Analysis of the economic effect of increasing the reliability of information systems of digital agricultural enterprises

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Abstract. This article discusses the analysis of the economic effect of increasing the reliability of the information system that provides the processing and storage of information for digital agricultural enterprises. A special downtime calculation technique is used, based on the TCO Advisor Client & Server Model. The necessary data for the calculation are presented, as well as intermediate and main indicators. These metrics can also be used to calculate total cost of ownership. It is noted that this information may be of interest to top managers of digital agricultural enterprises who solve problems in assessing the performance of computing servers and networks.

1. Introduction

Under the economic effect is meant the receipt of real economic returns from the use of the entire information system (IS) or its individual functional units used for digitalization of modern agricultural enterprises. But the definition of economic efficiency at the stage of implementation of the system is not always feasible, since the digital agricultural enterprises (DAE) prior to implementation does not have a controlling system that implements the stage of economic analysis and accounting [1-3].

Creating an information system is not just technical development, but rather a project that is a unique process, limited in time and aimed at achieving strictly defined goals [4-6].

On the other hand, the life cycle of an information system has been measured for decades, and its functioning cannot be considered in isolation from the services offered by its developers to support the life cycle. These services include: company inspection and reorganization of business processes; commissioning (tuning and finalizing the system); training; maintenance, modernization and adaptation. Of significant importance is the use in the DAE of space technologies for remote sensing of the Earth, lease of space communication channels, the use of manned and unmanned aircraft systems for precision farming [7-9].

As experience [10–13] shows, the justification of such an expensive project does not lend itself to well-known methods for evaluating economic efficiency. It is impossible to calculate either the total discounted income, or the internal rate of return, or even the payback period, as there is no evidence of
cost reduction or profit making associated with making optimal management decisions. At the same time, to assess the impact of such decisions on the production activities of the enterprise, we need a large amount of information, its comparative analysis and generalization of the results.

2. Methodology for analyzing the economic effect of increasing the reliability of an information system

The effect of increasing the reliability of the information system is to reduce downtime, which is important in the activities of the enterprise. The negative effect of any error or failure in the corporate network is very high and reaches tens and hundreds of thousands of dollars.

To perform the analysis, there is a special technique for calculating downtime (a technique based on the TCO Advisor Client & Server Model) [14-16]. Although much attention is paid to it in the general methodology for calculating the total cost of ownership, this technique is rarely used separately.

The necessary data for the calculation:
- Number of employees (A1).
- Number of administrators (A2).
- Average work week (work hours per day and work days per week) (A3; A4).
- Company annual gross income (A5).
- Admin Hourly (A6).
- Hourly wage employee (A7).

The hourly wage of employees includes all types of payments (salaries, bonuses, options), in addition, insurance costs.

1. Planned server shutdowns (include shutdowns caused by backup operations of server contents and reconfiguration):
   - blackouts every month (A8);
   - average outage (A9);
   - number of users disconnected in this case (A10);
   - number of administrators involved for this (A11).

2. Unscheduled shutdowns of the server (include shutdowns caused by power failures, equipment failure, software errors and human errors):
   - number of outages every month (A12);
   - average outage (A13);
   - number of users disconnected in this case (A14);
   - number of administrators involved in this case (A15).

Now, after entering the initial data, it is necessary to determine the intermediate indicators:
- Income per employee ($/hour)
  \[(B8) = A5/((A3*A4*50)*A1).\]
- Scheduled outages (hours)
  \[(B9) = A8*12*A9*(A10+A11).\]
- Unscheduled outages (hours)
  \[(B10) = A12*12*A13*(A14+A15).\]
- Planned server shutdown costs
  \[(B12) = B13+B14.\]
- Planned costs for administrators ($/year)
  \[(B13) = A8*12*A9*A11*A6.\]
- End-user planned costs ($/year)
(B14) = A8*12*A9*A10*A7.

- Unplanned server shutdown costs
  
  (B16) = B17+B18.

- Unscheduled expenses for administrators ($/year)
  
  (B17) = A12*12*A13*A15*A6.

- Unplanned costs for end-users ($/year)
  
  (B18) = A12*12*A13*A14*A7.

As a result, we obtain the following key indicators:

- Lost revenue ($/year)
  
  (B7) = B8*(B9+B10).

- Total cost of server shutdowns ($ year)
  
  (B21) = B7+B12+B16.

- Costs per hour of server shutdown
  
  (B23) = B21/((A8*12*A9)+(A12*12*A13)).

