Dynamics in Information Demand Patterns: A Case Study from Situative Maintenance

Kurt Sandkuhl, Holger Lehmann

University of Rostock, Chair of Business Information Systems, 18059 Rostock

{kurt.sandkuhl, holger.lehmann}@uni-rostock.de

Abstract. The paper investigates a topic related to demand-oriented information supply in organisations: how to discover the need for changes and updates in information demand descriptions, such as information demand patterns (IDP), and make them more dynamic. The research approach taken is explorative: using real-world requirements from projects motivating the IDP development, we investigate causes of change and a possible classification of these causes. We analyse information demand of selected roles, develop an IDP and analyse causes for changes in information demands. The contributions of this paper are (1) to motivate the need for research on dynamics in IDP, (2) the analysis of dynamics in a selected IDP, and (3) a classification of causes for the changes.

Keywords: information demand, information demand patterns, dynamics.

1 Introduction

In the field of information logistics, much research work during the last two decades has been spent on understanding the nature and practices of information demand [[1], [5]], developing methods and technologies for improving demand-oriented information supply in organizations [[2], [4]] and implementing or evaluating solutions for various application scenarios (see, e.g. [[3]]). However, judging from the published research work, IDP so far are considered as a rather static construct, i.e. the information demand of an organizational role captured in IDP is considered as quite stable. In a recently performed industrial case study we observed changes in IDP which give reason to believe that such changes also occur in other organizational settings. We argue that an enriched IDP-model representation could support detection and remedying such changes.

The research question discussed in this paper is “In information logistics, what are the causes for changes in information demand and how can changes be discovered in information demand patterns?” The research approach taken is explorative: using real-world requirements from projects motivating the IDP development, we investigate causes of change. We analyse information demand of selected roles, develop an IDP and analyse causes for changes in information demands. The contributions of this

paper are (1) to motivate the need for research on dynamics in IDP, (2) the analysis of dynamics in a selected IDP, and (3) a classification of causes for the changes.

The remaining part of the paper is structured as follows: section 2 briefly describes the research method we use. The background for our work from information logistics is described in section 3. Section 4 presents an industrial case showing examples for changes in information demand based on the demand of certain organizational roles. Section 5 investigates the causes for change. Conclusions and future work are discussed in Section 6.

2 Research Method

Research work in this paper started from the following research question which is based on the motivation presented in section 1:
RQ: In organizational information supply, why is the information demand of roles changing and how can these changes be categorized?

The research method used for working on this research question is a combination of literature study and descriptive case study. Based on the research question defined, we started to identify existing approaches for dynamics in information supply. The purpose was to find existing theories or approaches that investigate changes, evolution or observed dynamics in information demand. Since the literature study returned no such theories or approaches (see Section 3), we decided to perform a case study in order to gather information about possible manifestations of dynamics. Qualitative case study is an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources [10]. This ensures that the subject under consideration is explored from different perspectives that allows for multiple facets of the phenomenon to be revealed and understood. Within the case study, we used two different perspectives, which at the same time represent sources of data: We observed the activities in the industrial case (maintenance planning) and we analyzed documents from different phases the observed process, including the documents describing the facility in question, common instructions and administrative documents involved (cf. section 4.1).

Yin differentiates various kinds of case studies [10]: explanatory, exploratory and descriptive. The case study presented in Section 4 has to be considered as descriptive, as it is used to describe the phenomenon of information demand change in the real-life context in which it occurs. Based on the case study results, we conclude that there is a need for further investigating dynamics in information demand and suitable methodical support. This argumentative-deductive part is discussed in Section 5.

3 Background

This section will briefly describe the background for our work from information demand analysis (Section 2.1) and information demand patterns (Section 2.2).

3.1 Information Demand Analysis

Much work in information logistics has been spent on defining and understanding the characteristics of information demand. We will use the results of Lundqvist who defined information demand as follows: *"Information Demand is the constantly changing need for relevant, current, accurate, reliable, and integrated information to support (business) activities, whenever and where ever it is needed."* [[7], p.59]. Furthermore, Lundqvist's work confirmed the conjecture that information demand of a person is based on the roles and tasks this person has: "*Information demand depends on the role and tasks an entity has within a larger organization. If the role and/or the tasks change, so too will the demand"*. This role-centric perspective with task and responsibilities as primary characteristics was the starting point for developing a method for information demand analysis. This method consists of several interconnected phases that can be applied in a sequential and iterative manner. The information demand analysis (IDA) method was developed to support this task based on a well-defined method notion [[8]]. According to the IDA-method, the process of analysing information demand starts with scoping the area of analysis, includes modelling, analysis and evaluation of information demand context, and concludes in the application of the results in suitable information systems implementation and/or business process reengineering activities. The phases in the IDA process have a clearly defined list of prerequisites and expected outcomes as described in the method handbook [[6]]. The different phases have the following main characteristics:

- *Scoping*: Scoping includes definition of the area of analysis and has the purpose of selecting the part of an organization to analyse with respect to the information demand as well as identifying the individuals providing the necessary background information during the continued process of analysing.
- *Information Demand Context Modelling:* The main purpose of this phase is to identify the basic information demands based on the core concept of information demand context, i.e., which role needs to do what tasks and what does this require in terms of resources.
- *ID-Context Analysis and Evaluation:* Once the context related information is gathered this has to be analysed and represented in a format useful for continued work. During this phase a choice has to be made whether or not analysis should be continued and if so what refinements to focus on.
- *Representation and Documentation:* As the different analysis phases produce models and documents expressed in different notations the purpose of this phase is to collect and combine the results into a unified coherent representation that can be used to communicate the information demands as well as utilize them in activities aimed at improving information flow.

3.2 Information Demand Patterns

The basic idea of information demand patterns (IDP) is similar to most pattern developments in computer science: to capture knowledge about proven solutions in order to facilitate reuse of this knowledge. In this paper, the term information demand

pattern is defined as follows: *An information demand pattern addresses a recurring information flow problem that arises for specific roles and work situations in an enterprise, and presents a conceptual solution to it* [[9]]. An information demand pattern consists of different parts (see Section 5 for an example):

- The *pattern name* usually is the name of the role the pattern addresses.
- The *organisational context* explains where the pattern is useful. This context description identifies the application domain or the specific departments or functions in an organisation forming the context for pattern definition.
- The *problems* of a role are identified. The tasks and responsibilities a certain role has are described in order to identify and discuss the challenges and problems, which this role usually faces in the defined organisational context.
- The *conceptual solution* describes how to solve the addressed problem. This includes the i*nformation demand* of the role, which is related to the tasks and responsibilities, a *timeline* indicating the points in time when the information should be available, and *quality criteria* for the different elements of the information demand. These criteria include the general importance of the information, the importance of receiving the information completely and with high accuracy, and the importance of timely or real-time information supply.
- The *effects* of using the proposed solution are described. If the needed information should arrive too late or is not available at all, this might affect the possibility of the role to complete its task and responsibilities. Information demand patterns include several kinds of effects: potential economic consequences; time/efficiency effects; effects on increasing or reducing the quality of the work results; effects on the motivation of the role responsible; learning and experience effects; effects from a customer perspective.

The above parts of a pattern are described in the *textual description*. Additionally, a pattern can also be represented as a *visual model*, e.g., a kind of enterprise model.

4 Industrial Case: Maintenance Planning and Management

This section summarizes the design, content and results of a case study on dynamics in information demand which was performed in a medium-sized company offering facility maintenance services. The purpose of the case study was to study dynamics of information demand and why dynamics occurs.

4.1 Case Study Design

In order to investigate the origin of information demand dynamics, we had the possibility to study a case from facility maintenance. This case originated from a cooperation between industry and academia which aims at implementing process innovations in the case study company. This resulted in the rare opportunity to study information demand from inside the company. From a method perspective, we followed the recommendations of [10] for performing qualitative case analysis. The unit of analysis in the case study is the organisation unit “maintenance”, i.e. our work does not address repair or construction services. In this organisation unit we studied the

core work processes and the tasks and responsibilities of all involved roles. The data sources used are documents provided by the case study company and notes taken by the personnel involved in the project. Furthermore, one researcher worked several days in a maintenance team with the intention to observe potential differences with the management's view on how work processes should be performed and the reality in the field. The researcher collected information about the work processes, technologies used and practices by observing the co-workers and taking notes. The management of the case study company agreed to this procedure and the co-workers were informed about the purpose of the data collection.

