FOUNDATIONS OF MANAGEMENT INFORMATION SYSTEM QUALITY

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Abstract: Software engineering comprises many methodologies focused on the software manufacturing processes. Effective management of the implementation and deployment of the Management Information System (MIS) project requires the use of a interdisciplinary system approach. IT methodologies, oriented on the level of manufacturing processes, may be supplemented with universal methods in the area of management science, which allow for the management of activities related to ensuring the realisation of the organisation business goals. The aim of the article is to identify the MIS quality determinants, which constitute determinants of the effective quality management at the stage of modelling, implementation, deployment and operation of MIS.

Keywords: Quality of Management Information Systems, Quality Function Deployment method, quality management of IT systems.

1. Introduction

Implementation of Management Information System (MIS) in an enterprise is included in the high risk and high complexity projects. At the design stage of the Management Information System, the concept of business process x-engineering is being increasingly applied in order to effectively use the IT systems and to increase the enterprise productivity.

From the point of view of an enterprise, which introduces the Management Information System, the computer software implementation is one of the project objectives, but it does not guarantee that the needs of the business enterprise will be met. At the MIS design stage, special attention should be paid to the recognition and reorganisation of the business processes supported by IT solutions within an organisation. This will allow for rational selection of the system architecture by including an appropriate database management system constituting a key element of an effectively functioning IT system of the organisation. If the analyses

regarding the aligning of IT solutions to an organisation's business goals are conducted too late, e.g., after the implementation of a development team, they may result in high costs of introducing changes within the project. Taking the above into consideration, there is an urgent need to implement scientific research to develop methodologies enabling an increase in the degree of meeting the business needs of the organisations, which have decided to implement MIS.

2. Methodology

Quality of Management Information Systems is the subject of research in this elaboration. The aim of the research is to identify the MIS quality determinants, which constitute determinants of effective project management at the stage of modelling, implementation, deployment and operation of MIS. The research methodology, adopted in this elaboration, includes an interdisciplinary research approach considering theoretical analysis and synthesis of the subject literature, as well as the normative acts, use of elements of the system analysis and general theory of systems and mathematical modelling.

3. Quality of Management Information Systems

Functioning of the Management Information Systems in an enterprise may be analysed in terms of quality. In order to consider the concept of quality of the Management Information System, it is reasonable to define first the concept of the IT project success (Dobrosielski, 2010). The question, if it is justified and sufficient to apply the general criteria in the field of project management for the IT projects, should be analysed. The success is achieved only when the product was realised within the scheduled time and budget (Dobrosielski, 2010). The life cycle of MIS may comprise multiple stages, starting from modelling of the system architecture and database design through software implementation and equipment configuration to the implementation, training and system maintenance. As a result, there are many parameters and characteristics within the area of the IT project success evaluation, which may include, inter alia, proper implementation of the system modules in a selected programming technology, software testing, the server stability with regard to hardware and software, bandwidth and ICT networks reliability, database engine performance, measured by the query response time, successful training of personnel in terms of the MIS use or the IT safety level provided by the system.

When the above set of characteristics is taken into account, the concept of the IT system project success should be in multidimensional terms (Dobrosielski, 2010). Implementation of the Management Information Systems in the enterprise should be accomplished within the scheduled time and budget and translate directly into optimising economic processes implemented within an organisation, e.g., by reducing the costs and shortening the execution time. Fundamental guidelines for software engineering, individual stages of implementation and testing, risk management and product quality, which is MIS, should result from such assumption (Dobrosielski, 2010).

The problem related to the quality of information systems is one of the software engineering main issues. According to the PN-EN ISO 9000 standard, quality is generally defined as "the extent to which a set of inherent properties of the object fulfils the requirements" (PN-EN ISO 9000 standard: 2015-10). General systems theory may be used to bring the above quoted definition to the IT systems field. In the subject literature it is common to assume that the systemic quality of the object may be considered as a function of usability, functionality, reliability, safety and efficiency, which may be registered as (Bojarski, 2010; quoted after: Skopiński, and Zaskórski, 2010, p. 111):

$$Jakość = f(U, F, R, Ry, E) \tag{1}$$

where:
U – usability,
F – functionality,
R – reliability,
Ry – safety,
E – efficiency[1].

At this point it is worth quoting the international standards regarding the quality of computer software, which is ISO/IEC 9126-1: 2001 and its subsequent series ISO/IEC 25000. The former standard distinguishes the following properties of the information system describing its quality (ISO/IEC 9126-1: 2001):

- usability – performing basic functions expected by the system user,
- functionality – ability of the system to meet the needs expected by the user,
- reliability – ability of the system to guarantee efficient operation under certain conditions and time,
- efficiency (performance) – determined by the relation between the software performance and the system resources employed for this purpose,

[1] More on the issue of the quality and efficiency at the level of business processes of an organisation has been presented by (Skopiński, Zaskórski, 2010, p. 105-117).

