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How to Use Linear Programming for Information System Performances Optimization

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Abstract

Background: Organisations nowadays operate in a very dynamic environment, and therefore, their ability of continuously adjusting the strategic plan to the new conditions is a must for achieving their strategic objectives. BSC is a well-known methodology for measuring performances enabling organizations to learn how well they are doing. In this paper, "BSC for IS" will be proposed in order to measure the IS impact on the achievement of organizations' business goals. **Objectives:** The objective of this paper is to present the original procedure which is used to enhance the BSC methodology in planning the optimal targets of IS performances value in order to maximize the organization's effectiveness. **Methods/Approach:** The method used in this paper is the quantitative methodology – linear programming. In the case study, linear programming is used for optimizing organization's strategic performance. **Results:** Results are shown on the example of a case study national park. An optimal performance value for the strategic objective has been calculated, as well as an optimal performance value for each DO (derived objective). Results are calculated in Excel, using Solver Add-in. **Conclusions:** The presentation of methodology through the case study of a national park shows that this methodology, though it requires a high level of formalisation, provides a very transparent performance calculation.

Keywords: linear optimization, information systems, performance management, balanced scorecard

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Introduction

Strategic performance management is a relatively young field of managerial science. It deals with problems of effective strategy implementation and validation of its contribution to organization's success (Brumec et al., 2002). During the implementation of planned activities it is not unusual that dynamic environment of organisation changes (Dumičić et al., 2002; Dumičić et al., 2014). Therefore, the ability of continuously adjusting the strategic plan, to the new conditions, represents the prerequisite for the successful accomplishment of strategic objectives. Implementation of the strategic plan is usually based on the accomplishment of the planned activities (De Waal, 2006). Each activity contributes to the accomplishment of a certain strategic objective of the organisation. Accomplishment of strategic objectives is measured by performances. By carrying out the activities, the organisation should, within a period of time in future, accomplish the transformation from the current value of performance (as is) to the future value of performance (to be). It is often expected that IT architecture follows up the business strategy, in order to align IT with the business's strategic objectives (Ross, 2003). In this context, it is essential for managers to estimate the impact of new the information technology (IT).

Balanced Scorecard methodology (BSC) is a popular concept of the balanced view of the organisation's performance (Roest, 1997). It was originally established by Kaplan and Norton and its purpose is to support organisations to define their development strategies, as well as to observe the success of the implementing those strategies (Ross, 2003). Development of the BSC is based on the empirical experience of the large number of organisations, in order to avoid disadvantages of measuring effectiveness only by financial indicators. Implementation of the concept enables not only planning and organizing the process of strategic management but also supports controlling the level of accomplishment of strategic objectives. In Strategic Planning of Information System methodology (SPIS) (Brumec, 1996; Brumec, 1998; Brumec et al., 1999; Brumec et al., 1998), BSC is suggested as a very powerful tool for measuring the impact of new information technology (IT) on business performances (Brumec et al., 2002). The purpose of this paper is to provide guidelines for measuring the IS impact on the achievement of organization's business goals, and also to introduce s quantitative methodology for optimizing organization's strategic performance.

The proposed "BSC for IS" concept is similar to the classical BSC concept. The basic ideas for reshaping the BSC perspectives stem from the facts that IS project works in favour of not just individual clients, but also of both the end user and the organization as a whole and fact that the IS department should be perceived as internal, rather than external service provider (Martinsons, 1999). Accordingly, the perspectives for measuring the IS performances are customer (end user) orientation, business values, internal processes and preparedness for the future.

The primary strategic objectives of the IS are divided into two types: (1) objectives related to efficiency and (2) objectives related to effectiveness. The efficiency-oriented objectives relate to the processes. It is, therefore, necessary to consider them through the perspective of internal business processes. The effectiveness-oriented objectives relate to the users and, therefore, are analysed through the perspective of orientation towards the users and the perspective of business values. Recognition of the need for innovations and learning and also the perspective of preparedness for the future, encompasses technologies, business opportunities and challenges which will ensure stability of growth and development.

In this context, the paper will show the original procedure used to enhance the BSC methodology in planning the optimal targets of IS performances value in order to maximize the organization's effectiveness.

Methodology

Formulation of IS Performances Relationship Structure

According to the defined mission, it is necessary to define the future progress of development of the organization, i.e. the vision of organization. This means that organization's vision sets the general guidelines which have to be followed in order to accomplish mission. Implementation of the vision is formalized through developing organization's strategies.

A badly formalized vision, formed as announcements, may be transformed into descriptively and quantitatively determined set objectives (SO). Set strategic objectives are derived from the vision, which is why they are named set strategic objectives. For every SO it is necessary to determine strategy and activities. Results of activities are measured as level of accomplished derived objectives (DO). The name derived strategic objective results from the fact that they are derived from the set strategic objective. This procedure requires forming judgments and strategies (Hell et al, 2009).

One of the tools which can be used for defining strategies for each SO is SWOT, or to be precisely extended SWOT. It provides results, shaped into four types of strategies:

- Direct strategy – which arises when using organizational strengths in order to eliminate weaknesses.
- Direct strategy which is using the opportunities for removing threats from the environment.
- Indirect strategy, that is using organizational strengths for removing threats form the environment.
- Aggressive (shape-to-future) strategy that is using the strengths of the organization and new IS/IT as opportunities for achieving business objectives.

Next step is to derive activities from each strategy so they can be seen as the expansion of a descriptive part of the DO. This results from the fact that every activity is undertaken with the particular goal (1:1). Unlike activities, more strategies can be accomplished through one activity (m:1).

