Section 3. Mathematical and instrumental methods of economics

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Express-evaluation of statistical characteristics of the distribution of the spent time and resources of users on working with web applications: universal technique

Abstract: Proposed and tested technique of express-evaluation of resource intensity processes of user interaction with Web applications. The technique allows to realize the optimal choice of a concrete web shell on the criterion of minimum time and workforce on work with the software; allows quick assessment of the statistical characteristics of the distribution of labor costs and time to perform the functions and to load web pages

Keywords: express-evaluation of statistical characteristics; cost estimation resources; web applications; statistical characteristics of the distribution of spending assessment of time and labor.

Introduction. Today the market offers a lot of web application shells, which differ on a number of parameters that characterize the consumer quality of goods, including the resource intensity of operation — cost of labor, time, finance for implementation and maintenance of web application, such as: web-site, web-portal, tools and program system.

However, the question is how can we quickly perform a comparative assessment of timing, labor and financial resources investment for the operation of the purchased or created web application?

How to make the best choice of a particular shell form the variety of shells comparable by functional completeness and cost?

How to evaluate the statistical characteristics of time spent for implementation of the required functions when using web applications?

Below is the example of analysis of existing web sites of successful companies, which is considered to be the universal method of quantitative assessment of labor costs and user time spent for working with the web application that allows to answer these questions.

Preliminary notes. 1) The behavior of any individual is probabilistic. This refers to any activity of an individual, including the time spent on mastering of any new educational material. Thus, different individuals differ from each other not only by the time spent on performing of the same business operations, but even a single individual can perform one operation within very different time periods, and the coefficients of variation and distribution dextrality are very large (see., e.g. [1–3]); 2) While using the software systems in the Internet, the variation coefficient and asymmetry of system load time (time spent for obtaining of the required result) will significantly increase in comparison with their usage in the local environment; 3) The experimental assessment of statistical characteristics of implementation time for web applications functions shall be carried out by grouping users (potential clients — buyers of web...
application), depending on values of the classification criteria (sex, age, education, etc.), and performing of simulation modeling with account of the characteristics of time consumption distribution in each of the groups, and the proportion of a particular group among the users; 4) If following the result of a full-scale experiment the values of statistical characteristics and distribution of time spent for implementation of a selected subset of functions of the comparable web applications were obtained, the significance of time consumption differences can be evaluated using the methods of non-parametric statistics, or by comparing the user's time consumption at the predetermined probability of result obtaining — for example, at the probability of 80, 90 or 95 percent.

**Features of the offered method.** The offered method includes the following steps:

**Step 1.** Grouping of potential users depending on the values of classification criteria relevant to a particular domain (age, sex, physiological features of character, etc.);

**Step 2.** Assessment of proportion of each group in the general amount of potential users-customers;

**Step 3.** Assessment of time spent by each group of users for completing of the selected functions of web-based applications — for organization of interaction of each group of users with the web application;

**Step 4.** Planning and carrying out of the experiment, assessment of actual (obtained in experiment) law of distribution of time spent by the users of each classification group for performing of the studied function (or subsets of functions), i.e. the assessment of time spent for obtaining of the result required by the user (see the example, [4; 5]);

**Step 5.** Comparative analysis and selection of tools for building and/or automated synthesis of simulation models of user interaction with web application;

**Step 6.** Simulation modeling for the assessment of time spent for (in all groups of user clients) performing of the specific function and/or selected subsets of the analyzed functions (with account of proportion of each group in the general amount).

**Step 7.** Analysis of the simulation results — statistical characteristics (mathematical expectation, dispersion, coefficient of variation, asymmetry, and excess), distribution and cumulative probability histogram. The assessment (with any predetermined probability) of time spent by the user for performing of the selected subset of functions.

**Example of assessment.** We will consider the offered method using the example of assessment of the statistical characteristics of time spent for implementation of functions and loading of web sites of the management companies (MC) engaged in the sphere of housing and public services. For comparison, six web sites — top 5 of Moscow MCs websites (based on the research of “Expert RA” Rating Agency and “Moscow United Energy Company” OJSC carried out in February, 2015) and one Rostov-on-Don MC web site were selected: www.ds-exp.ru; www.evagd.ru; www.uknahichevan.ru; www.dezub.ru; dez-hm.ru; dezyasenevo.ru. Using a table of random numbers, Z1-Z6 identifiers were assigned to these web sites.