4.2 Summary of Case Study Data

The case study company is medium-sized company from the North German region, which offers services in the field of ventilation, air conditioning, refrigeration and clean room technology. Since 1996, the company has been audited regularly according to ISO 9001 (quality management standard). Therefore, requirements regarding the traceability of the document flow, handling of complaints, development and application of quality-relevant measures and continuous further training in the industrial engineering and commercial areas are permanently implemented.

The employees of the company are specialists in ventilation, air conditioning, refrigeration, electrical, control engineering an energy consulting. The range of services relates to the business areas of project planning, production, delivery, assembling and service.

The case study is part of a cooperation project with the title *situational maintenance support*. The focus is on the area of maintenance & service, i.e. this organization unit of the company was examined more closely. The company's maintenance department carries out service activities on customer objects whose installations were built either in-house or by third-party suppliers. The project was initiated because the company was dissatisfied with the provision of information to its employees. The reasons were no uniform reports for maintenance and service, as well as in part the outdated work with analog documents.

In this context, the actual status of the processes was recorded and modeled, all relevant roles identified and their information demand determined using the method of information demand analysis[1].

To illustrate this, an example process of the maintenance department, in particular the role of the maintenance manager, is described below (see figure 1). The role of the *maintenance manager* must consolidate all relevant documents after receiving a confirmation of a new maintenance order. This role is also responsible for communicating with customers & employees and for preparing and follow-up maintenance. The activities of this responsibility include, for example, arranging appointments, executing & checking orders, writing invoices, creating checklists & protocols and

[1] Lundqvist, M; Holmquist, E; Sandkuhl, K (2009): Information Demand Context Modelling for Improved Information Flow: Experiences and Practices. In: IFIP. Aachen.

instructing technicians. Below is an excerpt of a process of the role maintenance manager in modelled form.

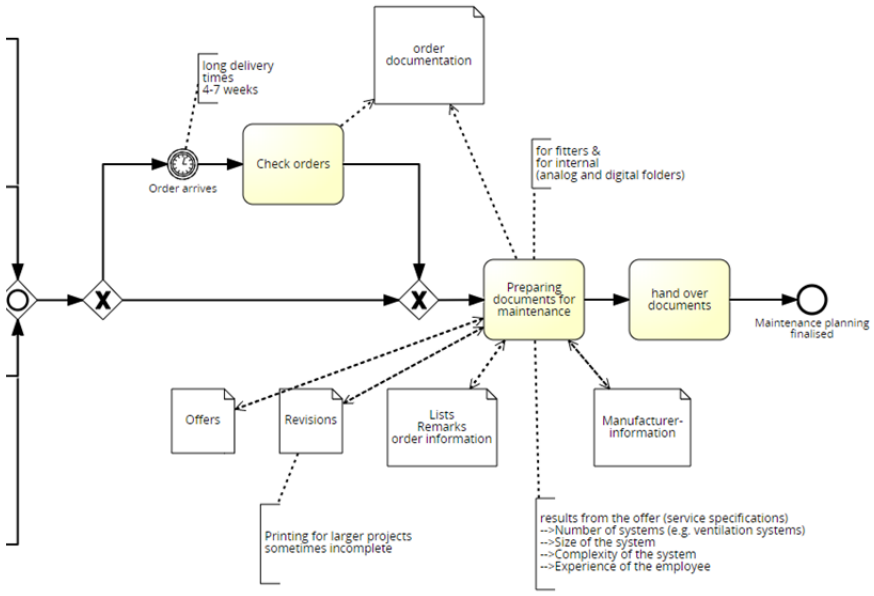

Figure 1. Section of a process model of the role Maintenance Manager

Several roles within the company show a certain dynamic with regard to the demand for information. This means that due to various factors, such as special requirements of customers, experience of the respective employees, use of components of new / other manufacturers, the information demand of a role can change.

4.3 Information Demand of the Maintenance Manager

For one of the roles, the head of the maintenance unit, we captured the information demand using the structure of information demand patterns (IDP). For brevity reasons, we only include an excerpt of the IDP. The pattern description follows the structure introduced in section 3.2. The first element is the context where the pattern is useful:

Context:
The context for this pattern is the management of maintenance in ventilation, air conditioning, refrigeration and clean room technology industries, in particular industry sectors with complex physical products. Own installations or third-party objects in the mentioned industry require regular maintenance, which must be carried out by trained personnel. Change reports, standardization updates, customer- or enhancements requests usually initiate changes in maintenance processes, materials or installed systems.

