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Concept into Architecture (CiA) – Integration of Domain Expert Knowledge into the Creation of Operational NAF-Architectures

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Abstract

Integrating the knowledge of domain experts in the creation of models, especially in challenging tasks such as the creation of enterprise architectures (EA), is of particular importance. The involvement of domain experts in the creation of these models is an important feature of successful projects. The focus of this paper is on the development and application of an easy-to-understand modeling method for collecting expert knowledge and a tool for automated transfer of this generated knowledge into a defined standard. These artifacts are developed and embedded in the specific context of Action Design Research (ADR) principles. Presented as a method called CiA (Concept into Architecture), they support the targeted involvement of domain experts in the modeling process and contribute to the integration of expert knowledge.

Keywords: Integration of Domain Expert Knowledge, Modeling Methods, Modeling Tools, Operational Architectures

1 Introduction

Architecture frameworks, such as the Zachman framework established by Zachman [1], are intended to promote the development of enterprise architectures (EA). These frameworks are used in companies as well as in the field of public administration or in the security domain [2]. Within the NATO alliance, the so-called NATO Architecture Framework, or NAF [3], is used for the creation of enterprise architectures in complex security environments. In this context, the modelling of processes is given a high priority in the context of enterprise architectures (EA): they are tangible for domain experts and modelers and form the starting point for architecture projects.

The regulations of the Bundeswehr prescribe the creation of different views of an EA in the context of procurement processes. The so-called operational architectures, which are defined by individual views of the NAF, are of particular importance at the beginning of a procurement project. The Bundeswehr defines operational architectures as the totality of operational processes, as well as the associated organizational elements and their mutual exchange requirements, in their operational context. Process models are an essential component of the operational architecture [4].

2 Related Work

This paper describes, using Action Design Research (ADR) according to Sein et al. [5], the development of a modelling method and tool that supports the involvement of

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domain experts in the process of modelling and automatically creates an operational NAF architecture consisting of a process model and the associated information exchange model from their contributions. Thus, according to Kaidalova et al. [6], it addresses relevant problems in the creation of EA. It builds on the work of Simões et al. [7], [8] with regard to process modelling and on the work of Sandkuhl et al. [9]–[11]with regard to the integration of domain experts.

The integration of domain experts in the creation of models and the extraction of business-related information, as well as its transfer into a model, is of particular importance. Kaidalova et al. [6] described this as one of the two practical challenges in modelling EA. Furthermore, Kaidalova et al.. [6] describe the degree of formalization and the level of detail of models as another challenge. Especially in the early stages of an EA project, it is therefore necessary to avoid overly complex models and to ensure that all stakeholders should be able to work with the developed models.

Process models and the information exchange relationship models based on them are an essential part of an operational architecture. Therefore, the consideration of work in the area of process modelling, the automated creation of process models and the involvement of stakeholders in process modelling is of particular importance.

Process Mining. The automated transfer of existing data into a model, as one of the challenges defined by Kaidalova et al. [6], can be found especially in the area of process mining, for example in the work of van der Aalst [12], [13]. Process mining deals with the extraction of information from existing data, which is generated through the use of, for example, workflow management systems (WfMS) or enterprise resource planning systems (ERP) (event logs). This is followed by the automated creation of process models with the support of tools. The process models created in this way represent the actual state of an organization. Process mining is therefore suitable for documenting existing processes ("as-is").

Storytelling. Projects that involve the implementation of a new process must ensure the integration of experts from the area under consideration. There are various approaches for integrating these experts into the process of EA creation. One approach frequently mentioned in the literature is the so-called story telling [14]. In this approach, experts, users or other stakeholders are asked about an issue and describe their view of things, related to requirements, handling in daily work, etc. This technique is also called a supporting method. This technique is also used as a supporting method in the area of requirements elicitation, such as in the REM4DSPL method presented by Sousa et al. [15]. In the implementation of storytelling, various approaches can already be seen in the literature. The transformation of the narrative into a standard or a form that can be used for the application follows on from the story telling as a continuative work. However, this transformation always leaves room for interpretation, which can have a negative impact on the final result. Therefore, several automated approaches exist in the field of storytelling

Gonçalves et al. use working in groups in their approach [16]. The results developed in the group and secured in prose form the input for the automated transfer [17]. Text mining is used to identify keywords, from which processes are then generated automatically by a tool using BPMN [18].