Numerical element of every objective, in the context of this paper, is observed as performance, i.e. measure of objective. In this manner, cause-consequence structure of impact between performances depends on the cause-consequence structure of the strategic objectives. Specifically, it is to be expected that there are influences among certain activities in the real system. It means that undertaking one of activities, regarding IS development, can influence on the effect of another business activity. Since every activity is undertaken in relation to a precisely set objective, it can be concluded that the structure of all objectives is the same as the structure of all activities. A chain of interconnected objectives, in the context of this paper, are called the causes-consequences chain (CCC). Based on previous, it means that it is possible to establish a direct relationships among IS and all other business performances of an organization.

Possibility of processing a large number of relationships between performances demands using the matrix (Hell et al., 2009). Meaning, every row expresses the performance which makes a direct influence on performances in the column. Hence, every column expresses the performance on which a direct influence is made by performance in row. Depending on the existence of direct relationship among performances, the elements in the table gain the values 1 or 0. In example, if there is a direct influence, the value 1 is entered. If not, the value 0 is entered. Every cell in the table is supposed to be filled in this way.

According to the previous explanation, the set objectives (*l*) is determined and the derived objectives (*k*) is derived. The final set of performances can be presented by the following expression (1)

$$\widetilde{C} = \{C_1, C_2, \ldots, C_n\}, \qquad n=k+l \tag{1}$$

A direct influence among performances may be presented in the strict form of the square matrix (Hell et al, 2009) (2). The order of the square matrix SEP (Structure of Enterprise Performances) represents a total number of the performances, including IS performances.

$$SEP = \begin{bmatrix} 0 & c_{12} & c_{13} & \cdots & c_{1n} \\ c_{21} & 0 & c_{23} & \cdots & c_{2n} \\ \vdots & \vdots & \vdots & & \vdots \\ c_{n1} & c_{n2} & c_{n3} & \cdots & 0 \end{bmatrix}. \tag{2}$$

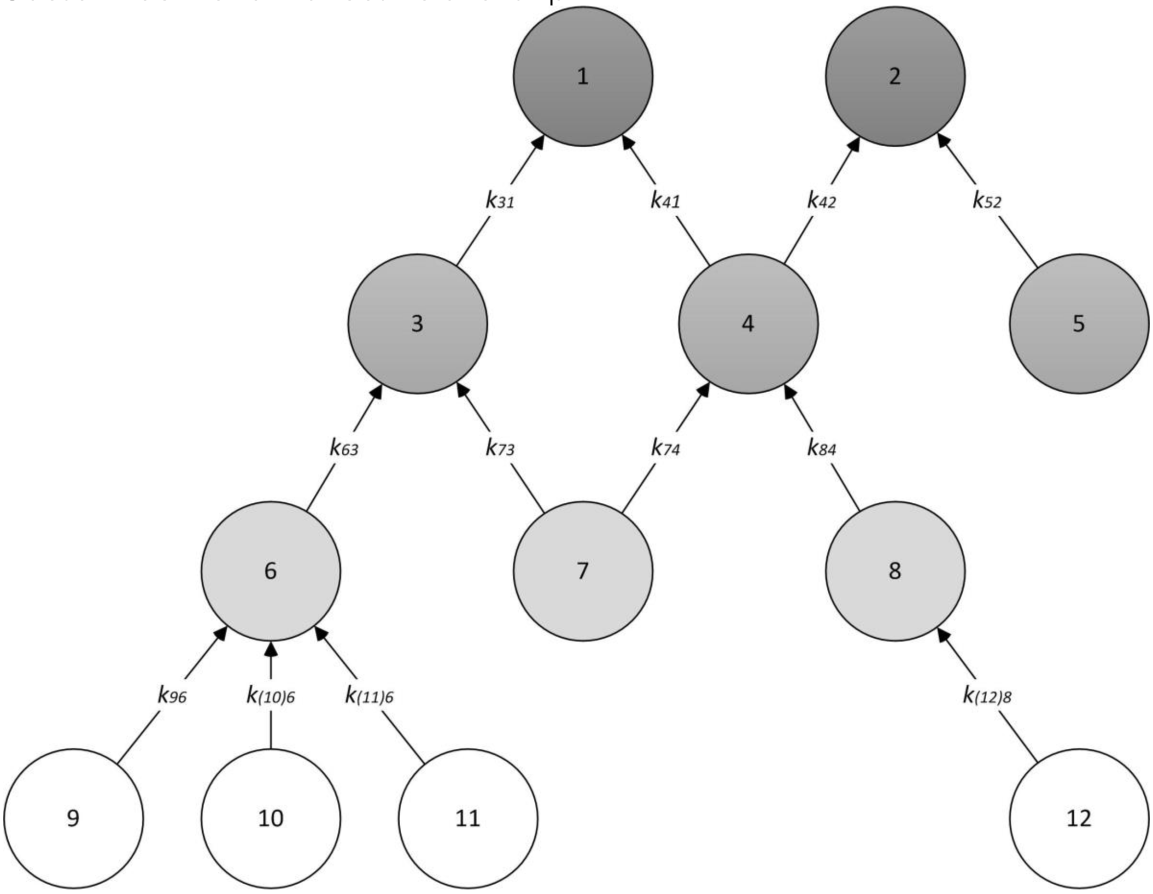
According to the previous explanation, elements of the SEP matrix are $c_{ij} \in \{0,1\}$. Index of SEP elements indicates index of performances of observed direct relationship. In this way, formal prerequisites for optimization performances value are met.

