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An Overview of Multi Agent System Approach in Knowledge Management Model

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⁴
Abstract—Multi-agent system approach is now widely used as a solution to real-world problems, including problems in the organization model. The complexity of the organizational environment demands a model of knowledge management (KM) improvement that can create innovation and responsiveness process, this matter caused by rapid changes, so the knowledge will grow and improve continuously. Multi-agent system is seen as an approach that can achieve this goal, through its characteristics. This paper describes an overview of implementation of multi-agent system approach to KM models, including a review of several research contributions related to that domain. Assessment of any research results are discussed with systematically to compare each contribution of each researcher. At the end of this paper, we make conclusion and propose a preliminary study that needs further study, which is expected can give new idea and description for other researcher at this domain to invent a value of novelty on the future.

Keywords—multi-agent systems, knowledge management, organizational models

I. INTRODUCTION

Complexity of organizational environment, has prompted the organization management to make effort in regulate all resource, in order to the organization can running proactively and flexible in facing every situation changes. Characteristics and behavior every element on an organization needs adjustment and translation with the system that will be a main supporter as an effort to reach the organization goals. All activity on organizational environment needs some mechanism as a represent from real world characteristics and behavior. The background of that matter is a view on organizational environment in systems as services, according to Alter [1] is a computation of organization service, can viewed as entity, the meaning is organization service automation viewed as entity activity, for different entity, including resources provision that used by different entity. Based on above description, process of interaction pattern in an organizational environment need organization learning that connected with maintaining and increasing capital of its knowledge (intellectual capital), so it can innovate and has ability to learn, adapt, and change as a main competency for survival. In other words, an organization in maximizing its business processes can implement a model that is known as knowledge management (KM).

Lately a lot of research has been carried out to assess the application of KM models, in order to enhance and improve any organization's business processes. From a number of research results, there are some findings that indicate that the

KM models still have some drawbacks. Among them, according to Rahman [2] and Kamble [3], KM in development at this time, have an activity handling and management of knowledge is growing very rapidly and is quite difficult, so spending more time in service delivery organization, therefore causing a decrease overall productivity. Laclavik [4] says the KM is a centralistic solution that not meet requirement of the necessity to handle distributed and heterogeneous environment. KM become a critical factor for organization success, but it is a difficult process, so it is need formalization from some concept to monitoring every activity process, the effect is KM can more easy to organized in dynamic environment and can full fill collaboration necessity and its social aspect [5].

Based on fact and researchers opinion, KM environment is heterogeneous and dynamic environment, so that knowledge growth will improve and change very fast for adaptation to its environment, this is critical condition for an organization, if it can't evaluate and plan an appropriate⁵ strategy for KM. This paper, explain about implementation of multi agent system approach in KM model, based on comparison of many research output. The aim is to learn every chance of organization model revision through KM life cycle. In addition we propose a preliminary study that can be considered and act further through deeper study.

II. GROWTH OF KNOWLEDGE

An organization model, according to Alter [1], can be viewed as a work system that is a system where people and/or machine working using information, technology and other resources, to produce product and/or services for internal or external customer. Main factor in design activity of organization service is described with many dimension of design, namely structure hierarchy, scope of involvement, integration level, complexity, frequency and automation level [1] and it should be realized, that organization environment will change follow its, life cycle. This transformation must be handled, with include concept and tools to evaluation, analysis and model design. To manage changes of organization environment, it is relate to intellectual capital of that organization, where knowledge will growing up and develop continuously to meet the necessity every level of organization.

Currently, KM becomes a dominant trend in organization business. As frequently mentioned in literature, the knowledge role has collaborative aspect that is someone can receive and use best knowledge with information reuse that have collected and annotated by other or with utilize relationship within it

community [6]. Besides, KM system must be able to adapt with environment changes and different necessity. However, in practices KM very difficult to face situation and current condition, where information resources available like flooding, uncontrolled, and sustainably coming. This condition can impact to information quality that would be created into knowledge. There are many factors inaccuracies information resources cause, ranging from solution selection that used to handle operational process, or solution that related to planning and evaluation process. In addition, other matter that should be thought with abundant of information resources today, is the growth of knowledge itself, over time, knowledge will sustainably grow and also with the problems associated with it.