The implementation presented by Simões et al. [7] tries to obtain as much information as possible about a process from individual experts. This is supported by a tool presented

by Simões et al. [8], which enables the user to model a process without having any knowledge of modelling. Here, the user is provided with a graphical interface that enables him to describe a course of action. A BPMN model is automatically created from the documented information.

Participative Modelling. The two methods described above actively involve experts in the creation of process models. In this way, operational information is obtained, which makes a significant contribution to the creation of models of the company. This methodology addresses the challenges described by Kaidalova et al. regarding the extraction of information as well as its transformation [6].

A further use of the created models by the experts, such as the use of the process models as part of an EA, is not part of the consideration of the methods shown. Hauder et al. [19] define this as a problem that frequently occurs in practice. Banaeianjahromi and Smolander [20] define the origin of this problem in the lack of communication regarding the necessity of an EA and the resulting lack of cooperation between modellers and experts in the area to be modelled. The approach recommended by Stirna et al. to solve the problem of lack of communication and collaboration also refers to the active involvement of experts in the domain to be modelled through participatory modelling [21]. Here, the creation of models takes place in the form of group work, with the group consisting of modelers and domain experts. The challenges described by Kaidalova [6] are addressed directly, as the necessary information is provided through the participation of the experts and transformed through the documentation of the modelers.

Grass-Root Modelling. In order to make the development of models available to a broader layer of an organization without the support of experts in the field of model-ling, Sandkuhl et al. describe the so-called grass-roots modelling [9]. The aim here is to offer the experts the possibility to present their operational knowledge in the form of a model, which can later be transferred into a standardized form. This must be defined before modelling begins [22].

Work in the field of grass-roots modelling deals both with the provision of tools and methods for modelling by the experts and with the transformation of created models into a form specified by the organization [10].

The work of Reiz et al. [11], [23], for example, shows a method for modelling using PowerPoint. This method makes it possible for experts to easily document their knowledge in the form of a model using familiar tools.

The present work is also specifically in this area, since the presented method Concept into Architecture (CiA) provides an easy-to-learn and intuitively applicable method for modelling, as well as a tool that automatically creates an operational architecture (process and associated information exchange model) according to the organization's specifications from the data collected with it.

3 Used Research Design - Action Design Research

Work that deals with practical problems of an organization and attempts to solve them through the development and evaluation of artefacts is located in the field of design-oriented business informatics [24].

The aim of the Action Design Research (ADR) method is to solve organizational problems through a design process with inherently interwoven activities to create

artefacts, combined with their application in the organization and simultaneous evaluation [5].Sein et al. [5] describe the typical application field:

"ADR reflects the premise that artifacts are ensembles shaped by the organizational context during development and use".

ADR considers the influence of the organization and the implications that result from the different interactions within an organizational context. Furthermore, ADR focuses on the relevance of developed artefacts within an organization and how these changes through their use. The special feature of ADR is that the involvement of users does not end with the collection of information, but they are involved in the development of artefacts together with the researcher.
At the beginning of ADR, an initial problem is identified. To solve the problem, artifacts are implemented and evaluated in several iterations. These artefacts should contribute to the solution of the identified and practice-relevant problem [25]. The focus here is on demonstrating the usefulness of the artefacts. In order to achieve this, the design process must, among other things, be designed for the acceptance of the developed technology in the context of the organization (and thus the subsequent users) and also address the question of what influence the result of the research has on the environment of the artefact [26].
The present work was carried out in the department for CD&E projects in the Bundeswehr Planning Office (PlgABw), where one of the authors was employed at the time of the research. CD&E stands for "Concept Development and Experimentation" and is used to optimize capabilities, e.g., by testing new technologies or adapting existing processes. CD&E projects also include the creation of operational architectures as a basis for later procurement.
The starting point of the study was the identification of the status quo with regard to the creation of operational architectures according to NAF in CD&E projects and the derivation of the associated problem (initial problem formulation according to Sein et al.. [5]).
Based on this, the CiA method for addressing the identified problem was developed and applied, taking into account the operational specifications as well as the requirements of the potential users. The framework for this was provided by two CD&E projects. The period of the research extended over about four years.

