

Complexity management - a gap in current methodologies

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Abstract: *This article follows up on the author's 2010 article "How and why complexity arises in IS" in the magazine Systémová integrace (Systems Integration), which dealt with IS complexity as an important challenge for informatics, presenting a definition of complexity and describing the mechanisms by which it arises and its effects on an enterprise. The article also included a questionnaire study, through which several hypotheses were tested. In 2016 the author conducted a new study, using the same questions as in 2010 for one part and for the other part adding several other related questions on the reasons by which complexity arises in information systems and which methodologies are used for complexity management.*

Keywords: Complexity, methodology, metric, enterprise architecture, information systems.

1. Introduction

The scope of use of information and communication technologies (ICT) and their complexity are constantly growing. With these rise the demands for the procurement, implementation and maintenance of such systems. IT management is faced with the issue of ever-increasing costs and rapidly developing technologies, the understanding and mastery of which requires close cooperation between managers and qualified IT professionals. (Bruckner et al., 2012; Holub, 2012) Not only do the importance and complexity of information systems (IS) and other information and communication technologies grow, but alongside them so too does the amount of relevant investment. The extensively complexity of enterprise information systems has negative impact on business as some related works shows. (Abrams, 2009; Geer, 2009) Current methodologies does not deal with IS complexity sufficiently as confirmed by the questionnaire study.

The main objective of this article is to determine the change in the perception of complexity among the professional public in recent years. To achieve this goal, a comparison of two questionnaires from 2010 and 2016 is used. The objective is defined as the response to the following research questions:

- Will the hypotheses confirmed by the 2010 study also be confirmed by the 2016 study?
- In what parameters and in what direction has the perception of complexity changed since 2010?

A secondary objective of the article is to evaluate questions from the 2016 study that were not included in the first study in 2010. These objectives are defined as the responses to the following questions:

- Can insufficient time for implementing a demand be a reason for excessive complexity to arise in an information system?
- Are solutions implemented in a hurry subsequently integrated or removed, or are they left in their original state?

and confirmation of the hypotheses:

- 2016_H1: current methodologies used when building information systems do not sufficiently address the issue of complexity
- 2016_H2: one of the reasons for the emergence of excessive complexity is insufficient time for implementing solutions

2. IS complexity

The term complexity is often used in the literature and in methodologies and frameworks that deal with IT management. There are several varying metrics, such as the simple number of lines of source code, information entropy, the function point method and others. (Albrecht and Gaffney, 1983; Arora and Barak, 2009; Kolmogorov and Fomin, 1999; Recker et al., 2010) None of them have been put to use in the most frequently used methodologies such as RUP, ITIL, COBIT or TOGAF. Intuitively we imagine the term complexity to represent the size of a system, the number of functions and considerable costs for procurement, service and maintenance. From various points of view, we come to recognise the individual aspects of IS complexity, such as the amount of data and information, complicated processes, many-branched organisational structures, confusing user interfaces, sophisticated hardware and software. These characteristics then have an impact on the whole organisation, its employees, its economic results and even on each other. It is clear that a business whose processes and enterprise architecture are complex will need a complex IS or even multiple IS.

In order to study the IS complexity, the author set a definition of complexity as the sum of all entities (elements and connections) in the UML models of all content dimensions of the system, which were selected using the MMDIS methodology. (Holub, 2012, 2011) The MMDIS methodology (Voříšek and Vysoká škola ekonomická v Praze., 2008) provides a multidimensional view of an IS through individual content dimensions (data, procedural, organisational, hardware, software, etc.), from which the author selects those relevant for resolving the given problem at the appropriate stage of the lifecycle (development, implementation or change to an IS) and assigns a UML model with appropriate granularity to each. This defines the metric and this can then be used to compare multiple systems or solution variants.

2.1 Reasons for and mechanisms of complexity

The reason for procuring or expanding an enterprise information system is the requirement for securing support for business processes. The starting point for this should be solely the enterprise's requirements and the resulting information system should meet all these and only these. This is not always the case, however, and the

decision-making process for acquiring and implementing and operating such a system is also influenced by interests that do not always coincide with the interests of the enterprise. Thus decisions are often made that lead to an increase in the IS complexity, as shown by an article from 2012 (Holub, 2012). One of the reasons for increased complexity not described in that article is the situation where the contracting body demands a quick and cheap solution, which is implemented as a separate component of the enterprise's ICT without any or only with limited integration into the main enterprise information system. This results in increased complexity, as new applications and data repositories are created without subsequent attention tending to be paid to the integration thereof. One of the goals of this article is to verify that solutions are truly sometimes developed that due to a shortage of time are not integrated into the existing architecture and to check whether this integration takes place later or not at all.

