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BUSINESS PROCESS ANALYSIS METAMODEL IN IT PROJECTS

PHD THESIS

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ABSTRACT

The PhD thesis addresses the issue of business analysis in IT projects based on business processes and introduces a new solution in the form of a *Business Process Analysis Metamodel (BPAM 1.0).* The PhD thesis contains a formal definition of the method and its verification for use in an IT project. The method is consistent with the standard for describing metamodels, i.e. *Model Driven Architecture* provided by Object Management Group. The solution is characterized by genericity and flexibility, i.e. it can be used to build solutions for the needs of any IT project, and for models created on the basis of the model, those elements which are necessary to achieve the intended goal are selected. The proposed method of conducting analysis on the basis of BPAM 1.0 metamodel was successfully presented at conferences and is used in IT projects.

The doctoral dissertation consists of six chapters. In addition to the chapters, there is an introduction and a summary. This PhD thesis contains theoretical basis and practical research.

Introduction

In the introduction to this PhD thesis, the subject matter of the thesis was justified and the main objective was defined, namely: a *formal definition of the Business Process Analysis Metamodel (BPAM 1.0), which will be the language of business process analysis in IT projects filling the gap in communication between the business layer and IT operations.* Apart from the main objective, a number of specific objectives belonging to the groups were identified such as: theoretical and cognitive objectives, methodological objectives and practical objectives. The main idea was also formulated, which was as follows: *there is a need to develop a formal language for the analysis of business processes in IT projects, characterized by complementarity in terms of specific analytical layers and allowing to fill the communication gap between the business layer and the IT activity.* Moreover, the following auxiliary ideas were adopted:

1. The business process analysis metamodel provides a set of flexible elements with their definition and links to describe reality from a specific perspective.
2. The introduction of a set of flexible elements allows to create models more efficiently.
3. The business process analysis metamodel provides a common understanding of the concepts by the stakeholders involved in the IT project.
4. The business process analysis metamodel is generic, i.e. it can be used to build solutions for any IT project.

5. The business process analysis model based on the metamodel provides a visual and friendly interface for communication in an IT project, which translates into increased efficiency.
6. The application of models compliant with the business process analysis metamodel allows the identification of gaps and bottlenecks in the company's operations.
7. The business process analysis method in IT projects is in line with the EDUF (*Enough Design Up Form)* principle, i.e. it allows to create a solid foundation for all further work.

The introduction also presents the methods and techniques used in the dissertation, which were used to prove certain theses. In this part the author also described the reserach procedure used (Fig. 1.).

