GAMES: Virtual Worlds and Reality

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Simulation of economic factors in public sector

Juozas Patasius, Irena Patasiene, Martynas Patasius

Abstract

The works in public sector get lots of state funds, so the effective use of these funds is an important national task.

The paper analyzes objects of public sector the qualitative parameters of which change in time depending on the influence of the environment and users of the objects. The state of these objects can be described by some index, describing the quality of the objects. User of objects (representative of the society) suffers losses depending on these indexes. The indexes (and the losses) become worse as the time passes. To decrease the losses, periodical improvement of the state of the object of public sector (repair) is necessary. The costs of the repair depend on the type of repair. In such case the rational time and type of repair has to be found. The paper describes the means and the mechanism allowing to chose them optimally to minimize the expenses of the society that consist of both expenses of the users and expenses of the maintainers. Also, the improvement of quality must be economically feasible, that is, the sum invested must be less than the income (decrease of user expenses). When solving the same problem, the winner is considered to be the player who achieves the best indexes of quality with the minimal expenses of maintenance. Maintenance of road network is considered as a partial case of the object of public sector.

Keywords: simulation and gaming; economy of public sector, teaching.

Introduction

The works in public sector get lots of state funds, so the effective use of these funds is an important national task. To maximize the efficiency of the public sector the investments have to be used for economically feasible works only and the process of maintenance has to be optimal (according to the chosen criteria). Naturally, to achieve that, it is necessary to create the organisational and technical measures that would help to solve these problems. First of all, the technical-software measures that would help to find the necessary amount of funds and the optimal distribution of them for different objects have to be created. The usefulness of the objects depends on their qualitative indexes that change as time passes.

In this case, a problem of organization of the works in the way that would achieve the acceptable quality with minimal expenses arises. On the other hand, it is important to change the qualitative indexes to achieve the required quality. It is useful to create a quality control system of public sector (QCSPS) that would allow planning of qualitative indexes of an object. Its essence is minimizing the expenses of the society that consist of both expenses of the users and expenses of the maintainers. The system is created for rational distribution and use of funds (Patasius at al 2003, 2006).

On the other hand, it is important to have enough specialists for these works. Because of that training is performed in schools. However, it is important to ensure that the students would be taught using advanced teaching methods and would have the suitable tools for such learning. That makes it advisable to create a model of QCSPS analogous to business games (Klabers 2006).

Computer business games often use simulations – the method of analysis, programming and decision-making that (comparing with traditional methods) is more comprehensive and lets extensive evaluation of the system being analyzed and the external factors. It enables us to comprehend of random nature of various phenomenon, their uncertainty and complex interaction in the real world. In many cases the simulation is the only way to find the right solution of the problem. Simulation allows simple and fast testing of the system being created, its visualization and test its behavior in various circumstances, even without a physical prototype (without risk). All that can be applied in studies of economic environment (Rutkauskas 1999).

Properties of the objects of the public sector

We will consider the part of the public sector that consists of many objects of the same type (roads, streets, water pipes etc.). The objects of the public sector are characterized by some qualitative indexes the totality of which can be defined to be the quality of the objects q that can be described by a number. Objects deteriorate during the use so their quality changes (worsens):

$$Q = f(t) \ ;$$

Worsening of quality of each of the objects happens with different speed. That depends on the external factors influencing the object and on the number of users of the object (for example, number of the cars using the road). Figure 1 shows the change of quality of an object for numbers of users n1<n2<n3. Users of the object suffer higher or lower losses depending on the object's quality. It is important to estimate the change of object user's expenses in such case. The lower the quality of the object, the more losses the users suffer. Figure 2 shows the change of expenses of the users as the time passes for three different numbers of the users n1<n2<n3.