4 Automated Creation of an Operational Architecture - CiA

The involvement of domain experts in the process of creating process models in the context of operational architectures and their further use in the course of the project is a challenge in any CD&E project. This topic is much discussed, both in the context of large projects involving external consultants and in smaller internal Bundeswehr projects.

The development and application of CiA, based on the initial problem formulation, was carried out in the context of two successive CD&E projects. In both projects, operational architectures were to be newly created. Since no experts from the fields of EA or modelling were available in the projects, the prerequisites for evaluating CiA

under real conditions were given. The members of the respective project teams, the project team in the first project consisted of ten and in the second project of five domain experts of the area under consideration, constituted the target group for the use of CiA.

4.1 Initial Problem Formulation – Status Quo of the Organization

First, the previous procedure for creating operational architectures in the context of CD&E projects was identified. The evaluation of existing documents (regulations, guidelines, etc.) formed the starting point for documenting the previous approach.

The governing regulation [4] shows that a "capability gap and functional requirement" (FFF) must be created at the beginning of a project. According to the regulation, this FFF contains an operational architecture at the process level. The minimum requirements necessary for this are provided by an information exchange model (NOV-2) and a process model (NOV-5).

The specifications shown regarding the required views are also confirmed by a guideline [27], which is created by a central office. This guideline also regulates the use of the software to be used, the "Sparx Enterprise Architect" (Sparx EA) from Sparx Systems, as well as the specifications to be used, which are provided by the Bundeswehr Architecture Data Model (ADMBw).

In order to ensure the necessary practical relevance, further data was collected by means of participant observation in two CD&E projects. These observations showed an established approach consisting of three phases:

- Phase 1 - Information gathering & data collection
- Phase 2 - Manual transfer of data into a NAF-compliant model
- Phase 3 - Content quality assurance & further use of the models

For information gathering & data collection as a contribution to the creation of a process model in the context of an operational architecture, an innovative method was used in both projects: the so-called picture map method (BKM) [28]. Established standards such as BPMN [18], EPK [29] or IDEF0 [30] were not used - the experience with these methods in a concrete context was not positive, the notations were not known and were perceived as too complex by the users. The BKM is an analogously applicable method for collecting information and securing it in the form of a process model.
The aim of the BKM is to depict and document procedures and processes in a group work based on a framework scenario with the help of different cards, the so-called picture cards. For further data collection, expert interviews were conducted [31]. Six experts were interviewed on topics such as the methods and tools used in CD&E projects and the involvement of experts in the creation of rational architectures. Furthermore, information was to be identified to verify the observed procedure. The evaluation of the interviews confirmed the observed established approach consisting of three phases.

The following problems in the creation of operational architectures were identified from the observations and the interviews:

For **information gathering & data collection**, the use of established standards is not practicable, as these require knowledge in the field of modelling. This is contrary to an easy and quick learning, which would require a training of the domain experts. Since the experts in the area under consideration only work with operational architectures during

the project, which is limited in time, this would be too time-consuming. For this reason, methods that are easy to learn and can be applied analogously, such as the BKM, are used. Although these are suitable for information and data collection, their results must **be manually transferred into a NAF-compliant model** by modelers. The quality assurance of the content must now be carried out by the experts who supplied the data. This is hardly possible due to a lack of knowledge in the field of EA, which means that the content of the NAF-compliant models cannot be validated by the domain experts. This also precludes further use of the models by the experts.