Limitation of Performances Value Increases

The classic BSC concept, in the phase of planning the effects, includes the implementation of determined activities. However, in the real system, implementing the activities can depend on various limitations. That is why it is necessary to adjust an expected level of accomplishment of objectives to the potential limitations. The concept of the strategic management shown in the paper emphasizes two types of limitations.

The classic type of limitation, to accomplish the expected level of accomplishment of objectives, is availability of resources for implementing precise activities. Allocation of resources also depends on structure of performances relationships. Based on the previous formalization, this implies that we need to impose restrictions caused by the structure of performances relationships. It is a consequence of influences that occur between objectives. Achievement of the lower positioned IS objectives is a prerequisite for accomplishing the effect of activities, which are carried out as a purpose of their superior business objectives. This is shown on the Fig.1. It means that for positive change of accomplishment of objective 3, first there has to be positive change of accomplishment of objectives 9, 10, 11, 6 and 7.

Figure 1
Cause-Effect Performances Relationship



Source: Author's illustration

Coefficients of influence between performances (of objectives) have been derived and defined by the expressions (3) (Hell et al., 2009).

$$k_{ij} = \begin{cases} \dfrac{c_{ij}}{\sum_{i=1}^{n} c_{ij}} & if \quad \sum_{i=1}^{n} c_{ij} \neq 0 \\ 0 & if \quad \sum_{i=1}^{n} c_{ij} = 0 \end{cases} \quad . \tag{3}$$

Let the n be the number of all performances and i number of performances which are at the beginning of CCCs. This means that there are n–i of calculated performances. This results in the existence of n–i limitations, which can be defined by the system of inequality (4) (Hell, Vidačić, & Garača, 2009).

$$\begin{cases} 0 + k_{21} \cdot m_R C_2 + \cdots k_{i1} \cdot m_R C_{n-i} + \cdots + k_{n1} \cdot m_R C_n \geq 1 \cdot m_R C_1 \\ \quad 0 + \cdots k_{i2} \cdot m_R C_{n-i} + \cdots + k_{n2} \cdot m_R C_n \geq 1 \cdot m_R C_2 \\ \quad \vdots \qquad \vdots \qquad \vdots \\ \quad 0 + \cdots + k_{n2} \cdot m_R C_n \geq 1 \cdot m_R C_{n-i} \end{cases} . \tag{4}$$

Coefficients k_{ij} for $i \neq j$ have been calculated from equation (3). The system of inequalities (4) includes $n\text{–}i$ inequalities in which each inequality indicates one limitation to the calculated performance.

Defining objectives and their performances and determining “as is" and "to be" values sets the range for change of a performance. The defined range of performance enables the calculation of the relative change of performance. The relative change of performance of the objective C_j during the observed period of the strategic cycles is calculated according to the expression (5) (Hell et al., 2009).

$$m_R C_j = \frac{mC_j - mC_j(0)}{mC_j(T) - mC_j(0)}, \qquad j=1,\dots,n \tag{5}$$

In expression:

- n stands for the number of the determined objectives,
- mRCj stands for the relative value of performances of the objective Cj,
- mCj(0) is an initial value of the performance of the objective Cj,
- mCj is a current value of the performance of the objective Cj at the end of the observed period and
- mCj(T) is the expected value of the performance of the objective Cj at the end of the strategic cycle with the time T.

The relative change calculated in this way can occur in the segment [0,1].

Calculation, done by using the relative value in the given concept, imposes a prerequisite of inequality and maximum value of a performance for all strategic objectives i.e.:

$$0 \leq m_R C_i \leq 1, \ \forall \ i=1,\dots,n. \tag{6}$$

In this way, all the limitations have been included which enables the final determining of the optimal strategy (using an elaborated procedure).

The nature of each IS development activity indicates specific resources for its implementation. By determining the accompanied IS’s DOs, the measures and the range of changes are clearly defined. This is accomplished by implementation of the planned IS development and other business activities. This means that all necessary resources can be generated from activities and performances of DOs.

$$\begin{cases} r_{11} \cdot m_R C_1 & + & \cdots & + & r_{k1} \cdot m_R C_k \leq R_1 \\ r_{12} \cdot m_R C_1 & & & & r_{k2} \cdot m_R C_k \leq R_2 \\ \vdots & & & & \vdots \qquad \vdots \\ r_{1r} \cdot m_R C_1 & + & & + & r_{kr} \cdot m_R C_k \leq R_r \end{cases} \tag{7}$$

Values r_{ij} indicate the required allocation of resources for 100% of accomplishment of k DOs which require the implementation of the observed activity. Every inequality in expression (7) indicates limitation caused by the availability of one particular resource (R_i) (Hell et al., 2009). This defines and mathematically formalizes the set of limitations over the total level of accomplishment of DO based on the availability of resources.

Optimization of IS Performances Value

Fact that organization should be observed as a whole system is basic characteristic on which this model has been developed. It means that the accomplishment of strategic objectives should not be observed partially, however they should be observed in the context of accomplishment of set strategic objectives. Such an approach indicates that the maximum accomplishment of all DO is not always optimal. Determining the optimal level of accomplishment of strategic objectives represents a problem which can be solved by using linear programming.

Problem of linear programming can generally be the problem of maximum or the problem of minimum. This analysed problem belongs to the problem of maximum of the linear programming since idea is to maximize the value of set SO performances. Specifically, considering limitations caused by available resources and the determined structure of performances relationships, it is necessary to find the optimal level of accomplishment of derived strategic objectives.