Systematic handling of such requests requires coordination of decision making and implementation. The role responsible for coordinating and managing maintenance works, specific processes, products, product parts or system is often called maintenance manager. The information demand pattern describes the information demand typically experienced by the role maintenance manager.

The pattern is supposed to be useful for enterprises producing and maintaining physical products with different variants and various released configurations. The pattern focuses on the maintenance manager, i.e. it does not include change implementation and change audit. In enterprises integrating change administration, implementation and audit in the same role, the pattern can be used as starting point, but needs to be extended.

The next part is the problem addressed by the pattern:

Problem:

The pattern addresses the general problem of delayed decisions, redundant activities and inconsistent data in engineering change management and the resulting product or quality problems. This includes the following problems, which were observed by practitioners in engineering change projects:

The pattern addresses the general problem of delayed decisions, hard-to-plan activities and inconsistent data in change management and the resulting product or quality problems. This includes the following problems, which were observed by practitioners in engineering change projects:

- Updates of used standards regarding the offer and planning of maintenance can influence these activities.
- Incorrect planning of both personnel and materials can result in delays and additional workload. The reason for this are varying system sizes, which cannot always be handled in the same way.
- Insufficient communication with other departments, such as measurement, control and regulation technology department, can lead to personnel and time shortages.
- Inadequate analogue information supply to the technicians causes an unsatisfying work flow on site because diverging requirements of some customer make it difficult to implement uniform processes
- Diverse customer requirements, especially for larger enterprises, sometimes do not allow the use of uniform documents and protocols. Because they use their own protocols.

It follows the information demand, which is based on the tasks and responsibilities of the role under consideration:

Information Demand:

The information demand is based on the tasks and responsibilities of the role. The tasks of the maintenance manage include

- Responsibility: to manage all stages of the whole maintenance lifecycle (a) data gathering, (b) quotation calculating, (c) planning maintenance, (d) performing maintenance, (e) quality management
- Collect data from own installations as well as from external objects, ensure its completeness & integrity and prepare them for further use.
- Calculate and prepare quotations for maintenance, including technical details, maintenance intervals, material and personnel planning as well as planned costs
- Coordinate personnel, materials and maintenance processes
- Decision-making on the basis of various requirements

The information demand of the role maintenance responsible consists of:

- To receive all relevant revision documentation regarding the object to be maintained and it´s technical units
- To get all information about general conditions of a maintenance object like contact persons, special requirements of the system, time restrictions etc.
- To get all information about diverse customer requirements like separate protocols that need to be used, activities that deviate from standard procedures, etc.
- To receive all information about working documents like protocols, work report, checklists, remarks or additional service reports
- To have access to the standard sheets to prepare quotations an maintenance activities
- To have access to the documentation of the installation at production time
- To have access to the documentation of history of maintenance of the installation
- To have access to the documentation of the manufacturer components used within an installation

The quality criteria for the information demand information use three levels:

- Decisive: you can’t manage without this information
- High: it is very important to have, but in worst case you could complete the task without
- Nice to have: you will manage without this information, but this will affect the result

For each pattern, the quality criteria are summarized in a table, which includes the information demand (left column), the general importance of this information, and the importance to get the information accurately, as soon as possible and completely. Table 1 shows an extract of the quality criteria for the example pattern:

Table 1. Quality criteria for example pattern

Information Demand	***General importance***	***Accurate***	***In real time***	***complete***
Revision documentation	*Decisive*	*Decisive*	*High*	*Decisive*
general conditions	*Decisive*	*High*	*High*	*High*
working documents	*Decisive*	*High*	*High*	*High*
history of maintenance	*High*	*High*	*Nice to have*	*High*
Standard sheets	*Decisive*	*Decisive*	*Nice to have*	*High*
[…]	*[…]*	*[…]*	*[…]*	*[…]*

The effects of not receiving the needed information or of receiving it too late are described in a short text and in a table. We will only include an excerpt of this text and table (table 2) due to space limitations:

Effects:

If the needed information should not be available or arrive too late this will have effects on the area of responsibility of the maintenance manager :

- Economic effects: the economic consequences could be
  - Increased costs by unnecessary and additional maintenance activities
  - Increased cost by Incorrect material consumption due to improper planning
- Time/efficiency of the task: maintenance management and maintenance processes will need much more time and will be less efficient. An example is
  - If wrong or too little material has been taken to a maintenance object, an extra trip to the object may be necessary.
  - If a standardization used for preparation and documentation changes, this can mean a revision of the complete documents.
- The customer relationship might influenced negatively. Examples are:
  - Contractual conditions such as duration of maintenance, used material or operational capability of the systems cannot be guaranteed.
- […]