Intelligent agent is a software development paradigm as part of computer science and artificial intelligence [7]. Multi agent system which used in KM domain, such as functionalized to assist user in accomplish the work or to capture the knowledge and propose it to right person, at right time, in right form [6]. With the advantages of this agent, many researchers have conducted experiments to reduce drawback of KM.

III. DISCUSSION

An interesting research field like agent based KM has grown, with its aim to relate KM with agent-base model. Basic feature of agent can reduce some drawback of KM approach [8]. According to literature study, there are some contribution from research have special characteristics and rich with innovation ideas.

A. Multi Agent System and Knowledge Management

One of main characteristic in software agent is autonomous that reference to principal that agent can operate by itself. Autonomous agent has control to manage itself, Beside that as a solver entity, with limitations and linker that define very well, designed to fulfill certain goals and show flexible behavior and proactive. Autonomous agent has ability to interact with other agent, using certain communication language. So, that its can make social ability that possible to understand its environment, responds the changes or reach the goal through adaptation and reaction toward others [6]. Fig. 1 gives an overview of a multi-agent system, the shared environment that the agents occupy, each agent has a sphere of influence in this environment, i.e. a portion of the environment that they are able to control or partially control, an agent has the unique ability to control part of its environment.

Above the environment, we see the agents themselves, which stand in various organizational relationships to one another (for example, one agent may be the peer of another, or may have line authority over another). Finally, these agents will have some knowledge of each other, though it may be the case that an agent does not have complete knowledge of the other agents in the system [9]. So, multi agent can be defined as collection of heterogeneous computation entity which has own problem solver, and ability to interact toward others to reach all objectives [10]. With that characteristic, multi agent system can be considered able to make automation of organization service, as a system to handle activity that can be done by an entity, for different entity, including resources

provision that will be used by other entity. Resource that has central role is knowledge. That knowledge needs organizing which always coordinates with each other.

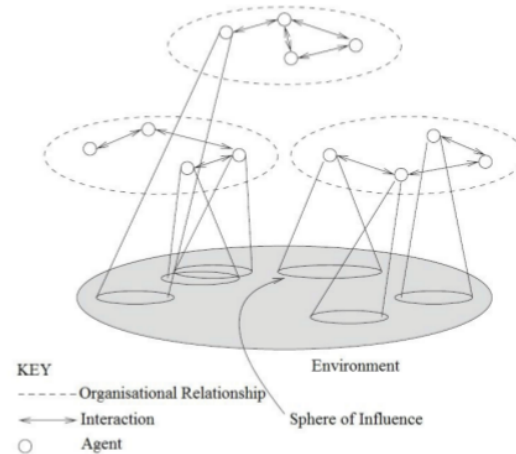


Figure 1. Typical structure of a multi-agent system [9]

Knowledge organizing can be represented through other agent characteristics. According to Bhat [8], beside has autonomous characteristics, also, agent has reactivity and knowledge base. Agent technology is one of technology which is able to handle collaborative distributed environment and social interaction. Group of agent in multi agent system can determine objective and behavior by itself, and integrate functions to complex task finishing, such as manage work path and knowledge searching. This will help ensure an effective platform for coordinate and cooperation in managing knowledge. KM within the organization has a cycle with the stages that are tailored to the role and function within the organization's knowledge needs. There are various concepts that illustrate the cycle and KM processes, but in this paper we use the definition according Dalkir [11], as can be seen in Fig. 2 the process of KM focus on the flow of knowledge and process capture/ creation, sharing/ dissemination, and distribution/ acquisition of knowledge is facilitated by technology within the organizational culture.

According to Mild [6] and Silwattananusarn [12], the relevant agent technology is used as a requirement for KM, with considering any characteristics. KM environment can be implemented as a community of various types of agents that work together to provide the necessary support for users as its working knowledge. In its implementation the software agent used as tool to manage resources, as a unifying distributed heterogeneous components, and to personalize knowledge and navigation [6]. According Klusch [13], agent-based services in KM can consist of : (1) seek, obtain, analyze, integrate and archive information from heterogeneous sources, (2) inform when new information on specific information is available, (3) negotiate and receive information, (3) explaining the relevance, quality and reliability of information, (4) learn, adapt and evolve with the changing conditions.



