COLLABORATIVE SYSTEMS AND MATHEMATICAL MODELS FOR LEADING ECONOMIC PROCESSES

Irina Barbu[1]

Abstract

A collaborative system is an interdisciplinary field located at the intersection of economics, computer science, management and sociology. These systems are focused on building connections between people, equipment and information.
In the context of collaborative systems, the mathematical models used to simulate business processes provide information for building applications that help optimizing the business processes and contribute to sustaining economic decisions.

Keywords: collaborative system, mathematical model, simulation, repair, maintenance.

The business environment of the world goes through rapid changes. Managers analyze business processes in search of ways to increase the competitiveness of the systems they manage, so they can successfully face the challenges of the global economy.
No business can exist without being part of a network of business, working pro-actively and disseminating information for achieving objectives. Thus emerged the notion of collaborative system, which is an interdisciplinary field located at the intersection of economics, computer science, management and sociology. These systems are focused on building connections between people, equipment and information.

In the context of collaborative systems, the mathematical models used to simulate business processes provide information for building applications that help optimizing the business processes and contribute to sustaining economic decisions.
For example, we consider the area of revisions and repairs. Maximizing the profit and minimizing life cycle cost of used equipment are the objectives of any company.
The pressure of competition force companies into minimizing the total cost of assets ownership and developing their management activities. Since the costs determined by the periods in which production is interrupted because repairs are growing, companies focus on maximizing equipment life cycle maintenance programs properly.

Complex technical systems reliability and efficiency are particularly important in any company. When such a system cannot be used due to a component failure, the company has basically two options. First, is to repair the defective component. The second option is to replace the defective component with another component of the stock, and to restore at a later date.
The second option is almost always the most suitable one because most of the times the technical complexity of the fault requires special equipment and knowledge. The question that arises in this context is "how many components must be kept in stock, so as to ensure a certain level of interoperability of the equipment?" Or "Given the budget limitation for

[1] PhD Candidate Irina Barbu, Academy of Economic Studies, Bucharest, irinabarbu@gmail.com

purchasing, which components are kept in stock in order to maximize the average equipment availability?”

Hence the need for a system that manages components in order to ensure that necessary parts are available without a stock level that is too high.
The improvement of maintenance and repair activities for equipment and machinery is one of the main ways that ensure a better use of production capacity, therefore increasing the efficiency of companies.
The rational usage and the equipment efficiency require proper operation as well as maintenance and in order to keep the design parameters or technical limits allowed. In case of defects, the time for fixing the problem becomes a critical element.

The techno-economical aspects of revisions and repairs have important applications in the production and provide the means of regulating it. Planning and inventory control are critical components in the management of company assets. In case the necessary components are not available for maintenance or repair activities, the unavailability of equipment is prolonged. If too many components are available in stock, they determine excessive costs and make difficult the inventory management.
The complex aspect of managing overhaul and repair activities is the ability to find a balance between maintenance costs and total costs.
Efficient management requires making the best decisions on equipment acquisition, overhaul and repair activities and determining the optimal timing for inspections and repairs.

Simulation is a technique for achieving numerical computer experiments, which involves building mathematical and logical models that describe the behaviour of a real system (or its components) over a longer period of time. While not providing exact solutions (but suboptimal), the simulation is an effective research technique for complex economic problems at the firm level that cannot be studied analytically (economic and mathematical models for optimization).

Simulation technique is mainly used when obtaining an analytical solution for a certain problem is impossible or very expensive. While investigating the behaviour of systems characterized by complexity is difficult to accurately predict all the possible consequences of a decision, any changes that may arise, timing and intensity of external disturbance.

Because of the complexity of real economic systems, stochastic dependencies between different variables and parameters considered, not all systems can be adequately represented by a model that can be solved by analytical methods and covering all issues for management decision analysis, economic horizon real. In such cases, it is considered that the simulation technique is the only available alternative.
Using simulation we can obtain more options from which the manager will choose the best one while taking into account the conditions corresponding to a certain moment.

Through simulation we can:
• determine the functional form of expression of the relationship between the phenomena studied and the values of model parameters can be estimated;

• test different remedies that can be made explicit in the model;
• achieve a better structuring of the problem investigated;
• demonstrate the solution to the problem that makes the decision.

The process of creating a simulation model is based on a mathematical model in which economic uncontrollable variables are expressed depending on the controllable ones, so that it meets certain performance criteria. These interdependencies can be expressed by logical conditions or procedures that can be solved only by computer. An economic and mathematical model which is associated with these procedures is a simulation model.

An example of such a simulation model is the one that examines time usage.
The problem to be solved is to check the possibility that a technician maintains a number of N cars. In order to do this, the following steps are executed:
• We collect data about the time between two faults and fault repair time;
• Repair functions (cumulative frequencies) are converted into indexed tables;
• We establish the optimal criterion (e.g. the lifetime of the machine, the downtime, etc.).
• We develop a scheme of calculation and interpretation of results.

