Models and mechanisms for planning service improvements

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Abstract. Models and mechanisms for project portfolio management, constantly generated by the IT service provider and designed to optimize IT processes of IT service life cycle stages are the subject of this article. The service improvement plan is formed from the project portfolio and is aimed at achieving critical indicators of IT services market success relevant for the current period. Two linear and one nonlinear models of the problem of forming a service improvement plan were considered. The criteria chosen for task optimization are absolute and relative value of the complex IT process efficiency indicator. Problems take into account the investment costs on implementing projects and changing the operational costs on functioning of optimized IT processes. All the problems were solved with the use of network programming methods.

1. Introduction
The structure of IT service lifecycle proposed in the ITIL-3 includes a continuous improvement stage. It is intended for improvement (in terms of efficiency and cost) the IT processes of the main stages (strategy, design, implementation and operation), which perform production functions, as well the support for service application by users.

Improvement projects are initiated both by the personnel of the stage, to whom this function had been delegated, and by specialists of the main stages. Each improvement proposal goes through several processing stages (filters). In particular, changes in the performance indicators of the improved IT processes are evaluated, and the impact of these improvements on changes in the performance indicators of the processes associated with improved process is assessed. Changes of operating costs (costs on functioning of the improved IT process) and the related processes are estimated. Note that not every project changes operating costs. A decision is ultimately taken on implementing or rejection the project proposal. All the agreed proposals enter into the portfolio of service improvement projects. Taking into account the allocated investments for the next planning period, the group
for improvement services plans implementation of the most effective projects (forms the current service improvement plan).

2. Formalization of a problem on generation of a service improvement plan

Let \( P = \{ p_i | i = 1, m \} \) and \( \{ z(p_i), i = 1, m \} \) - are respectively the sets of projects initiated by personnel of different stages of IT service life cycle, and costs required for implementation of these projects.

The effectiveness \( q_i = q(p_i) \) of an individual project, with regard to its contribution to the life cycle efficiency in the large, is determined by the values \( \Delta \mu_{ik}(p_i) \) of changes in the performance indicators of the stages planned to be achieved, as a result of the project implementation.

In this case \( n = 1, N_{ik} = 1, l = 1, L_k \), where \( N_{ik} \) - is a number of effectiveness indicators describing process 1 of the stage k, \( L_k \) - a number of process on the k-th stage, \( K \) - a number of life cycle stages. Having set weight coefficients \( \alpha^i_n(p_i), \sum_{n=1}^{N} \alpha^i_n = 1 \) for effectiveness indicators of IT processes of all stages, weight coefficients \( \gamma_k(p_i), \sum_{k=1}^{K} \gamma_k = 1 \) for the life cycle, and having made transformation of the local indicator measurement scales \( \mu_{ik}(p_i) \)to a single discrete point scale of a given rank \( R \), it’s necessary to define effectiveness \( q_i = q(p_i) \) of the individual project \( p_i \) for the life cycle in the following way [2]:

\[
q(p_i) = \sum_{k=1}^{K} \gamma_k(p_i) \sum_{l=1}^{L_k} \beta_{il}(p_i) \sum_{n=1}^{N_{kl}} \alpha^i_n(p_i) \Delta \mu_{ik}(p_i) .
\]

By \( \Delta z_{ik} \) denote the change of operating costs on functioning of the process 1 of the stage k linked to the implantation of project \( p_i \). Subsequently, the total change \( \Delta z_i \) of operating costs linked to implantation of the i-th project will be:

\[
\Delta z_i = \sum_{k=1}^{K} \sum_{l=1}^{L_k} \Delta z_{ik}.
\]

Let \( \Delta z > 0 \) - is a change of operating budget admissible for the IT service provider in the next planning period. Let also \( z^* \) - are investments which may be directed to the implementation of optimization projects in this period.