- maintainability (ease of maintenance) – susceptibility of the system to perform certain modifications,
- ability to migrate – ability to transfer the system to a different organisational, hardware and software environment[2].

It is possible to define the individual properties describing the system quality through assigning a set of specific attributes. According to the quoted ISO/IEC standards, feature of the system functionality may be described by the attributes of interoperability, functional compliance, accuracy, usefulness and the protection quality (standard of ISO/IEC 9126-1: 2001). On the other hand, the property of system efficiency may be described by the attributes of reaction time, used resources and performance compliance (ISO/IEC 9126-1: 2001).

Among the series of ISO/IEC 25000 the standard, which is significant regarding the quality related to MIS is ISO/IEC 25010: 2011 "Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuaRE) – System and software quality models". The ISO/IEC 25010: 2011 standard supplements the distinguished properties with additional ones, i.e., safety and compliance and introduces a number of changes.

It is noteworthy that there are other models which provide the basis for the possible development of a formal set of the software quality criteria. The McCall, Boehm, Boeing models as well as the FURPS methodology must be distinguished in this respect.

Appropriate adjustments of the distinguished properties and attributes to the customer needs at the design stage of MIS is of key significance for the effective functioning of the system within an organisation. Such adjustment is enabled by applying the appropriate methodology of software development, which will include the distinguished set of the information system quality attribute in addition to the orientation on the program code implementation and its testing.

4. Quality function deployment (QFD) method as an opportunity to improve the quality of Management Information Systems

In software engineering, there are many software development methodologies focused mainly on the implementation of the program code and its testing. From the perspective of the organisation implementing MIS, as indicated in the introduction, software is the only objective of the IT project and may not guarantee achieving the business goals of an organisation. It is reasonable to supplement methodologies oriented exclusively on software development with the methods enabling to manage the achievement of strategic goals related to the implementation of MIS.

[2] More information on the evolution of the software quality standards has been presented by Kobyliński, 2015, p. 91-101).

The Quality Function Deployment (QFD) method is known in the management-related sciences, and since the moment it was created, it has been successfully used to design and improve the quality of material products. QFD was used, among others, by Mitsubishi, Ford and General Motors (quoted after Toruński, 2013). Release of ISO 16355-1: 2015 by the International Standards Committee, which is the formal standardisation recognition of the QFD method, shows the method's potential.

It may be generally described, that using the QFD method enables formal translation of the identified customer requirements into technical characteristic of the product. QFD method may be applied without limitations exclusively for material goods. OFR method shows properties to being efficiently used at the level of information systems design as well, such as the Management Information Systems.

A set of matrices, referred to as "the house of quality" is a basic analytical tool in the QFD method. It is generally accepted that forming "the house of quality" matrix is performed according to an algorithm, which comprises a set of subsequently following steps (Hamrol, and Mantur, 1999; quoted after Sikorski, 2002, p. 122):

1. identifying requirements of the customer, the future user of the product,
2. determining the importance of customer requirements,
3. customer benchmarking – comparing with competitors,
4. determining the relative importance of the customer requirements,
5. identifying technical factors, which affect meeting the customer's identified needs,
6. determining the strength of relationship between the technical factors and the identified requirements of the customer,
7. determining the importance of technical factors,
8. technical benchmarking – comparison with the competition,
9. determining the relation between technical factors,
10. determining target values of the technical factors and indicators of complexity.

A set of customer requirements for the Management Information System, which is being created, is defined as the first step of the above algorithm. A set of functional and non-functional system requirements, corresponding to the identified and the newly designed business processes of an organisation, is determined by means of the information technology methodologies in the area of software engineering at the initial stage of the project. From the perspective of the system architect and development team, the set of customer requirements provides the basis for the database model and subsequent work related to the implementation of individual modules of MIS. However, by means of the QFD method, the set of customer requirements may be translated in a formal way into the technical parameters of the designed system. Degrees of importance, which determine the priority factors for completion of the implementation objectives of the proposed MIS, are determined for individual elements of the set of customer requirements in accordance with the QFD method.

At the stage, when the customer benchmarking is being performed against competitive systems for the proposed MIS, the QFD method assumes the assignment of areas in which the designed system may have an advantage over competing solutions. Another important stage in the QFD method is determining the importance of requirements of the future system user. When this step is being implemented, it is possible to use the table shown below (Sikorski, 21.09.2018).

Table 1.
Determining the relative importance of the system user requirements

Requirement	Customer benchmarking			Comparative indicators					
	N	Y	Z	A	P	B	C	D	E
Report generation time	4	4	3	5	4	1	1.3	6.5	0.02
Safety of information with respect to ...	4	4	5	5	5	1.25	1.9	11.88	0.04
….	….	….	…	….	…	…	…	…	…
								total	1

Note: based on (Sikorski, 21.09.2018).