2.2 Approach to complexity in existing methodologies

An important instrument for building information systems and technologies is frameworks and methodologies that include processes and procedures that not only concern new information systems but also the development of existing ones. Rapid development and deployment of the newest technologies places demands on the development of these theoretical instruments.

Based on his own experiences in the field and after analysing the most frequently used methodologies, the author is of the opinion that the issue of complexity is not sufficiently addressed in the existing methodologies used for managing IT. Despite the fact that several of them mention the risks and costs associated with high complexity, none of them provide any guidelines for managing or even reducing complexity. Only TOGAF (The Open Group, 2013) mentions the lower complexity of IT infrastructure as a precondition for reducing risk and improving return-on-investment. In Chapter 5 it states that complex architecture is difficult to manage and subsequently recommends dividing it into sub-phases in such cases. In Chapter 22 it points out the danger of increasing complexity stemming from the use of SOA architecture. It also mentions reducing the complexity of enterprise architecture as a means to reduce costs, but it does not introduce any method for comparing complexity, nor any metric by which the complexity of enterprise architecture could be measured.

3. Questionnaire

In order to answer several research questions and verify one of the hypotheses of this article, a questionnaire was used which was drawn up in 2010 as part of Czech Science Foundation research project no. GAP403/10/0303, in which the author participated and produced a set of questions on the topic of IS/ICT complexity. The study provided valuable output for this article and thus the author decided to repeat the study in 2016 to test whether the data are still current while also acquiring temporal data for comparing whether the evaluation of complexity has changed in any way. At the same time, the author included several further questions with the potential to confirm or disprove other hypotheses and answer further research questions.

3.1 Results of 2010 study

Six hundred Czech companies took part in the study¹, which was prepared by the Department of Information Technologies at the University of Economics Prague in 2010. In addition to other topics (Bruckner, 2010) it was also focused on the issue of IS complexity. The study brought to light several important aspects of the issue of complexity and supported a hypothesis on the negative effects of complexity. ("GAP403/10/0303 Enterprise Architecture as a principle in managing small and medium organisations Provider: GAO - Czech Science Foundation (GA ČR), Primary beneficiary: University of Economics Prague / Faculty of Informatics and Statistics, Project period: 2010-2012.," 2010)

The study from 2010 confirmed the following hypotheses:

- 2010_H1: IS complexity is a current and important topic
- 2010_H2: Complexity has negative effects on an enterprise
- 2010_H3: The causes of complexity are not always legitimate or even legal

It also verified that IS/ICT complexity brings with it the negative effects of increased maintenance and training costs, and to a lesser extent system slowdown and instability and worsened user ergonomics.

3.2 Results of 2016 study – comparison with 2010

In light of the fact that five years had passed since the first questionnaire study took place, the author posed the question of in what way the perception of complexity has changed during that time, and prepared a new separate study in which he used the same questions, to which he received responses from 28 respondents with more than ten years of experience in the following roles presented in Figure 1.

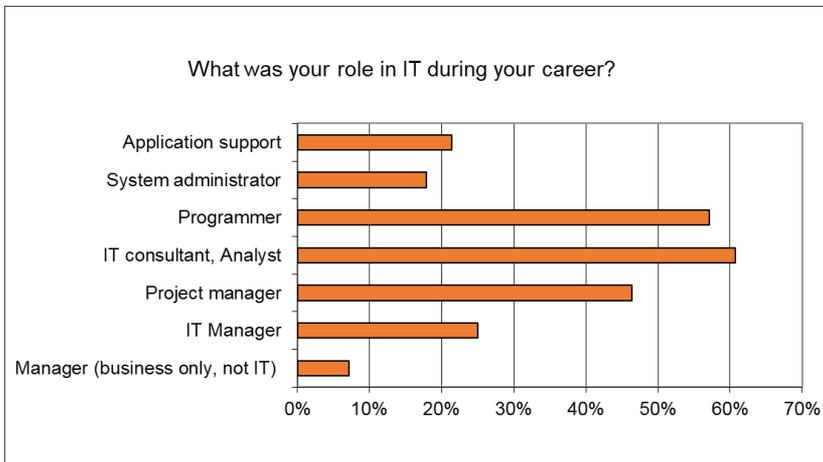


Figure 1 - Structure of 2016 study respondents, source: author

¹The questionnaire was part of Czech Science Foundation research project no. GAP403/10/0303.