Let us introduce a variable to formalize the problem at hand:

\[
x_i = \begin{cases} 1, & \text{if a project is entered in portfolio of accomplishable projects} \\ 0, & \text{if this is not the case} \end{cases}
\]

3. Linear models of a problem for forming service improvement plan

The simplest model of the problem under study is the following (linear model 1):

\[
q(x) = \sum_{i=1}^{m} q(p_i) x_i, \rightarrow \max
\]

\[
z(x) = \sum_{i=1}^{m} z(p_i) x_i \leq z^* .
\]

It does not take into account changes in operating costs. Problem consist in definition of such \( x_i, i = 1, m \),
which maximize the criterion (4), but also meets the restrictions (5) on the total amount of investments. Task belongs to a class of knapsack problems and is solved by the dichotomy programming method [3,4].

Another model of the problem in question increasingly reflecting realities will be the following (linear model 2):

\[
q(x) = \sum_{i=1}^{m} q(p_i)x_i \rightarrow \max
\]

\[
z(x) = \sum_{i=1}^{m} z(p_i)x_i \leq z^*
\]

\[
\Delta z(x) = \sum_{i=1}^{m} \Delta z_i x_i \leq \Delta z^*
\]

Problem consist in determination \(x_i, i=1,m\) maximizing the criterion (6), but also meeting the restrictions (7) and (8), respectively, on the total amount of investments and on the admissible change of the operating budget in the planned period. The presence of two constraints does not allow the direct application of the dichotomy programming method to solve the problem (6) - (8). To make this possible, it is necessary to divide a plurality of projects \(P = \{p_i | i=1,m\}\) into two subsets:

\[
\{p_{i|1,m}\} = \{p_{i|1,m^o}\} \cup \{p_{i|1,m^o}\}, m=m^o+m^o,
\]

where \(m^o\) and \(m^o\) – number of projects, which change and do not change operating expenses of processes, respectively.

Then the solution of task (6) - (8) can be reduced to the successive solution of three following problems:

1. Construction of dependency \(q^o(x), \Delta z^o(x)\) of efficiency and operational cost changes for a subset \(\{p_i | i=1,m^o\}\). This requires to solve the task:

\[
q^o(x) = \sum_{i=1}^{m^o} q(p_i)x_i \rightarrow \max
\]

\[
\Delta z^o(x) = \sum_{i=1}^{m^o} \Delta z_i x_i \leq \Delta z^o
\]

Problem (10) – (11) – is a typical knapsack problem. Let \(\{x^o\} = \{(x_1,x_2,x_3,x_4)\}\) - is a set of decisions of the problem (10) – (11), and \(\{(q^o(x^o), \Delta z^o(x^o))\}\) - is a sets of related pairs of both a criterion value (10) and constraint (11).

2. Construction of dependency \(q^i(x), z^i(x)\) of efficiency and operational cost changes for a subset of projects that do not change operational costs. This requires to solve the task:

\[
q^i(x) = \sum_{i=1}^{m^i} q(p_i)x_i \rightarrow \max
\]

\[
z^i(x) = \sum_{i=1}^{m^i} z(p_i)x_i \leq z^i
\]

It’s the same typical knapsack problem. Let \(\{x^i\} = \{(x_1,x_2,x_3,x_4)\}\) - is a set of decisions of the problem (12) – (13), and \(\{(q^i(x^i), z^i(x^i))\}\) - are sets of related pairs of the criterion value (12) and constraint (13).