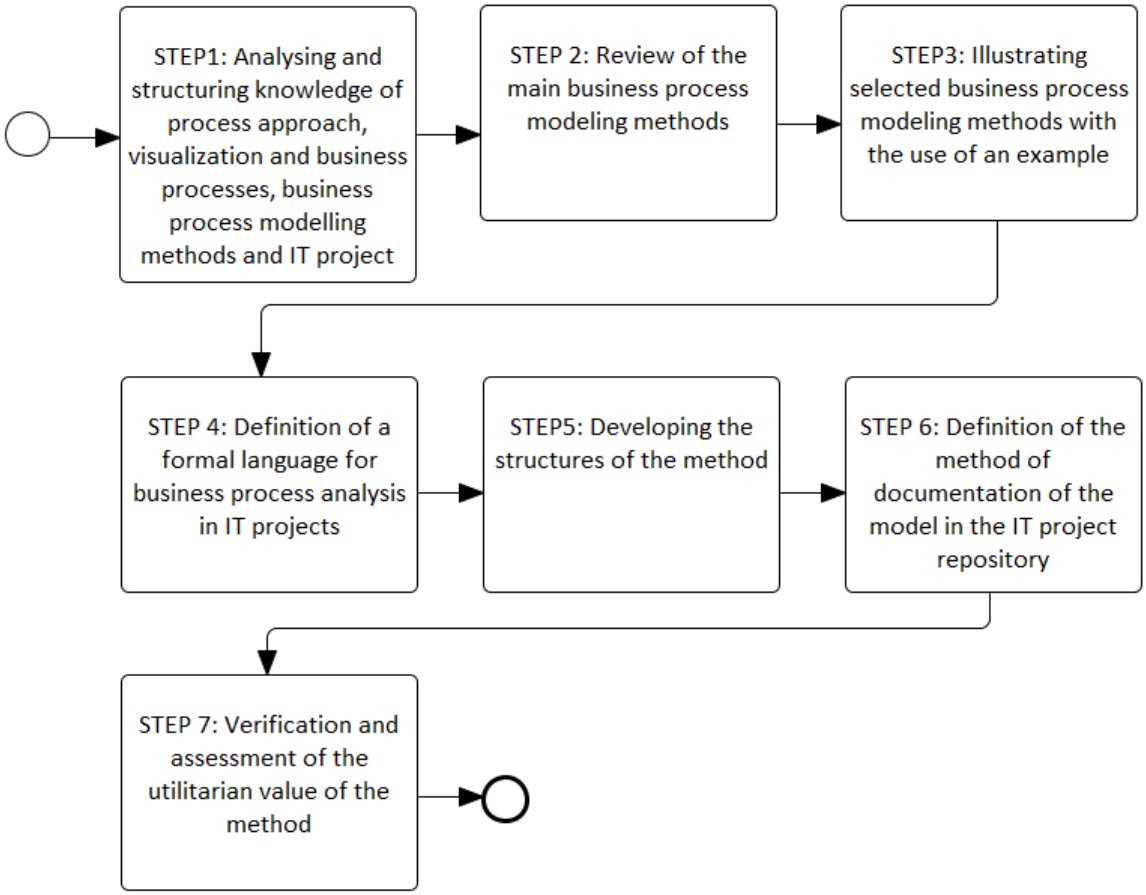

Figure 1: Research procedure
Source: Own study

The introduction is followed by a specific part of the work consisting of six chapters.

1 Chapter.

The first chapter contains the theoretical basis for business processes, in particular the process approach in an organisation with a high level of reliability. It describes ways of process identification, reviews the criteria for process classification, presents the essence of analysis and modelling of processes and implementation of IT projects.

In this chapter, the author indicates the definition of the IT process and project, which will be used for further consideration. According to the adopted definitions, a process is a *sequence of activities changing input resources into output* and an IT project is an *undertaking aimed at improving the organisation and its processes by creating and implementing an IT system in accordance with the documentation required for a given project*.

The author points out that regardless of whether an IT project is implemented in a classic or agile approach, the *analysis phase* is crucial. It is in this phase that processes are identified, analyzed and evaluated, which will be improved through the use of the IT solution. It is here that the customer's requirements for the future process and system are collected. It is from this phase that the direction of process improvement and, consequently, of the entire organisation is derived. The analysis in IT projects is carried out in two stages, i.e. as a *business analysis* (performed by a business analyst) and a *system analysis* (performed by a system analyst).

Business analysis provides business models, i.e. models that describe people, places, things, environment and rights related to a certain area, where the occurrences of these models are things existing in nature (and not their representation in the information system). Such guidelines for business analysis are provided by MDA (*Model Driven Architecture*).

Looking at the Object Management Group guidelines, the basis for business analysis is *the Business Motivation Model* and *the Business Process Model*[Object Management Group 2015].

The business motivation model allows to present a project concept in many dimensions in order to know why a given project is undertaken, i.e. what is the goal, what the organisation has the means to achieve it, i.e. what is the strategy, mission, what are the business rules and policies, and what the organisation will gain from introducing given solutions. It is also a determination of business processes that will implement a given strategy, SWOT analysis and determination of internal and external impact factors. The business motivation model should be used mainly in the requirements collection phase. It should be verified whether a given requirement affects the achievement of the project objective or not. This allows to avoid a situation in which the project will constitute a set of requirements that do not meet the objectives of the organisation.