Other indicators are calculated in a similar way to determine the total cost of ownership. In addition, this information may be of interest to those who want to evaluate the performance of their servers and networks.

3. Results and discussion

Calculations based on the proposed methodology for analyzing the economic effect of increasing the reliability of the information system for a digital agricultural enterprise, implemented as a standard in the territory of the Krasnoyarsk region [17], are given in tables 1-3.

**Table 1. Calculation of the cost of downtime of the equipment of IS DAE.**

| Index                     | Designation | Analogue | New IS | Deviation absolute | %  |
|---------------------------|-------------|----------|--------|--------------------|----|
| System reliability       | N           | 99.2     | 99.9163| 0.7163             | 0.72% |
| Number of employees      | A1          | 55       | 55     | 0                  | 0.00% |
| Number of Administrators | A2          | 3        | 3      | 0                  | 0.00% |
| Average workweek         | A3          | 8        | 8      | 0                  | 0.00% |
| Working days per week    | A4          | 5        | 5      | 0                  | 0.00% |
| DAE passing cash flows ($/hour) | A5   | 12470311.11 | 12470311.11 | 0.00 | 0.00% |
| Administrator hourly wage| A6          | 6.21     | 6.21   | 0                  | 0.00% |
| Hourly wage worker       | A7          | 6.85     | 6.85   | 0                  | 0.00% |

**Table 2. Planned server shutdowns.**

| Index                     | Designation | Analogue | New IS | Deviation absolute | %  |
|---------------------------|-------------|----------|--------|--------------------|----|
| Blackouts every month     | A8          | 0.0833   | 0.0833 | 0                  | 0.00% |
| The average duration of shutdowns, h | A9    | 8        | 8      | 0                  | 0.00% |
Table 3. Unscheduled server shutdowns.

| Index                                            | Designation | Analogue | New IS | Deviation absolute | %     |
|--------------------------------------------------|-------------|----------|--------|--------------------|-------|
| Blackouts every month                            | A12         | 1        | 1      | 0                  | 0.00% |
| The average duration of shutdowns, h             | A13         | 5.84     | 0.611  | 5.23               | 89.55%|
| Number of disconnected users                     | A14         | 55       | 55     | 0                  | 0.00% |
| The number of administrators involved            | A15         | 3        | 3      | 0                  | 0.00% |
| Flow per employee ($/hour)                        | B8          | 113.37   | 113.37 | 0                  | 0.00% |
| Scheduled outages (hours)                         | B9          | 8        | 8      | 0                  | 0.00% |
| Unscheduled outages (hours)                       | B10         | 4064.64  | 425.26 | 3639.38            | 89.54%|
| Planned server shutdown costs                    | B12         | 49.7     | 49.7   | 0                  | 0.00% |
| Planned expenses for administrators ($/year)      | B13         | 49.7     | 49.7   | 0                  | 0.00% |
| Planned costs for end-users ($/year)              | B14         | 0        | 0      | 0                  | 0.00% |
| Unplanned server shutdown costs ($/year)          | B16         | 27713.57 | 2899.53| 24814.04           | 89.54%|
| Unplanned expenses for administrators ($/year)    | B17         | 1306.12  | 136.65 | 1169.46            | 89.54%|
| Unplanned costs for end-users (руб/год)           | B18         | 26407.46 | 2762.88| 23644.58           | 89.54%|
| Possible lost flows ($/year)                       | B7          | 461700.80| 49117.49| 412583.31          | 89.36%|
| Costs of server shutdowns ($/year)                | B21         | 489464.07| 52066.72| 437397.35          | 89.36%|
| Costs per hour of server shutdown                 | B23         | 6268.75  | 3395.92| 2872.83            | 45.83%|
| The cost of new equipment, $                       | E-1         | -        | 157536.00| -               | -     |
| The total cost of server shutdowns, $             | E-2         | 489464.07| 209062.72| 279861.35          | 57.18%|

Thus, it can be seen from table 3 that a new, more reliable information system, even taking into account the additional costs (see E-1 in table 3) associated with the acquisition of equipment, will reduce the overall costs in case of failure of the information system (see E-2 in table 3) more than doubled.

4. Conclusion

As a result, on the basis of the presented approach, an analysis of existing methods, models and algorithms for reliable assessment of information processing systems can be performed, as well as system engineering solutions that provide multi-stage optimization of the development plan for cluster structures of information systems for digital agricultural enterprises.
In the framework of the practical implementation of the software support system for the design of IS, the choice of a method for assessing the reliability properties of an information system is justified, taking into account the analysis, the specifics of the organization and the amount of data provided.

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