Business Process Oriented Autopoietic Knowledge Management Support System Design

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Abstract

One of the approaches connected with the use of knowledge management systems in organisations is process oriented knowledge management. This approach assumes that knowledge management (KM) processes are focused on the aspect of their usage context in the form of tasks performed by business process participants (Business Process Management – BPM). This relatively young approach has evolved over years, resulting in the focus during the development of systems on the participants and environment of a process. One of the trends in the development of process oriented knowledge management is treating such solutions as autopoietic systems. This approach assumes a range of additional characteristics of a technical and social solution being built. Autonomy, clearly defined boundaries of a system, lack of a direct impact on a system from outside, self-organisation and adaptation mechanisms required in such systems indicate the need for a new perspective on the integration of BPM and KM. This paper will present analysis of the theory of process oriented knowledge management and an autopoietic system, as well as proposing a model for building such business process oriented autopoietic knowledge management support systems.

Keywords: autopoietic system, knowledge management, knowledge management support system, business process oriented autopoietic knowledge management support system

1. Introduction

For proper completion of the tasks assigned to them, employees of an organisation often require a specific and codified knowledge that they can use when taking actions. The theory of IT systems used in organisations distinguishes between Business Process Management, which is connected with an organisation’s business processes, and Knowledge Management, which is related to the process of organisational knowledge management. In the literature, these theories are often analysed separately, but some researches indicate the necessity of addressing and analysing these issues jointly. Currently, we can observe departure from the approach assuming inaccessibility of business processes in favour of the social approach, which is related to the participant of a process, both in an organisation and outside it [1]. This facilitates integration of both these approaches. Dynamism of knowledge management processes and business processes, necessity of their integration, required definition of the structure of the links between knowledge resources and an organisation's processes, as well as the fact that such systems are human-oriented - all these factors encourage search for new trends in the development of the design of a process oriented knowledge management support system. Such solutions can be autopoietic systems. They can support the process of automation of tasks in such systems, and aid their integration and assessment. The aim of this paper is to analyse the issues of building business process oriented autopoietic knowledge management support systems and propose a methodology to support their design. The paper consists of three parts. The first part will address the issues of integration of business processes and knowledge management systems. It will present the premises of their use and review literature on both these approaches, showing various aspects of their design and development. In particular, it will indicate papers which have presented the theories that have been applied in the methodology presented further in the paper. The second part will deal with the issues of autopoietic systems connected with the aspect of their design and development. Synthesis of different research approaches will allow to define the elements of the developed methodology with reference to system modelling. The third part of the paper will present the stages of the proposed methodology for the process of designing a business process oriented autopoietic knowledge management support system.