The business process model represents a sequence of activities within an organisation that aim to do some work, transforming input into output providing value to the client [Hammer, Champs 1993, p.38;Object Management Group 2017, p.145]. It contains information about the contractors of particular activities as well as documents and resources necessary for the process. It consists of a set of objects and relationships between them[1] and provides a simplified reality picture of how an organisation transforms its inputs into the values offered to clients and shareholders [Czekaja 2009, p.26, 58]. The business process model allows you to understand: how a company works and how making a change can improve the achievement of its goals. The creation of business process models in IT projects allows for two key benefits:

1. transfer of an IT project from an IT to a business level - redefining the organization's goals by imposing changes on them that will be achieved after the IT system implementation,
2. defining the context for system requirements - allows for managing business requirements for the system and tracking the impact of changes at the business level on expectations for the IT product[2].

The second important element of business analysis is *to define business rules and a dictionary of business terms*. Business rules are part of the business process. They are the internal regulations of a given organisation, which it must follow in its activities [Hnatkowska, Walkowiak 2009]. Business rules are grouped into policies, which constitute a field of activity[3]. The dictionary of business terms contains a set of terms with their definition. It is essential in the process of communication and common understanding of the scope of the project.

Another element is the *collection of business requirements*. These are the business objectives of the organisation, which are to be achieved with the software being created. The requirements collection is usually carried out through a series of business workshops and business analysts, where one goes through successive system functionalities inscribed in the analysed business process [Wojtachnik 2017, p.360]. The requirements are written down in the form of a Business Requirements Specification document [Li, Guzman, Tsiamoura, Schneider, Bruegge, 2015, p. 582-591].

The business case is made more detailed by system analysis. It consists in developing requirements for the future IT system. It is a search for an answer to the question of what the *system should do to meet the demands and expectations of the user defined* in the business analysis

[1]The methodology provides a set of principles and techniques for process design and evaluation.
[2]Without context, it is difficult to manage requirements, the number of which for complex IT solutions is counted in hundreds.
[3]Security policies, cost management policies, individual customer service policies, etc.

and resulting from the shape of the future business process. The requirements are written in the form of the System Requirements Specification document [Wojtachnik 2017, p.359-367].

From the above it can be concluded that the development of *business process models* is crucial for the software manufacturing process and, consequently, for the implementation of the IT project.

2 Chapter.

The second chapter focuses on the visualization of business processes and communication in IT projects. With regard to business processes in IT projects, visualization has been defined as a *graphic representation of business process models created with the use of modelling tools that are part of the IT project*. Communication in an IT project is presented as a *process in which there is a mutual exchange of thoughts, information and knowledge between members of the project team using various means*. This chapter points to a significant role in *business-IT* communication, as the visual description of the business process makes it a real object of consideration and makes it a conceptual starting point for talks about a future IT project between business and IT.

3 Chapter.

In this chapter, an attempt is made to examine popular methods of business process modelling. In the first part of the study, the classification and characterization of individual methods from 1962 and Petri network until 2013 and BPMN notation was made. They can be generally attributed to high-level visual notations with intuitive meaning, mainly addressed to the business management environment and low-volume basic notations with detailed and formal semantics, mainly addressed to the IT community. The characteristics of individual notations allowed us to conclude that the use of less detailed notations (example FC, FFBD) is beneficial for organisations that model their processes in order to study their effectiveness. In a situation when a company wants to introduce an IT solution in a given process, it is recommended to use more detailed methods allowing to transfer the project directly to the software (example BPMN, whose scheme allows for transcription into BPEL).

In order to find out about the superiority of one method over another, an attempt was made to stamp a business case in each of the methods using appropriate tools (second part of the study). The problems encountered were primarily limited access to documentation containing concise information about a given method. Many methods do not have a formal description of their application (no official standards) and some of them have such accurate descriptions that it is impossible to assimilate them. Notation specific to each model has also been a problem. Each

standard has unique symbols, markings or artifacts, so creating individual models was very time-consuming.

The created models were evaluated from the perspective of the business process creator (business analyst) and the perspective of the business process model (business and IT) user. The method that collected the highest marks and was recommended when implementing IT solutions is BPMN.

The analysis of business process modelling methods used in the design of IT solutions indicates that these methods focus mainly on the perspective of the flow of activities in the process. The methods do not take into account perspectives that result from the process analysis, i.e. from the specification of business requirements. They do not illustrate the connections between the models from the business world and the IT world, which present the overall scope of the implemented IT project. They are understandable for one of the groups, i.e. either for business or IT.