Table 2. Summary of effects for example pattern

	Economic effect	***Time efficiency***	***Quality effect***	***[…]***
Revision Documentation	*High*	*High*	*High*	*[…]*
General Conditions	*Low*	*High*	*Moderate*	*[…]*
[…]	*[…]*	*[…]*	*[…]*	*[…]*

The above matrix shows the relations between information and effects. The following categories were used in the table:

- Low: The impact of any missing/inaccurate/late information is low.
- Moderate: The impact of any missing/inaccurate/late information is limited.
- High: the impact of any missing/inaccurate/late information may be considerable.

The timeline and the visual model of the information demand pattern are not included in the paper due to space restrictions.

5 Dynamics in Information Demand

In this section, we present possible changes in the information demand of the "maintenance manager" which can be observed in the case study and their reasons. Therefore, we dedicate ourselves to the question asked at the outset why the information demand of a role within an enterprise can change and for which reasons this happens. Within the case study, several influencing factors have arisen regarding the dynamics of the information requirements of the role of the maintenance manager (see figure 2). In the following the 3 examples Updates of standard sheets, diverse customer requirements and special manufacturer components are presented as an excerpt.

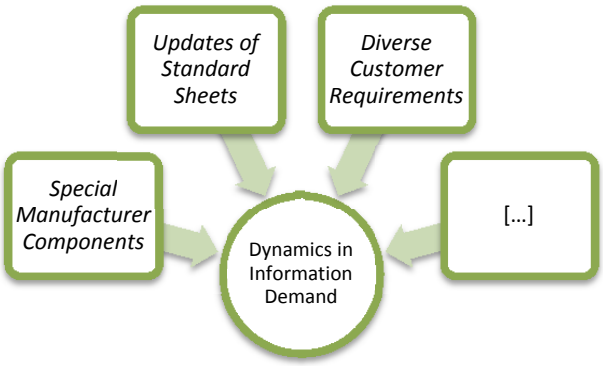

Figure 2. Influencing factors for dynamics in information demand

Updates of Standard Sheets:

The initial collection of information for third-party objects, the calculation of quotations, the planning of maintenance and the preparation of practical documents for fitters are based on so called "VDMA[2] standard sheets". The corresponding standard sheets of the VDMA-24186[3] standard are updated at regular intervals and thus cause a variable information demand for the maintenance manager in the case study. The reason for the changing need for information lies in the use of the standards and its topicality within the activities of the maintenance manager. The quotation for a

[2] Verband Deutscher Maschinen- und Anlagenbau e.V. (VDMA) is europe's largest industrial association with around 3200 members and is headquartered in Germany. One of the central topics of the VDMA is standardization and technology policy.

[3] available at https://aig.vdma.org/en/viewer/-/v2article/render/21480821, last call at 29.08.2018

maintenance assignment is based on the VDMA standard 24186, which means that uniform component designations and the maintenance procedures proposed by the VDMA for the respective component are used in the quotation. Based on the quotation, the maintenance manager creates documents for the persistent documentation and for the work instructions of the fitters such as checklists, inventory lists or protocols. If the maintenance manager receives the information about the update of the VDMA standard too late, in the worst case all documents created would have to be revised.

Diverse Customer Requirements:

Usually the maintenance manager uses the uniform documents of his own company to plan and carry out maintenance. However, sometimes it is necessary to deviate from the standard procedure due to special customer requirements. Some customers pretend to have their own maintenance protocols completed. This is often the case with larger companies, which also increases the complexity of the information content. If the information about this particular requirement is not known or is only known too late, both the planning process and maintenance could be affected to a negative degree.

Special manufacturer components:

In most cases of maintenance, the manufacturer and the type of components are known and can be maintained on the basis of the VDMA documents and the know-how of the technicians. In some special cases, previously unknown manufacturers or components were found in third-party objects whose required maintenance activities could not be clearly determined. In these situations, either manufacturer-specific documentation is required or the respective customer service must be contacted in order to carry out and log correct maintenance. This is also a variability of information demand to which the maintenance manager must react.