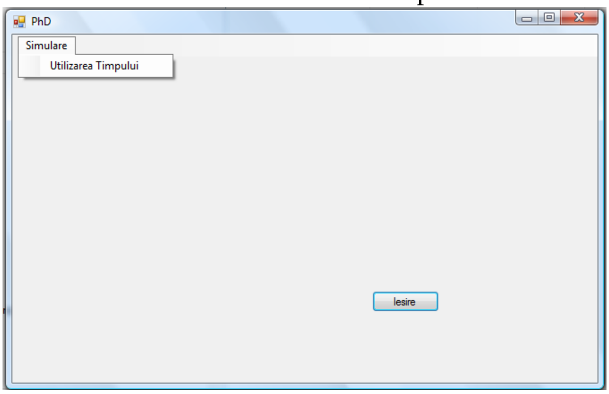
We assume that the service discipline is FIFO. Simulation algorithm is built on the principle of increasing clock variable and use the following list of variables and parameters:
TID - the time between two consecutive failures;
TRD – the time needed for repairing a fault;
TA1 - waiting time for an equipment to be repaired;
TA2 - waiting time for a technician due to failure to produce any faults;
STA1 – sum of all waiting times for the equipment;
STA2 - sum of all waiting times for the technician;
T1 - uptime and downtime of the machine;
T2 - time of employment and vacancy for the technician;
DELTA - the difference between T1 and T2;
NCS - counter of simulation cycles;
SEN - number of events that need to be simulated (by event we mean a shutdown or repair of machinery);

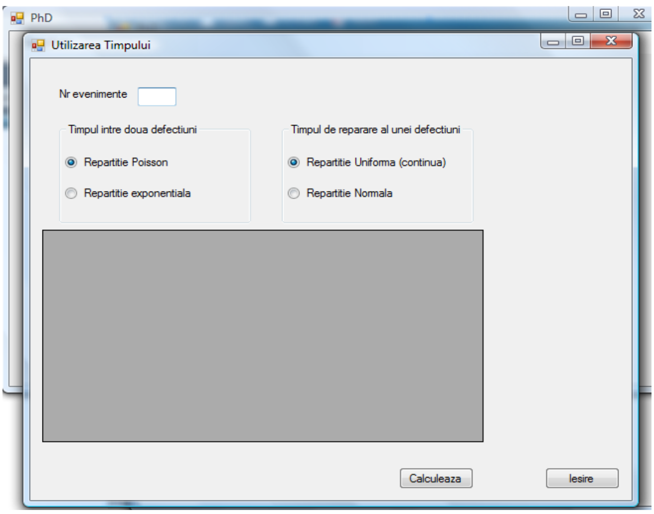
We start by providing the input data: SEN and TID parameters and TRD (known). We know the distribution of variable TID and the parameters of this distribution, so we generate the time between two successive failures. Next we calculate the total T1 time for operation and downtime of equipment / machine (it is a kind of machine clock) and then we determine the difference between T1 and T2 (technician time).
We verify if the technician is available. If he is not available (DELTA <0), then we determine the waiting time for the machine that is down (STA1) and we assign zero to the waiting time of the technician (TA2) as he repairs another machine.

When the technician is available (DELTA $\geq$ 0), we test to see if he is waiting (DELTA $\geq$ STA1). If so, we determine the waiting time for the technician (TA2), then increase the counter STA2 with the waiting time TA2 and we assign zero to the waiting time of the equipment (TA1), as this machine will be repaired as of this moment. If DELTA = STA1

(i.e. the end of a repair time coincides with the beginning of a failure) then we assign zero to variables TA1 and TA2 and the technician begins the repair operation. We generate the fault repair time, and we increase the technician's clock with times TRD and TA2.
We count the number of simulation cycles and we test if the number of events was covered. If so, we proceed to the calculation of statistics, otherwise we return for a new cycle of simulation.

Finally we consider statistics as a total failure, idle times, number of workers used for repairs, the time consumed for repairs.
Observation:
We accept the hypothesis that TRD failure times can not overlap at more than two cars.
Please note that the process described above can simulate a tele-working process where the service station is the technician and the terminals are represented by the machines.
The model described above was implemented in an application as follows:



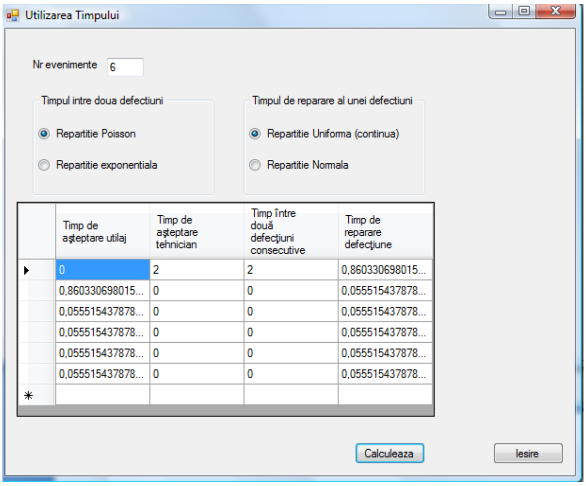


We enter the number of events that need to be simulated and click on 'Calculate' button.
The application populates the table with the values obtained for each simulated event:
• waiting times for equipment repair;
• waiting time for a technician due to failure to produce any faults;
• the time between two consecutive failures;

• the time for repairing a fault;

Every time we change the type of distribution by selecting a radio button, the table rows are deleted.

'Calculate' button is pressed again to populate the table with the values obtained from the new function chosen.



Conclusions:

The mathematical models that refer to wear theory and the replacement of equipment propose to decide on the choice for purchasing of a certain type of equipment, on the optimum duration equipment usage, on the timing and procedures for replacement or repairing the equipment, on ensuring spare parts, on equipment performance in the context of technical progress, on the possibilities of keeping the equipment in accordance with the latest technology, etc.

The activities of maintenance and repair of equipment and machinery represent a very important element in production activities, providing business efficiency improvements. Rational and efficient use of machinery requires both proper operation and maintenance and repair to maintain the design parameters or technical limits allowed. Overhaul and repair activities are a crucial means of regulating production.

Bibliography:

1. Vaduva, I., Stoica, M., Odagescu, I. - "Simularea proceselor economice", Editura Tehnica, 1983.
2. Vaduva, I. – "Modele de simulare cu calculatorul", Editura Tehnică, 1977
3. Dobre, I., Mustata, F., - "Simularea proceselor economice", Editura INFOREC, 1996.