1. **Assessment of time spent for implementation of functions.** To assess the actual time spent for implementation of functions of the selected web sites, 40 residents of different age from several houses of Rostov-on-Don were involved. All participants of the experiment were divided into three age groups — 20–40 years old, 40–60 years old and participants over 60. We analyzed the time spent to perform only one function — “Getting of information about the house.” This function was selected based on the fact that it is implemented in the vast majority of MCs web sites and is one of the most compelling functions.

To increase the calculation accuracy, the experiment included several approaches. Table 1 presents the averaged results of time spent for function implementation for each of nine subjects (3 representatives of each age group). The average values and values of the minimum and maximum time spent on implementation of the function were evaluated for each web site.

To compare the web sites by the time spent for implementation of the selected function, SIM-UML [6] system of automated synthesis of simulation models was used. The system allows to:

— maintain a list of variables, set the quantitative characteristics of the model, and take into account
the stochastic nature of the modeled business processes [7]; — build UML-models, which determine the characteristics of business processes, using the graphic designer; — automatically generate the source code of a simulation model.

Table 1. – The results of the experiment

| Age (years) | Residents | The spent time of user on implementation of the function using the web site |
|-------------|-----------|-------------------------------------------------------------------------|
|             |           | Z1 | Z2 | Z3 | Z4 | Z5 | Z6 |
| 20 to 40    | Э1        | 12.22 | 13.50 | 18 | 15.30 | 14.60 | 15.43 |
|             | Э2        | 12.53 | 13.90 | 20.12 | 14.18 | 14.32 | 17.65 |
|             | Э3        | 13.01 | 14.06 | 19.75 | 15.10 | 15.14 | 16.55 |
| 40 to 60    | Э4        | 20.20 | 23.61 | 37.56 | 24.06 | 25.02 | 26.78 |
|             | Э5        | 22.17 | 23.75 | 38.12 | 25.71 | 23.87 | 27.38 |
|             | Э6        | 21.86 | 24.07 | 38.47 | 26.12 | 24.77 | 30.12 |
| From 60 and more | Э7                | 33.32 | 37.20 | 59.36 | 46.06 | 44.82 | 47.41 |
|             | Э8        | 33.01 | 38 | 59.36 | 46.31 | 43.45 | 48.23 |
|             | Э9        | 34.17 | 36.36 | 55.24 | 47.73 | 46.65 | 50.03 |
| Min         | 12.22 | 13.50 | 18 | 14.18 | 14.32 | 15.43 |
| Max         | 34.17 | 38 | 59.36 | 47.73 | 46.65 | 50.03 |
| Average value | 23.2 | 25.75 | 38.68 | 30.96 | 30.49 | 32.73 |

As a result of simulation modeling, the statistical characteristics (mathematical expectation, dispersion, variation coefficient, excess, and asymmetry) and distribution (table and histogram) of time spent for implementation of the “Getting of information about the house” function were obtained for each MC (see Table 2).

Table 2. – The results of the simulation modeling

| Parameter | Z1 | Z2 | Z3 | Z4 | Z5 | Z6 |
|-----------|----|----|----|----|----|----|
| The number of iterations | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| Average value | 23.28 | 25.91 | 38.29 | 30.92 | 30.26 | 32.54 |
| Dispersion | 20.47 | 24.37 | 68.42 | 46.5 | 41.8 | 49.57 |
| Standard deviation | 4.52 | 4.93 | 8.27 | 6.82 | 6.47 | 7.04 |
| Coefficient of variation \(K^{(01)}_{var}\) | 0.19 | 0.19 | 0.22 | 0.22 | 0.21 | 0.22 |
| Asymmetry | -0.04 | -0.04 | 0.13 | 0.03 | -0.01 | 0.04 |
| Excess | -0.6 | -0.59 | -0.55 | -0.6 | -0.63 | -0.64 |
| Min | 12.41 | 14.26 | 19.45 | 14.96 | 15.08 | 16.43 |
| Max | 33.32 | 37.62 | 58.59 | 47.34 | 46.26 | 49.70 |
| Modal interval | 20.0–21.9 | 24.87–27 | 37.2–40.8 | 29.7–32.6 | 29.3–32.1 | 28.5–31.6 |

Using the data of Table 3, we can determine the probability that the values of time consumption will be within the predetermined range. For example, with the probability of 0.9 it is arguable that when using Z1 website, the user will spend less than 29 sec for implementation of the selected function.

