Applying Smart Technologies: Evaluation of Effectiveness

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ABSTRACT

This paper discusses the various aspects and perspectives of applying the smart technologies in software solutions. Based on experience acquired during software development projects, the author proposes criteria to evaluate the effectiveness of enhancing of existing products with smart technologies. The evaluation of effectiveness can be used to support decision making on implementing the smart technologies in existing products or products in development.

Keywords: Smart Technologies, Effectiveness, Maintenance

1. INTRODUCTION

Development of an information system should not only ensure conformity of the software with the initial system requirements, but also build a solid base for further development, improvement and maintenance of the information system.

The smart technologies [1] are based on the idea about "smart" software that like living beings is able to "self-management". It means the software should be able to handle unpredictable events in unknown environments. Unlike external solutions providing specific supporting features form outside a smart technology conform software is able to react on external (changes in the infrastructure, changes in external systems etc.) and internal (internal structure, functions of the system etc.) events adequately by itself.

The concept of smart technologies includes already verified components like self-testing [2], external environment testing [3], intelligent version management [4] but also other features that are topicality for further research. The proposed concept of smart technologies is related to the concept of autonomous systems announced 2001 by IBM [5, 6, 7]. Both concepts set as a goal the increasing of software "intellect" to achieve a wide range of non-functional features – an ability to adapt itself to variable external events, self-recovering, self-optimizing etc.

The typical (but not all possible!) components of smart technologies are following:

- Business model-based interpretation system's functionality – the functionality of information system changes according to business processes described in the configuration
- Built-in version management and data synchronization – automatic updating of software versions from the central server, including the conversion of data structures and data
- Self-testing - ability to check the internal integrity by automatic execution of test cases in the productive environment and to inform users and developers about detected inconsistencies
- Environment testing - ability to analyze the external environment (for example, options of operating system and data base management system), to adapt itself to the specific environment and/ or to inform developers about detected inconsistencies
- Data quality monitoring - ability to check the completeness and integrity of data accumulated in the database
- Availability testing – monitoring of system availability using agent technologies; ability to inform remote about the status of the software and additional components needed for a correct functioning
- Security and load testing - monitoring of system security using agent technologies; ability to provide monitoring of performance and load balancing

Practical experience [4] shows, that the decision about applying of smart technologies can be made not only during the initial design and development of an information system but also in later phases of the development or maintenance, e.g. within the new release of the software or as an separate project.

Nevertheless developers should make a SWOT-analysis to settle on the applying of smart technologies. There should be a number of criteria evaluated within the decision making to prove or to disapprove the usage of smart technologies in the concrete case. The goal of this

paper is to discuss empirically identified criteria for evaluation the effectiveness of applying smart technologies.

2. EFFECTIVENESS vs. EFFICIENCY

The notion of effectiveness can be explained as a „power to be effective; the quality of being able to bring about an effect" [8] or „the extent to which a program or service is meeting its stated goals and objectives" [9].

In contradiction to efficiency that describes the degree of achievement of definite parameter values and in fact is close to the notion of productivity, the effectiveness is an ability of an object or a process to fulfill predefined goals under definite conditions.

The evaluation is described as a "systematic determination of merit, worth, and significance of something or someone using criteria against a set of standards" [10].

The most precise form of evaluation is measurement, but it is not the only way to evaluate something. The measurement is "the process of assigning a number to an attribute (or phenomenon) according to a rule or set of rules" [10].

So there can be identified the following preconditions to evaluate the effectiveness:

- Choice of criteria characteristic for effectiveness
- Identifying of optimal values for criteria (etalon values)
- Description of evaluation (measurement) process

The next chapters outline a proposal for different criteria inferred from the practical evidence collected in real software development projects. Identifying of optimal values for criteria and description of an exact evaluation process to have a basis for decision making for or against usage of smart technologies in information systems are a subject for further research.

3. ECONOMICAL CRITERIA

The prime task in every commercial project is to evaluate the potential return on investment. Every rational market participant will be ready to invest only in that case if in closer or further future the investments could bring a profit [11].

Hence the first criterion proposed for the evaluation of effectiveness is prospective return on investment. It is a variable that can be calculated on the basis of investment return plan that contains a comparison of an initial investment and discounted future cash flows.

The commonly used effort, cost and schedule estimating methods (e.g. COCOMO [12]) can be employed for the estimation of an initial investment. But the following adjustments should be taken into account:

- Previous experience and efforts in implementing of smart technologies can reduce the necessary initial investments; it is rather possible that already once developed smart technology components will be adaptable for similar tasks than if the components are to be developed from scratch.
- Modularity of the product to be prepared with smart technologies: the more modular is the software product the easier is to add to it "just" one more module.
- The available time schedule should be comfortable enough to implement and/or integrate smart technology features besides the basic functionality desired by the customer explicitly.
- Feedback and level of user tolerance show whether the concrete users will be able and ready to tolerate short-term inconveniences if they would arise and take an active part in the improvement of the product features. Not all customers are happy to be involved in "experiments". Doubtless more open for innovations in their projects are long-standing customers with high allegiance to the supplier.