6 Summary and Outlook

Based on a case from maintenance management, this paper investigated if changes in the information demand of organisational roles occur and what the reasons are. The main observation is that we found several kinds of changes in information demand of the role maintenance manager. A next step could be a coherent classification of these changes for better reuse possibilities. In this context, we also assume that by analysing the effects of changes in information demand, a division into levels can be made:

- High-level changes in IDP – new tasks for organisational role
- Low-level changes – how the ID is expressed
- Implementation changes – how the ID is manifested

In future work, we intend to investigate how the detection of dynamics could be done in a systematic way. Our conjecture is that the use of the context analysis / context modelling approaches (e.g. [11]) could be feasible and useful. We intend to test context modelling methods for applicability and to develop a context model (cf. [12]) formalizing the variation that cause changes in the information demand.

Acknowledgement: The work within the frame of the SIWA project presented in this contribution was funded by Dr. Diestel GmbH, the State of Mecklenburg-Vorpommern and the EFRE Programme of the EU.

Literature

[1] Dinter B., Winter R.:. Information Logistics Strategy-Analysis of Current Practices and Proposal of a Framework. in Proceedings of the 42nd Hawaii International Conference on System Sciences. Los Alamitos: IEEE Computer Society, (2009)

[2] Lin F., Sandkuhl K.: A New Expanding Tree Ontology Matching Method. in On the move to meaningful internet systems. OTM 2007 Workshops. Berlin: Springer (2007)

[3] Meister S., Stahlmann V.: Telemedia l ILOG Listeners. Information Logistics Processing of Telemedical Values Using CEP and HL7. in Ambient Assisted Living. 2012. Berlin Heidelberg: Springer (2007)

[4] Billig A., Blomqvist E. and Lin. F.: Semantic Matching based on Enterprise Ontologies. In Proceedings of the 6th International Conference on Ontologies, DataBases, and Applications of Semantics.. Berlin Heidelberg: Springer, (2007)

[5] Lundqvist M.; Holmquist, E.; Sandkuhl, K.; Seigerroth, U., & Strandesjö, J. Information Demand Context Modelling for Improved Information Flow: Experiences and Practices. In IFIP Working Conference PoEM, The Practices of Enterprise Modelling, 2 (pp. 8 - 22). LNBIP 39, Springer Verlag, (2009)

[6] Lundqvist M.: Handbook for Information Demand Analysis. Version 1.0, Deliverable 4 of the infoFLOW project, April 2010, Jönköping University, School of Engineering, (2010)

[7] Lundqvist M.: *Information Demand and Use: Improving Information Flow within Small-scale Business Contexts.* Licentiate Thesis, Dept of Computer and Information Science, Linköping University, Linköping, Sweden, ISSN 0280-7971, (2007)

[8] Lundqvist M., Sandkuhl K., Seigerroth U.: Modelling Information Demand in an Enterprise Context: Method, Notation and Lessons Learned. International Journal Systems Modeling and Design, Vol. 3 (1), IGI Publishing. (2011).

[9] Sandkuhl K.: Information Demand Patterns. Proc. PATTERNS 2011, The Third International Conferences on Pervasive Patterns and Applications, pp. 1-6. September 25-30, 2011; Rome, Italy. ISBN: 978-1-61208-158-8 (2011)

[10] Yin, R. K.: Case Study Research: Design and Methods, Third Edition, Applied Social Research Methods Series, Vol 5; Sage Publications, Inc, 2002; 3rd edition, 2002.

[11] Sandkuhl, K. and U. Borchardt. 2014 “How to identify the relevant elements of context in Context-aware Information Systems?” 13th International Conference on Business Informatics Research (BIR 2014), September 22-24, 2014, Lund (Sweden). LNBIP, Springer.

[12] Berziša, S.; Bravos, G.; Gonzalez, T.; Czubayko, U.; España, S.; Grabis, J.; Henkel, M.; Jokste, L.; Kampars, J.; Koç, H.; Kuhr, J.; Llorca, C.; Loucopoulos, P.; Pascual, R.; Pastor, O.; Sandkuhl, K.; Simic, H.; Stirna, J.; Valverde, F. and J. Zdravkovic. 2015. “Capability Driven Development: An Approach to Designing Digital Enterprises” Business & Information Systems Engineering, 57(1):15-25, 2015, ISSN: 2363-7005, DOI: 10.1007/s12599-014-0362-0