3. Formation of the set \(\{x\} = \{(x_1,x_2,x_3,...,x_8)\}\), as a product of solution sets \(\{x^o\} = \{(x_1,x_2,x_3,x_4)\}\) and \(\{x^i\} = \{(x_5,x_6,x_7)\}\) of solutions, respectively, of problems (10) – (11) and (12) – (13):

\[
\{x\} = \{x^o\} \times \{x^i\}
\]
4. Search on the set (14) of the optimal solution of a problem:

\begin{align}
q(x) &= (q^*(x^o) + q^u(x^u)) \rightarrow \text{max} \\
(z(x) &= z^*(x^o) + z^*(x^u) \leq z^*_\text{max}.
\end{align}

4. Nonlinear model of a problem

The \( q/z \) value (specific efficiency) is chosen often as an indicator of project efficiency, which shows what effect is per unit of cost. For that reason, it may be necessary to formalize the problem considered in the form of the following nonlinear model:

\begin{align}
q(x) &= \sum_{i=1}^{m_n} q(p_i)x_i(\sum_{i=1}^{m} (z(p_i) + \Delta z_i)x_i)^{-1} \rightarrow \text{max} \\
\Delta z_i &\leq z(x) = \sum_{i=1}^{m_n} z(p_i)x_i \leq z^*_\text{max} \\
\Delta z^* &\leq \Delta z_i \leq \Delta z^*.
\end{align}

The introduction of the left part of the restriction (18) is necessary, as in its absence the criterion (17) can choose the solution with unacceptably small use of the investment budget as the optimal solution.

The solution of the problem (17) - (18), in a similar manner to the method of solving the linear problem (6) - (8), is possible on the basis of decomposition into three subtasks:

1. Construction of dependency \{q^o(x), \Delta z^o(x)\} of economical efficiency and operational cost changes for the subset \{p_i | i = \overline{1, m'}\}. This requires to solve the task:

\begin{align}
q^o(x^o) &= \sum_{i=1}^{m_n} q(p_i)x_i(\sum_{i=1}^{m} (z(p_i) + \Delta z_i)x_i)^{-1} \rightarrow \text{max} \\
\Delta z^o(x^o) &= \sum_{i=1}^{m_n} \Delta z_i x_i \leq \Delta z^*.
\end{align}

Let \( \{x^o\} = \{(x_1 x_2 x_3 x_4 x_5)\} \) is a set of solution of problem (20) – (21), and \( \{(q^o(x^o), \Delta z^o(x^o))\} \) is a set of related pairs of criterion values (20) and of restriction (21).

2. Construction of dependency \( q^u(x), z^u(x) \) of economical efficiency and operational cost changes for a subset of projects that do not change operational cost. This requires to solve the task:

\begin{align}
q^u(x^u) &= \sum_{i=1}^{m_n} q(p_i)x_i(\sum_{i=1}^{m} (z(p_i) + \Delta z_i)x_i)^{-1} \rightarrow \text{max} \\
z^u(x^u) &= \sum_{i=1}^{m_n} z(p_i)x_i \leq z^*.
\end{align}

Let \( \{x^u\} = \{(x_1 x_2 x_3 x_4 x_5)\} \) - is a set of solution of problem (22) – (23), and \( \{(q^u(x^u), z^u(x^u))\} \) are sets of related pairs of criterion values (22) and of restriction (23).

3. Formation of the set \( \{x\} = \{(x_1 x_2 x_3 x_4 x_5)\} \), as a product of solution sets \( \{x^o\} = \{(x_1 x_2 x_3 x_4 x_5)\} \) and \( \{x^u\} = \{(x_1 x_2 x_3 x_4 x_5)\} \) of solution, respectively, of problems (20) – (21) and (22) – (23):

\begin{align}
\{x\} &= \{x^o\} \times \{x^u\}.
\end{align}

4. Search on the set (24) of the optimal solution of a problem:

\begin{align}
q(x) &= (q^o(x^o) + q^u(x^u))(z^o(x^o) + \Delta z^o(x^o) + z^u(x^u))^{-1} \rightarrow \text{max} \\
z^*_\text{min} &\leq z(x) = z^o(x^o) + z^u(x^u) \leq z^*_\text{max}.
\end{align}
5. Example of solving linear and nonlinear problems

Tables 1 - 5 provide, respectively, initial data on IT process parameters of IT service life cycle and initial data on investment projects. This data are used to illustrate the procedures for solving linear problems (4) - (5) and (6) - (8) and nonlinear problems (17) - (19).