A function which requires a set maximum, i.e. the function of an objective, is defined by the expression (8)

$$Max\left(\frac{1}{l}\cdot\sum_{j=1}^{l} m_j C_j\right). \quad (8)$$

Following elements have been determined:

- functions of performances of SO defined by the expression (8),
- limitations caused by the performances relationship structure defined by the expression (4),
- limitations caused by availability of IS resources defined by the expression (7),
- prerequisite of no negativity and maximum value of performances defined by the expression (6).

The observed problem includes all required elements for implementation of the linear programming in order to define the optimal strategy. The gained result indicates the optimal values of DOs performances for maximum of value of performance of SOs. Sum of product of performances optimized values and r_i indicate total of *i* resource needed.

Case Study: National Park “Plitvička Jezera”

Introduction

Idea of this case study is to show example for using linear programming for IS performances optimization on the example of national park. Values used in this case study are hypothetic and they are pro forma for presenting procedure when applying this approach.

It should be emphasized that the national park “Plitvička jezera” is very distinctive protected area according to both Croatian and international standards. In 1979, it was incorporated in the UNESCO list of world cultural and natural heritage. The main activities of the institution are to protect, maintain and promote national park for the purpose of protecting and preserving the authenticity of nature, ensuring the smooth progress of natural processes and sustainable use of natural resources, and also monitoring the implementation of conditions and safeguards. In addition to the core business of this institution, there are more subsidiaries of hospitality, trade, technology and infrastructure.

Institution is operating under the principles of the Law on the Protection of Nature as a public institution, but finances of park are under regulations for a companies because the park is self-financing (Sikic, 2007). Because of that national park is considered to be the main economic initiator in the whole region.

Formulation of IS Performances Relationship Structure

Following mentioned methodology, formulation of performances relationship structure begins from National park mission. Forming vision is skipped because vision already exists.

Organization's vision is: *"National park Plitvička jezera will remain World Natural Heritage UNESCO, Croatian leader in preserving and promoting the unique natural and cultural values in their valuation trough the sustainable tourism for the benefit of the region, the local community and visitor satisfaction"*.

Transforming vision to quantitatively determent set of strategic objectives (SO) results in three SO:

- SO_1 – Preserve unique biodiversity of karstic rocks allowing undisturbed natural processes and ensuring the protection of the areas with negligible human impact
- SO_2 – Cooperation of local population and park's management in planning and implementing local development
- SO_3 – Providing availability of a true experience of the park natural values for the visitors.

Following step is to define strategies and activities for each SO, since the same procedure is applicable for each SO, this procedure is going to be done only for the SO_1. Tool used for defining strategies is SWOT. Accordingly, below in Table 1 list of all generated strengths, weakness, treats and opportunities based on SO_1 can be seen.

Rows in matrix represent weaknesses (w1, w2, w3, w4, w5, w6, and w7), threats (t1, t2, t3, t4, t5, t6 and t7) and opportunities (o1, o2, o3, o4, o5, o6, o7, o8, o9 and o10); and, on the other hand, columns represent strengths (s1, s2, s3, s4, s5, s6, s7, s8, s9, s10 and s11) as well as opportunities (o1, o2, o3, o4, o5, o6, o7, o8, o9 and o10). Reason for double use of same opportunities, i.e. they can be seen both in rows and columns, is to create better view for final defining strategies.

Weaknesses are: inadequate methods of monitoring flora and fauna (w1), undeveloped system for monitoring preservation (w2), lack of education of the local population (w3), outdated program for environment protection (w4), undeveloped technology for guides (w5), unrecorded water stream (w6), and undefined optimal capacity of the park (w7).

Threats are: lack of communication regarding environmental protection (t1), harmful effect of humidity (t2), abandoned waste (t3), law changes about protected areas (t4), costs of implementing new technologies (t5), uninformed visitors about management precautions (t6), and lack of protected areas register (t7).

Strengths are: computer literacy of employees (s1), will for improvement and development (s2), computer records of flora and fauna (s3), educational billboards (s4), meteorological knowledge (s5), records in 3d full HD format, (s6), use of photo equipment (s7), use of GIS system (s8), use of is KEC (s9), use of mobile explore Croatia (s10), and money inflow.

Opportunities are: methods of infrared detection and video recording (o1), better system for situation monitoring (o2), education of the visitors (o3), use of plant monitoring software (o4), video monitoring (o5), environmentally friendly illumination (o6), monitoring records of Google earth (o7), use of NISNPS projects (o8), development of e-guide (o9), and cooperation with forecasting IS (o10).

Matrix is filled with values 0 or 1. Value 1 is put only where there is impact among SWOT elements. Filled matrix is shown on the next page.

Table 1
SWOT Elements Based on Park's SO_1

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	o1	o2	o3	o4	o5	o6	o7	o8	o9	o10
w1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
w2	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
w3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
w4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
w5	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
w6	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
w7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
t6	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
t7	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
o1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o2	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
o3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o9	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
o10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Author's calculation

Based on extended SWOT, strengths and opportunities combining is enabled in order to develop strategies which would eliminate weakness and reduce threats.

Strategies are defined after analysing the matrix by rows. It is necessary to consider only rows which contain at least one value 1, otherwise strategy makes no sense since element represented in columns do not have any impact on element in row. Using this approach it can be seen that first row (w1) contains three fields filled with 1, meaning:

- Money inflow (s11) has impact on inadequate methods for monitoring flora and fauna (w1).
- Methods of infrared detection and video (o1) have impact on inadequate methods for monitoring flora and fauna (w1).
- Better system for situation monitor (o2) has impact on inadequate methods for monitoring flora and fauna (w1).

