Evaluation of Readiness of IT Organizations to Agile Transformation Based on Case-Based Reasoning

Cezary Orłowski[1(✉)], Tomasz Deręgowski[2], Miłosz Kurzawski[3], and Artur Ziółkowski[1]

[1] Department of Information Technology Management, WSB University, Gdansk, Poland
{corlowski,aziolkowski}@wsb.gda.pl
[2] Acxiom Corporation, Gdańsk, Poland
Tomasz.Deregowski@acxiom.com
[3] Faculty of Management and Economics, Gdańsk University of Technology, Gdansk, Poland
mkurzawski@zie.pg.gda.pl

Abstract. Nowadays many of IT organization decides to change the way of delivering from classic, waterfall approach to agile. This transition is called "agile transformation" (AT). The problem of this process is that part of companies started AT without any analysis. This causes that many of transitions fails and organizations must return to old methods of delivering. Cost of return is significant and number of projects with violated project management triangle is bigger than before. In this paper authors described the results of conducted research and the model of evaluating of readiness to agile transformation based on case-based reasoning.

Keywords: Agile transformation · Case-based reasoning · Associative rules

1 Introduction

Today's IT world is changing very fast. IT organizations must look for solutions, which allow to build competitive advantage. Many companies decide to change the approach of delivering from classic, waterfall to agile. This transition is called "Agile Transformation" (AT) [1].

AT is very complex process therefore it was divided into four perspectives [1]: project perspective, processes perspective, organizational culture perspective and technology perspective. Perspectives are the areas of functioning of organization [2]. Between them are some dependencies, but in view of complexity, authors decided to consider each of them separately. This article focused only on perspective of processes, which scope includes changes in project management techniques.

Beside perspectives, during agile transformation process, there is another key element called trigger. This is the factor that lead to the decision to abandon current, classic way of delivering and to replace it by agile methodologies [1]. During previous

DOI: 10.1007/978-3-319-54430-4_75

research, based on observations authors identified four, main groups of triggers: effectiveness triggers, forcing triggers, project triggers and motivational triggers [1]. Decision to start agile transformation is often taken without any analyse in example when the decision is taken by company management. This causes that many of agile transformations fails and IT organization must return to the previous way of delivering [3]. In consequence more projects than before AT finishes with violation of project management triangle. In addition, returning to previous methods is expensive. These are the reasons why it is so important to evaluate readiness of organization to agile transformation before process of changes starts.

This article, which is the continuation of research conducted last years by authors, presents the model of evaluation of readiness to agile transformation of IT organizations, based on case-based reasoning method. This paper is divided into four chapters. The first one is the introduction to the topic. Second contains obtained results during quantitative research and the method of data reduction. In chapter three authors have described model based on case-based reasoning method and verification of the model. The last chapter is the summary of research.

2 Associative Data Analysis

During the studies on agile transformation authors decided to conduct quantitative research. As a result, data about IT organizations has been gained. In further steps, because of the number of data, authors decided to use associative data analysis to find dependencies among data. In next subsection, there are described obtained results.

2.1 Qualitative Research and Results

Qualitative research included in its scope preparation of questionnaire and handing it over to team leaders, managers, directors and board members of IT organizations. The survey was divide into three main sections [1]:

- **Organization** – questions about characteristics of organization i.e. size or number of development teams.
- **Processes** – the aim of this section was to verify the level of processes in organization. Authors have decided to use definition of processes from Capability Maturity Model Integration (CMMI) standard [4]. For each of processes definition four-point scale has been used:
  Process is not defined
  Process is defined but not implemented
  Process is defined and partially implemented
  Process is defined and fully implemented
- **Agile transformation** – questions about processes of transformation, key factors, problem and used solutions to resolve occurred problems.

As a result of research authors have obtained data from twelve IT organizations. Among these companies, nine were after agile transformation process. The scope of

data was very wide, therefore the decision to reduce data has been taken. Process and method of reduction is described in next subsection.