In response to the above, the author decided to create a *Business Process Analysis Metamodel (BPAM 1.0*), which will be the language of business process analysis in IT projects filling the gap in communication between the business layer and IT operations and will allow for the visualisation of the scope of the implemented IT project.

4 Chapter.

The fourth chapter presents the current state of knowledge concerning metamodels and indicates premises for building *a Business Process Analysis Metamodel (BPAM 1.0)* in IT projects. In this chapter an integrated model of business process analysis in IT projects was developed and evaluated. The conclusions from the conducted study authorised the author to adopt the following assumptions, which were used in the construction of the metamodel:

1. The method is based on the 3 *Process Flow Layer (*PFL*)*, the *Requirements Specification Layer* (RSL) and the *Data Layer (*DL). The basis is the Process Flow Layer.
2. In the process flow layer, the business process description method is used in accordance with the BPMN notation.
3. At the requirements specification and data layer, UML and SysML notation is used.
4. The model is simple, complete, general, unambiguous, expandable.
5. The method is generic, i.e. it can be used to build models necessary for business process analysis for any IT project. In order to implement it effectively, it should be adapted to the specificity of a given IT project.
6. The method is based on level 2 of process description, i.e. the analytical level. It means that on the business process diagram, activities will have specific types, e.g. an activity

performed manually without the support of the IT system, an activity performed entirely by the IT system. The lack of this level makes it difficult to estimate the cost of changes in the IT project.

7. The method is consistent with the OMG (*Object Management Group)* metamodel descriptor standard, i.e. *Model Driven Architecture level M2 Layer Metamodel*.
8. The model contains elements representing the structure and behaviour of processes.
9. The method allows to visualize the scope of the implemented IT project.

The culmination of chapter four was the development of a formal definition of *the Business Process Analysis Metamodel (BPAM 1.0). According to the* definition, the Business Process Analysis Metamodel is a set of concepts, definitions and links between them, which are used to analyse business processes in IT projects. The context diagram is shown in the figure below (Fig. 2.).

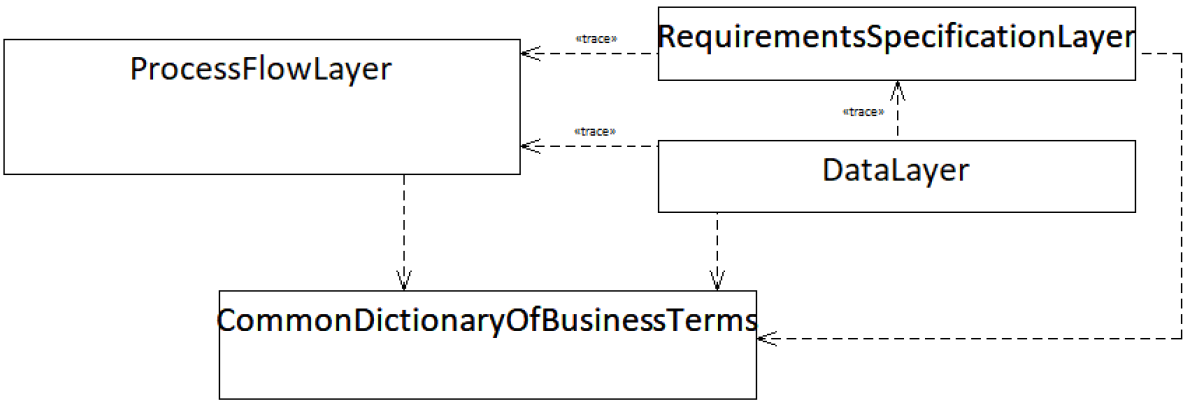

Figure 2: Context diagram for visualisation of BPAM 1.0 metamodel
Source: Own study

The context diagram shows that the requirements specification layer and the data layer are only created when the process flow layer (*trace* dependency) is created, and the data layer is also dependent on the requirements specification layer. In addition, the diagram shows that a common dictionary of business terms is created from all layers.