Taking in the consideration one strength (s11) and two opportunities (o1 and o2) impacting one weakness (w1), first strategy can be formed. First strategy assumes using these elements (s11, o1 and o2) in order to eliminate one weakness (w1). But, after switching to second row (w2) it can be seen that same elements have impact on w2 as well as they have on w1. That is the reason why first strategy can be defined as use of one strength (s11) and two opportunities (o1 and o2) in order to eliminate two weaknesses at the same time (w1 and w2). Meaning, park can eliminate old methods of monitoring the flora and fauna (w1) as well as the poor system for monitoring preservation (w2), using financial funds (s11) which have to be invested in the purchase of products on the market such as the method of infrared detection and video (o1), and better monitoring system (o2).

Following the same approach, it can be seen that there are six more strategies. Aas a final result all seven strategies are shown in the Table 2.

Table 2
Matrix of Extended SWOT Strategies

No	Strategy label	Description of strategies
1	S11+O1+02=W1+W2	Using financial funds (S11) to invest in the purchase of products on the market such as the method of infrared detection and video (O1), and better monitoring system (O2). It is necessary to take advantage of these opportunities in order to eliminate the current weakness - meaning old methods of monitoring the flora and fauna (W1) as well as the poor monitoring system preservation (W2). The systems were not enough precise.
2	S2+S7+O2=W6	Using will for development and improvement (s2) for more efficient use of existing photo equipment (s7) and use of new monitoring system preservation with the purpose of recording all unrecorded waterfalls (w6) and, in that way, eliminate one of parks weaknesses.
3	S1+S11+O9=W5	It is necessary to use financial funds (S11) for stimulating employees so they could be encouraged for usage of the new technologies for guides and visitors (O9), thanks to their IT skills (S1). All that with goal of eliminating the problem of insufficiently developed technology for conductors (W5).
4	S10+O3=T6	In order to eliminate threat of uninformed visitors (t6) it is necessary to use educational billboards (s10) and to increase visitors education (o3) during their visit
5	S3+S7+O7=T7	One of big threats is the absence of the register of protected areas (T7) because it is necessary that the park's management is aware of exactly all protected areas so they could be promptly and adequately protected. It is necessary to upgrade computer records (S3), use photo equipment (S7) and use Google records (O7) to define more precisely protected areas.
6	S1+S11=O9	Using computer literacy of employees (s1) and financial funds (s11) to develop e-guide (o9). E-guide can have a huge impact on other fields too.
7	s11+o5=T6	Increase amount of abandoned waste (t6) is a big treat since it can ruin unique nature. It is required to invest financial funds (s11) in a new and better video monitoring (o5) in order to reduce waste and to know how to manage it.

Source: Author's calculation

Next step is to derive activities which must be carried out in order to achieve derived goal (DO). For example, first strategy mentioned before contains activity (label c1) „*Teaching staff through seminars so they could use new programs*“. Idea is to increase educational level of employees so they can be skilled for using new methods. This specific activity will be measured with the number of certificates which employees need to gain by attending seminar. Current value for measuring this is 0, and "to be" value is 80%, i.e. 80% of employees will be educated on how to use new methods. Unit of measuring this activity is number of certificates. Meaning, only employees who are able to finish whole seminar and pass the exam can earn certificate and become educated employees.

Since there are seven formed strategies, each of them has corresponding activities, measures, as well as other information shown in Table 3.

Table 3
Matrix of activities and derived strategic goals (DO)

Goal label	Activity description	Direction of change	Object of change	Measure	As is	To be	Unit of measure
C1	Teaching staff through seminars so they could use new programs	Increase	education level of the employees for working with new methods	certificate	0	80%	number of certificates
C2	Create reports using new methods of monitoring and also photographing condition in park	Increase	water streams records	number of registered water streams	0	30	number of reports
C3	Distribution of e-guides among visitors and guides.	Increase	development of technology for guides	% of usage of distributed e-guides	0	80%	usage of applicatio n
C4	Development of new billboards and leaflets.	Increase	educated employees for working with new methods	number of new leaflets	100	180	number of leaflets
C5	Update of existing data in order to create register of protected areas.	Increase	development of register of protected areas	% of register developme nt	0	100%	register developm ent
C6	Organizing workshops for all employees on the topic of developing e-guide	Increase	e-guide	% of guide developme nt	0	100%	guide developm ent
C7	Prompt reaction of waste removal using adequate sanctions	Decrease	amount of waste	average amount of waste per square meter	0,40	0,10	kg

Source: Author's calculation

Thus, next step is to create cause-consequences structure impact between performances, i.e. measure of objectives. This is done by putting same performances in rows as well as in columns and filling values 0 or 1 according to relationships between those performances. The result of this procedure is shown below.

Table 4
Matrix of Goals Structure

	X	C7	C3	C4	C5	C6	C2	C1
X	0	0	0	0	0	0	0	0
C7	1	0	0	0	0	0	0	0
C3	1	0	0	0	0	0	0	0
C4	1	0	0	0	0	0	0	0
C5	1	0	0	0	0	0	0	0
C6	0	0	1	1	0	0	0	0
C2	0	0	1	0	1	0	0	0
C1	0	0	0	0	0	0	1	0

Source: Author's calculation

Table 4 shows direct influences in form of square lower triangular matrix. Column labelled with "x" represents SO, therefore that column provides information about performance's impact on chosen SO. For example, impact of C7 is shown in second row, meaning that C7 has influence only on X. Also, looking at the second column, it can be seen that nothing has impact on C7 (whole column is filled with 0) etc.