The following graphs present a comparison with the results from 2010. The graph bars in this chapter are coloured differently depending on what year the results come from. The 2010 values are marked in blue, the 2016 values in red/orange.

A marked difference in the perception of complexity can already be seen in Figure 2, where there is a clear shift to higher incidence of complexity. In fact, not even one respondent was found in 2016 that had not encountered problems with complexity, compared to 2010 when it was more than a quarter of them. This result not only once again confirms hypothesis 2010_H1: IS complexity is a current and important topic, but does so even more emphatically.

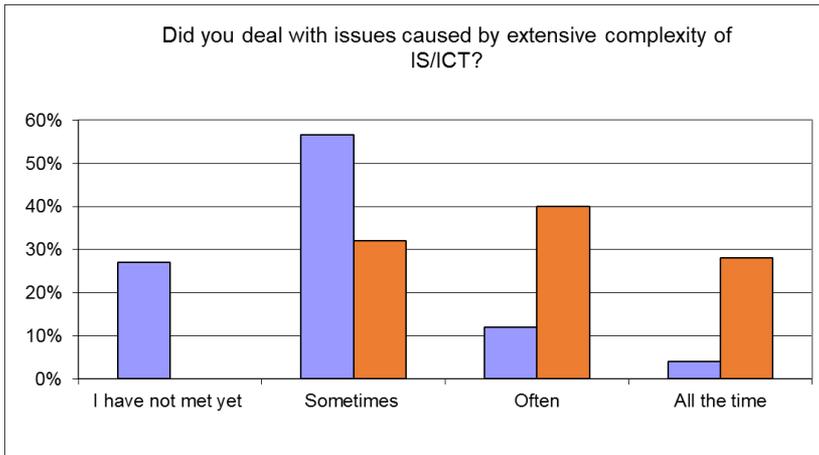


Figure 2 – Comparison of frequency of responses by respondents in 2010 and 2016 studies to the question: "Do you deal with issues caused by extensive complexity of IS/ICT?", source: author

When stating the reasons for the growth in complexity, the greatest shift was in the interest of suppliers, which more than quadrupled, as shown in Figure 3. The interest of suppliers in complexity of a business's IT cannot be considered a legitimate reason and complexity that arises in this manner in all likelihood does not correspond to the needs of the enterprise and is thus superfluous.

This result supports hypothesis 2010_H3: The causes of complexity are not always legitimate or even legal, and the growth in the frequency of responses placing the blame for increased complexity on the policy of suppliers emphasises the severity of the problem. As several sources on this topic show (DSAG, 2012), the policy for development of enterprise information systems is not always in keeping with the interests of the customer, with new versions of a system increasing their complexity, implementing more and more functions, modules or even offering additional new systems. Another factor are systems integrators, and their interests again need not coincide with those of the customer.