Having a context diagram, the author described in detail each of the individual layers. Each layer contains appropriate diagrams:

1. process flow layer:

– business process diagram,

2. requirements specification layer:

– business requirements diagram,

– use case diagram,

– supporting elements,

3. data layer:

– class diagram.

The diagrams and elements used to build them are linked by means of relationships. In addition to these layers, the method includes additional elements, i.e. the characteristics of the project, the definition of the business case to which it relates, the business purpose and the performance measures. The method has its visual form, which is used for business process analysis in IT projects.

5 Chapter.

In chapter five, using the case study method, the BPAM 1.0 method was implemented in the IT project. The aim was to extend and generalise the theory of business process analysis in IT projects using the BPAM 1.0 method.

The study made use of a common case, which made it possible to show the analysis phase in its natural context, i.e. as part of an IT project. As part of the case study, the theory concerning the analysis of business processes in IT projects using the BPAM 1.0 method was confronted and its properties were presented.

The case study has allowed to answer the research questions raised:

1. What are the properties of the model created using the BPAM 1.0 method?
2. What is the work in the IT project repository? ,
3. Why are traditional models not enough for software production?

The BPAM 1.0 model-making method and the model itself have many advantages over traditional methods (Table 1.).

Table 1. Traditional method and BPAM 1.0 based method

Name of the property	**Traditional method**	**BPAM 1.0 method**
Starting point	The starting point is not specified - it may be a process, it may be a business need.	The starting point is the business needs defined for the IT project.
Set of elements	There is no formally defined set of elements produced in the business process analysis phase. There is a list of desirable elements in the literature, but no guidelines for their application.	Formally defined set of elements necessary for business process analysis including obligatory and optional elements. The elements have their definition.
Linking to other models created in the business process analysis phase of the software production process	No formal link.	The formal link shown by the <<trace>> tracking relationship.
Notation for the business process	Depending on the notation adopted, the level of understanding differs, if the notation PN,RAD,EP	It is based on the most commonly used and understandable notation, i.e. BPMN.

	is used in process modelling, there are problems in understanding it. No problems for the BPMN notation.	
Notation for other elements of business process analysis	Freedom of choice. Most often UML.	It is based on UML and SysML.
Categorisation of processes	Freedom of application.	Processes are categorised.
Process measurement	Freedom to determine the measures.	Definition of the measures is a precursor to business process analysis.
Objective of the IT project	It should be defined.	It must be defined
The principle of EDUF (*Enough Design Up Form*)	Depending on the adopted level of detail of business process analysis in a given IT project.	It is respected regardless of the IT project.
Working in a repository	No guidelines.	Defined.

Source: Own study

The analysis made allowed it to move on to the next stage, in which the author has made an assessment of the metamodel. The assessment is an expert evaluation carried out by the author of the thesis and referred to the evaluation of utility and benefits.

6 Chapter.

The utility assessment was based on such criteria as: efficiency, effectiveness, satisfaction. In terms of each of the criteria, the method based on the BPAM 1.0 model indicated benefits in relation to traditional methods.

The evaluation of the benefits identified advantages and disadvantages in relation to traditional methods. The method based on the method has more advantages compared to the traditional method. Its main advantage is flexibility, formalization and looking at the project from different perspectives (layers). Its main disadvantage is the need to have skills in modelling and using IT tools.

Conclusion

This thesis proposes a new *language for describing business analysis in IT projects expressed* with *BPAM 1.0 (Business Process Analysis Metamodel)*. In the introduction to the thesis the main objective was indicated. This objective has been fully achieved and its results, i.e. the concept together with the formal description of the BPAM 1.0 metamodel, can be found in chapter 4.5 of this thesis. The thesis was also connected with achieving a number of specific objectives. Theoretical and cognitive objectives together with the chapter number in which the goal was achieved are indicated below (Table 2.).