Limitations of Performances Value Increases

Classic type of limitations, when implementing activities, is availability of resources needed for fulfilling activities. It is well known that every activity needs some kind of the resources, so in this case study there are two types: (1) human resources and (2) financial resources. Estimations for each activity are done and shown in the table below.

Table 5
Matrix of Resources Estimation

		A1	A2	A3	A4	A5	A6	A7	MAX
Human resources	R1	10	80	50	5	80	60	10	240
Financial resources (000 kn)	R2	2.500	12	20	5	2	30	5	2.000

Source: Author's calculation

For achieving activity A1, which refers to teaching stuff through seminar so the new methods can be implemented; there is need for 10 people and 2.500.000, 00 KN. Every amount shown in the table is the amount of resource needed for accomplishing 100% of each activity.

Financial resource are mainly intended for buying new product and licenses for new methods, and human resources are needed for dealing with whole implementation process. Since allocation of resources depends on structure of performance relationship, coefficient of influence between performances need to be calculated. Coefficient of influence between performances are calculated using expressions (3) from methodology.

Calculation of coefficient of influence for (c7), which refers to second row (2) and first column (1) in table, is calculated below. This coefficient can be calculated since condition of no-negativity is met, meaning c_{21}≠0 (can be seen in Table 4).

$$k_{21} = \frac{c_{21}}{\sum_{i=1}^{8} c_{i1}} = \frac{1}{4} = 0{,}25$$

All other coefficients are calculated in same way and are shown in the table below. Nine coefficients can be calculated: k_{31}, k_{41}, k_{51}, k_{63}, k_{73}, k_{21}, k_{64}, k_{75} and k_{87}, since other do not met the condition.

Table 6
Coefficients of Influence

	k(X)	**k(C7)**	**k(C3)**	**k(C4)**	**k(C5)**	**k(C6)**	**k(C2)**	**k(C1)**
k(X)	0	0	0	0	0	0	0	0
k(C7)	**0,25**	0	0	0	0	0	0	0
k(C3)	**0,25**	0	0	0	0	0	0	0
k(C4)	**0,25**	0	0	0	0	0	0	0
k(C5)	**0,25**	0	0	0	0	0	0	0
k(C6)	0	0	**0,5**	**1**	0	0	0	0
k(C2)	0	0	**0,5**	0	**1**	0	0	0
k(C1)	0	0	0	0	0	0	**1**	0
SUM	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**0**

Source: Author's calculation

Based on calculated coefficients in Table 6 and goal structure in Table 4, cause-consequences diagram with coefficients of influence between performances can be formed.

Figure 2 shows that c2 – *creating reports using new methods of monitoring and also photographing condition in a national park*, cannot be achieved without previous achievement of activity c1 – *teaching staff through seminars so they could use new programs*. Yet, c5 – *updating of existing data in order to create register of protected areas* and c3 – *distribution of e-guides among visitors and guides* cannot be done without a prior c2. Also, C3 – *Distribution of e-guides among visitors and guides*, depends on c6 – *organizing workshops for all employees on the topic of developing e-guide* same as c4 depends on it – *development of new billboards and leaflets*. C7 – *Prompt reaction of waste removal using adequate sanctions* does not depend on any other activity and, there so, has direct impact on SO without need for achieving any previous activity.

Second are limitations caused by structure of performances. Furthermore, since number of performances is 8 (n) and number of performances which are at the beginning of CCCs is 3 (i), there are 5 limitations (n-i). Limitations caused by structure of performances are calculated using expression (4). Limitations caused by available resources are calculated using expression (7). After formalising the limitations everything is prepared for final step in this procedure – optimization.

Table 7
Limitations Caused by Structure of Performances

m(C5)	**m(C3)**	**m(C4)**	**m(C2)**	**m(C1)**	**m(C6)**	**m(C7)**			
0,25	0,25	0,25	0,00	0,00	0,00	0,25	0,885	≥	m(X)
0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,69334	≥	m(C5)
0,00	0,00	0,00	0,50	0,00	0,50	0,00	0,84667	≥	m(C3)
0,00	0,00	0,00	0,00	0,00	1,00	0,00	1	≥	m(C4)
0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,69334	≥	m(C2)