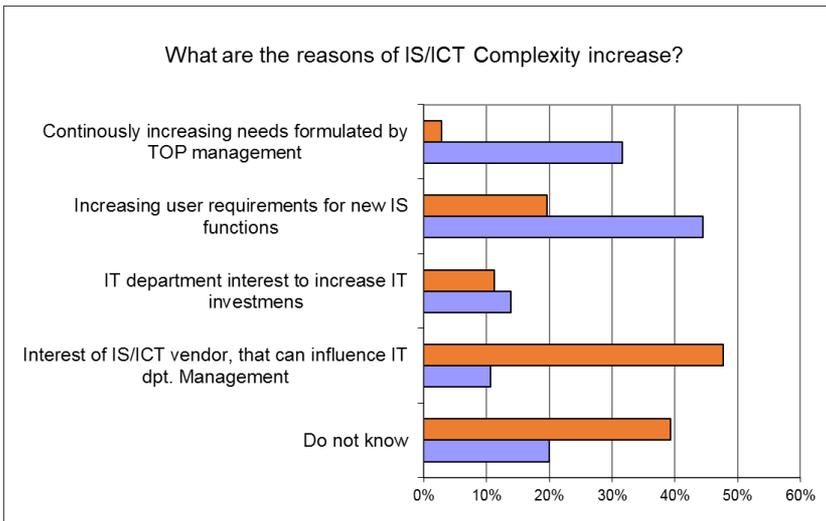


Figure 3 – Comparison of frequency of responses by respondents in 2010 and 2016 studies to the question: " What are the reasons for growth in IS/ICT complexity?", source: author

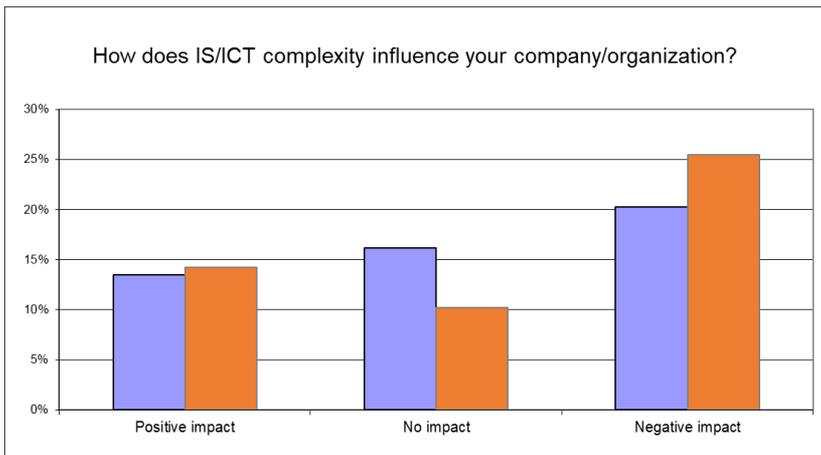


Figure 4 – Comparison of frequency of responses by respondents of 2010 and 2016 studies to the question: "In what way does IS/ICT complexity influence your enterprise/organisation?", source: author

Public and publicly funded organisations needlessly overspend on IT contracts by demanding unnecessary services or inappropriate information systems, as stated for example by audit company APOGEO

"The reasons need not even be corruption, but rather the buck-passing of public officials and their attempt to be covered at all costs. For this reason they prefer to oversize things or choose an inappropriate strategy out of ignorance. The result is

overpriced projects that often do not even meet the expected function or are already outdated by the time they are completed." (APOGEO, 2011)

Figure 4 also shows a shift to a negative perception of complexity. While roughly the same percentage of respondents mentioned the positive impact of complexity, the number of respondents stating negative effects rose significantly, while the number of respondents that had not observed any effect fell.

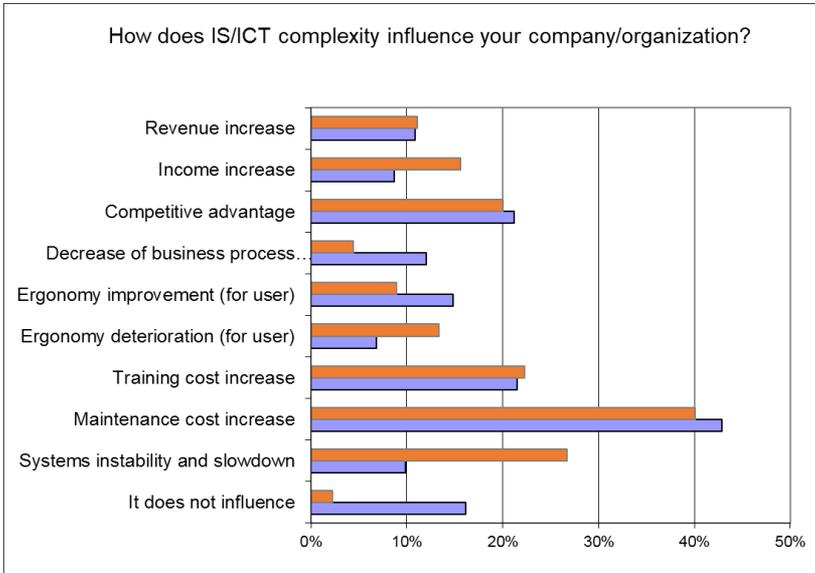


Figure 5 – Comparison of frequency of responses by respondents in 2010 and 2016 studies to the question: "In what way does IS/ICT complexity influence your enterprise/organisation?", source: author

The distribution of responses to the question "In what way does IS/ICT complexity influence your enterprise/organisation?" (Figure 5) essentially remained similar.