Table 3. – The spent time on perform the functions of each of the analyzed web applications and the value of the accumulated probability \(P_i\)

| Z1 X min | X max | P_1 | Z2 X min | X max | P_2 | Z3 X min | X max | P_3 | Z4 X min | X max | P_4 | Z5 X min | X max | P_5 | Z6 X min | X max | P_6 |
|---------|-------|-----|---------|-------|-----|---------|-------|-----|---------|-------|-----|---------|-------|-----|---------|-------|-----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 12.4 | 14.3 | 0.02 | 14.2 | 16.4 | 0.02 | 19.5 | 23 | 0.03 | 15 | 17.9 | 0.02 | 15.1 | 17.9 | 0.02 | 16.4 | 19.5 | 0.03 |
| 14.3 | 16.2 | 0.07 | 16.4 | 18.5 | 0.08 | 23 | 26.6 | 0.08 | 17.9 | 20.9 | 0.08 | 17.9 | 20.8 | 0.09 | 19.5 | 22.5 | 0.09 |
### 2. Comparison of MC websites by the time required for page loading.

The analysis of web site page loading speed (Table 4) was conducted using the online service for measuring of web page loading speed (GTmetrix service). The analysis included the following:

— front page (home page) — main page from which you can jump to other sections;

— page containing the information about residents’ houses — page actively visited by users and containing large volumes of systematized information about houses and everything related to them;

— documentation page — standard page containing documents/links to different documents (reports, information on rates, etc.).

The resulting tables of one of the characteristics will include the page assessment carried out using YSlow parameter — Firebug extension, which evaluates the page according to different characteristics.

| The name of the evaluated page | Name of the website | The download speed (%) | YSlow (%) | Load time (с) | The page load time in comparison with the Z1 |
|-------------------------------|---------------------|------------------------|----------|--------------|------------------------------------------|
| **Main page**                |                     |                        |          |              |                                          |
| Z1                            | 84                  | 90                     | 2,55     | 1            |
| Z2                            | 73                  | 72                     | 4,80     | 2            |
| Z3                            | 74                  | 69                     | 4,26     | 2            |
| Z4                            | 73                  | 81                     | 2,76     | 1            |
| Z5                            | 49                  | 68                     | 3,71     | 1,5          |
| Z6                            | 82                  | 87                     | 7,53     | 3            |
| **The page containing the documentation** |                 |                        |          |              |                                          |
| Z1                            | 84                  | 93                     | 1,21     | 1            |
| Z2                            | 60                  | 72                     | 3,65     | 3            |
| Z3                            | 76                  | 69                     | 4,05     | 3            |
| Z4                            | 38                  | 84                     | 2,20     | 2            |
| Z5                            | 52                  | 68                     | 3,77     | 3            |
| Z6                            | 65                  | 82                     | 3,47     | 3            |
| **The page containing information about houses** |                |                        |          |              |                                          |
| Z1                            | 84                  | 94                     | 1,08     | 1            |
| Z2                            | 79                  | 86                     | 1,87     | 1,7          |
| Z3                            | 77                  | 68                     | 4,08     | 4            |
| Z4                            | 38                  | 84                     | 2,38     | 2            |
| Z5                            | 50                  | 73                     | 4,97     | 5            |
| Z6                            | 65                  | 82                     | 3,38     | 3            |

According to the data presented in Tables 4, the tested pages of MC Z1 web site have the maximum loading speed (84%), the highest YSlow rate (more than 90%), and the minimum loading time (a few times less compared to the majority of the considered web sites). Based on the analysis results, we can conclude that Z1 web site operates much quicker than its competitors, and, therefore,
it minimizes the time spent by users for working with the web application.

Such comparative analysis of the user’s efforts and time spent for working with the web site widens the user’s choice of a specific shell from the variety of comparable shells. For example, if the client is interested in a very limited, but intensively used set of certain functions, the user can select the application, which performs these particular functions within the minimum time limit.

Conclusions. 1. The method of express assessment of resource intensity of user’s interaction with different web applications was offered. The method allows to carry out a comparative assessment of time, labor and financial resources spent on operation of the purchased or created web application with the minimum resources spent; select the best specific web shell (from a set of shells comparable by the functional completeness and cost); assess the statistical characteristics of labor and time spent for implementation of the required functions and for downloading of web pages. The experiments with the leading companies web sites show that even when the web sites of the same application are used the time (resources) spent by the user for performance of the same functions differs significantly.

2. For the purpose of express assessment of users resources spent on working with the web application, the original sequence of steps was created, which includes dividing of potential users of the web application into groups (by certain classification criteria), assessment of proportion of each group in the general amount of users, preparing of experiment plan, selection of simulation tools for automated synthesis of simulation models, creation of simulation models and analysis of results of the simulation. The use of this method widens the user’s choice of the best web application (by the criterion of minimum resources spent), which meets the user’s requirements to the fullest extent.

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