2. Theory of designing a process oriented autopoietic knowledge management support system

The approach presented in the paper is consistent with the concept that knowledge management systems should be considered in relation to their context of use [2],[3],[4]. An organisation's business processes constitute such context. The issue of combining both these approaches is essential, as on the one hand new knowledge is generated as a business process is performed, and on the other hand, the knowledge about the process is of significant value for the organisation. The origins of process oriented knowledge management can be traced to the work by Biney [5]. In terms of business processes, the methodologies and tools designed to support business processes should ensure automation, efficiency and flexibility. In terms of knowledge management, of importance are cooperation, searching and taxonomy [6]. The concept of a process oriented knowledge management support system addressed in the paper is connected with the theory [7] in which business process oriented knowledge management is an element designed to support the integration of the human- and technology-oriented approach to knowledge management systems. Maier and Remus [7] point out that in the development of such systems it is vital to address in the first place a strategy, which should define the framework of a business process and knowledge management process. Further, topics/content should be considered, which means that the solution being designed should extend an organisation's knowledge resources to include knowledge about the processes and knowledge created and used by processes, and in particular their users. They also pay attention to the context of information use. In this stage, an important function of the system is to filter knowledge to prevent its overload. The third element of this approach is instruments and systems, with possible technical solutions being indicated. What is important in terms of designing such systems, the authors indicate the possibility of using tools designed to support business process modelling. Consequently, activities, roles, responsibilities and resource can be included in the operation of such systems. The tasks of systems created in this way include process modelling, simulation, monitoring and controlling. The last element is KM organization and process, which implement various instruments and activities. KM processes provide services across process participants and processes themselves. KM processes are composed separately from business processes and are composed as part of them. Further guidelines on the integration of BPM and KM can be found in the work by Jung, Choi, & Song [8], in which the authors present their system and its architecture. The work features an accurate analysis of the tripartite division of organisational knowledge in systems integrating BPM and KM. It also indicates their use in the life cycle of KM and BPM. It does not, however, address the aspect of designing solutions discussed in this paper or the methodology of their development. When designing such systems, the approach presented in the work [9] by Aguilar-Savén can be used to some extent. In it, the author comprehensively discusses various methods for business process modelling as well as methodologies used during their design, but the work focuses on business process design without reference to KM. What's important from the perspective of KM, it points out the necessity of dividing requirements into technical and social ones. The latter refer to the aspect of communication between a system’s elements. When integrating KM and BPM, it is necessary to define the structure of a business process. Guidelines on that can be found in the work by Sergio & de Cesare [10] where the authors point out that we currently see the third wave of the development of the process oriented approach, where an organisation's processes are focused on users and their environment. They also indicate vital element of a process, which include process, activity, service, role, goal, event, and rule. Further, it is worth mentioning the paper by Sivri & KrallMann [11] which presents a 6-stage life cycle of an implemented system. However, the authors do not address methods for designing such a solution. They indicate, as part of the presented life cycle, the standards concerning only BPM without reference to KM. As pointed out by Soo, Devinney, Midgley, Deering [12] KMSS should consist of a range of sub-systems that ensure access to an organisation's data which allows employees to obtain required information, connect people in a network of informational links within an organisation and beyond it, and enable knowledge transfer among the system's users. This is particularly important in the context of business processes which can be numerous in an organisation and may additionally require shared knowledge resources. Failure to address the above-mentioned aspects of designing and building a system addressed in this paper may subsequently lead to problems connected with its implementation and use. What is apparent in this approach is focus on business processes, knowledge flows and the participant, and limited reference to the dynamism of changes taking place in the structure of the system. The approach, while assuming changes in the performance of a business process and changes in knowledge flows, hardly addresses the issues of changes in the structure of the relations of the links between the elements of a technological system designed to support such activities. As a result, adaptation of the operation of a system being developed to the needs of an organisation consists in changing the definition of a business process and knowledge flows as part of specific tasks of a process. From the perspective of autopoietic systems discussed in the next chapter, this is insufficient.

3. Introduction to the theory of autopoiesis and its use in the integration of BPM and KM

In the article [13] Maturana specified the concept of autopoietic systems. He pointed out that autopoietic systems are systems in which the key element is interaction of separated elements of a system, which operate in a specified space, and recursivity of such operations. In his research, Maturana was in favour of biological approach to examining autopoiesis, unlike Varela, who opted for examining it in artificial systems as well. The research undertaken in this paper refers to the latter approach. The necessity of separation of autopoiesis of living systems and of technical systems was also indicated by Munster [14]. As was indicated by Nash [15], the cooperation of machines and humans in the context of a system's autopoiesis leads to the emergence of new data, which consequently can be used as a source of subsequent decisions. Such autopoiesis of a system, as pointed out by [16], can be used in knowledge management systems supported by agent technology.

The concept of autopoiesis addressed in this paper is connected with the theory of open and closed systems presented by Ludwig von Bertalanff, one of the authors of General System Theory. According to its assumptions, closed systems are characterised by the lack of changes in their structure of internal relationships once the internal balance is achieved and lack of communication with the external world. They are contrasted with open systems, which interact with their environment. The impact of the environment contributes to dynamic changes to the structure of such a system. It is important to note that autopoiecic systems are organizationally closed [17] (or partially open) and self-referential. The lack of full openness results from the lack of a direct link of the whole autopoiecic system to its environment. Consequently, it has links with its environment in terms of the structure. It is however closed in terms of the organisation of its elements, as its environment cannot impact it. For the impacting entity, the change in the structure of an autopoiecic system can be implicit. As a result, autopoietic systems are characterized by the lack of environmental impact on their functioning, which results from the internal mechanisms which operate within it. Therefore, autopoietic systems cover self-production, self-referentiality and self-organisation.