Figure 2. Cycle of Knowledge Management [10]

B. Comparison of Results

On this paper, to explain research contribution which resulted by researcher on this field, we define reference requirement based on several step and relevant criteria with the aim of this research, namely : (1) identifying the main problem on organization model, such as explained at part I and II, (2) explain problem solution, as described at part III A, (3) determine and discuss the reference about KM solution for organization model, to understand the fact and improvement requirement, (4) compare and discuss the reference about multi-agent system on KM model, to looking for a chance for future research. There are facts as result of research, as effort in implementation of KM solution, as seen on Table 1.

TABLE I. KNOWLEDGE MANAGEMENT IMPLEMENTATION FACTS

Knowledge Management Implementation Facts	
No.	Description
1	A systems approach needs to be correct explanation of the system, entities, services, structure of knowledge. [14][15]
2	Grounded theory Methodology, focus on supporter and resistor characteristics and knowledge perception. [16]
3	The model is based on aspects of why, where, how, technology alignment, processes, leadership, and learning. [17][18]
4	Development framework and taxonomy of K-Portal, web-based learning, and cloud services campus. [19][20][21][22]
5	Based on the needs of the organization obtained the KM strategy implementation through 7 stages of activity. [23]
6	The application of technologies for learning organizations internal and external knowledge. [25][32]
7	Provision of disaster relief information, for decision making, historical analysis, and predictions of disaster [26]
8	Repository school assets, problem solving, knowledge sharing, optimization and process control. [27][28]
9	The research leading to intelligent systems, ICT for knowledge sharing, data mining and knowledge discovery. [29]
10	Characteristics KM architecture consists of exploration, capitalization, management, retrieval, knowledge base. [30][31]
11	Collaborative environment through knowledge based / case based reasoning system can automate the process of care. [24][33][44]
12	The process of knowledge transfer through a model dependencies and visualization on the complexity of the system. [34][36][38]
13	Sharing knowledge with a combination of shared services as a repository and communication media e-learning. [35]
14	Socio-technical approach, through the design of a community component, architecture, structure, metrics collaboration. [37]

Knowledge Management Implementation Facts	
No.	Description
15	The design of intellectual property protection in collaborative environment with cryptographic approaches. [39]
16	Approach to information retrieval and knowledge extraction needs taxonomic identification of KM. [40][41][42]
17	The use of 3D Platform (CAD) functioned as the manager of knowledge to simulate the process. [43]

Based on facts on Table 1, KM implementation at various organization is very heterogeneous and have characteristics that suited with condition and needs of organization it is self. This matter indicates that KM model needs appropriate scenario, so that system needs can extracted completely. Clarity to characterize organization model, [45][46][47] and alignment all resources [48][49][50][51] become important factor. This matter also based from several other research result as seen at Table II, that indicate the KM needs some approach that help to improve the performance.

TABLE II. IMPROVED KNOWLEDGE MANAGEMENT NEEDS

Improved Knowledge Management Needs	
No.	Description
1	Each stage requires KM technology as a tool to capture and create knowledge to improve organizational performance. [12]
2	KM requires a system that is reactive and proactive and in accordance with user expectations, the agent concept can be adopted and positioned as a specification of a service. [6]
3	Challenges in the KM system is the effectiveness of KM, and the integration of aspects of hard and soft, agent approach can provide an opportunity to make it happen. [8]
4	Multi-agent can enrich the theory and modeling of the various terms of the collaboration, are collaborating smart embedded devices to learn and adapt to socio-technical systems. [52]
5	Agent can better understand the attributes and relationships that can lead to success or failure of the development of a system. [53]
6	Ontology approach can make the relationship between KM and multi-agent systems, which are used to develop the architecture for many application areas. [54]
7	Agent paradigm can be used to analyze models of organization and knowledge needs, and providing a reusable architecture. [55][56]
8	Generic agent models can be established to develop a KM system, and reuse knowledge. [55][56]
9	Agent can be used to analyze the effectiveness of knowledge transfer in accordance with the objectives of stakeholders. [58]
10	Organizational reengineering process can be done through an agent that is used to analyze abstraction, representing the people, organizations and systems involved in the organization. [59][60]
11	Organizational models can be developed by the actors by defining several types of agents to support any part of the KM. [61][62]
12	The system can be modeled to improve the performance and reduce the response time of service by using multi-agent network, 2. KM approach and service architecture. [63][64][65][66][67]
13	Multi-agent system architecture can be developed to monitor the activities of the organization as a KM tools. [68]
14	The system can provide scalability, usability and support the adaptation of the system, through an agent that automatically knowledge transfer and thus improve service quality. [2][3]
15	The system can be developed for technical and organizational, technical factors such platforms, ontology, data, etc. organization factors such development process, environmental changes, etc. [8]

There are a number of research works, which seeks to integrate KM solutions through a multi agent system, with the aim to meet the needs and optimize the performance of the KM system, as can be seen in Table 3.