2.2 Association Analysis and Data Reduction

Associative analysis is the method of extraction of item sets for discovery of association rules [9]. First of all, it is necessary to build associative rules. The single rule has following form (2.1) [7]:

$$X \rightarrow Y \tag{2.1}$$

which means **IF** X **THEN** Y. This method assumed that are two sets of data: set of observations (2.2) and set of elements which occurred in observations (2.3).

$$\mathrm{O} = \{\mathrm{O}_1,\mathrm{O}_2 \ldots \mathrm{O}_n\} \tag{2.2}$$

O_n - single observation

$$\mathrm{E} = \{\mathrm{E}_1,\mathrm{E}_2 \ldots \mathrm{E}_n\} \tag{2.3}$$

E_n - single element

Each of single observations can contain any combination of elements from set E. This is single subset (2.4) [5].

$$\sigma(X) = |\{O_n | X \subseteq O_n, O_n \in O\}| \tag{2.4}$$

Important parameters which characterizes the power of association between X and Y are support (2.5) and confidence (2.6). Support specifies how often associative rule is applicable in set O. Confidence specifies how frequently Y occurs in transactions from set E, which contains X [8].

$$s(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{N} \tag{2.5}$$

$$c(X \rightarrow Y) = \frac{\sigma(X \cup Y)}{\sigma(X)} \tag{2.6}$$

Based on support and confidence it is possible to limit the set of elements. Low value of support and confidence may indicate that there is no association between elements.

During the analysis of association, it is necessary to determine lowest acceptable value of support (mins) and confidence (minc). In this article authors assumed that set O contains 12 elements (2.7). Every single element of set is the observation from quantitative research. Set E contains 22 elements (2.8). Every single element it is the process described in CMMI standard).

$$O = \{O_1, O_2, O_3, O_4, O_5, O_6, O_7, O_8, O_9, O_{10}, O_{11}, O_{12}\} \tag{2.7}$$

where:

O_1 = answers of respondent 1
…
O_{12} = answers of respondent 12

$$E = \{E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_9, E_{10}, E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}, E_{17}, E_{18}, E_{19}, E_{20}, E_{21}, E_{22}\} \tag{2.8}$$

E = {Project Monitoring and Control (PMC), Requirements Development (RD), Project Planning (PP), Configuration Management (CM), Process and Product Quality Assurance (PPQA), Supplier Agreement Management (SAM), Measurement and Analysis (MA), Organizational Process Definition (OPD), Organizational Process Focus (OPF), Organizational Training (OT), Integrated Project Management (IPM), Risk Management (RSKM), Product Integration (PI), Requirements Management (REQM), Technical Solution (TS), Validation (VAL), Verification (VER), Decision Analyst and Resolution (DAR), Organizational Process Performance (OPP), Quantitative Project Management (QPM), Causal Analysis and Resolution (CAR), Organizational Process Performance (OPP)}.

Authors wanted to check if there is any association between level of each process and success of agile transformation. Based on this, 22 association rules (2.9) have been built.

$$X \rightarrow Y \tag{2.9}$$

where:

X = $\{E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_9, E_{10}, E_{11}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}, E_{17}, E_{18}, E_{19}, E_{20}, E_{21}, E_{22}\}$
Y = success of agile transformation

The rule can be understood as: **IF** process E_n is implemented in organization **THEN** agile transformation is success. For example, for process E_1, there is following rule: **IF** Project Monitoring and Control process is implemented **THEN** agile transformation is success.

Table 1 is the matrix of answers of respondents. Value 0 for process (E_n) means that answer to the question about this process was: "Process is not defined" or "Process is defined but not implemented". Value 1 for process means that answer to question about this process was: "Process is defined and partially implemented" or "Process is defined and fully implemented". Value 0 for Y means that organization is before agile transformation or transformation failed. Value 1 for Y means that organization is after agile transformation and has implemented agile partially (some principles were not implemented) or fully (methodology implemented in accordance with all principles).

Table 1. The matrix of answers of respondents

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	Y
O_1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
O_2	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
O_3	1	1	1	1	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
O_4	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1
O_5	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
O_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
O_7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
O_8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
O_9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O_{10}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
O_{11}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
O_{12}	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1

For each process (E_n) and observation (O_n) authors have calculated the value of support and confidence. Table 2 presents obtained results. As minimum value of mins assumed 0,15 and for minc 0,60.