The first two aspects of autopoiesis refer to a system's capability of self-production, which involves generation of a system's elements by the system itself, and self-referentiality of a system, which involves creation of relationships between the elements of a system. The most complex aspect of the development of an autopoiecic system is its self-organisation (often considered as synonymous with system auto-morphosis). As indicated [18], a self-organised system is composed of many locally functioning and interacting components. In principle, self-organisation of the abovementioned components, or more precisely subsystems, has a local nature. Subsystems functioning in a particular environment take measures to achieve a particular task. It is assumed that their structure is built as a bottom-up process, where individuals organize themselves. It should be mentioned that self-organisation is often mistakenly perceived as the concept of self-adaptation. The difference in the two approaches is related to the process of structuring a group of subsystems. In the case of autoadaptation we are dealing with a top-down approach [19]. In the case of self-organisation, bottom-up process follows from the assumption that self-organisation is initiated by the units that are part of the system. Therefore, its base consists of interacting system components that have a local nature and initiate changes in the system as a whole. In the case of autoadaptation, it is the system’s response to changes in the environment and the need to adapt the system to these changes. Self-organisation (also described as automorphosis) is based on the appropriate definition of a system through the prism of functions that it has to meet [20]. In the case of autoadaptation, the goal of a system is shown from above and is related to the adjustment to specific conditions/purposes imposed by the environment or a system. On the other hand, self-organisation has a bottom-up nature. Components of the system, organize themselves to carry out the tasks/functions. Here one can indicate that the components of adaptability are seen as vertical relations, while self-organisation is seen as horizontal relations between system elements. As a result, self-organising systems often show features of self-management [21], which in turn have the features of self-optimisation, self-configuration, self-healing and self-protection capabilities [22].

Self-optimalisation is related to the search for possibility of reorganising a system structure in order to improve its efficiency and effectiveness, in terms of tasks. This concept should not be confused with self-adaptability. Self-adaptability is aimed at adjusting the system to the changing environment, while self-optimalisation is focused on the improvement of indicators describing the functionality of a given system. Self-configuration is associated with determining the structure of the system under the influence of rules set in a top-down fashion. It should be pointed out that this approach affects the autonomy of system element, because configuration of the system refers to its initial state, and imposes certain behaviour on individual elements. Self-healing involves the search for ways to change the state of a system that is invalid/not recommended for an acceptable state. An example here is the failure of selected components. In that case, triggering the processes of self-organisation, self-adaptation, self-production allows the system to continue its operation. The last feature is self-protection, it relates to the protection of a system from attacks.

The concept of autopoiesis presented here is one of the key approaches in the development of knowledge management systems [23], [24] where the process of managing an organisation's knowledge is considered in terms of autopoiesis. However, these considerations refer to the social aspect, not a technical one, connected with designing an IT system in this field. The use of autopoiecic solutions as an element supporting the operation of organisations, in particular knowledge-based organisations, requires that a solution being developed is focused on aiding business processes and supporting them through the resources of codified knowledge possessed by an organisation. The use of such solutions should (based on the use of the theory of software agents) ensure specific system features [16]. It should be stressed here that society, whether it is a human organisation or artificial society, can build autopoietic structures, but society itself should not be equated with autopoiesis. This is because society as a whole imposes certain social and organisational standards and constraints, which, applied to a certain group, sub-system comprising certain entities (structure) and relationships between them (organisation), enable examination of autopoiesis in such a group. Consequently, citing Maturana and Varela [25], an autopoietic system should have the features of autonomy, individuality, organizational closure and self-specification of boundaries. One should stress here the autonomy of a system’s elements, which has not been addressed earlier. The above-mentioned features of self-organisation and self-adaptation require autonomous operations of the elements of a system, therefore autonomy should refer not only to an autopoietic system, but also to its components. Abou-Zeid [26] points out that coupling lower-order level autopoietic systems in terms of their structural links enables achievement of a higher-order level autopoietic system. Structural coupling of such systems is achieved through cyclic and continuous interactions between them. It results from structural openness of a system and its organisational closure. He also pointed out that autopoietic perspective of the operation of an organisation and IT systems suggests “strong” approaches to systems development. These theories of autopoietic systems considered in terms of a process oriented autopoietic knowledge management support system allow to point out a range of new features of such systems. Based on the discussion undertaken herein it can be indicated that autopoiesis in an organisation's IT systems refers to development of systems:

- whose components (sub-systems) operate autonomously and can interact with one another - in the context of business process oriented autopoietic knowledge management support systems discussed here this makes it possible to dynamically develop the structure of a technical system which not only adapts to the changes in the structure of a business process and knowledge flows, but also regulates its operations aimed at improvement of performance and effectiveness. An example of such a mechanism is a system self-regulation mechanism based on the concept of reputation as proposed in works [27],[28],
- which have clearly defined boundaries - such systems’ links to their environment cannot be direct and based on the exchange of information and its context, i.e. knowledge,
- which are partially open, where the system's environment has not a direct impact on the organisation of its elements and its internal architecture - a system's capability of self-regulation makes it necessary to enclose it from its environment and results in the lack of direct manipulation of its operation. In such a case, an autopoietic system cannot be controlled, but it should be based on principles and standards indicating how it should behave. This is a key aspect of the assumed autonomy of the elements of such a system, which also ensures its security.
- which are auto-referential and operate recursively in a continuous way - due to the dynamism of the elements of such a system and autonomy of their operations the rules and standards should define the relationships of the links between the elements. In such a case, the sub-systems of an autopoietic system should have mechanisms of interaction through sending messages and entering into relations based on that.
- which are self-productive, where an autopoietic system can create its own elements - an advantage of an autopoietic system is its ability to create not only knowledge, as indicated in process driver knowledge management, but also elements of the system, i.e. the subsystems of the autopoietic system. Thanks to that, for improvement of the effectiveness of the performance of processes in such a system, additional sub-systems can be created to take over the fulfilment of tasks of the already existing systems.
- which are self-organising, where the elements of a system temporarily cooperate in a certain configuration, which is a bottom-up process - self-organisation is a key aspect of autopoiesis. In IT systems, e.g. in the OO approach, static view of a system's architecture can be seen. In the case of an autopoietic system, it is necessary to assume that the architecture of the system can evolve within the principles and standards applied in the system. As a result, the system can adapt to the changes in

the business process or knowledge management process. It can also change its structure without the influence of these factors, e.g. for improvement of the effectiveness of its operations.

- which are self-adaptive, where the process is top-down and can be connected with the process of securing the proper operation of a system - here we can see the biological approach to a technical system based on genetics mechanisms. In an autopoietic system, there have to be mechanisms for top-down indication of possible statuses of the system. This results from the necessity of limiting the evolution of a system's elements beyond the defined boundaries,
- which apply developed knowledge in subsequent iterations of a system's operation - elements of an autopoietic system use organisational knowledge as they perform the tasks assigned to them. As a result, they process organisational knowledge by themselves as humans do. This makes it necessary to code meta-knowledge in such a way that it is understandable for humans and subsystems that make up an autopoietic system,
- which are capable of self-optimisation and self-configuration of their structure - the self-organisation process of an autopoietic system should contain mechanisms designed to support this process. While in classical systems of process oriented knowledge management it is possible to optimise and simulate a business process, the knowledge that is processed in this case refers only to the aspect of the process that takes place in an organisation. From the perspective of an autopoietic system, an additional type of knowledge is the knowledge about how the process runs from the level of the technical sub-system, which also impacts the efficiency of a business process.
- which generate and use knowledge, rules, relations, regulations - consequently, such systems obtain new types of knowledge about the operation of a technical system which can be reflected in the performance of business processes and knowledge management processes.

In terms of designing an autopoietic system which is a component of a knowledge management system and is focused on supporting business processes, the key elements of its operation are knowledge, rules, relations, and regulations:

Knowledge – for proper operation, an autopoietic system requires the use of knowledge, which on the one hand allows the system to work, while on the other hand, is generated by the system itself. From the perspective of an IT system, it is important here to relate information to knowledge. In terms of building autopoietic KMSS, essential is the concept of knowledge [29] that assumes the existence of embodied knowledge and encoded knowledge. The former emerges during the operation of an autopoietic system. It is generated by the system and used in its operation. The second type of knowledge is knowledge regarding the structure of a system, encoded in its base structure. From the perspective of an organisation, organisational knowledge refers to the knowledge of the entities that constitute the organisation as well as relations, regulations and operating principles of those entities within a given organisation. Consequently, knowledge as organisational knowledge requires context of its use [30] and has to be linked with the action to which it refers.