For estimation of prospective cash flows can be used both bottom-up and top-down approaches. The bottom-up approach estimates the minimal savings of costs/ expenses could be achieved by enhancing the software product. The typical examples are transport and personnel costs that were spent for traveling to end users as well as installation materials, hardcopy of documentation, partly user support resources etc. It is some kind of "production-oriented" way to find the break-even-point where the initial investment becomes profitable.

The top-down approach is based on the estimation of the market opportunities, i.e. the achievable prices and sales volume is evaluated to have a view of feasible gains of smart technologies.

The simultaneous usage of both approaches returns the gap where the prospective cash flows should fit in to be realistic.

When both components – the initial investment and prospective cash flows – are obtained, they should be made comparable. The usual way to do it is a discounting of future cash flows with the rate of interest (called also discount rate).

Incorporation of smart technologies into software products is beneficial if the initial investment is less than the present net value of prospective cash flows. But there

should never be forgotten that the calculations are based on the estimated (not real!) values. In particular the effort estimation methods can be very inaccurate in some cases [13].

4. QUALITY CRITERIA

The quality of a product or service is intrinsically linked with reputation and hence is crucial to organisation's sustainability. Although, the total quality of service or product certainly affects the profit margin and other performance and financial ratios, the quality achieved by implementing smart technologies can hardly be measured. Prevailing practice in quality evaluation is based on experience values acquired during similar projects.

One of the possible quality criteria to evaluate the effectiveness of smart technologies is efficiency of customer support. This variable shows in what extent the level of client support could be improved if the software product is equipped with smart technologies. Alternatively there could be estimated if the existing customer support level can be assured by reduced amount of support staff.

Assuming that the given number of support resources is fixed, in order to increase efficiency, either more clients should receive support, or service quality for existing clients should be increased. If implementation of smart technologies has not resulted in increased number of clients, still the effectiveness is positive due to fewer resources used to provide more qualitative support to the same number of clients.

The efficiency of customer support can be qualitatively measured by interviewing clients and analyzing selected users' messages, etc. The quantitative indicators can include number of supported users (number of processed cases) in a certain period of time or average proceeding time of problem processing.

Another possible criterion for evaluation of the effectiveness of smart technologies is efficiency of maintenance.

As the developers consider software maintenance as a very significant area for applying smart technologies the task of this criterion would be to show if the quality of software equipped with smart technologies is increased. Quick problem detecting, short problem solving time, low number of user reported errors – all these are quantifiable variables indicating high quality of maintenance and resulting in client satisfaction.

Especially considerations on quality assurance could enhance integration of smart technologies into strategically important products, even if economic returns on such investments can be expected only in long-term.

5. OTHER CRITERIA

Unlike the previously described criteria targeted at profit and reputation, the organizational criteria deal with developers' organizational and technical ability to carry out the development and the necessary integration of smart technologies into end-products.

The development of smart technologies is not possible without highly professional system architect and skilful (able) developers. On the one hand, the development of smart technologies requires good academic knowledge and professional background, but on the other hand, such development also requires profound understanding of product's architecture and functionality. During the development issues such as work-discipline, rigorous following the guidelines and avoiding the use of specific techniques that could cumber maintenance should be considered.

However, these criteria are hardly quantifiable; therefore evaluation of these criteria is preferably done by experienced architects and developers.

Since implementation of smart technologies contribute to significant changes in software construction, potential error probability is not excluded; therefore a well-designed crisis management plan should exist from organizational point of view. Strict and prudent managers possessing power of persuasion are the best support in such cases. The developed end-product should undergo scrupulous testing, therefore appropriate technical support including virtual machines and powerful central server should be available.

The main goal of applying smart technologies is maximizing of profits expected in long-term. Reduced expenses or improved quality of software – the customer should have a clear concept of an added value. The task of marketing activities is to promote the emotional and practical adjustment of the customer to the improved product, to motivate the user to be familiar with the new features of the product. So, the decision about (for or against) smart technologies means also the answering the question if there is a marketing power in the enterprise that is able to "make money" from the technological innovation.

6. EMPIRICAL DATA SOURCES

Principles of smart technologies are partially implemented and approved in various software development and maintenance projects. Although, in neither of software products smart technologies were implemented to the full extent, the gathered experience shows that usage of even only several features or narrowed version of features can bring an additional effectiveness and economical benefit.