Figure 1: Change of quality as the time passes

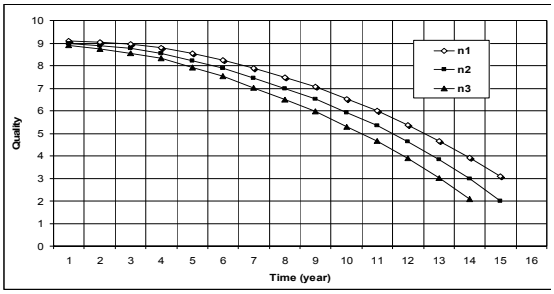
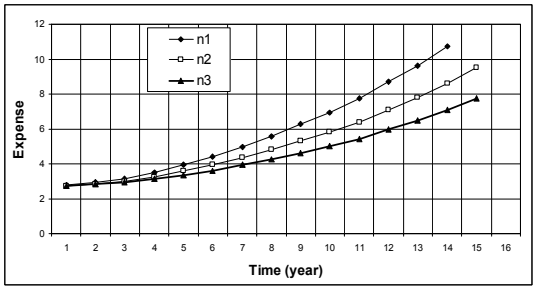


Figure 2: Change of user expenses as the time passes



The group of public sector objects of the same type consists of k objects. It is important to know the average quality of the group, as that is considered by QCSPS to be the generalized qualitative index:

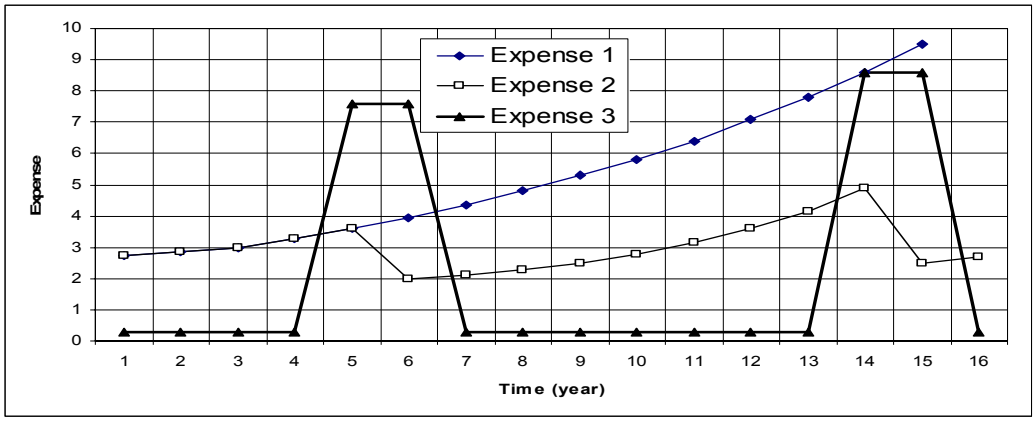
$$Q(t) = \frac{\sum_{k=1}^{n} q_k(t)}{n} \ ;$$

As the time passes, *q* decreases and the quality restoration (repair) becomes necessary. We assume that repairs can be of several types, differing by increase of quality, technologies used and the price. Generally, the higher the increase in quality, the higher the price of repair.

The task of QCSPS is to achieve the value of $Q(t)$ not less than Q_{req} (requested) in some time period *T*. The *q* of every object also has to be higher or equal to some required q_{req}. That has to be done with minimal expenses of the society, consisting of expenses of the users and the expenses of the maintainers. That can be achieved by choosing right times and methods of repair. There is another requirement for the objects of the public sector – the repairs can only be performed if they are economically feasible. That means that the income (decrease of user expenses, compared with the forecasted state without repairs) has to be higher or equal to the maintenance expenses. That is illustrated by Figure 3.

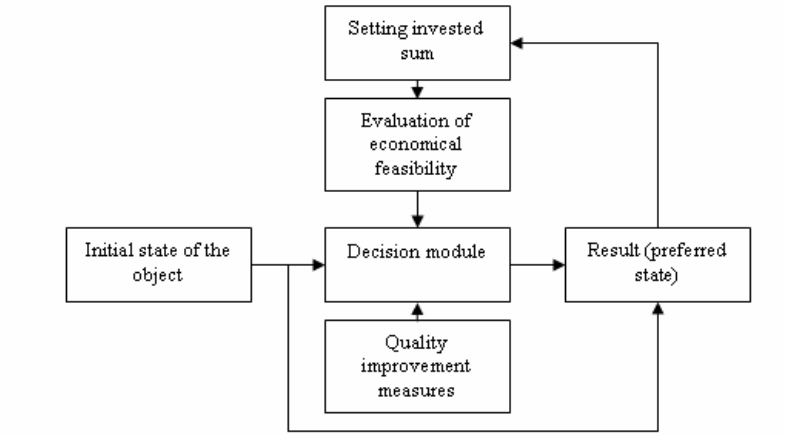
The curve expense 1 shows the change of the user expenses without repairs. The curve expense 2 shows the change of the expenses of users if the repairs are performed. Curve expense 3 shows the expenses of the maintainers. For the sake of simplicity, it is assumed that the maintainer has expenses only during repairs. The first repair would be considered to be economically feasible only if the area under expense 3 for the first repair is equal or less than the area between expense 1 and expense 2 until the year 14. It might be noted, that the maintainer expenses are higher for the second repair as it results in the higher growth of quality.