Reference to the types of knowledge as used in business processes can be found in the work [8], which indicates the existence of knowledge about a process structure and simulation (process template knowledge), knowledge about instances of the process of its evaluation (process instance knowledge), and knowledge generated during performance of the process (process-related knowledge).

From the perspective of autopoiesis, knowledge itself can be considered as autopoietic [29]. Other researchers [26] point out that it is a key element of an autopoietic system due to its relationship with an element of an autopoietic system. The use of KMSS should facilitate the process of individual learning, support team learning and organisational learning [31]

Consequently, they should support autopoiesis of the knowledge management process itself, extending the process of individual teaching of employees by elements of group and organisational teaching.

Rules – as was indicated, an autopoietic system is composed of components. These components require defined principles of operation related to their roles in the system. The operating principles of a system should be defined by its developer (primary principles) and in a dynamic way, by the system itself (secondary principles). Primary principles should be more important than the secondary ones and should not be changed by the autopoietic system. The operating principles of a system are defined by its architecture and are connected with the aspect of communication between the elements of such a system.

Relations – another key element of an autopoietic system is interaction between its elements. Because of that, relations are built dynamically and based on possessed knowledge of each of the system's elements. Relations result from communication between the autonomous elements of a system, which are unable to directly control their own behaviour. On the other hand, relations result from the roles fulfilled by the autonomous elements of the system. These roles may arise from the role of a business process's participant or the role connected with the tasks in an autopoietic system.

Regulations – an autopoietic system, due to its continuity of operation, requires regulatory mechanisms that will dynamically control the processes taking place within it. The mechanisms contribute to the system's self-organisation. Research in this area shows [27] that the use of software agent societies may aid the development of such a mechanism. An example o such a regulatory mechanism is the proposed mechanism for a system regulation based on reputation of the autonomous elements of the system [28]. The differences in viewing the technical approach to a process oriented knowledge management system as indicated here make it necessary to present a possible approach to building its architecture.

The discussion on the concept of a process oriented autopoietic knowledge management support system as presented in this chapter leads to the conclusion that when building such solutions it is necessary, apart from defining the mechanisms for business process designing and elements of a knowledge management system, to indicate the third element that integrates a knowledge management system and business processes.

4. Proposal of a methodology for designing an autopoietic knowledge management system

This is due to the fact that an organisation's operation is a dynamic process in which business processes and knowledge management processes are dynamic and can be performed separately as part of defined life cycles. As a result, the methodology for designing a process oriented autopoietic knowledge management support system should take into account the possibility of its use in the situation when an organisation already has one or both of these systems implemented and needs to use mechanisms for their better integration. The example of designing a business process oriented autopoietic knowledge management support system in the process of auditing an organisation's personal data protection is available in article [32]. The article also presents the relationship between the elements of the proposed methodology. Consequently, the approach proposed assumes the existence of three basic elements. The first stage is identification and modelling of business processes. This stage defines integration of an autopoietic solution as part of a process being performed requires indication of the place where the business process will be supported by the process oriented autopoietic knowledge management support system. For that reason, it is necessary to specify how the process will run and which stages of the process will be supported. The second stage is identification and modelling of an organisation's knowledge resources There may already be a knowledge management system that uses a specific knowledge management cycle in the organisation where process oriented autopoietic knowledge management support system is being designed. In this case, the codified and non-codified organisational knowledge created at this stage can be used as part of the system being developed. These stages (stage 1 and 2) can be carried out independently, in any cycles. Their implementation enables diagnosis of the processes taking place in an organisation and the sources of knowledge that they generate. This knowledge is necessary in the process of designing process oriented autopoietic knowledge management support system. The third stage is designing and implementation of a process oriented autopoietic knowledge management support system This stage involves integration of the existing knowledge management system as part of the defined business processes. This system should meet the earlier specified demands of an autopoietic system and ensure integration of organisational knowledge as part of performed business processes. Detailed description of all the sub-stages, relationships between them and assumed tools has been presented in table 1.

