- Throughput
- Bottleneck utilization
- Productivity

Typical inputs include:
- Cycle time
- Staff levels
- Arrival/order rates
- Average order size

1.4 Possibilities of simulation
1.4. Mogućnosti simulacije

There are many scenarios that can be simulated. As a general rule systems that involve a process flow with discrete events can be simulated. So you should be able to simulate any process of which you can draw a flowchart.

The processes you will gain most benefit from simulating are those that involve change over time and randomness. For example a gas station. Nobody can guess at exactly what time the next car will arrive at the station, whether it will decide to purchase gas only, etc. It is not possible to model complex dynamic systems like this effectively in any other way.

1.5 Reasons to simulate
1.5. Razlozi za simulaciju

There are many process improvements you can make using simulation: higher quality and efficiency from capital assets, better management of inventory, higher return on assets - this list is endless. However, some of these improvements could be made without simulation, so the real question is 'Why use simulation instead of another method?'

Simulation vs. real life experimentation

Cost: Experimenting in real life is costly. It is not only the capital expenditure of hiring new staff or purchasing new equipment but also the cost of the effects of these decisions. What if you fire 3 employees and then find you cannot cope with the workload and you loose customers? The only cost with simulation is the software and the man hours required to build the simulation.

Repeatability: In real life it is really difficult to repeat the exact circumstances again so you only get 1 chance to collect the results and you cannot test different ideas under exactly the same circumstances. So how do you know which idea is really the best. With simulation you can test the same system again and again with different inputs.

Time: If you want to know whether hiring another 3 doctors will reduce patient waiting lists over the next 2 years you will actually have to wait for 2 years. With simulation you can run 2, 10 or even 100 years into the future in seconds. So you get the answer now instead of when it is too late to do anything about it.

Simulation vs. other mathematical modeling techniques

Interaction of Random Events: Some other mathematical tools can mange to effectively model a steady state scenario but only simulation lets you build in random occurrences like a machine breaking down and see the effects of this further down the line. The more complex the scenario is the more these tools fall down and simulation is the only answer.

Non Standard Distributions: Many mathematical techniques force the model builder to describe a situation as an approximation, it takes an average of 5 minutes to serve each customer. In real life this is not the case. It takes 3 minutes to serve the customer if they have 4 items, it takes 7 minutes if they have 20 items. Approximate mean results such as resource utilization time and customer waiting time are all inaccurate. Only simulation gives you the flexibility to describe events and timings as they actually are in real life.

Makes you think: Simulation provides a vehicle for a discussion about all aspects of a process. The rule

Table 1 Used parts
Tablica 1. Upotrijebljeni dijelovi

	Machine ID / *ID stroja*			
	1	*2*	*3*	...
Part ID ID dijela	100065	100065	100065	...
	100066	**100066**	**100066**	...
	100086	**100086**	**100086**	...
	100087	100087	100087	...
...	...	...	...	...

Part ID – A globally unique part identifier (number) in the ERP system / *ID dijela – jedinstveni broj dijela proizvoda u ERP sustavu;* Machine ID – A globally unique machine identifier (number) in the ERP system / *ID stroja – jedinstveni broj stroja u ERP sustavu*

Table 2 Probability profile of the product structure
Tablica 2. Profil vjerojatnosti strukture proizvoda

	Machine ID *ID stroja*	**Probability** *Vjerojatnost*	**Machine ID** *ID stroja*	**Probability** *Vjerojatnost*	**Machine ID** *ID stroja*	**Probability** *Vjerojatnost*	...
	1	%	*2*	%	*3*	%	...
Product ID	**230639**	23,32	260298	17,71	260298	17,71	...
ID proizvoda	260299	34,71	260299	34,71	260299	34,71	...
	260300	17,68	260300	17,68	260300	17,68	...
	260307	4,8	260307	4,8	260307	4,8	...
...	...	...	...	...	...	...	...

Product ID – A globally unique product identifier (number) in the ERP system / *ID proizvoda – jedinstveni broj proizvoda u ERP sustavu;*
Machine ID – A globally unique machine identifier (number) in the ERP system / *ID stroja – jedinstveni broj stroja u ERP sustavu*

and data collection forces you to consider why elements work in a certain way, if they could work better. It also brings to the surface inconsistencies and inefficiencies especially between different sections of a process that work independently. Sometimes the simulation does not even have to be finished and the framework it has provided to think through the issues reveals the solution.