Based on results from Table 2 it was possible to limit the set of processes. Only 5 from 22 elements comply with conditions mins = 0,15 and minc = 0,60. New set E (2.10) contains five processes.

$$E = \{E_1, E_2, E_3, E_4, E_{10}\} \tag{2.10}$$

Associative rules allowed to limit the set of processes which are significant during evaluating a readiness of organization to agile transformation. Next step of research was to create generic case, build database of cases (with limited set of elements) and use case-based reasoning (CBR) to predict the result of agile transformation and problems which probably occur during AT. Next chapter of this article contains the description of CBR method and built database.

Table 2. Values of support and confidence for elements

E_n	$\sigma(X)$	$\sigma(X \cup Y)$	$s(X \to Y)$	$c(X \to Y)$	E_n	$\sigma(X)$	$\sigma(X \cup Y)$	$s(X \to Y)$	$c(X \to Y)$
E_1	3	2	0,1667	0,6667	E_{12}	2	0	0,0000	0,0000
E_2	3	2	0,1667	0,6667	E_{13}	0	0	0,0000	N/A
E_3	4	3	0,2500	0,7500	E_{14}	2	1	0,0833	0,5000
E_4	3	2	0,1667	0,6667	E_{15}	1	1	0,0833	1,0000
E_5	1	0	0,0000	0,0000	E_{16}	1	1	0,0833	1,0000
E_6	0	0	0,0000	N/A	Ei_{17}	1	1	0,0833	1,0000
E_7	3	1	0,0833	0,3333	Ei_{18}	0	0	0,0000	N/A
E_8	1	0	0,0000	0,0000	Ei_{19}	0	0	0,0000	N/A
E_9	0	0	0,0000	N/A	Ei_{20}	0	0	0,0000	N/A
E_{10}	6	4	0,3333	0,6667	Ei_{21}	0	0	0,0000	N/A
E_{11}	0	0	0,0000	N/A	Ei_{22}	0	0	0,0000	N/A

3 Evaluation Based on Case-Based Reasoning

Case – based reasoning (CBR) is a method for finding similarity and solutions for problems based on cases from past. The biggest advantage of this method is that is based on knowledge and experiences from past, not on theory. CBR cycle consist of four stages: retrieve, reuse, revise and retain [6]. Authors decided to use Case – Base Reasoning to find similarity between IT organizations deciding to change the way of delivering. Construction of database and generic case are described in next subsection.

3.1 Generic Case and Database of Cases

At first stage of preparation of database authors decided to prepare generic case (Table 3) Prepared base contains 10 records (cases), each described by 28 variables. Table 3 presents variables, types and possible values. Figure 2 is the screenshot, which presents ready-made base of cases (Figure 1).

Each case is described by 28 variables grouped into 5 main categories:

- Organizational characteristics – variables such as size, number of team member etc.
- Processes – boolean variables which describes if each process is implemented in organization.
- Triggers – boolean variables which describes if each triggers occurs in organization.
- Agile transformation – previous methodology, chosen methodology and status of agile transformation.
- Problems – boolean variables which describes if some problems occur during agile transformation.

Model of evaluating consist of three layers: input, processing layer and output. In the input there are 19 variables (every variable from Table 3 excluding Agile Transformation Status and Problems). Processing layer compares inputted organization with cases in database. Output is percentage similarity of inputted organization with cases in the base. Figure 3 is a graphical presentation of the model.

To verify whether variables have been properly chosen authors decided to make two tests. Results of verification are described in next subsection.

3.2 Verification

Authors randomly chosen two cases to verify if cased-based model works properly. First organization is company after agile transformation, second where agile transformation is in progress. Variables for both companies inputted into model are presented in Figs. 3 and 4.

Table 4 presents results of comparison of evaluated organizations and cases from base. Hit indicates how assessed organization is similar to organizations stored in data base.