Table 1. Detailed description of all the sub-stages

Stage number	Purpose of the use	Possible tools and standards	Example of possible realtions	Effects
3.1.1	Identification of the context of a system development consisting in linking the task or event of a process. The system will be triggered when it becomes necessary to perform a task or event from the business process.	BPMN, ARIS or other notation that makes it possible to map the business processes of an organisation.	1.4 1.5	Indication of the context of the system operation with reference to the business process from stage 1.
3.1.2	Identifying which knowledge elements can be used during the performance of a task of event of a business process. Each time this stage is triggered, information about knowledge resources is transmitted to stage 3.1.4.	Interviews with employees, analysis of the documents processed during the execution of a task. Codification through e.g. RDF, RDFS, OWL, meta-data, rule-based systems, databases.	2 3.1.4	Indication of knowledge sources that can be used in a task or event of a business process without reference to whether they will be directly linked to a process or used also by autopoietic elements.
3.1.3	Linking a knowledge element that is not processed by an autopoietic system with a task or event of a business process.	Diagram of relations between a specific coded element of knowledge and a task or event of a business process.	3.1.2 1.4 1.5 2	Possibility of indicating which elements of knowledge will be used in a business process.
3.1.4	Initial identification of knowledge elements which will be linked with an autopoietic system. This stage is triggered by 3.1.2 after the identification of the source of knowledge and when an autopoietic element is built.	RDF, RDFS, OWL, meta-data, rule-based systems, databases.	3.1.2 3.2.1	The effect is initial identification of knowledge elements that will be used to build an autopoietic system.
3.1.5	Initial identification of knowledge elements generated and transmitted to a task or event by an autopoietic system. Based on the analysis of organisational knowledge from stage 3.1.2 it should be determined what knowledge can be provided to a business process.	RDF, RDFS, OWL, meta-data, rule-based systems, databases.	3.5.2 3.2.1 3.4.3 2	The effect is specification of the initial structure of the knowledge elements generated by an autopoietic system.
3.1.6	Linking a knowledge element processed by an autopoietic system with a task or event of a business process.	Diagram of relations between a specific coded element of knowledge and a task or event of a business process.	1.4 1.5	The effect is indication of which knowledge elements generated by an autopoietic system are used during a business process
The effect of the stage is diagnosing which task will be the context of a system usage, to which knowledge resources the system has access, which knowledge resources will be used directly in a business process and which ones will be processed by an autopoietic system and what are assumed effects of its operation. This stage relates to the feasibility study stage in IT system design methodologies and allows to diagnose whether a system can be built based on possessed organisational knowledge. It is the system developer's responsibility to choose the methods for coding meta-data of knowledge resources and rules for creating relationships between them.				
Stage number	**Purpose of the use**	**Possible tools and standards**	**Possible approaches**	**Effects**
3.2.1	Identification of tasks to be performed within an autopoietic system. This stage is carried out by the designer based on users' requirements regarding knowledge resources in a task of a business process. During definition of a system's task it is possible to return to stage 3.1.4 and indicate the necessity of defining additional knowledge resources of a system and to stage 3.1.5 and indicate new knowledge resources generated by the system.	Use case diagram, Hierarchy diagram.	3.1.4 3.1.5 3.2.3 3.2.4 3.4.1 3.4.2 3.5.1 3.7.1	The effect is specification of the functional scope of an autopoietic system Tasks should be designed to obtain knowledge from stage 3.1.5.
3.2.2	Identification of the roles performed by autopoietic elements. This enables subsequent grouping of tasks from 3.2.1	Autopoietic elementes roles relations diagram.	3.2.1 3.4.1 3.5.6	The effect is indication of the roles that will be performed by an autopoietic system in the system
3.2.3	Identification of emergencies that may occur	Diagram of relations between	3.2.1	The effect is indication of