Communication: As simulation is visual and animated it lets you clearly describe your proposal to others. Its more convincing than just displaying the end results as people cannot see where these came from. Simulation is so effective in communicating ideas that many companies now use it as a sales tool to sell their products.

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

2.1 Realizing the simulation
2.1. Realizacija simulacije

If we want to realize a simulation, the first thing we should do is to understand the situation. In this particular case as, mentioned above, our partner was a multinational market-leader hardware-manufacturing company that wanted to know whether it was worth building a new hall and increase the troughput or not. In the new hall there are about 30 hardware-manufacturing machines of 6 types, with more than a 1000 connections between them, resulting of course in different kinds of simulation parametres and different kinds of goals. There is, however, a common goal between them and this is to maximize the troughput. Of course, it is not always certain that this can be achived by the sum of local troughput maximums.

2.2 Concept and model
2.2. Koncept i model

The simulation model is based on the SIMUL8 toolkit library, as well as on the customer needs. In this case the main concept was to develop a simulation, which can be easily used and which has a widely reusable output.

Further to the above, we created some simple, but marginal *parametres* that are easy to obtain, and with them the output values of the simulation represented the reality. There are two kinds of parametres: *global* and *local*.

With *global* parametres, you can obtain the following:

– What are the parts necessary for any product to be assembled (Table 1)

With this option we can define an array of parts that are needed in the simulation at all. This array is the base of a generator script, which generates the SIMUL8 objects with the proper parametres (i.e. Part Number) that represents the real-life parts.

– What kinds of products to be produced and in what ratio

In this array we can define what kind of product should be produced and in what machine ratio by machine. Of course it is possible to produce a product in 0%. This means that this product will never be produced in the current simulation context.

Here we have to mention the opportunity to define the optimal product matrix, because every product has a price and a cost of production. If we could define a proper ratio product by product for minimizing the global cost and maximizing the global price, we would get the optimal producing matrix. Backward of this method is the demand of a huge computer capacity. One variation takes 10–15 minutes to play on a mid-range computer, thus if we suppose that the global result takes e.g. 1000 step, we get a huge time as bare computer time, not to mention if the 1000 step is not enough!

– What parts are needed for a product to be assembled

It is a marginal part of simulation, when SIMUL8 defines the parts for a product. There is a built-in script,

Table 3 Product data retrieved directly from SAP
Tablica 3. Podaci o proizvodu preuzeti iz baze SAP

Product ID *ID proizvoda*	**Product description** *Opis proizvoda*	**Quantity** *Količina*
230639	FZ-AXARM N620A06116L	163 773
230640	FZ-AXARM N620A06116R	114 728
263183	FZ-AXARM N620A05116L	34 014
263184	FZ-AXARM N620A05116R	30 842
331513	FZ-AXARM HEBEL L NT	26 347
...	...	...

Table 4 Parts data retrived directly from SAP
Tablica 4. Podaci o dijelovima proizvoda preuzeti iz baze SAP

Product ID *ID proizvoda*	**Part ID** *ID dijela*	**Part description** *Opis ili naziv dijela proizvoda*	**Quantity** *Količina*
230639	208888	BUCHSE AX-BD GEBREMST	1000
230639	242405	AXERBD-K 12/20-13	1000
230639	232011	SENK-NIET AXER	2000
230639	374834	FALZAXERWINKEL	1000
230639	349639	Hebel links	1000
230639	349634	Exzenter	1000
230639	263188	STELLPLATTE	1000
230639	100059	V.KART.29	10
230639	**100066**	TAUSCHPALETTE	0,63
230639	100126	V.KART.	0,63
230639	**100086**	ZWISCHENLAGE	1,25
230639	232815	DIST-HOLZ L320	2,5
230639	232817	QUER-HOLZ L787	1,25
230639	100090	HEFTZWECKE 42/19 NK	12,5
230639	100271	KUNSTSTOFFBANDGIERUNG	3,75
0**230639**	100301	ETIKETT-1 99X105	10
230639	100302	ETIKETT-3 148X105	2,5
230640	208888	BUCHSE AX-BD GEBREMST	1000
230640	242405	AXERBD-K 12/20-13	1000
...	..	...	...

which solves this problem. There are two tables, where in the first table (Table 3) we store products (identified by a ProductID), while in the second table (Table 4) we store the parts (identified by the *PartID*) and of course here we use the *ProductID* as a foreign key to decide which part belongs to which product.

