Research on Cognitive Information Systems in Enterprise Environment

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Abstract. The aim of the publication is the clarification of the meaning of the cognitive information systems that helps to conceptualize the primary areas of operation, in the world of enterprises with examples. It helps to understand the future, points to the potential benefits and highlights the importance of the development a methodology that efficiently helps and guide the EE (Enterprise Engineering) society to implement CIS (Cognitive Information Systems) into EE and enterprise environment. The rapid change of world causes new challenges in the enterprise environment. Those challenges increase the chance for client or customer satisfaction meanwhile improve companies' efficiency, optimize processes, operation etc. Due to the complexity and speed, enterprises are not able to answer these challenges easily in time. Skills to manage the actual situation are rarely available in one single person or in one team, therefore one of the possible solution is to leverage the capability of a cognitive information system.

Keywords: Business Information Systems, Cognitive Information Systems, Information Systems Modelling, Business Process Alignment, Digital transformation.

1 Introduction

The concept of *Cognitive Information System* (CIS) appeared as an intersection and shared area of Information Systems [1], Cognitive Sciences and Cognitive Infocommunicaton [2]. Modelling, analyzing, and designing information systems in the most recent technological advancement makes it possible– at the same time –, and makes it an obligation for architectural and design principles that combine the development of technology and theories of Cognitive Sciences. We think of architecture of information systems within enterprises in the sense of Zachman [28] and TOGAF framework [13]. Zachman in our days is called ontology, both architecture framework are general methodologies, therefore this would help to place the information systems in an enterprise environment, ensure theoretical background in this stage of the research. ArchiMate is a concrete software/IT architecture design methodology, meanwhile DEMO is a behavior model, focus on the functions and processes. DEMO is built on the PSI (Performance in Social Interaction) theory [8] In this theory, an enterprise (organization) considered as an interaction of social individual subjects.[6].

Cognitive Sciences offers the analysis of cognitive tasks, i.e. the investigation of decision making, of reasoning skills of examined subjects whilst the subjects deal with a set of complex information [25]. Interdisciplinary research on human expertise and on domain specific cognition has yielded theoretical and methodological background that can be employed to create architecture and design principles that can assist in the realization of CISs [19]. Cognitive Sciences studies "*the principles, architectures, organization, and operation of natural and artificial intelligence systems*" [11], thereby Cognitive Sciences is an intersection of scientific domains among artificial intelligence, psychology, linguistics, anthropology, neurosciences, and education. The approaches of informatics that can be exploited on the common field of Cognitive Sciences and information systems are as follows: knowledge representation, ontologies, description logic, computational linguistic, machine learning, and computational intelligence, thereby CIS is a valuable tool for business process management.

The preliminary research is part of the preparation work of a PhD thesis to aim for a future dissertation.

The research methodology that were applied during the research analyses and assessment of the available (limited) publications pursued the comparative study pattern, i.e. studying and comparing the results published in articles, then a case study paradigm has been used for observing and monitoring the work with a CIS during daily operation. The literature survey is restricted on the domain of the CISs in the enterprise environment.

2 Literature Survey

CISs can be regarded as an interdisciplinary research topic that has emerged as an interaction between information systems and Cognitive Sciences including psychology, neuroscience, cognitive modelling, cognitive ergonomics, linguistics, biology, anthropology, and various branches of artificial intelligence [19]. The most essential characteristics of the research area:

Information interchange and interactions between the

Proceedings of the XX International Conference "Data Analytics and Management in Data Intensive Domains" (DAMDID/RCDL'2018), Moscow, Russia, October 9-12, 2018

humans and machines (carbon and silicon agents) have need of cognitive capabilities: CISs are socio-technological systems, i.e. interactions between humans within the system environments and between humans and machines with the cognitive capabilities may happen as well, the information interchange can be characterized the way of the communication and use of the services provided by cognitive systems. The answer to the question what makes a system cognitive is the following according to Hurwitz:

> "*Three important concepts help make a system cognitive: contextual insight from the model, hypothesis generation (a proposed explanation of a phenomenon), and continuous learning from data across time.*" [12].

This imply Big Data analyses and understanding where the problem which was addressed to the CIS is enabling the cognitive system to provide various recommendations, using the mechanism of machine learning and model building. IBM Watson analyze the data in context based on which generates hypotheses meanwhile provide various outputs as predictions or recommendations for solutions with various level of reliability.

