

# Automation of Cost Evaluation Methods When Choosing a Commercial Web Resource Through the Example of Primorsky Krai

L V Mkhitaryan<sup>1</sup>, G F Pavlenko<sup>1</sup>, T N Popova<sup>1</sup>, G P Ozerova<sup>1</sup>

<sup>1</sup>FEFU, Vladivostok, Russia

E-mail: fareastcon2019@gmail.com

**Abstract.** The paper discusses practical methods used to evaluate the technical and economic features of the software system design project: the COCOMO method, PERT method and the method of estimating labor costs based on the database dimension. These accurate methods ensure simplicity of calculation and can be applied at relatively early stages of a web resource set-up. The paper emphasizes the process of building e-commerce systems. Based on these methods, a software solution was developed that allows for a fast and efficient evaluation of the technical and economic features of a web resources design project, including labor costs, duration, project cost, etc. The software solution may be of use for both IT project managers and customers looking to build a web resource who will be able to gain an understanding of the cost of a web resource set-up and to estimate their available financing for such undertaking.

## 1. Introduction

A commercial web resource is an information system, which uses web technologies to present and transfer data. It is designed to control the process of trading goods or services on the Web [1-12]. Over the past 2-3 years electronic commerce (EC) has become the world's fastest growing IT domain, which it still is today. According to McKinsey & Company, by 2020, approximately 1.4 billion people will join the ranks of online store customers worldwide, with 85% of them being from Asia Pacific region [15]. In Russia, the e-commerce market is also rapidly growing: as of year-end 2017, its volume reached 1.04 trillion rubles and in 2018 the figures increased to 1.292 trillion rubles [14]. Unfortunately, the situation is only the opposite in Primorsky Krai, where the e-trade opportunities remain largely unrealized. Research suggests that the e-commerce infrastructure in Primorsky Krai has not yet taken shape [9]; besides, the e-commerce market of Primorye is, by any standard, behind Chinese electronic resources [10, 11].

One of the issues hindering the e-commerce development in Primorsky Krai is the fact that local entrepreneurs either have low levels of competence in the subject or lack any knowledge on e-commerce, since none of the region's universities provide the necessary training [16, 17]. Development companies dictate their own terms of pricing for such electronic resources. The cost of EC systems mostly does not reflect the associated labor effort that is why many entrepreneurs are reluctant to make the switch to online business, since they doubt they would be able to recoup the investment. For this reason, offline business is dominant in Vladivostok and the region in general.

To solve this problem, it is proposed to computerize certain methods of evaluating the technical and economic features of web resources to enable the customers to estimate their available financing prior to an acquisition of, say an online store.

## 2. Relevance

Before starting its work, a company that builds web resources should obtain as much information as possible about the required features of a system and clarify its cost. To this end, a pre-project analysis and project cost evaluation are done in the early stages of a web resource set-up. This kind of evaluation helps web-project managers to make efficient planning and assign the resources.

The works of V.V. Lipaev, G.F. Pavlenko, Robert T. Fatrell, Donald F. Shafer, I. Linda, E.V. Astakhova, Yu.N. Abasova and others served as a theoretical framework of this study.

## 3. Problem statement

It is necessary to computerize the methods of evaluating the cost of a web resource set-up.

## 4. Theoretical

An evaluation of the information system cost consists in determining the total cost of resources required to implement a project functionality. There are methods that ensure a reasonable evaluation of the cost of development, as well as other technical and economic features, since an underestimation of the cost results in substantial losses for the developer. On the other hand, overestimation is none the better, since the project may turn out to be budget-unfriendly and unaffordable for the customer. This is especially true of the e-commerce systems, those being the most frequently ordered projects.

Depending on the initial data acquisition technique, a number of methods are used when calculating monetary and labor costs associated with the project development [13]:

- Expert assessment
- Analog method
- Research and empirical methods
- Algorithm simulation methods
- Simulation modeling method
- Bayesian networks
- Function points method
- Basic COCOMO constructive model-based method
- PERT method
- Database dimension-based estimation method

Some of these methods duplicate each other, i.e. the use of different methods for calculations leads to the same results. This is useful because it provides a means for monitoring the quality of assessment of the system's technical and economic features. Let us consider the methods that play a fundamental role in evaluating the technical and economic features of a software system.

The labor costs are evaluated in compliance with the COCOMO model, which establishes the relation between the software code size and the software solution labor intensity. The COCOMO method, developed for a waterfall life cycle model, consists of three models oriented towards use in three phases of a software life cycle:

- –basic
- –transition
- –deep or extended model

All three models work with two basic equations, however, the factors for the models are determined with various levels of detail.

$$E = a \cdot (KLOC)^b, \tag{1}$$

where E = labor costs in person-months  
a, b = factors calibrated against statistics

KLOC = software size, in thousands of source code lines

For the basic model, it is set to 1; for the transition model, it is defined by 15 cost factors; for the deep model, the effect of these multipliers is assessed at each life cycle step [11]. COCOMO-based estimates were acquired as a result of processing the statistical data obtained from 160 real international projects [10].