With *local* parametres, you can obtain the following:

- Timing
  This allows you to say how often work will arrive. A variable or label can be entered of course.
- Routing In parametres
  Controls how work is selected by the work center.
- Routing Out parametres
  Controls how work leaves the work center.

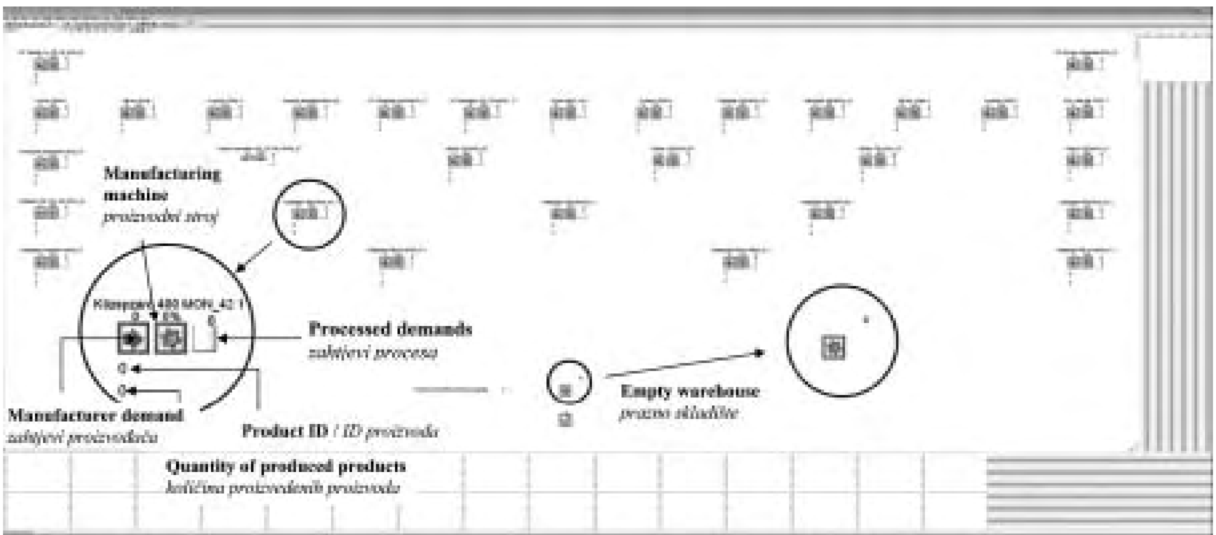

Figure 1 Scheme of simulation processes
Slika 1. Shema procesa simulacije

Table 5 Produced products
Tablica 5. Izrađeni proizvodi

	Machine ID / *ID stroja*												
Product ID *ID proizvoda*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	...	**Psc.** *Kom.*	**Pal.** *Paleta*	**Mass, kg** *Masa, kg*
...	...	...	...	...	...	...	...	...	...	...	...	...	...
260297	0	0	0	0	0	0	0	0	0	...	0	0	0
260298	0	0	0	0	0	0	0	0	0	...	0	0	0
260299	503	894	984	665	1000	0	728	0	0	...	4774	6	2349
260300	0	0	0	0	0	0	0	969	879	...	1848	1	1214,28
260303	0	0	0	0	0	0	0	0	0	...	0	0	0
260304	0	0	0	0	0	0	0	0	0	...	0	0	0
260305	0	0	0	0	0	0	0	0	0	...	0	0	0
260306	0	0	0	0	0	0	0	0	0	...	0	0	0
260307	0	0	0	0	0	0	0	0	0	...	0	0	0
260308	0	0	0	0	0	1000	0	0	0	...	1000	1	530
260309	0	0	0	0	858	0	0	0	0	...	858	2	514,81
...	....	...	...	...	...	...	...	...	...	...	...	...	...