Table 2. Achieving specific objectives - theoretical and cognitive objectives

No.	Objective	Chapter number in the thesis
1.	analysis and identification of business process modelling methods used worldwide	**Chapter 3. 3.2.**
2.	Exemplification of selected methods of business process modeling, which constitute a multidimensional form of business process definition	**Chapter 3. 3.3.**
3.	comparative analysis of selected types of models and diagrams	**Chapter 3. 3.3.**
4.	identification of limitations resulting from the application of a given business process model	**Chapter 3. 3.3.**
5.	selection of elements for the creation of the method	**Chapter 4. 4.5.**
6.	the establishment of definitions, the links between the different elements and the indication of their mandatory character and their optionality	**Chapter 4. 4.5.**
7.	identification of rationale for using the metamodel in business process analysis	**Chapter 4. 4.2.**

Source: Own study

In addition to theoretical and cognitive goals, methodological goals have been implemented. The list of objectives with the indication of the chapter in which the goal was achieved is presented in the table below (Table 3).

Table 3. Achieving specific objectives - methodological objectives

No.	Objective	Chapter number in the thesis
1.	determination of assumptions determining the selection of the components of the method	**Chapter 4. 4.5.**
2.	definition of the components of the method	**Chapter 4. 4.5.**
3.	creation of a method of business process analysis in IT projects	**Chapter 4. 4.5.**
4.	formulation of a standard for the creation of models based on the metamodel for business process analysis	**Chapter 4. 4.5.**

Source: Own study

In addition to the theoretical-cognitive and methodological objectives, practical objectives have been achieved (Table 4).

Table 4. Achieving specific objectives - practical objectives

No.	Objective	Chapter number in the thesis
1.	implementation of the methodological model in an IT project	**Chapter 5. 5.3.**
2.	validation of the methodological model for specific areas of economic knowledge	**Chapter 5. 5.4.**
3.	evaluation of utilitarian value	**Chapter 6. 6.1. 6.2.**

Source: Own study

In order to prove the truthfulness of the main and auxiliary ideas, the research procedure for the thesis, as described in the introduction, was carried out. For individual steps of the procedure ((Fig. 1.), the chapters in which the given step was implemented were assigned (Table 5.).

Table 5. Thesis reserach procedure - step 1

No	**Step in the reserach procedure**	**Chapter number in the thesis**
1.	Using the method of analysis and criticism of literature, the current state of knowledge in the field of process approach, business process visualisation, business process modeling methods and IT projects was presented and structured. It was established that achieving a high level of reliability in operation is possible thanks to the improvement of processes mainly through the use of IT solutions, implemented within IT projects.	**Chapter 1.** **1.1.** - the state of the art on process approach is presented **1.2.** - the characteristics of the main element of the process approach, i.e. identification and classification of processes, are presented **- the classification method chosen for the method is APQC classification** **1.3.** - the essence of the **analysis and evaluation of** business **processes** is presented and indicated **as a starting point for** actions aimed at **improving the organisation** **1.4.** - the essence of **improving the organisation by improving its processes** is presented **1.5.** - describes **the importance of IT projects in improving the organisation** and the essence of **business process analysis** in software development**, in particular business process models** **Chapter 2.** **2.1.** - the model is presented as a source of knowledge for the organisation

		2.2. - the way in which business process models are created is presented **2.3.** - the value of the visualisation is shown **2.4.** - the importance of visualization in business and IT communication is presented
2.	In the next step, an overview of the main methods of modelling business processes described in the literature is also presented using the method of analysis and criticism of the literature. It was noted that there are many standards of business process modeling applicable in IT projects, but there is no well-established approach to creating business process models and conducting analyses on their basis, which will allow for the implementation of an IT solution. There is no standard that would connect the world of IT and business and would allow to clearly define the scope of the implemented project that is understandable both for people from IT and business. Conclusions from the analysis of the literature confirmed the validity of undertaking further research on methods of business process analysis in IT projects.	**Chapter 3.** **3.1.** - a demonstration of the classification of modelling methods **3.2.** - the characteristics of the modelling methods have been determined
3.	Then, using the case study, observation and interview methods, selected business process modeling methods were stamped, analyzed and evaluated in order to see the superiority of a given method over another. The evaluation was concluded with the conclusion that the terminology used, the modelling approach, and the level of detail of the models created are not clear. What is created is understandable either for business or for IT. It has become justified in this situation to undertake research work aimed at integrating both these areas, i.e. the world of IT and business.	**Chapter 3.** **3.3.** - a case study for modelling methods is described - selected business process modelling methods were stamped - analysis and evaluation of the selected methods was carried out **3.4.** **- the choice of business process description method for the BPMN method was made**
4.	Therefore, using the design method, case study, interview, observation, a formal language of business process analysis in IT projects has been developed, characterized by complementarity in terms of specific analytical layers, allowing to combine the worlds of IT and business and visualize the scope of the implemented IT project. It was decided that such a language would be *the Business Process Analysis Metamodel (BPAM 1.0).*	