Figure 3: Expenses of users and of maintainers



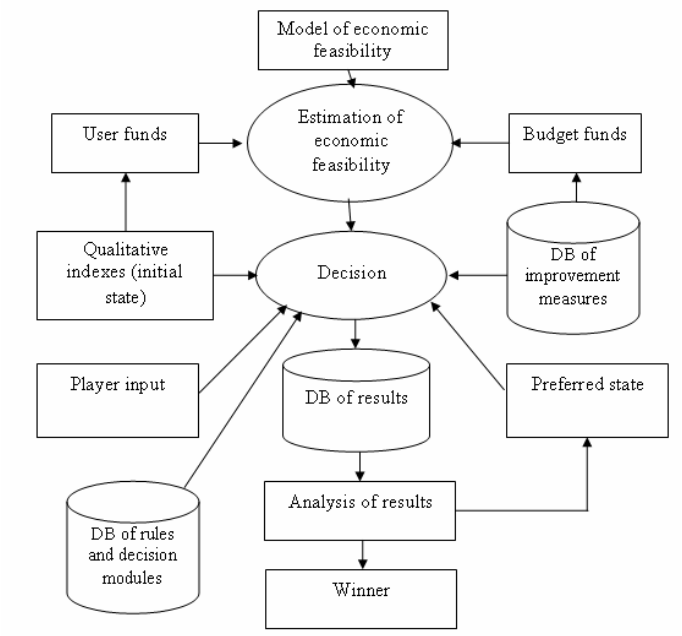
To support the quality maintenance of objects of such type, a quality control system that could help to model and compare various variants of action. For that parameters of the object, their dependencies on the users, the types of quality improvement measures and their effectiveness. If their costs are known, not only the quality increase, but also the required costs can be estimated. The best result (highest efficiency with lowest expenses) will be achieved with the optimal measures. That way, changing the sum invested and optimally choosing the quality improvement measures, the possibility to manage the quality of the object (to create a quality control system) is achieved (Patasius at all 2007). But the efficiency of the system can only improved if the quality improvement is only performed when economically feasible. In such case the system's quality improvement schema shown in Figure 4 can be used.

Figure 4: The common functional schema of management system



The situation of the road network can be changed by changing the invested sum. That way, depending on the sum invested, the block of economic feasibility evaluation checks if the investment is feasible and the decision block chooses the applicable measures. After comparison of actual and forecasted situation it is decided if the change is acceptable. If the change is not acceptable, the sum invested has to be changed. The process is repeated, until the acceptable situation is reached. That means that the situation can be managed by the sum invested.
The quality management modeling system of the public sector consists of several functional blocks, each of which is designed as a software component. Such architecture of the system allows changing (improving) the blocks easily. The functional schema of the QCSPS is given in the Figure 5.

Figure 5: Functional schema of QCSPS



The model data bases store the data about the object, its parameters, measures that increase its quality, their costs, decision modules and rules, results of the decisions. The decision options are analyzed in the block of the economical feasibility evaluation, using the model of economical feasibility and data about the users and invested sums.
The decision block makes the main decisions concerning the time and type of repairs. That is done taking account of qualitative indexes of the object, the requested state of the object, the rules used, decision modules and quality improvement measures. The decisions can be modified according to the parameters defined by the player, their limitations, priorities of the quality improvement measures. The block of analysis of results analyses the data that is stored in the database of results and supplies the data for comparison with the requested state data. The results decide the further actions. If the results are not considered to be acceptable, the process is repeated. If the results are acceptable, the winner is decided. For that the qualitative indexes that have been achieved during the period modeled and the maintainer expenses are considered.