TABLE III. COMPARISON OF RESEARCH RESULTS

Comparison of Research Results			
Author	Focus	Storing	Process
Gandon	Project Memory	RDF	- Acquisition - Creation
Tian	Monitoring System	Knowledge base	- Acquisition - Creation - Dissemination
Blanzieri	Knowledge Transfer	Knowledge base	- Dissemination
Tacla	Personal Assistant	Knowledge base	- Acquisition - Creation - Dissemination
Laclavik	Agent Communication	RDF	- Acquisition - Creation - Dissemination
Dignum	Knowledge Transfer	-	- Dissemination
Soto	Knowledge Reuse	Knowledge base	- Acquisition - Creation - Dissemination
Monticolo	Project Memory	RDF	- Acquisition - Creation - Dissemination
Markus	Knowledge Transfer	-	- Dissemination
Van Elst	Personal Assistant	RDF	- Acquisition - Creation
Renata	Reengineering The Organization	RDF	- Dissemination
Talib	Knowledge Transfer	Knowledge base	- Acquisition - Creation - Dissemination
Košinár	Agent Communication	Knowledge base	- Acquisition - Creation - Dissemination
Gutiérrez	Knowledge Representation	Knowledge base	- Creation
Šaša	Service Oriented	Knowledge base	- Acquisition - Creation - Dissemination
Jain	Service Oriented	Knowledge base	- Acquisition - Creation - Dissemination
Oprea	Monitoring System	Knowledge base	- Acquisition - Creation - Dissemination
Bhat	Log Agent	RDF	- Creation
Ismail	Knowledge Acquisition	Knowledge base	- Acquisition
Rahman	Service Oriented	Knowledge base	- Acquisition - Creation - Dissemination
Kamble	Service Oriented	Knowledge base	- Acquisition - Creation - Dissemination

The discussion focus in the research is depicts about, savings is a means for storing knowledge, and the process is a KM cycle stages are handled within the scope of the study. A brief description of each research results in Table 1, are as follows:

- Gandon [69] – in 2002.

Developing multi-agent systems for the management of the company based on the semantic web ontologies. Adopting a

model of user preference and used different types of knowledge. This research work is focused on the evolution of knowledge it is related to the phase of creation / acquisition of knowledge because it will deal with the addition of the current memory. In general, it is a process of updating the knowledge to change and delete obsolete knowledge, to apply the learning spiral to update existing knowledge.

- Tian [70] – in 2003.

Propose a telemedicine system with multi-agent system approach, the system can provide monitoring and service at all times to patients. From the design goals, resulting interfaces group architecture, implementation group, the control group. Multi agent consist of monitoring agent, data processing agent, diagnosis agent, therapy agent, consultation agent, decision support agent, training agent, archival agent, department agent, and interface agent.

- Blanzieri [71] – in 2003.

Propose a multi-agent system through the system architecture for implicit culture support (SICS), which functioned for tacit knowledge transfer needs in the context of KM, CBR approach. The system incorporates a SICS at each agent to provide information to the user via an agent communication protocol. SICS observes user action, through a variant of the FIPA communication protocol, resulting in the exchange of information users' actions.

- Tacla [72][73][74] – in 2003.

The study focused on how the system automatically captures the operations performed on a desktop computer using a personal assistant agent, and how to set it up as a Lesson Learned. Adopting Petri Nets as a model approach and use the document as a kind of knowledge. Agent helps users to share the lessons learned are obtained. The proposed system provides a way for reuse of knowledge by explaining how to use it.

- Laclavik [4][75][76][77] – in 2005

The approach taken in this study is the use of ontology-based KM in multi-agent systems this study tries to make the connection between KM and multi-agent systems, especially the discussion of the semantic web for multi-agent systems. The use of KM with multi-agent system is used to develop a system architecture that is suitable for many application areas.