	during the operation of a system Such events should be reflected in a system's possible tasks, no connected directly with the process being performed.	an emergency and a task of an autopoirtic system.	3.2.4	emergencies that may occur during the operation of autopoietic elements that may disrupt the process of knowledge processing.
3.2.4.	Linking the diagnosed emergencies with the tasks of an autopoietic system	Diagram of relations between an autopoietic system's tasks and emergencies .	3.2.1 3.2.3	The effect is indication of emergencies that have to be programmed during programming the code to perform a task .
The effect of this stage is definition of tasks to be performed by an autopoietic system, roles to be fulfilled by system elements to perform these tasks and emergencies that may occur during the performance.				
3.3.1	Linking an autopoietic system's tasks with tasks and events of a business process.	Diagram of relations between an autopoietic system's tasks and tasks of a business process.	3.2.1 1.4 1.5	The effect is definition of the usage context of a system task/tasks in a business process.
3.3.2	Identification of relationships between the roles in an autopoietic system.	Change to the diagram of the relationships between the roles of autopietic elements.	3.2.2	The effect if an update of model 3.2.2, where the hierarchy of relationships between agents is built. The definition of such hierarchy is optional but it allows to indicate how rights can be delegated in a system, e.g. an autopoietic element in a given role may delegate tasks to other autopoietic elements whose roles are linked with it but is lower in the hierarchy.
The completion of this stage enables the specification of the hierarchic structure of relationships in the context of the organisation of the operation of an autopoietic system.				
3.4.1	Identification of the class of an autopoietic element that will be helpful in the process of its coding.	Class diagram, specific programming language	3.2.1 3.2.2 3.4.3 3.6.1	The effect of this stage is development of the definition of the class of an autopoietic element
3.4.2	Linking the class with the task performed in an autopietic system. For this purpose it is necessary to specify which classes will perform which roles in a system.	Diagram of relations between tasks and the class of an autopoietic element.	3.4.1 3.2.1	The effect is indication of an autopoietic element responsible for a given task performed by an autopoietcic system. A given task may be performed by several classes. Then, it will be necessary to develop the mechanism of their communication at stage 3.7.x
3.4.3	Linking the elements of knowledge with the class of an autopoietic element,	Diagram of relations between classes and knowledge resources.	3.1.5 3.4.1 3.4.3 2	The effect is indication elements of knowledge that will be processed by a given class of an autopoietic element.
The stage enables initial definition of an autopoietic element's links with its environment. The links being created are the basis for further specification of an autopoietic element.				
3.5.1	Identification of the tasks of the control system.	Diagram of tasks of the control element in a system.	3.2.1 3.5.2 3.5.3 3.5.5 3.5.6	The effect is specification of the functions to be performed by this element of an autopoietic system.
3.5.2	Initial identification of the elements of knowledge processed by a task of the control element.	Diagram of relations between the elements of knowledge and the task of the control mechanism.	3.5.1 3.5.3 3.1.4 3.1.5 2	The effect is initial identification of knowledge elements that will be used by a task of the control element.
3.5.3	Identification of additional resources of control knowledge that are relevant for the development of decision rules.	RDF, RDFS, OWL, meta-data, rule-based systems, databases.	3.5.1 3.5.2 2	The effect is indication of additional resources of knowledge that will be used only in the process of preparing decision rules
3.5.4	Identification of the rules of the control mechanism's operation.	Rule-based systems, heuristics.	3.5.2 3.5.5	Development of a set of rules for the analysis of knowledge resources
3.5.5	Assigning rules to tasks of the control system	Diagram of relations between the rules and tasks of the control system.	3.5.1 3.5.4	The effect is indication of the rules to be tested during performance of a given task of the control system
3.5.6	Assigning a class or role of an autopoietic element to a task of the control system.	Diagram of relations between classes and the control mechanism.	3.2.2 3.4.1 3.5.1	The effect is indication of the relationships of the control mechanism with the class of an autopoietic element or their group in the form of a role.
This stage ensures definition of the control elements of an autopoietic system. This is necessary in terms of autonomy of autopoietic elements and required control over their behaviours.				
3.6.1	Identification of initiated instances of	Diagram of links of the	3.4.1	The effect is indication of the