**Table 1. Initial data on IT process parameter values, stage 1.**

| \( \gamma_1 \) | \( 0.4 \) |
|---|---|
| \( \beta_{11} \) | 0.4 |
| \( \beta_{12} \) | 0.3 |
| \( \beta_{13} \) | 0.3 |
| \( \alpha_{11}^1 \) | 0.5 |
| \( \alpha_{11}^2 \) | 0.2 |
| \( \alpha_{12}^1 \) | 0.3 |
| \( \alpha_{12}^2 \) | 0.6 |
| \( \alpha_{13}^1 \) | 0.4 |
| \( \alpha_{13}^2 \) | 0.5 |
| \( \alpha_{13}^3 \) | 0.1 |

**Table 2. Initial data on IT process parameter values, stage 2.**

| \( \gamma_2 \) | \( 0.3 \) |
|---|---|
| \( \beta_{21} \) | 0.4 |
| \( \beta_{22} \) | 0.6 |
| \( \alpha_{21}^1 \) | 0.8 |
| \( \alpha_{21}^2 \) | 0.2 |
| \( \alpha_{22}^1 \) | 0.5 |
| \( \alpha_{22}^2 \) | 0.3 |

**Table 3. Initial data on IT process parameter values, stage 3.**

| \( \gamma_3 \) | \( 0.2 \) |
|---|---|
| \( \beta_{31} \) | 0.3 |
| \( \beta_{32} \) | 0.5 |
| \( \beta_{33} \) | 0.2 |
| \( \alpha_{31}^1 \) | 0.6 |
| \( \alpha_{31}^2 \) | 0.2 |
| \( \alpha_{32}^1 \) | 0.2 |
| \( \alpha_{32}^2 \) | 0.4 |
| \( \alpha_{33}^1 \) | 0.9 |
| \( \alpha_{33}^2 \) | 0.1 |

**Table 4. Initial data on IT process parameter values, stage 4.**

| \( \gamma_4 \) | \( 0.1 \) |
|---|---|
| \( \beta_{41} \) | 0.4 |
| \( \beta_{42} \) | 0.2 |
| \( \beta_{43} \) | 0.2 |
| \( \alpha_{41}^1 \) | 0.2 |
| \( \alpha_{41}^2 \) | 0.5 |
| \( \alpha_{41}^3 \) | 0.3 |
| \( \alpha_{42}^1 \) | 0.7 |
| \( \alpha_{42}^2 \) | 0.3 |
| \( \alpha_{43}^1 \) | 0.2 |
| \( \alpha_{43}^2 \) | 0.8 |

**Table 5. Initial data on portfolio of service improvement projects.**

| \( \pi_1 \) | \( \pi_2 \) | \( \pi_3 \) | \( \pi_4 \) | \( \pi_5 \) | \( \pi_6 \) | \( \pi_7 \) | \( \pi_8 \) | \( \pi_9 \) |
|---|---|---|---|---|---|---|---|---|
| \( q(\pi_1) \) | 0.592 | 0.384 | 0.420 | 0.212 | 0.15 | 0.576 | 0.816 | 1.374 | 1.334 |
| \( \Delta z(\pi_1) \) | 5 | 2 | 1 | 3 | 2 | 0 | 0 | 0 | 0 |
| \( z(\pi_1) \) | 14 | 16 | 19 | 9 | 8 | 10 | 13 | 21 | 7 |

According to the initial data, the first five projects change the operating costs on IT processes functioning, and the last four - do not change (\( m^o = 5, m^n = 4 \)). Let us put \( \Delta z_{\max} = 90, \Delta z^* = 5 \).

5.1 Results of solving linear problem 1

Having solved the problem (4) - (5) by the method of dichotomic programming, following three best results will be obtain, table 6.