- Dignum [78][79] – in 2006.

Propose a framework called OperA to analyze models of organization and knowledge needs, providing the architecture to build KM systems. Frame works distinguishes between description of application and knowledge representation and provide it in general. Agent of community responsible for matching supply and demand of knowledge, with consideration preferences of the user, Agents cooperate with each other and dynamically adapt to the current environmental conditions.

- Soto [55][56][57] – in 2007.

Propose a generic model for developing KM, which aims to harness and reuse knowledge. Agent system architecture has two agencies, namely the user agency and agency knowledge.

Agency user interface consists of agent and personal agent, interface agent works as a bridge between the agent and the user, to display information to the user. Personal agent responsible for obtaining user profiles to determine the preferences of the user. Knowledge agency functioned to support the activities in each stage of the process of KM cycle.

- Monticolo [80][81][82][83] – in 2007.

Propose organizational approach which aims to analyze and model of the process used by the project team using various kinds of knowledge. Developing a model of an organization called the role of interagency organization competence and knowledge, to identify the knowledge that results from the interaction between the roles played by professional actors. Defining the topology and taxonomy of knowledge memory to represented the project. Multi agent system comprised of several types of agents to support any part of the KM process to assist in exploiting the knowledge engineer.

- Markus [58] – in 2007.

Introducing an agent-oriented modeling approach for analyzing the effectiveness of knowledge transfer in accordance with the objectives of stakeholders, using different types of knowledge, namely documents, links etc. This study develops a method of modeling knowledge transfer agent (KTA), to analyze the effectiveness of knowledge transfer instruments. Aims to meet the need for different levels of analysis, rapid and thorough, in-depth investigation conducted on knowledge transfer instruments

- Van Elst [84][85] – in 2007.

Propose an approach to memory workbench, memory based on the semantic wiki systems, supporting both manually and automatically for an explanation of wiki documents. Aiming to support user tasks via the relevant information (ie, search) and contributes to the reuse of knowledge. Personal information model (PIMO) as vocabulary provides a vocabulary for describing elements of the personal information on your desktop. Consist of a relatively informal tags or elements of a map, such as elements of the topics, as well as the more formal aspects of the expressivity of RDF/S.

- Renata [59][60] – in 2009.

Focus on reengineering the organization to support the implementation of KM. Developing an approach called Agent-oriented Recipe for KM Systems Development (ARKnowD), to support the development of KM in organizational settings. Develop a recommendation system called Knowledgeable Agent for Recommendations (KARE), to recommend based information retrieval and knowledge artifacts to support the fulfillment of the request user knowledge. Agent used to analyze abstraction, representing the people, organizations and systems involved in the regulation of the organization.

- Talib [86][87] – in 2010.

This research describes an agent, planned to increase communication, deliberation, and group decision making. System architecture created from several agent community in community of practice (CoP). Agents learn from previous experience and various knowledge from others agent. Agent

will help user on information and problems solving discovering to decision making. Agent is a tool that used to act on behalf of organization CoP to do some action repeatedly and it is time-based system.

- Košinár [88] – in 2010.

The proposed model focuses on communication and learning and design knowledge based analyst for the improvement and optimization of knowledge, through a statistical approach to the algorithm time to live (TTL) and the TTL advanced version with the priorities and the use of simple and conditional probabilities. Knowledge flows model describes the implementation of knowledge-based multi-agent systems. Description logic-based inferences engine, FIPA SL for procedural requirements semantics.

- Gutiérrez [89] – in 2011.

Propose a model of knowledge representation with multi-agent systems approach, to support the design phase in a distributed environment. Aiming to help reduces the space of design solutions by standardizing the definition of constraints and variables that may affect the implementation of the model. Knowledge engineering into account different variables and constraints are removed from the product Life Cycle. The method is applied to minimize inconsistencies in combinatory models. Shared variable domains juxtaposed with fuzzy logic, in order to ensure that the resolution of the conflict if it consists of two or more that share variables.

- Šaša [90] – in 2011.

This study has the objective to automate and integrate the conceptual level of the framework of the evolution of the knowledge base with service-oriented systems. Automations of the process of translation data into the knowledge base of the organization, the integration of KM activities into theirs daily work. Service oriented architecture platform is used to collect information from different resources, automate query the knowledge base of the business process, and the specific tasks the human knowledge base.