	autopoietic elements based on the classes of autopietic elements.	instances of autopoietic elements with the class.		instances of autopoietic elements that will be initiated upon the start of the system.
3.6.2	Identification of behaviours that a autopoietic element will execute based on its class.	Development of the diagram of relations between the class of an agent and the behaviours that will be defined in it.	3.4.1 3.6.4 3.6.5	The effect is indication of behaviours executed by a given class.
3.6.3	Identification of behaviours that will be subject to control by the control system.	Development of a diagram of relationships between the tasks of the control mechanism and the behaviours of agents based on the class assigned to them.	3.6.2 3.6.5	Preparation of a diagram of relationships between the control mechanism and the behaviour of an agent.
3.6.4	Identification of knowledge resources used by the behaviour of an autopoietic element.	Development of a diagram of relationships between the behaviour and class.	3.4.3 3.6.2 2	The effect is indication of relationships between the used knowledge defined in the class of an autopoietic element and its behaviour.
3.6.5	Assignment of the defined behaviours of an autopoietic element to the plan of operation of an autopoietic element.	Definition of a diagram of the sequence of the execution of behaviours of an autopoietic element.	3.6.3 3.6.2 3.7.1 3.7.3	Specification of the relationships between the behaviours of autopoietic elements and indication of their relations with the task that is performed by a given class.
This stage ensures a more accurate specification of the elements of an autopoietic system. Apart from knowledge on the task being performed, the system should possess knowledge on the control mechanism applied to it This allows to specify what knowledge about the operation of an autopoietic element should be provided to the control mechanism and what knowledge will be able to used by this system as part of its behavior.				
3.7.1	Identification of messages generated and received by autopoietic elements and behaviours that require interaction with the environment,	Diagram of relationships between the messages and behaviours of autopoietic elements.	3.2.1 3.6.2 3.6.5 3.7.2	Diagnosing the necessity of communication between the elements of a system with reference to the behaviours executed by them and links between them
3.7.2	Identification of the required knowledge of an autopoietic element during execution of a specific message.	Assigning a knowledge resource to a transmitted and received message.	3.7.1 3.6.4	Diagnosing a knowledge resource used in a given message.
3.7.3	Specification of the structure of a message, the resource of transmitted knowledge and the resource of received knowledge.	Development of the structure of a message in a specific standard for transmission of messages.	3.7.1 3.7.2 3.6.5	Development of the structure of a message and the scope of knowledge that will be transmitted between autopoietic elements.
This stage makes it possible to define the principles of the impact of autopoietic elements on other autopoietic elements in a system. For that purpose, it is necessary to define mechanisms of interaction between system elements. The approach proposed assumes communication of elements based on defined messages.				

The theoretical considerations presented in this section are connected with the author's field of research connected with the use of autonomous systems (in particular agent systems) to support the operations of knowledge-based organisations. Earlier research in the area of the analysis of methodologies for building software agent [27],[28],[16],[33] life cycle of process oriented knowledge management, architecture of agent-oriented knowledge management system [16], building the control mechanism of an autopoietic system [28], and its evaluation [27] enabled the specification of the presented methodology for building an autopoietic system within the framework of the concepts of BPM and KM.

5. Conclusions and future work

The proposed methodology for the process of designing a business process oriented autopoietic knowledge management support system assumes division of the process of building such a solution into three separate stages, which can be completed independently. This approach is essential from the perspective of an organisation's operation and maturity of systems in each of the indicated areas. The proposed methodology does not disturb the existing BPM and KM processes in an organisation, if they exist, and triggers such processes if they do not exist. What's important, it assumes the use of a business process oriented autopoietic knowledge management support system only in the context of selected business processes and their tasks. Thanks to that, the implementation of such a system can be cyclic and focused on specific business processes. However, the use of this approach to a wide range of business processes brings additional benefits. The knowledge diagnosed at stage 2 can be used by subsequent autopoietic elements of a system allowing stage 2 to be omitted. It also enables the results of a system's operation to be adapted to subsequent business processes that require the same knowledge. Additionally, thanks to dynamic inclusion of a system's autopoietic elements in subsequent processes, control mechanisms can better evaluate their effectiveness [28], [27]. The main advantages of the proposed approach include [32] supporting: decision-making processes of decision-makers by providing them with contextual knowledge, integration of the ontology on organisational knowledge resources, possibility of terminological integration of defined knowledge resources within the framework of the terms used in standardised ontologies, the use of elements of BPMN notation and extension of its artefacts by elements used by a knowledge engineer in designing a system, indication of methods for integrating autopoietic systems as part of decision-making processes of a decision-maker. Further stage of the research will be relating the methodology proposed to the social aspect of building a process oriented autopoietic knowledge management support system connected with the impact of so developed solutions on the organisation in which they are created.

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