Table 3. Generic case characteristics

Variable	Type	Possible values
Organization Size (V1)	String	Micro, Small, Medium, Big
Geographical dispersion of team members (V2)	String	No, Yes but less than 6 h, Yes and more than 6 h
International Environment (V3)	Bool	True, False
Number of developers teams (V4)	String	1 team, 2–5 teams, >5 teams
Type of client (V5)	String	External, Internal
Organization Type (V6)	String	Product – Oriented, Service – Oriented
[Process] Project Monitoring and Control (P1)	Bool	True, False
[Process] Requirements Development (P2)	Bool	True, False
[Process] Project Planning (P3)	Bool	True, False
[Process] Configuration Management (P4)	Bool	True, False
[Process] Organizational Training (P5)	Bool	True, False
[Trigger] Need to reorganize organization (T1)	Bool	True, False
[Trigger] Violation of project management triangle (T2)	Bool	True, False
[Trigger] Improve efficiency of delivering (T3)	Bool	True, False
[Trigger] Decision-Makers decision (T4)	Bool	True, False
[Trigger] Employees initiative (T5)	Bool	True, False
[Trigger] Changing philosophy of organization (need to be Agile) (T6)	Bool	True, False
Used Methodology (V7)	String	None, RUP, MSF, PRINCE2, other options
Chosen Methodology (V8)	String	SCRUM, Agile, XP, other options
Agile Transformation status (V9)	String	No (failed), Yes but partially, Yes, fully)
[Problem] Reluctance of employees (PR1)	Bool	True, False
[Problem] Low level of knowledge about chosen methodology (PR2)	Bool	True, False
[Problem] Low management commitment (PR3)	Bool	True, False
[Problem] Lack of description of transformation processes (PR4)	Bool	True, False
[Problem] Problem with availability of team members (PR5)	Bool	True, False
[Problem] Lack of tools (PR6)	Bool	True, False
[Problem] Lack of common vision (PR7)	Bool	True, False
[Problem] Change the way of thinking of employees (working in short iterations) (PR8)	Bool	True, False

Fig. 1. Screenshot of cases database

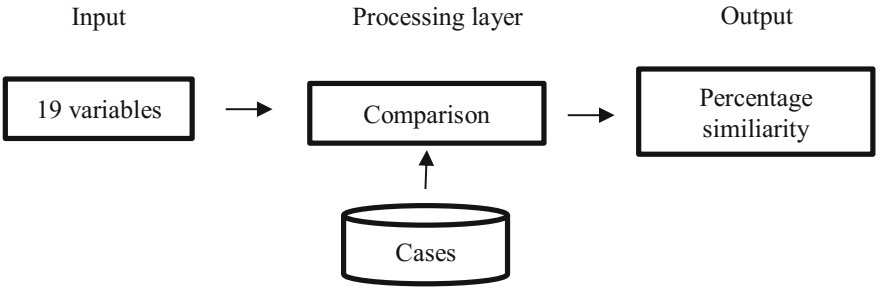

Fig. 2. Scheme of the model

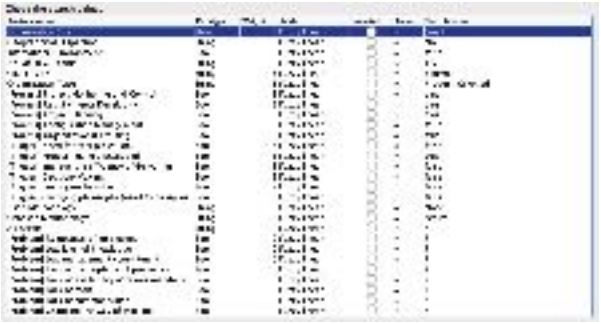

Fig. 3. Variables and values for case 1 - organization after AT

For Case 1 three cases have been taken to further analysis, because percentage match was the same for three cases from database. For Case 2 two because percentage match was the same for two cases from database (Table 5).

As shown in Table 6 algorithm predicted that agile transformation will succeed partially and it is probable that three problems occur. In reality organization has implemented partially Scrum and two problems of predicted occurred. Percentage level of matching of predicted and real result is 88%. This value may indicate that model is working properly and accuracy of prediction is high.

As shown in Table 6 there is probability that organization should successfully finish agile transformation but it is also probable that four problems occurs. Organization should implement corrective actions to decrease likelihood of problems. In further steps it is planned to compare real result of AT in this organization with prediction.