- Jain [91][92][93] – in 2012.

The basic objective of this research is to improve performance, and reduce the response time of service. This study proposes a model called the enterprise KM system (EKMS). EKMS is a distributed system that is designed using a service-oriented architecture approach. This study discusses the agent-based knowledge service-oriented system that integrates KM approach, the software agent technology, and service-oriented architecture. In this study agent is set to act as a service provider, applications can search the repository service, and then select the agent that provides the desired service.

- Oprea [94][95][96][97] – in 2012.

This research has a focus of study to create a system that can perform the monitoring and evaluation of activities by utilizing the KM system. The study proposed multi-agent system architecture developed to monitor the research activities. In this study, an intelligent system is used as a decision-making and / or advisor to the selection of university management strategies. In addition, the system also functioned,

adaptation to the needs of the university with the current economic realities of the world of work, in the context of periodic evaluation of university activities.

- Bhat [98] – in 2012.

Propose a model log agent to record all activity or file activities and events carried out by the agents of different agents in the KM system. The model was designed using the JADE framework through FIPA standards. Event log is created in XML format extensible providing a clear structure for each event is different. The advantage of using a model log agent is able to collaborate with other agents that have been implemented to perform the tasks of KM.

- Ismail [99] – in 2012.

This study proposes a framework of multi-agent systems to seek knowledge networks, analyzing and managing reputation points. With the aims to make the process of identifying sources of expert knowledge in order to fulfill the requirement in managing personal knowledge or personal. This model can do the tapping tacit knowledge that is embedded in the process of externalization.

- Rahman [2][100] – in 2012.

2 This research proposes the architecture of KM system using multi agent systems, to the needs of the effectiveness of the circulation of knowledge in the public sector. This study discusses the implemented system for providing communication between of agent. The use of knowledge is done by using the experience / past cases agent. Reduce the overhead of time and serve relevant knowledge at the right time and provide the best solution, as well as increasing the productivity of the system and quality of service.

- Kamble [3] – in 2013.

KM architecture proposed provides scalability, reusability and adaptation support system. This study describes how agents communicate with each other to automatically disseminate knowledge to produce a rapid process and can ultimately improve the quality of organizational services. Form the system architecture and the communication between agent automatic computations. The system architecture provides the solution according to the demand requirement.

C. Summary and Further Research

This paper discusses the topic of multi-agent system approach to KM model, the underlying issue in the discussion of this paper: (1) the diversity and complexity of organization environment that strive rapid changes, and affect to organization knowledge, (2) KM solutions need adaptation which can anticipate the problems. This problem made knowledge roles in organization not working properly, and the impact to performance of the services organization. The current solution is through multi-agent system approach, the solutions can be classified based on goals, as follows: (1) multi agent as modeling technique, where the agent is used to represent organization environment for organization's KM operational system, (2) multi agent as implementation of KM function, to coordination KM processes.

The advantage of this solution is multi-agent system approach with its characteristics able to extract necessity of created system, but several solution all of them almost talking about operational process, it is very little that explain about evaluation, moreover about planning to control knowledge growth. Based on those explanations, we can take an idea for further research, it is how the knowledge can sustainably grow and develop according with its environment needs, so that can adapt with changes that will arise.

IV. CONCLUSION

Organizational model when viewed from an explanation of this paper's, is a heterogeneous environment and have a level of complexity that requires control and coordination between the elements in harmony with the other elements. Organizational problems are not only related to the elements of the technology, but the interaction factor, process, as well as the behavior of information technology and organizational culture is an element that should be getting attention for the accomplishment of the organization's systems. KM can be an important factor in determining the achievement of these goals, if they have strategies and techniques with proper design. Multi-agent systems as a paradigm of software with characteristics can be the perfect solution for the improvement of KM performance. Various works have been discussed in this paper, the focus of research contributions covering the needs of modeling and implementation techniques, so that the organization can be a political reality automation services through the ability to extract a model of organizational needs. In addition, research studies to try to meet the elements of harmony between people, processes, and technology as the components that are interconnected within the organizational environment. According to results, appeared new idea about controlling the growth of knowledge as a form of adaptation toward changes. This matter can be used as preliminary picture for further research, with point of view not only from operational side, but from planning and evaluation side that can determine sustainability of knowledge growth.

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