M. Sikorski presents that Table 1 may consist, inter alia, of the following columns (Sikorski, 09.21.2018):

- i – customer requirements (system user),
- N_i – level of fulfilment of the *i-th* requirement of the customer by the designed MIS,
- Y_i,Z_i – state of fulfilling the *i-th* requirement of the customer by the competitive systems,
- A_i – degree of importance of the the *i-th* requirement of the system user,
- P_i – target level of the fulfilment of the *i-th* requirement, which is aimed to be as a result of the system implementation by an organisation,
- B_i – indicator of improving the fulfilment of the *i-th* requirement of the customer requirement.

$$B_i = \frac{P_i}{N_i} \tag{2}$$

- C_i – indicator determining if the improvement of the fulfilment of the *i-th* requirement is a strong point of the designed MIS,
- D_i – absolute weight of the *i-th* requirement of the system user:

$$D_i = A_i B_i C_i \tag{3}$$

- E_i – relative requirement for the *i-th* requirement of the system user:

$$E_i = \frac{D_i}{\sum_{i=1}^{n} D_i} \tag{4}$$

where n – number of the requirements of the system customer.

Determining the importance of customer requirements through the QFD method enables the formal identification of priorities in the project and provides the system architects and development team with a new set of information useful at the design stage of MIS.

Attributes describing MIS, regarding the customer requirements, are determined at the stage of identifying technical characteristics according to the quoted algorithm of the QFD method. The QFD method assumes that technical characteristics should be expressed in a measurable manner and should reflect real characteristics of the product in the manufacturing process. In the process of translating the proposed assumptions into the designing of MIS, it is necessary to assign technical characteristics of the system, which create conditions for a proper selection of the database architecture, the implementation of individual modules of the system and the software and hardware level.

The next step in the QFD method of QFD is to determine the correlation between the customer's requirements and technical characteristics through determining the strength of relationship between a given requirement and its corresponding technical parameter (Sikorski, 21.09.2018). Relative importance of the T_j technical elements in the QFD method is determined as the sum of the products of coefficients of the importance of *i-th* requirements and coefficients of their dependencies from *j-th* technical parameter, which may be represented as follows (Sikorski, 21.09.2018):

$$T_j = \sum_{i=1}^{n} A_i Z_{ij} \tag{5}$$

where:

A_i – degree of importance of the *i-th* requirement,

Z_{ij} – correlation between the *i-th* requirement and the *j-th* technical parameter.

Values of the obtained T_j coefficients allow the system architect to identify, in the formally objectified manner, the key technical characteristics of the proposed MIS in terms of the applied technology and ICT solutions.

It is possible to determine a set of technical characteristics of the system, which is being modelled, by using the QFD method at the initial stage of the MIS designing. This set may provide the basis for the system architect and the development team within the scope of the proper selection of information technology applied in the project. Depending on the set of formal system characteristics, defined by the QFD method, it is possible to properly select technologies in the following areas:

- database systems: using the classical relational database model or choosing the NoSQL solutions, including, the types of key-value, document and graph database; the latter types are recommended for organisations with specific information,
- front-back and back-end programming technologies

- software level in the field of operating systems for the customer computers and server services,
- layer hardware in the field of server solutions and the ones related to the customer computers,
- layer hardware solutions in the area of computer networks.

It is worth noting that using QFD method makes it possible to take into account the quality properties and attributes of the information systems, defined in ISO/IEC 9126-1 and ISO/IEC 25010 standards, at the MIS designing stage.

Proper selection of the technology used in the MIS project, which has been supported by a formal set of technical characteristics of the system, determines the achievement of business goals related to the implementation of the Management Information System from the viewpoint of an organisation. Use of the QFD method enables the support of the classical methods of software development, which are oriented on the code program by formal assignment of the system characteristics in the area of meeting the needs of the system users.

5. Summary

Software development methodologies, which are oriented exclusively on the process of implementing the program code and its testing, cannot guarantee the achievement of business goals of the organisation implementing the MIS. The authors postulate that the effective management of the process of design, implementation, deployment and maintenance of MIS within an organisation requires a systemic approach, which involves an interdisciplinary approach in the field of computer and management sciences. The Information methodologies, oriented on the software implementation, may be successfully supported by universal methods and tools in the area of management sciences, enabling the management of activities related to quality assurance of the product.

The QFD method may successfully support traditional software methods, because it allows for a formal translation of identified customer requirements into the the technical parameters of the Management Information System. Determining technical characteristics of the product by means of the QFD method may provide the basis for the appropriate selection of technologies applied in the project, which increases the chances of meeting the business goals of the organisation implementing the MIS.

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