The CIS is a socio technology system, which impacts the large environment in which it is used. Ogiela [20] collected areas of application of informatics and information technology where cognitive information processing techniques are incorporated into various systems as business information systems, biomedical systems, identity and access management, autonomy and embedded systems etc. The difference between cognitive and traditional information systems can be grasped by the notion of cognitive methods. Wang postulates that a "denotation mathematical" approach is required that own structures, tools, and methods beyond the traditional mathematical logic [27]. However, the referenced mathematical areas are as follows: Concept Algebra, Real-time Process Algebra, and System Algebra. The business applications that are listed in Ogiela [20] considers multiple utilization in various industrial segments.

Economic ratio interpretation within the decision-making analysis for an enterprise; usually linked to some decision which can be transformed in some way to financial benefit [23]. The same can be told about ratio analyses. The ratio analysis is part of the evaluation of credit worthiness. In general, such an analysis evaluates the risk of repayment and considers how it will be repaid.

The stock exchange games (belonging to decision-making analysis too) can be perceived by the same way, i.e. due to the nature of the analyses is not far from ratio analyses considering cognitive resonance. The cognitive resonance linked to the market expectations as any investment on stock exchange movements [22].

Currently, the human, carbon agent extended with a silicon agent that can be considered as an intelligent information systems extended with embedded knowledge-bases and reasoning capabilities. The two facets of data interpretation should be fitted together, at least in the sense of rough sets; if they cannot be reconciled then the trial to integrate the different views of data to understand them is not successful. However, there are CISs, which apparently analyze unstructured data without two facets data interpretation, but in fact there are deep semantic analyses behind of data integration. The semantic analysis is the overarching concept for CISs. The major elements are as follows: data pre-processing, data representation, linguistic perception, pattern classification, data classification, and finally cognitive resonance and data understanding [21]. The information architecture that can provide an opportunity for creating a framework to describe the information exchange between the human parties along with her/his supporting silicon agent and CISs can be grounded in Enterprise Architecture [13], [28] and LIDA [14][10]. The basic principle of LIDA (Learning Intelligent Distribution Agent) that either silicon agents (machines, software, robot, artificial artefacts etc.) or carbon agent (human, animal) should continually discern its environment, decode the sensory data and then operate according to the sensed information. The advantage of the LIDA model as an architecture is that it focuses on the cognitive processes and their structure at both conceptual and computational level [9]. The LIDA and similar cognitive architectures offer the chance to apply it for complex planning and scheduling tasks that are parts of program and project management in enterprises.

3 Digital Transformation and Enterprises

The digital transformation of enterprises affects the business model and business architecture including the business process models, considers and impacts all aspects of the enterprise. Integration of CIS into EA give the chance to fill the gaps and improve the process chains for value creation, the actors and roles related to processes thereby each single element of EA is impacted by digital transformation. The „*Digital transformation (DT) – the use of technology to radically improve performance or reach of enterprises –is becoming a hot topic for companies across the globe. Executives in all industries are using digital advances such as analytics, mobility, social media and smart embedded devices – and improving their use of traditional technologies such as ERP – to change customer relationships, internal processes, and value propositions"* [7]. As it can be seen from the quotation, the business level meta-process is the Digital Business Transformation [4], i.e. the profound restructuring and reengineering of enterprises or organizations. This procedure can be perceived as a total redefinition of EA in light of CIS, leveraging its capability.

The alignment requirements between business model and technology to be applied can be examined in a systematic approach. A simplistic version of IT strategy formulation and strategic alignment can be used:

Analysis of the impact of the Information and Digital Technology on the Business Sector. Elaboration of multiple scenarios for investigation of possible amendment of value creation whereby the technologies to be applied and the market niche scrutinized. The deliverable is a proposal for changes.

Gap analysis of actual EA, and technology position of the enterprise and opportunities. The second stage comprises the analysis of products, services, customers/consumers, and geographical distribution including cyberspace, Thus, an IT and digital strategy for business will be developed. The deliverable will enclose the description of gaps on the competencies and EE.

Develop the roadmap for alignment between future business model and actual Cognitive EA. The alternatives of future scenarios will be developed. The various aspects of Digital Transformation are conceptualized in detail. Various perspectives of Cognitive EA promoting CIS will be affected as e.g. Business Process for Value Creation, Collaboration and Workflow Model, the Functioning Enterprise. In this way, the future EA is articulated, then the layer for technology, physical and operational architecture is worked out. The alignment between the operation model and business and IT services will be carried out.