This result reaffirms the hypothesis 2010_H2: Complexity has negative effects on an enterprise.

An important shift is the reduction in the group of respondents who believe IS/ICT complexity does not affect their business is worth mentioning. This result also confirms the findings from Figure 2 and strengthens the confirmation of hypothesis 2010_H1. There was also significant growth in the number of responses that complexity causes system slowdown and instability.

Also significant is the shift in perception of the influence of complexity on system ergonomics from the perspective of the user. While in 2010 more respondents held the opinion that complexity has a positive impact on ergonomics (15 %) than a negative one (7 %), in 2016 the results show a clear shift to a negative perception: only 9 % state a positive impact on ergonomics, while 13 % evaluate its effects as negative.

Other questions were also added to the study, the responses to which helped the author in other work.

3.3 2016 results – additional questions

In order to answer research questions and confirm the hypotheses from 2010, several additional questions were included in the 2016 questionnaire. To confirm hypothesis 2016_H1 the question: "What methodology helps you to decrease IS complexity?" was included in the questionnaire. The responses to this question correspond to the analysis of applicable methodologies, of which only TOGAF addresses the issue of complexity, and even then only in part. The highest number of answers for ITIL can be attributed to its widespread distribution. The main evidence comes from the relatively high frequency of responses that none of the methodologies is suitable, that they use their own approach and, especially, that they would welcome a methodology that could help reduce complexity. The individual frequencies are shown in Figure 6.

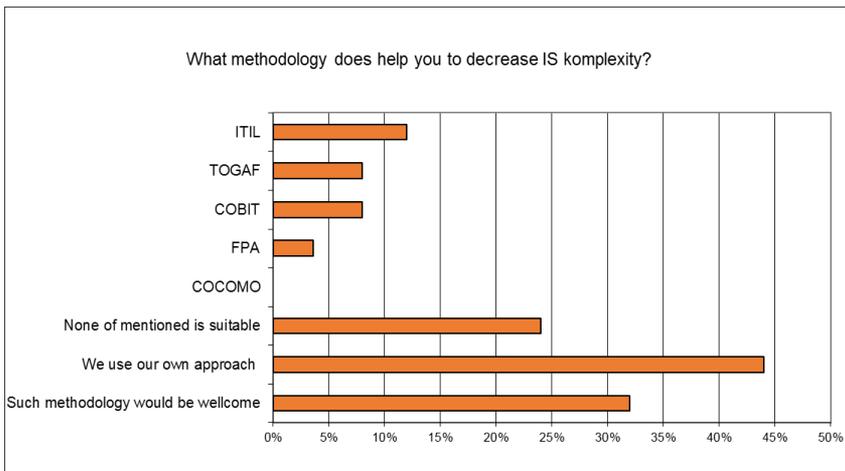


Figure 6 - Frequency of responses to 2016 study question “What methodology does help you to decrease IS complexity?”, source: author

To answer the research questions

Can insufficient time for implementing a demand be a reason for excessive complexity to arise in an information system?

- **Are solutions implemented in a hurry subsequently integrated or removed, or are they left in their original state?**

and to confirm hypothesis 2016_H2

- **2016_H2: one of the reasons for the emergence of excessive complexity is insufficient time for implementing solutions**

the questions to which the responses are depicted in the following Figure 7, Figure 8 and Figure 9 were included in the questionnaire and subsequently evaluated.