The PERT method is used to calculate the expected duration either of a project or a single process. In project management, the PERT method is almost always used with a critical path [10]. Project completion date will depend on the critical path. The PERT method and the critical path method differ fundamentally from one another in the area of application. The critical path is used to estimate the completion date of the project in whole. To estimate the execution time of a task or process, we need to know the optimistic, pessimistic and most likely estimate of the task duration. The PERT formula is as follows:

$$E = \frac{O+4M+P}{6}, \quad (2)$$

where O = optimistic estimate of the task duration

M = most likely estimate of the task duration

P = pessimistic estimate of the task duration

In this equation, the value of the most likely estimate of duration is 4 times higher than the optimistic and pessimistic estimates. For a more thorough analysis and prediction of the tasks duration, it is possible to calculate a standard deviation and variance of the PERT method estimate by adapting the normal formula of statistical variance:

$$D = \frac{(O-E)^2+4(M-E)^2+(P-E)^2}{6}, \quad (3)$$

$$STD = \sqrt{\frac{(O-E)^2+4(M-E)^2+(P-E)^2}{6}}. \quad (4)$$

Database dimension-based estimation method. The information system dimension is defined by a number of objects, attributes and their interconnections on the object-based diagrams of business processes.

The database dimension is determined from the following formula [10]:

$$R = 2 \times n \times 5 \times k \times 10 \times m \quad (5)$$

where n = number of domain objects (tables) (the number of interconnections between tables is unlimited and depends on the database structure)

k = total number of interconnections between objects

m = number of domain attributes per one object (the number of interconnections between attributes depends on the number of sources of attribute information generation)

When building a software system, the normalized value is a number of the developed attributes included in the tables through the established interconnections. When n, k and m values equal 1, their quantifying value is 100. Development time is determined from the formula:

$$T = 0.01 \times R \times w, \quad (6)$$

where w = labor output standard of software system development, based on statistical labor output standards [11].

As seen above, the calculation done for the evaluation of the project's technical and economic features using the above methods consists of computing operations, the sequential operation of which requires, first, certain knowledge that makes it possible to use the above methods and, second, takes time; moreover, it does not exclude errors resulting from the human factor. All these issues make it impossible for an unprepared person to assess the cost of a web resource.

## 5. Practical significance

To cut down the computation time, reduce the likelihood of errors and, most importantly, make the evaluation accessible not only for project managers, but mainly for potential customers acquiring web resources, a software solution was developed. This solution automates the calculations following the methods for evaluating the project's technical and economic features. The application developed in the

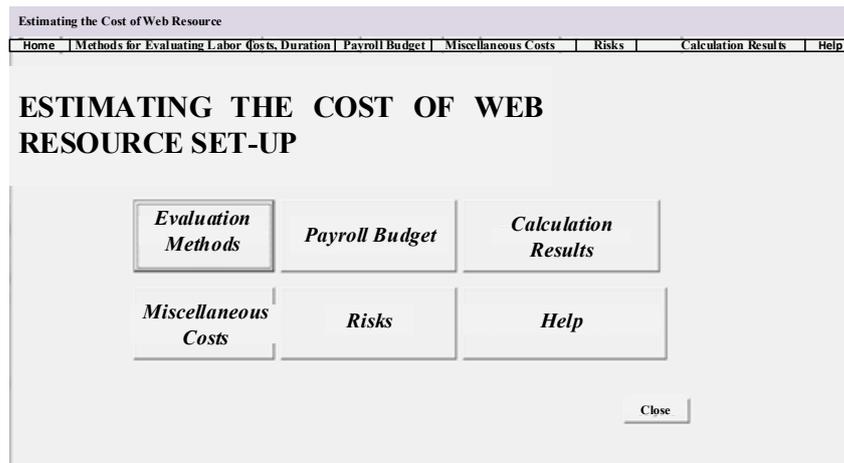
Delphi environment provides for the automation of the subsequent calculations done for the technical and economic features of the project using the above methods:

- labor cost estimation following the database dimension method
- COCOMO-based calculation
- PERT-based calculation
- payroll budget estimation
- project risk estimation
- cost calculation of web resource development

The software interface is rather user-friendly and includes 7 main tabs (windows):

- Home
- Methods for Evaluating Labor Costs, Duration
- Payroll Budget
- Miscellaneous Costs
- Risks
- Calculation Results
- Help

Figure 1 shows “Main” program tab, which contains the following buttons: “Evaluation Methods”, “Payroll Budget”, “Miscellaneous Costs”, “Risks”, “Calculation Results”, “Help”. By clicking these buttons, a user can navigate between the tabs. Click the “Close” button to quit the program.