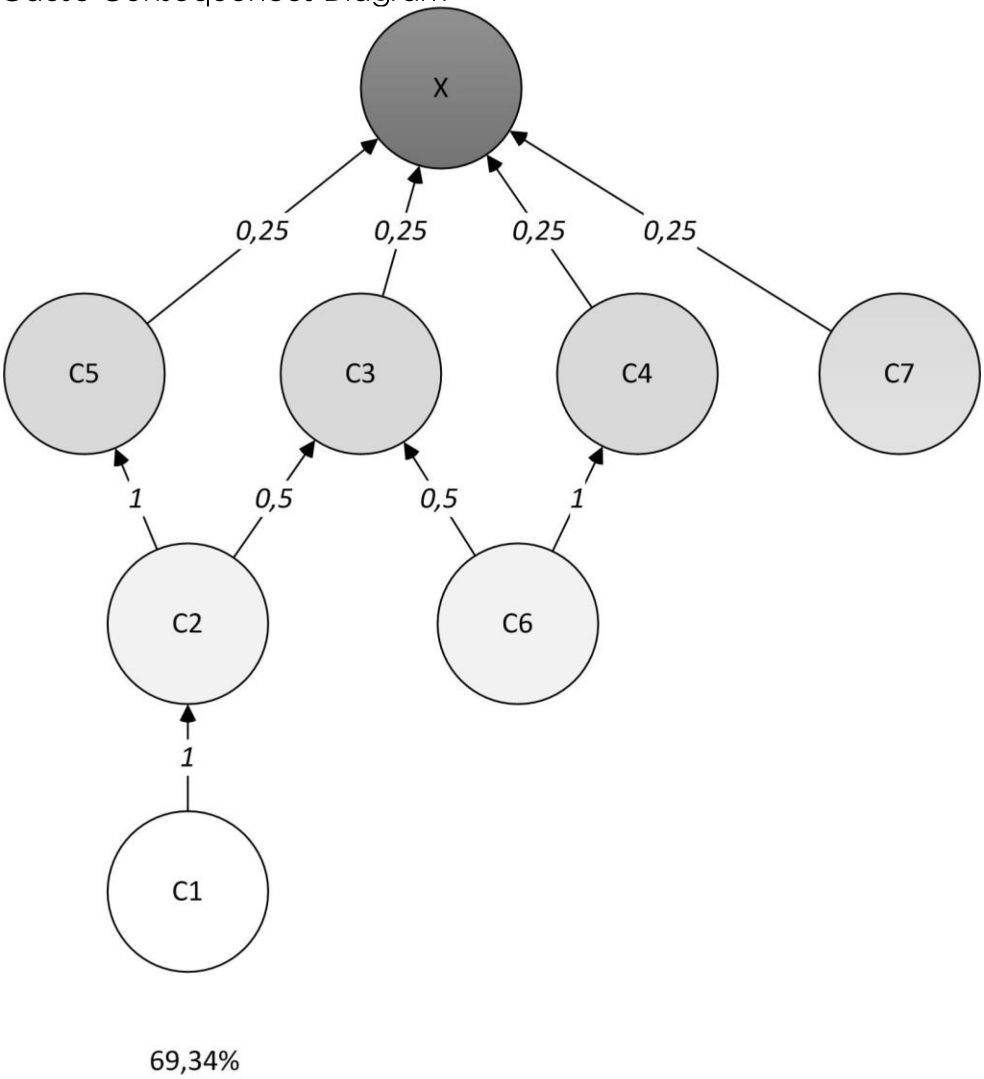
Source: Author's calculation

Table 8
Limitations Caused by Available Resources

Goals	C5	C3	C4	C2	C1	C6	C7	Estimation of resources		Limit
re1	**80**	**50**	**5**	**80**	**10**	**60**	**10**	**235,2021**	≤	**236**
re2	**2**	**20**	**5**	**12**	**2.500**	**30**	**5**	**1800**	≤	**1.800**

Source: Author's calculation

Figure 2
Cause Consequences Diagram



Source: Author's illustration

Optimization Of IS Performances Value

After taking in consideration performances relationship structure and limitations, final thing is to calculate optimal performances value for achieving SO_1.

Final calculation of optimization is done in Excel using tool Solver. Solver is add-in in Excel, used to perform what-if analysis. Solver can run thousands of calculations and return the optimal result if it finds a solution (Excel, 2013). Before performing the calculation, 23 limits (constraints) need to be defined.

Limits are:

- Optimal performance values for each goal can have three types of limits (1) optimal performance value has to be equal or bigger than minimum value, (2) optimal performance value has to be equal or less than maximum value and (3) optimal performance value has to be equal or less than limitation caused by structure of performances. Last limit does not exist if there is no limitation caused by structure of performances. Since in this case study there are five limitations caused by structure of performances plus maximum and minimum value for each of goal (including SO_1), total number of constraints is (8*2+5) 21.
- There are two types of resources, meaning that there are two more limits. Estimated value for each resource must be equal or less than resource limit.

Minimal and maximal value also needs to be defined (Hell et al., 2009).Optimal performance value is calculated using Solver, based on Simplex LP method. Final result of SO_1's optimal performance value of function is 88, 5%. Other values are shown in Table 9.

Table 9
Optimal Performance Values

Coefficients of SO	**m(X)**	**m(C5)**	**m(C3)**	**m(C4)**	**m(C2)**	**m(C1)**	**m(C6)**	**m(C7)**
	1	0	0	0	0	0	0	0
activities		A5	A3	A4	A2	A1	A6	A7
Measures	m(X)	m(C5)	m(C3)	m(C4)	m(C2)	m(C1)	m(C6)	m(C7)
Min	88,50 %	69,33 %	84,67 %	100,00 %	69,33 %	0,00%	0,00%	0,00%
Optimal performance value	**88,50 %**	**69,33 %**	**84,67 %**	**100,00 %**	**69,33 %**	**69,33 %**	**100,00 %**	**100,00 %**
Max	100%	100%	100%	100%	100%	100%	100%	100%