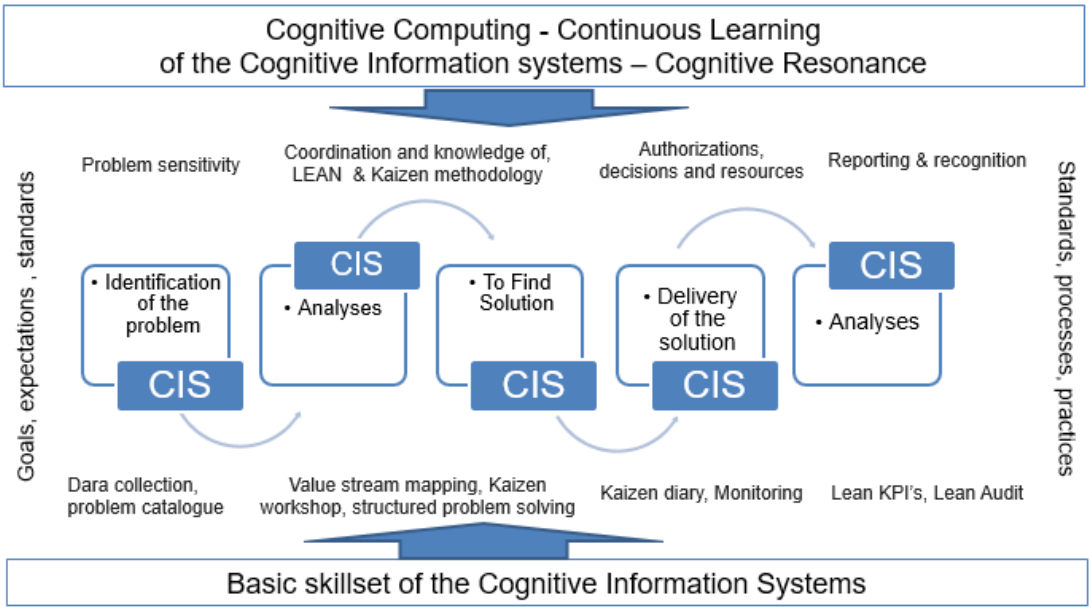

Figure 1. A high level combined figure about the steps of Kaizen with CIS

3.1 Enterprise Engineering and Cognitive Information Systems in Digital Transformation

Realization of the Digital transformation to become a Digital/ Cognitive Enterprise, EE ensure the necessary approach and methodology for the digital transformation. Lean philosophy followed by Kaizen methodology a possible tool of the transformation. Kaizen ensure the continuity of the continuous improvement focusing the entire business operation and following SU-HA-RI (Learn the rule, Follow the rule, Break the rule).

Enterprise become a cognitive enterprise via digital transformation leveraging cognitive information system capability for continuous improvement. Adopting various new tools, techniques and methodologies requires follow, SU-HA-RI to ensure the highest efficiency in the current situation, leveraging the flexibility given by "break the rule", which ensure the possibility to changing it. The simplified and combined figure demonstrate the areas (steps), where is the possibility to leverage various capability of CIS as an initial basic and high level framework of digital transformation, which ensure the needed flexibility to adapt CIS and its utilization to the current environment and situation. Based on the basic skillset off CIS improvement can be achieved on various segments, however with the capability of continuous learning, which is one of the requirement of CIS via cognitive resonance achievable the improved understanding of the enterprise need, which support the adaption of the methodology, and the concept of the continuous improvement. This process iteration by iteration increase the knowledge about the enterprise itself and its environment and need.

Our view that CIS not only helps to understand the concept of the continuous improvement, however it helps buy-in on visualization but supports the entire adoption realization, implementation, with further advantages. CIS involvement step by step drives the enterprise on the way of digital transformation to become a cognitive and digital enterprise meanwhile improve its knowledge, efficiency etc.

4 Illustrative example of cognitive business operation and analyses

The new operational ways with new business processes,

business process management and process reengineering, agile corporate management, process documentation, are set of activities in order to manage your processes in a fast, error-free, and cost-effective way. CIS is a tool to support the enterprise success providing business intelligence. The data is processed and analyzed at the point of engagement and possibly in combination with the venue data or social media information. Other industries also play an important role in the processing and analysis of moving data, such as healthcare, telecommunications, medicine production, and even power plant management [12].