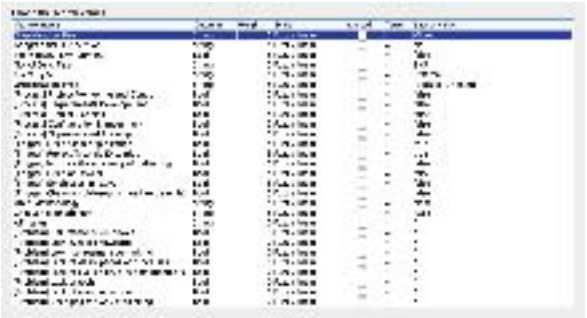

Fig. 4. Variables and values for case 2 - organization after AT

Table 4. Results of comparison for cases

Case 1		Case 2	
Case number	Hit [%]	Case number	Hit [%]
1	48,7011	1	54,1169
2	48,7011	2	54,1169
3	48,7011	3	48,7011
4	39,3023	4	48,7011
5	39,3023	5	43,8049
6	35,1114	6	43,8049
7	31,1753	7	43,8049
8	31,1753	8	35,1114
9	31,1753	9	31,1753

Table 5. Results for case 1

Variable	Evaluating organization	Case 1	Case 2	Case 3	Average	Degree of matching [1, 0]
V9	**Yes, partially**	Yes, partially	Yes, partially	Yes, partially	**Yes, partially**	**1**
P1	**True**	True	True	True	**True**	**1**
P2	**True**	True	True	False	**True**	**1**
P3	**False**	True	True	True	**True**	**0**
P4	**False**	False	False	True	**False**	**1**
P5	**False**	False	False	False	**False**	**1**
P6	**False**	False	False	False	**False**	**1**
P7	**False**	True	False	False	**False**	**1**
P8	**False**	False	False	False	**False**	**1**
						88%

Table 6. Results for case 2

Variable	Case 1	Case 2	Average
V9	Yes, fully	Yes, partially	**Yes**
P1	True	True	**True**
P2	True	False	**True**
P3	False	True	**True**
P4	False	True	**True**
P5	False	False	**False**
P6	False	False	**False**
P7	False	False	**False**
P8	False	False	**False**

4 Summary

This paper presents the case-based model to evaluate the readiness of IT organization to agile transformation. Article summarizes quantitative research made by authors and reduction of data by using associative rules. Based on selected variables, generic case has been built. This allowed to create database, which contains ten cases. Built model has been verified by two test cases – the first one was the organization which finished agile transformation with success, and the second one was organization in which AT is currently in progress. For first test case, model predicted success and three potential problems. Comparing to real result of transformation in this organization it is accuracy of prediction on level 88,89%. For second case the model predicted success and four potential problems. In further steps, when organization will finish transformation processes, authors want to compare predicted result with obtained in reality. This article is part of research on agile transformation. In next stages authors want to verify model in another organizations and add new cases into database. Furthermore, next version of model will not only return potential agile transformation status and problems but also proposition of its solutions based on experience from other organizations.

References

1. Orłowski, C., Deręgowski, T., Kurzawski, M., Ziółkowski, A., Chrabski, B.: Trigger-based model to assess the readiness of IT organizations to agile transformation. In: Hnatkowska, B., Warszawa, M.S. (eds.) Software Engineering: Improving Practice Through Research, pp. 207–221. Polish Information Processing Society (2016)
2. Orłowski, C., Deręgowski, T., Kurzawski, M., Ziółkowski, A., Chrabski, B.: Building project and project team characteristics for creating hybrid management processes. In: Hnatkowska, B., Warszawa, M.S. (eds.) Software Engineering: Improving Practice Through Research, pp. 241–255. Polish Information Processing Society (2016)
3. Orłowski, C., Deręgowski, T., Kurzawski, M., Ziółkowski, A., Chrabski, B.: The reference model of tools adaptation in the perspective of technological agile transformation in IT organizations. In: Hnatkowska, B., Warszawa, M.S. (eds.) Software Engineering: Improving Practice Through Research, pp. 223–240. Polish Information Processing Society (2016)

4. CMMI Product Team, CMMI for Acquisition, Version 1.3. Carnegie Mellon University (2013)
5. Osowski, S.: Metody i narzędzia eksploracji danych. Wydawnictwo BTC, Legionowo (2013)
6. Aamodt, A., Plaza, E.: Case-based reasoning: foundational issues, methodological variations and system approaches. AI Commun. **7**, 39–59 (1994)
7. Agrawal, R., Srikant, R.: Fast Algorithms for Mining Association Rules. IBM Almaden Research Center
8. Tan, P.-N., Steinbach, M., Kumar, V.: Introduction to Data Mining. University of Minnesota (2010)
9. Leskovec, J., Rajaraman, A., Ullman, J.D.: Mining of Massive Datasets. Cambridge University Press, Cambridge (2010)