Product ID – A globally unique product identifier (number) in the ERP system / *ID proizvoda – jedinstveni broj proizvoda u ERP sustavu*; Machine ID – A globally unique machine identifier (number) in the ERP system / *ID stroja – jedinstveni broj stroja u ERP sustavu*; Pcs. – The number of the pieces of the product with the given ID produced within the simulation / *broj izrađenih komada određenog ID proizvoda unutar simulacije;* Pal. – The number of the palettes of the product with the given ID produced within the simulation / *broj paleta gotovih proizvoda*; Mass – The net weight of the produced product of the given ID / *neto masa gotovih proizvoda*

– Tabel actions
  Tells a work center how to change a work item's labels as they come through the work center.
– Resources
  Requires a resource before work can be completed by e.g. a work center.

3 RESULTS AND DISCUSSION
3. REZULTATI I DISKUSIJA

As it can be seen on Figure 1 and Figure 2, finally, the simulation does not look too complicated, but inside there are many intelligent scripts working to satisfy specific needs. When we open the simulation, and fill in tha data in the tables mentioned above, SIMUL8 generates the whole simulation context with all the simulation objects, as required. There is a script for building the part-objects, another that creates the proper connections between the parts and the producer objects, and also another that generates demands according to the set needs as shown in Table 2. So after the simulation is started, every machine shows what kind of product is produced by itself right now, and how many are left from those to be produced from the defined value specified in the demand. As the simulation time passes by, some of the specific properties of the manufacturer

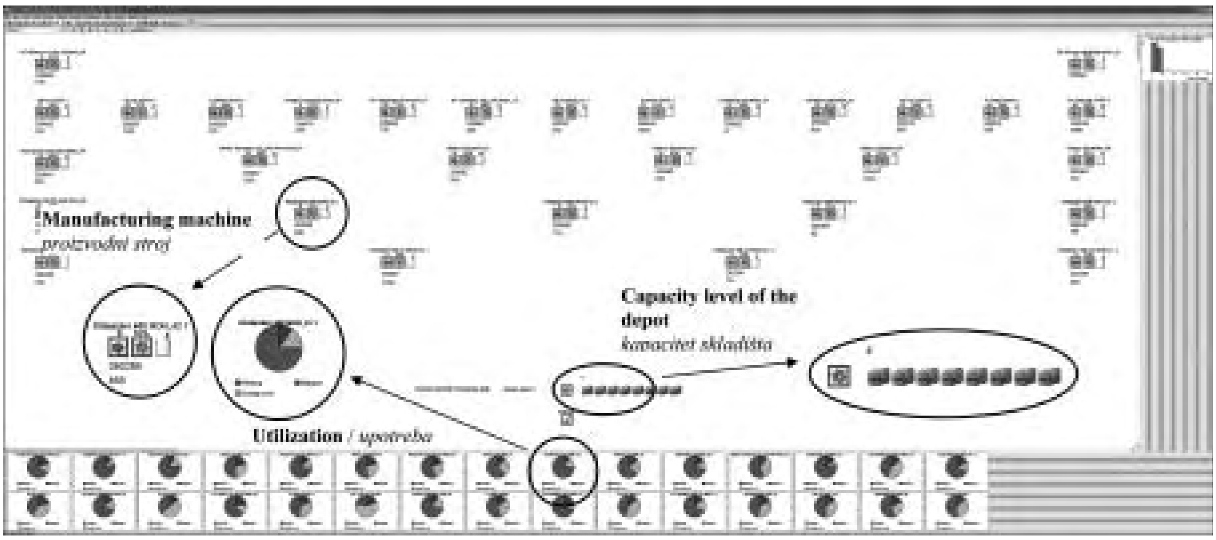

Figure 2 Simulation in 24 hour
Slika 2. Simulacija unutar 24 sata

machines become clearly obvious from the pie chart at the bottom of Figure 2.

Actually, there is no limitation of properties shown. It depends on the imagination of the simulation builder or on the customer needs. Every kind of value can be displayed graphically.

4 CONCLUSION
4. ZAKLJUČAK

It is obvious that evaluating the results always depends on the parametres that have been enetered into the simulation. The primary goal is to collect proper data for the simulatuion. Mostly this is understated, because it is hard to achieve and sometimes it takes a long time, e.g. in a company, where data are not stored in a modern way, or where there are many different kinds of machines with different kinds of parametres. It should be mentioned that collecting data is not cheap at all, and however it is worth it! In this particular case the primary goal has been reached, because we could give our customer accurate and relevant data. Since then the new hall has been built, and the after-sampled data confirmed the results of the simulation and brought satisfaction both for us and our partner.

5 REFERENCES
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