The development projects serving as a source for the research are shortly described in the next chapters.

6.1 Implementation of Version Management and Environment Checking

The Project A was started 2002, and the main task was to create an information system for finance management according to system requirements formulated by a public institution (ministry) in Latvia.

Already shortly after the first release of the software solution new customers accrued from the importance of the solution's functionality in the public sector. The number of users grew up from ca 100 in January 2003 to ca 500 in January 2004.

At the end of 2006 the solution in its different packages was used by ca. 1500 users. According to agreements the enterprise had to develop and deliver the software product but also to host the central data base and to provide the first level support (via helpdesk) to the end users.

The system was supposed to run in over than 600 public offices located throughout the territory of Latvia ensuring regular gathering of information by different time periods. Furthermore, the specific requirements dictated that in certain periods the most users will use the system simultaneously.

In view of a large amount of users and their geographical location as well as very restrictive agreements with customers and limited resources allocated for installation and maintenance services, developers made a decision to enhance the software product with one of the smart technology features – the automated version management (including both installing and updating). In approximately a year the developers added to the software product one more smart technology component – the automated environment checking (including comprehensive messaging).

An application that provided all required functions was already developed; therefore project task was to adapt application according to the requirements of automated version updating and environment checking (testing).

Additional human resources for the system adaptation accounted for ca 20% of the initial system developing resources. The most part of these 20% were invested into extensive testing and code review. In order to ensure reliability of the developed mechanisms, software testing with different infrastructure configurations was performed on virtual machines.

As a result an improved version of the software product was obtained ensuring completely automated remote installing and updating of software versions in different target environments (different computer systems with various operating systems, office packages etc.)

The automated feature for checking of external environment was developed as an independent but configurable module providing the "spying" (pre-checking of target environment) and informing functions necessary for detecting the adequacy of the target environment's parameters to the minimal technical values.

The following conclusions were captured within the project:

1. Adding of smart technologies to the software after the development is useful though requires more resources than including smart technology already in the software architecture design phase
2. Implementation of smart technology principle in software takes fewer resources than full-range configuration support. In the same time smart technology places fewer constraints on the acceptable means of expression.
3. Smart technologies allow reducing the efforts (time, resources) for software testing and setting up, thus increasing the client service level significantly
4. Smart technologies assist to provide software performance in a changing environment and environment containing heterogeneous platforms and infrastructure. Nevertheless mechanisms of smart technologies need regular adaptation to the environment changes, especially in case of standardized software.
5. It is very important to provide in-depth messaging mechanism to inform the developers about indicated problems in time.
6. Even the mechanisms making the users work easier should be appropriate explained to end users. The absence of a human in the set-up process of software is in discrepancy with users' former experience.

6.2 Implementation of Version Management and Data Synchronization

The Project B was started 2008, and the main task was to create a completely new version of an over 10 years old software product (to rewrite it). As the product had over 50 installations in various places of Latvia, there was already during the design phase decided to use the successful experience from the Project A and to include features of smart technologies (an automated version management feature) into the new version of the product.

The modernization, including the complete recoding of the core functionality, took approximately eight man-months.

The implemented solution of automated initial installation of the product was not as successful as originally desired. Due to specifics of the used commercial database

management system there was quite often assistance by the developers necessary to ensure, the initial installation will be performed successfully. However the automated updating of version including the data synchronization worked outstanding; it saved resources spent for user support and reduced effort necessary for software maintenance indeed.

The following conclusions were captured within the project:

1. The moment when the decision about enhancing the information system with the features of smart technology is met is less important than the concrete technical solution.
2. Implementing the functions of smart technologies it is advisable to use proven and robust architectural and technical solutions – it will reduce the number of problems to be solved simultaneously and improve the controllability of the development process.
3. Although the customers approve opportunities provided by the smart technologies, usually, they are not willing to provide additional financial means to ensure them.
4. The smart technologies are certainly cost–effective and should pay-off in long-term business projects and long-term cooperation with notable number of users and differently configured users' workstations. The Project A was started 2002, and the main task was to create an information system for finance management according to system requirements formulated by a public institution (ministry) in Latvia.

7. CONSLUSIONS

The following conclusions result from the practical experience described above:

- The prospective effect from the applying of smart technologies is considerable; it ranges over client service quality up to increasing of staff qualification.
- Even usage of single or several smart technology features can be profitable.
- Economical aspects are the main barrier for wider spread of smart technologies.
- Only very qualified and skilled supplier is able to fulfill the set of preconditions necessary to ensure the successful usage of smart technologies in commercial projects.
- Other hard evaluable factors like reputation of enterprise, marketing/sales capacity, user support level etc. also impact the final decision about the applying of smart technologies.

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