a.	First of all, the current state of the art in the field of metamodels is presented using the method of analysis and criticism of the literature. Using the literature knowledge from steps 1 and 2 and the knowledge from step 5, it was assumed that the metamodel should be based on 3 layers, i.e. process flow layer, requirements specification, data layer.	**Chapter 4.** **4.1.** - the state of the art on metamodels is described **- the definition of a business process analysis metamodel used in the thesis was defined** **4.2.** - the rationale for the construction of the metamodel has been established
b.	Based on the design method, an integrated model of business process analysis in IT projects based on 3 layers was developed.	**Chapter 4.** **4.2.** - an integrated business process analysis model based on 3 layers was built
c.	The model was then verified using the case study and interview method. The conducted research confirmed the truthfulness of the assumed assumption that the business process analysis metamodel in IT projects should be based on 3 layers.	**Chapter 4.** **4.3.** - a case study was presented for an integrated business process analysis model - the integrated business process analysis model was evaluated **- confirmed layers for the metamodel - process flow layer, requirements specification layer, data layer**
d.	In the next step, the elements of the individual layers are defined (descriptive method).	**Chapter 4.** **4.4.** - presented assumptions determining the selection of the components of the BPAM 1.0 method
5.	The above allowed to develop the structure of the metamodel together with the description of relations between individual elements (design and descriptive method) which is a formal language of business process analysis in IT projects.	**Chapter 4.** **4.5.** - a formal definition of the *Business Process Analysis Metamodel (BPAM 1.0*) was developed - the constituent elements of the method are identified and characterised

		- the concept of business analysis conducted with the use of the method is presented - the visual form of the metamodel shown
6.	In addition, a method of documentation of the metamodel in the IT project repository has been proposed.	**Chapter 4.** **4.6.** - rules were developed for documenting the metamodel in the IT project repository
7.	Finally, using the case study method, the utilitarian value of the *Business Process Analysis Metamodel* (*BPAM 1.0)* was tested and evaluated. The assessment was completed with the conclusion that BPAM 1.0 can be used to build solutions for any IT project and its application brings more benefits than traditional methods.	**Chapter 5.** **5.1.** - the research procedure used is described **5.2.** - a selected case study was presented **5.3**. - the implementation of the method of the selected case study was carried out **5.4.** - the analysis of the value of the method was performed **Chapter 6.** **6.1.** - the utility has been assessed **6.2.** - the benefits have been assessed

Source: Own study

The research procedure carried out confirms the main thesis idea and supporting theses ideas. To sum up, it can be said that the business process analysis metamodel in IT BPAM 1.0 projects is a unique scientific contribution of the author to the discipline of management and quality sciences in the field of social sciences. BPAM 1.0 complies with the OMG (*Object Management Group)* standard for describing metamodels. It contains a set of elements for describing and analysing business processes in IT projects placed in appropriate layers, i.e. the process flow layer, the requirements specification layer and the data layer. It can be used in any project, but should be adapted to its specificity.

As part of the work related to the development of the BPAM 1.0 metamodel, the author assumes the creation of a plug-in for IT tools used in modelling, allowing the structure of the

metamodel to be drawn. Thanks to this, the model will be able to be used more widely. In further research works, the author also assumes the extension of the metamodel with further layers and elements resulting from the remaining phases of software development - design, testing and implementation.

1. List of figures

2. List of tables

3. Bibliography

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