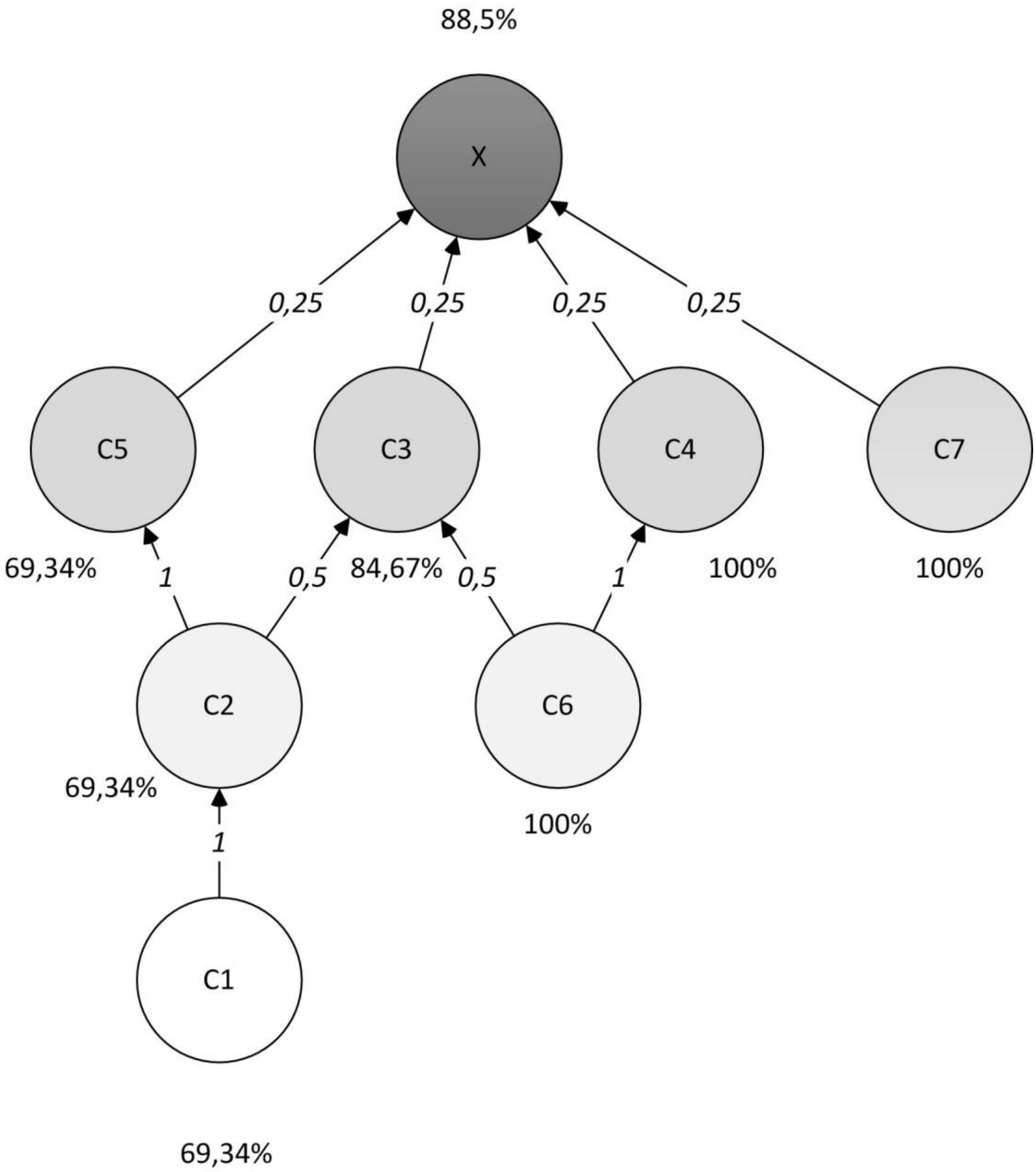
Source: Author's calculation

To conclude, maximum value of performance of strategic objectives (SO) derived from park's mission, who is preserving unique biodiversity of karstic rocks allowing undisturbed natural processes and ensuring the protection of the areas with negligible human impact, applying linear programming, is 88, 5%. In order to achieve this value of SO, optimal values of performances are also calculated and amount:

- C1 – Teaching staff through seminars so they could use new programs (69, 33%)
- C2 – Create reports using new methods of monitoring and also photographing condition in park (69, 33%)
- C3 – Distribution of e-guides among visitors and guides (84, 67%)
- C4 – Development of new billboards and leaflets (100%)
- C5 – Update of existing data in order to create register of protected areas (69, 33%)
- C6 – Organizing workshops for all employees on the topic of developing e-guide (100%)
- C7 – Prompt reaction of waste removal using adequate sanctions (100%)

Optimal values of performances calculated using Excel are also shown in Figure 3.

Figure 3
Cause Consequences Diagram with Optimal Values



Source: Author's illustration

This was an example of using linear programming for information system performances optimization in national park.

Conclusion

The original algorithm shown in the paper, based on the matrix calculation, enhances solving the economic problem of optimization of IS performances due to the maximization of accomplishment of the set strategic objectives. BSC is used for planning the optimal values of performance, in order to maximise the organizational effectiveness. The methodology was illustrated with a case study. Goal was to show how Park can maximise accomplishment of set strategic objectives using IT.

Idea was to start with transforming qualitatively described organization's vision to quantitatively determent set objectives (SO). Furthermore, derived objectives (DO) needed to be determined which required forming IT based business strategies.

Strategies were formed based on SWOT, and expanded swot was applied in order to estimate the level of capacity of the Park to accept IS/IT and the potential impact of the new it on achieving strategic goal.

It is hoped that proposed methodology will facilitate optimisation of organizational strategic performances. Though using this approach requires a high level of formalisation, performance calculation is much more transparent. Also, SWOT analysis is very often made in organizations but more often results are ignored or put aside. The paper leads us to conclude that the application of the linear programming within the classic concept of the BSC enables the optimization of IS performances. Also, it establishes a direct relationships among IS and all other business performances of an organization Periodical repetition of the suggested procedure of the optimization in the set discreet moments enhances the current method of management by implementing the strategy.

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