**Table 6. Optimal solution of the problem (4) – (5).**

| \( x = x_1 x_2 x_3 \ldots x_{10} \) | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| \( q(x) \) | 5.288 | 5.226 | 5.112 |
| \( z(x) \) | 90 | 89 | 84 |
5.2 Results of solving linear problem 2
Having solved the problems (10) –(11), (12) –(13) and (15) – (16) in accordance with decomposition schema, following three best results will be obtain, table 7.

| x = x_1x_2x_3...x_9 | 1 0 1 0 0 1 1 1 1 | 0 1 1 0 0 1 1 1 1 | 0 1 0 1 1 1 1 1 1 |
|-------------------|------------------|------------------|------------------|
| q(x)              | 5.112            | 4.904            | 4.846            |
| Δz(x)             | 4                | 1                | 3                |
| z(x)              | 84               | 86               | 84               |

5.3 Results of non-linear problem solving
Let \( z^*_{\text{min}} = 80 \) . Having solved the problems (20) – (21) in accordance with decomposition schema for the first five projects \( m^* = 5 \) , following results will be obtain, table 8.

| x_1x_2x_3x_4x_5 | 01010  | 01001  | 01000  | 01111  | 01110  |
|-----------------|--------|--------|--------|--------|--------|
| q^o             | 0.027  | 0.027  | 0.030  | 0.031  | 0.022  | 0.021  |
| Δz^o            | 2      | 4      | 3      | 5      | 2      | 4      |

| x_1x_2x_3x_4x_5 | 01010  | 01001  | 01000  | 01010  | 01001  | 01000  |
|-----------------|--------|--------|--------|--------|--------|--------|
| q^o             | 0.023  | 0.022  | 0.021  | 0.020  | 0.022  | 0.021  |
| Δz^o            | -1     | 1      | 3      | 5      | 0      | 2      |

Having solved the problem (22) – (23) for following four projects, following results will be obtain, table 9.

| x_6x_7x_8x_9 | 1111  | 1110  | 1101  | 1100  | 1011  | 1010  |
|-------------|-------|-------|-------|-------|-------|-------|
| q^o         | 0.080 | 0.063 | 0.091 | 0.061 | 0.086 | 0.063 |
| z^o         | 51    | 44    | 30    | 23    | 38    | 31    |

| x_6x_7x_8x_9 | 1001  | 1000  | 0111  | 0110  | 0101  | 0100  |
|-------------|-------|-------|-------|-------|-------|-------|
| q^o         | 0.112 | 0.058 | 0.086 | 0.064 | 0.108 | 0.063 |
| z^o         | 17    | 10    | 41    | 34    | 20    | 13    |

Form a set (24) and determine on this set optimal solutions of the problem (25) - (26), table 10.

| x_1x_2x_3x_4x_5 | 1 0 1 0 0  | 0 1 0 1 1  | 0 1 1 0 0  | 1 0 1 0 1  |
|-----------------|-----------|-----------|-----------|-----------|
| q               | 0.058     | 0.056     | 0.056     | 0.056     |
All four solutions differ slightly in the \( q \) and \( z \) values. The choice of the best of them should be provided to decision maker. Let us notice that at the given basic data the best solution \((1 0 1 0 1 1 1 1)\) of the nonlinear task \((17) – (19)\) coincides with the best solution of the second linear task \((6) – (8)\) and is the third in efficiency for the first linear task \((4) – (5)\).

Note. Removing constraint on \( z_{\min}^* \) for \( z(x) \) will result in the selection of the optimal solution given in table 11.

| \( z \) | 84 | 84 | 86 | 82 |
| \( \Delta z \) | 4 | 3 | 1 | 2 |

This decision, despite the significantly better value of the criterion, is unacceptable, as it uses only 30\% of the investment budget.

6. Conclusion
Models and mechanisms proposed in this article for managing service improvements can be used by IT providers of all types as to improve existing IT processes, so to effectively adapt IT activities to the market environment.

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