**Figure 1.** “Main” Window.

Figure 2 shows the calculations of labor costs and time required to set up a web resource. In this window, start with filling in data for the PERT method. To do so, add the project stages; once you add the stages, determine the optimistic estimate, most likely estimate and pessimistic estimates using the expert assessment method. After filling in the input data, click on the “refresh” button to calculate the duration; apart from duration, the program will calculate the variance and standard deviation values. Once you complete the calculations using the PERT method, proceed to calculating the labor costs based on the database dimension and COCOMO methods. To calculate the labor costs based on the database dimension, enter a number of entities per the database model (n), a number of interconnections between entities (k) and a number of attributes per entity (m). Enter the duration of the web resource set-up, in hours, calculated using the PERT method. Click on the “calculate” button to compute the database dimension (R), labor-output ratio, labor costs (T) in person/hour and the average number of staff (N). The COCOMO method works in a similar way, except that it uses a, b, c factors, a number of functional points and the programming language as input data. Click on the

“calculate” buttons, to calculate the labor costs of development, the average number of staff and the source software code size.

Figure 2. Methods for Evaluating Labor Costs, Duration of a Web Resource Set-up

Figure 3 illustrates the “Payroll Budget” window. The “Payroll Budget” window, in turn, contains several sub-tabs. Figure 3 presents the initial data necessary for the payroll budget calculation. This tab is populated automatically using the data obtained during the calculations of labor costs, and duration. The initial data on this tab include the labor costs calculated using the COCOMO method (labor cost estimation method based on the database dimension), duration value calculated using the PERT method, the development duration per each stage, and the average number of staff.

Np	Project Stages	Numb	Durat
1	Project Concept	4,474	0,092
2	Design	4,474	0,158
3	Databases	4,474	0,169
4	Functional Specification	4,474	0,072
5	Style	4,474	0,130
6	Layout	4,474	0,121
7	Implementation	4,474	0,138
8	Installation and Delivery to Client	4,474	0,109
	Days		58

Np	Project Stages	Labor Costs	Durat
1	Project Concept	5	5
2	Design	10	10
3	Databases	20	20
4	Functional Specification	5	5
5	Style	15	15
6	Layout	15	15
7	Implementation	20	20
8	Installation and Delivery to Client	10	10

T (Labor Costs)	9.940
D (Duration)	0.933
Average Number of Staff	4.474
Ni	4.629

Figure 3. “Payroll Budget” Window.

Figure 4 illustrates the calculation results; the window is automatically populated with the results acquired using the evaluation methods, the estimate of expenditures for building and implementing a

web resource is provided in the upper right corner. It presents the results of calculations of the payroll budget, variable and fixed costs of VAT, the cost of a web resource set-up with regard to risks and disregarding risks.

Home	Methods for Evaluating Labor Costs	Payroll Budget	Miscellaneous Costs	Risks	Calculation Results	Help												
<b>Labor Costs following the COCOMO Method</b> T= 1431,6489    8,9476809 D= 58 N= 4,4739031			<b>Estimate of Expenditures for Development and Implementation</b>															
<b>Labor Costs following Database Dimension-based Estimation Method</b> T= 1409,6128    8,9476809 D= 2 N= 4,40504			<table border="1"> <tr> <td>Payroll Budget</td> <td>62371,146</td> </tr> <tr> <td>Social Security Charge (30%)</td> <td>27892,3764</td> </tr> <tr> <td>Fixed and Variable Costs</td> <td>18162,4771</td> </tr> <tr> <td>Value Added Tax 20%</td> <td>18162,477</td> </tr> <tr> <td>TOTAL Disregarding Risk</td> <td>108974,866</td> </tr> <tr> <td>TOTAL with Regard to Risk</td> <td>133647,866</td> </tr> </table>				Payroll Budget	62371,146	Social Security Charge (30%)	27892,3764	Fixed and Variable Costs	18162,4771	Value Added Tax 20%	18162,477	TOTAL Disregarding Risk	108974,866	TOTAL with Regard to Risk	133647,866
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TOTAL with Regard to Risk	133647,866																	
<b>Duration following PERT Method</b> 58																		

Figure 4. "Calculation Results" Window.

The program contains other tabs that can be viewed in the application to the program:

- "% of Work Performed at Each Project Stage" tab
- "Percent of Staff of the j Type Brought in for Project Execution at the i-th Stage" tab
- "Wages" tab
- "Miscellaneous Costs" tab
- "Project Risks" tab
- "Help" tab

## 6. Conclusion

To sum up, the developed software solution is a universal tool designed not only to evaluate the cost of building web resources, but also to determine the cost of any kind of information systems. IT project managers, executives in charge of managing information systems development, and managers of any IT project can work with this program. Furthermore, this software application can be useful to potential customers acquiring web resources, who require to know the EC system cost to estimate their available financing for acquiring such a system. This software application is free, therefore, the administrative establishments of the city and region involved in business administration can recommend it to the entrepreneurs of Primorky Krai.

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