Companies typically focus on primarily structured, well-known, and frequently used data, however, there is a significant amount of stored data that is not analyzed, are dark data, due to a huge amount of data is generated in semi-structured and unstructured of format. These are usually log data from different equipment or security systems that can be of significant relevance to protecting the company's internal information, but may be important both for steady or continuous operation in evaluating the status of a machine or plant as these data for predictive analysis can help companies that they know exactly when a machine fails or when the traffic pattern changes [12].

At the University Medical Center, Groningen, Netherlands based on paper based administration system showed that over a 5-month period there were 592 hospital admissions and 7,286 medication orders, 60% of those had at least 1 prescribing or transcribing error. These errors resulted in 103 adverse drug events that were preventable, resulting in 92 cases that experienced temporary harm, 8 cases that required prolonged hospital admission, 2 cases that were life-threatening and 1 fatality [26]. Based on the results of developing systems that reflect the physical, cognitive and social needs and goals of a person or team in the context of the technology, environment and culture with which they operate, positively impacted all of the negatives created by the paper based system as medical errors, adverse events, reduction of mortality, and complications etc. [26].

The technological development is the outcome of the research and development activity, and furthermore innovation. The CISs like Watson completely different from the traditional information system, the result of the analyses completed with Watson might initiate the transformation of the enterprise, redefines the mode of operation. Commitment from the management, flexibility and the employee enablement is needed to implement a CIS, because changing organizational structure, flatting the organization hierarchy, simplifying the business processes, initiating standardization and automate of internal processes, occurs further impacts in various fields, that improving all fields of effectiveness in manufacturing, service providing etc. Beside efficiency extremely important the transparency, the zero level abuses and corruption on which CIS ensure various alternatives. Success in business process management required identifying the most effective and operable process in the current situation, which has the related controls build into the process flow to maintain the effectiveness to achieve the organizational objectives as part of the goals of the enterprise. Within the framework of business process management, the elemental step to analyze processes through breaking down into tasks, and identify firstly the areas, of potential risks. Based on the analyses, those segments have to be identified where immediate actions are needed.

Big Data Analytics and analyses form different sources with CIS, reduces the possibility of the noncompliance related to the corporate rules. CIS ability to analyze deviations, therefore, reveals the weaknesses and gaps within the processes. Analytics and measurement provides feedback for further development with various and concrete (agile practices) actions using different methodology of analytics like predictive, prescriptive etc. It provides information on impacts drivers and correlation within inputs and outputs and other factors.

According to CRM Fundamentals by Scott Kostojohn, the customer experience is becoming more important to businesses as a differentiator; the sophisticated grow and increased demand did not pair with loyalty [15]. CIS could help on management or employees buy in utilizing visualization capability, demonstrating impacts and factors in a combined view. *As is analyses* helps to understand the actual situation and it identifies the starting point of development. In case of lack of measurable output, the information system calls attention to potential KPIs (Key Performance Indicator) that are not conform to requirements and so their deviations should be analyzed. All extremism is a data to be analyses, as usually it is related to process gaps, which might call attention of internal audit. During customer behavior analyses possible to identify special needs and missing alignments. Big Data analyses, unstructured information analyses are realized by CISs bring the toolset of Data Science on the scene. Data driven operation, using CIS capability transforms operation to cognitive operation, and it transform the organization to cognitive enterprise. Kaizen methodology combined with the CIS ensure opportunities for the corporate for continuous improvement and for longer term, carries a change of view and working methodology. Each process improvement or reorganization brings close the expected Client satisfaction and. This is the basis of the continuous improvement, which provides further advantages. Both Kaizen methodology and cognitive computing supports the enterprise on various level form employee to management, providing differentiate view with various visualization and level of information about the enterprise itself and its environment. This cooperation would help for the quick and flexible adaptation to the client need and environment challenges. In complex organizations breakdown of functions for work streams that works individually and time to time by milestones interlocks with the other work streams to harmonize the collaboration to achieve and share the best practices under Kaizen umbrella, which results better performance and higher quality of the outcome.