The use of the game for educational purposes

The use of business games in the educational process creates new opportunities. Comparison of individual and group learning has shown that this form of studies enables every player to develop distinct abilities while trying to achieve the common team goal (Isaacs et al. 1992). Trying to achieve the common goal, debriefing for the previous steps and decision-making for the new iteration taking account of the mistakes done before gives the students to improve their critical thinking skill.
It is advisable to use the same software for both individual (lab assignments etc.) and group work. That can be made possible using component-based architecture. Data from both individual and group work is stored in the same databases.
The open structure of the database can also help the students to understand the processes performed. It is thought that it can improve the study results achieved by the students. The students can connect to the game database and learn to design rational interactive queries.
Organizationally the starting state of the game can be set by the teacher according to the educational needs. That is another requirement for the game design. That makes the game more complex, more interesting and more universal. Of course, the teacher has to have a strong background in the problem area to use that to the full potential, as the data used in the game should be similar to the ones used in the practice.

The decisions can be made intuitively, using the method of trial and error, but for better results it's recommended that at first each player should use the game individually, and later (after their introduction) optimization methods would be used. If only overview of public sector object management is planned, the use of optimization methods is unadvisable because of its complexity, but in such case the game can be reused in other modules. Various software tools can be used to help the decision-making. The choice depends upon the level of game organisation and integration to the study process. Such choice improves the realism still more, as the manager has to make the decision after discussion with the team.
It is important to evaluate the efficiency of the game. Various methods of this evaluation exist, but most accurate evaluations can generally be supplied by the users (students and teachers). It seems reasonable to agree with W. Kriz and J. Hense, (Kriz et al. 2006), that the best estimate for that is the change of knowledge. That can be ckecked using tests both before the game and several months after it.

The case of road network maintenance

To use the states funds dedicated for road maintenance effectively, road maintenance management system (RMMS) is used. It allows organization of road maintenance in the way that would minimize the expenses of society consisting of maintenance expenses (sum of road maintenance works and material expenses) and user expenses (for fuel, accidents, car repair etc.). The problem of road maintenance is considered to be a strategic task of the state, as it requires lots of budget funds. The roads are classified into several groups by importance with more attention given to the roads of higher importance. Road quality influences the losses of the road users, time passed in travel and road accident rate. Because of that it is important to assure enough funds for road maintenance and their efficient use. It is important to have ways to manage the situation.
The initial data in this case consists of road network data, road pavement parameters, data concerning traffic intensity, which can be taken from real databases of roads of national importance or of municipal roads, and of data concerning quality improvement measures and technologies that are used at the moment.
The described simulation system can be used to teach both road workers and students of road specialties. The tasks are formulated by the teacher. Many variants of tasks are possible with the main being:

- initial acquaintance with the system, analysis and evaluation of its components;
- finding the optimal levels of maintenance and necessary funding for the whole road network, or a part of it;
- finding the levels of maintenance with the suboptimal funding;
- finding the optimal solution in extreme situations.

Both individual and group study can be used. Is several groups are solving the same problem in parallel, their results have to be compared to find the winner. The teacher has to do this, taking into account originality of decisions and results. The main criterion is economical – minimal expenses of the society. The willingness to be the winner induces the willingness to solve the problems.
An important parameter of any game is the set of player-controlled parameters. In the game of road pavement management it's the type of road repair, the time of road repair, technologies used and the funds invested. The main modules and rules used include the road pavement deterioration model (Kereli 2000), influence of different types of them to the road quality, their costs, dependency of road user and road maintainer expenses on the road quality etc.

Conclusions

The described quality control system of public sector can be used to assure finding of funds necessary for maintaining quality of public sector objects (in this case – roads) and their distribution. Its essence consists in finding the ways to manage the quality of the objects by changing the sum invested, taking into account the parameters of the objects and dependencies of quality on conditions of environment and number of users. The described model of the system can

be used both for analysis of the real situations and for educational purposes. Using open structure databases the system can also help the students improve their query design skills and use the optimization methods to find the optimal solution.
In each case the users of the system are searching for the best solution. While comparing the possible solutions, the solution that allows achieving the required quality with lowest expenses or the better quality with equal expenses is considered to be better.

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