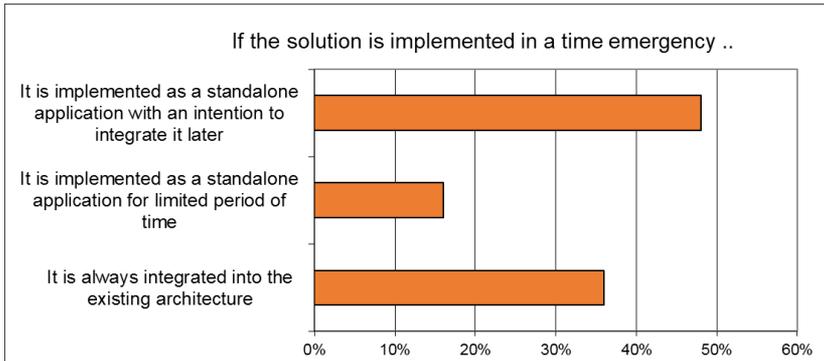


Figure 7 - If the solution is implemented in a time emergency .., source: author

From the distribution of frequency of responses to the question "If the solution is implemented in a time emergency .." it is evident that in most cases full integration of a solution is given up upon if there are time constraints. The reason for implementation of a separate solution need not be inability or unwillingness of a supplier to integrate the solution, but particularly for large companies that have strictly defined terms for possible changes to the system through release versions of core systems, it is impossible to synchronise the requirements of business with the release dates. In such cases integration of the given solution is generally planned for the next release, but it is installed earlier in "standalone" form. The necessity of integration is also eliminated for solutions that are to be used only for a certain period and are then removed. Problems arise when the planned later integration or removal of such a standalone solution does not take place. The result is a growth in the number of applications, data stores and other components in the enterprise's IS, which means growing maintenance costs and a burden on changes to the existing ICT elements at the enterprise and integration of new ones. The two following graphs show whether the original intentions are postponed or even given up on.

Figure 8 shows the responses to the question "If there is implemented a standalone application for a limited period of time, the application is in most cases:" which shows that the original intention to remove applications with a defined service life of up to a year is only successfully realised in a minimum of cases. In roughly three times as many cases, this application remains part of the enterprise ICT between one and five years and in the same number of cases for longer than five years.

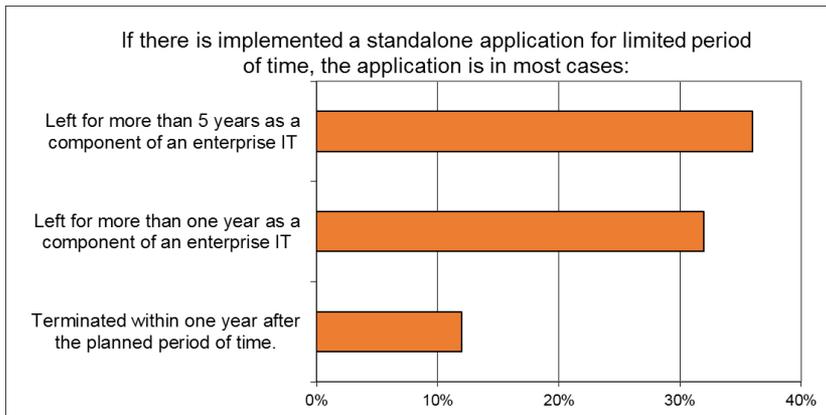


Figure 8 - If there is implemented a standalone application for limited period of time, the application is in most cases, source: author

We come to a similar conclusion after analysing the responses to the question “If there is implemented a standalone application with an intention of later integration, the application is in most cases:” as shown in Figure 9: The greatest number of applications remain unintegrated or are integrated only partially.

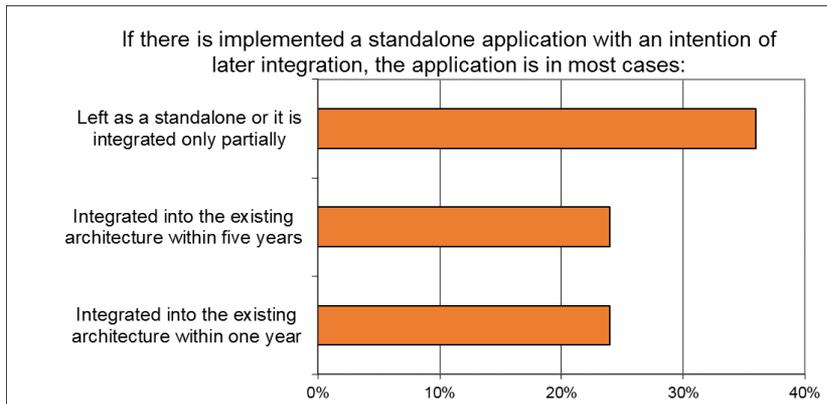


Figure 9 - If there is implemented a standalone application with an intention of later integration, the application is in most cases, source: author

4. Evaluation and comparison

The first study was conducted in 2010 and thus the author checked its results in 2016. As shown by the 2016 results and as shown by publications on this topic in recent years (Lemberger and Morel, 2013; Tarhini et al., 2015; Vidyaranya B. Gargeya and Cydnee Brady, 2005) as well as the author's own experience in practice, its results are still valid and are consistent with the current evaluation of the issue.