4.1 Classification and analyses with cognitive information system

Based on examination of various systems called CIS, recognized various level of complexity and significant further differences, through the notion of cognitive resonance. This scale would identify the maturity level of the system versus CIS. According to the investigation of various CISs, as different e.g. UBMSS CISs, Watson (IBM), Leonardo (SAP) and SAP HANAH. Cognitive search engines were not subject of analyses. The taxonomy of cognitive levels for the above-mentioned systems, is a scale in descending series is as follows: Watson (IBM) is ranked as within the highest cognitive level, Leonardo along with SAP HANA was following it, as it is a tool for cognitive system development too. Based on the categorization UBMS Systems were classified as a zero level CISs. The CIS maturity is tight coupled with the cognitive resonance level.

Traditional information system: (1) for basic level of business processes and basic level of cognitive resonance (basic level of business process, transactional high volume repetitive task). Traditional information system (2) with low complexity level of business processes, with initial level of cognitive resonance.

Cognitive information systems:

- CIS (1) with medium level complexity of business processes and low maturity for cognitive resonance
- CIS (2) with high complexity of business processes and medium maturity for cognitive resonance
- CIS (3) with high complexity of business processes and maturity for cognitive resonance

This evaluation can be developed and extended further with additional socio-ergonomic factors, however based on the experience there is a need to clearly identify the content of the CIS, which helps for carbon agents, in the corporate environment for business users, in the information technology environment for developers.

5 Future research direction

A CIS in an enterprise environment can be defined as a socio-technological information system that unifies the enterprise architecture and cognitive architecture (e.g. LIDA) in an overarching architecture approach. Considering the Zachman framework as an overarching approach, a CIS belongs to the views of Business Analyst / Strategic Planner, and System Analyst and System Designer. The CIS is involved in the process/function and data perspectives. A CIS is an adaptive system that can handle the dynamically changing business environment and can incorporate the alteration of business processes by a way that the realization of changes is implemented in a systematic and consistent manner through the three seasons of business processes, i.e. analysis, design and implementation / operation [3]. The above presented analysis about the concept of CISs in enterprises pinpoints the deficiencies of the recent advancements. *Firstly*, there is a need for integration of enterprise architecture and cognitive architecture approaches in the socio-technological environment of an organization. The architecture integration in this sense would lay the groundwork for an overall architecture that main objective would be to provide design principles for CISs to achieve cognitive resonance among the stakeholders. *Secondly*, enterprises come across regularly business problems as business process efficiency and effectiveness. The data set that was raised as the subject of the analysis in the case of UBMSS plays only minor role in the daily operation and strategic planning of companies. The data analytics as applied Data Science is a new source of information for enterprises to chase efficiency and effectiveness in their operations. Beside the algorithms of data science, the application of methods of data science requires adequate models beyond the default parameter set of the specific algorithms, and then the results of the analysis as patterns, relationships, association etc. should be interpreted for human cognition. The concept of cognitive resonance is a handy notion for perception and description of the real problem. The major task of the research is to exploit the cognitive architectures in line with enterprise architecture for defining models, determining results and exhibit the outcomes for stakeholders, senior management in concise and comprehensive format. Naturally, the available cognitive architectures should be investigated what can be integrated to the requirements of enterprise architecture and architectures of data science [16]. To create design principles for supporting model creation, model perception and interpretation will be the task of the research in the sense of Design Science Research paradigm[18].

6 Conclusion

We have overviewed the most recent literature on CISs related to business administration and economics. The definition of CISs refers to the cognitive architectures, data processing, models for insights hypotheses for new phenomenon and opportunity for the silicon agents for the continuous learning. The cognitive resonance provides a kind of interpretation framework for describing the information interchange between human and automated systems. Although, the ideas of economic analysis are superficial from point of operating enterprises where the management and information systems should solve in tandem serious problems. Hence, the research has plenty to do on defining the idea of CISs in economics, business administration, organization science, then it should formulate a reconciliation between the enterprise and cognitive architectures to leverage the tools of data science for business efficiency and effectiveness. The scientific and technological literature contains the description of massive CISs with the enormous resource requirements that may be accessible by huge international enterprises even taking into account some kind of cloud service as Software-as-a-Service and its cost. The subject of the research is two-pronged, on the side of the practice the main aim is to grasp the notion of CISs that can be used for micro, small and medium enterprises, on the other side of formal approach the goal is to establish a model that

define the business and information architecture, the major services exploiting the formal and semi-formal tool set of computer science.

Acknowledgement. The project has been supported by the European Union, co-financed by the European Social Fund (EFOP-3.6.3-VEKOP-16-2017-00002). This work is supervised by Professor Bálint Molnár, Faculty of Informatics, Eötvös Loránd University in Budapest.

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