Both studies confirmed the hypothesis that

- **The complexity of an information system has a negative impact on the business.**

and answered the following research questions of this article:

- **Is complexity our enemy? What are its positive and negative effects?**

The study showed that the effects of complexity are predominantly negative and include:

- **increased maintenance costs**
- **increased training costs**
- **system slowdown and instability**
- **worsened user ergonomics**
- Are the causes of complexity always legitimate?

Some respondents admitted to illegitimate reasons that lead to growing complexity, which are:

- **the interest of IT departments in increased investment**
- **the interest of IS/ICT suppliers**

The 2016 study, in the response of respondents to the question "What methodology helps you reduce IS complexity?", confirmed the conclusions of chapter 2.5, where no instruments for managing complexity were found in the most frequently used methodologies, thus confirming the hypothesis that:

- **The complexity of information systems is not sufficiently addressed by current methodologies.**

5. Conclusion

The article responded to all the posed research questions and confirmed both hypotheses. The first research question:

- **Will the hypotheses confirmed by the 2010 study be confirmed by the 2016 study as well?**

is answered positively, because the hypotheses

- **2010_H1: IS complexity is a current and important topic**
- **2010_H2: Complexity has negative effects on an enterprise**
- **2010_H3: The causes of complexity are not always legitimate or even legal**

were confirmed and in all cases with a higher percentage of respondents than in 2010.

The second research question:

- **In what parameters and in what direction has the perception of complexity changed since 2010?**

Is answered as follows: There was significant growth in the number of responses that complexity causes system slowdown and instability. The perception of complexity on system ergonomics in terms of the user also shifted from predominantly positive in 2010 to predominantly negative in 2016. The overall conclusion is that the shift in perception of complexity over the past few years has been marked. More respondents

are encountering problems associated with complexity more frequently and more of them are aware of the negative impact thereof. Even where IS complexity was seen as a benefit in 2010 (ergonomics), it is now viewed negatively.

To confirm the hypothesis

- **2016_H1: current methodologies used when building information systems do not sufficiently address the issue of complexity**

the currently most widely used methods were analysed at it was shown that only TOGAF partially addresses complexity, and only in passing, while the others do not address it at all. An assessment of the questionnaire leads to the same conclusion, as most respondents do not consider any of the stated methodologies to be suitable, with own approaches to complexity management predominating, and a significant portion of the respondents would welcome a methodology that deals with complexity.

In analysing another of the reasons for complexity growth, which was formulated by the questions:

- **Can insufficient time for implementing a demand be a reason for excessive complexity to arise in an information system?**
- **Are solutions implemented in a hurry subsequently integrated or removed, or are they left in their original state?**

the 2016 study showed that one of the reasons for growth of complexity is implementation of standalone solutions which, if they are not integrated from the start, generally remain unintegrated as part of the enterprise ICT, even in cases when their integration or elimination was originally planned. This confirmed the hypothesis that:

- **2016_H2: one of the reasons for the emergence of excessive complexity is insufficient time for implementing solutions**

The main contribution of this article is confirmation of the fact that IS/ICT complexity has a negative impact on an enterprise and is today an even more current topic than was the case in 2010.

The article also confirmed the hypothesis that the current methodologies most frequently used when building IS/ICT do not sufficiently address complexity. The management of IS complexity remains still an important gap in current methodologies which are used for building, acquisition and operation of information systems.

Another benefit was identifying a further reason for growing complexity – the implementation of unintegrated "standalone" solutions that are often left in their original state despite original intentions to integrate them or have them be temporary.

There is room for further academic work in a more detailed analysis of the causes and mechanisms of complexity growth and proposal of frameworks, procedures and instruments to limit this growth.

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