In order to optimize the established approach, it was decided to initially focus the work on the integration of methods that are suitable for data collection and information acquisition and whose results can be transferred into a NAF-compliant model (**automated creation of an operational architecture**). The automated operational architecture, consisting of an information exchange model and a process model, must be comprehensible to the domain experts in order to enable quality assurance of the content. This would allow the experts to be involved in all three phases of the established approach.

In order to achieve this, the requirements identified in the interviews were supplemented with a literature review and summarized in a catalogue of requirements. These requirements were compared with established process modelling standards in terms of their degree of coverage.

Table 1: Comparison of requirements catalogue with selected methods

	BKM	**BPMN**	**EPK**	**IDEF0**
A1: Analogue application	x	-	(x)	-
A2: Easy to learn	x	(x)	-	-
A3: Display as graph	-	x	x	x
A4: Results easy to understand	x	x	-	(x)
A5: Automatic transfer according to NAF[2] possible	-	-	-	-

The comparison of the requirements listed in Table 1 with selected methods and standards shows that neither the method established as a de-facto standard (BKM) nor a standard alone can cover all requirements. Therefore, the decision was made to develop an own modelling method that covers the requirements listed in Table 1.

4.2 Modelling Method CiA: Characterization and Analysis

The development of a modelling method is in line with the requirements of the ADR, as this represents the creation of artefacts to address problems identified in practice.

The graphical representation method (A3) recommended in the literature [32] also initially forms the basis for the development of the modelling method in CiA. The modelling method must be easy and quick to learn by experts and its application must not require any special knowledge in the field of modelling (A2, A4). The analogue application of the method in the form of group work must be given, as this represents the best practice of the organization observed in the CD&E projects and confirmed in the interviews (A1). Taking into account the information required for NOV-2

[2] During the period of the research, the German Armed Forces used the NAF version 3.1

(information exchange model) and NOV-5 (process model), the modelling method was developed specifically for the minimum requirements of an operational architecture (A5). This must enable the domain experts to create a process model that contains all the necessary information for NOV-2 and NOV-5.

Figure 1 shows an example of the modelling method used in the CD&E projects.

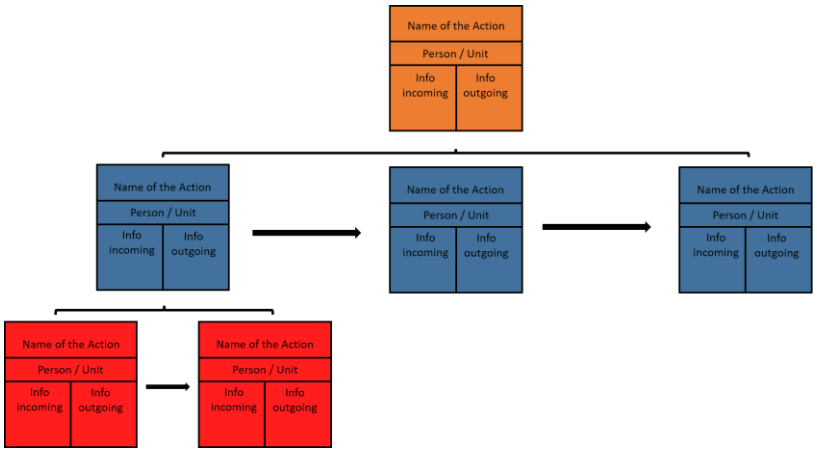

Figure 1: Modelling Method CiA

The modelling method contains only one element (node), which contains all data. Elements are linked by means of arrows (edge). An element represents a process step, which can be specified at a lower level. The nodes contain the data required for NOV-02 and NOV-05; "name of the action", "person / unit", "incoming and outgoing information".

The first node describes the entire process to be represented. This is defined in the subordinate levels by further nodes, each of which represents a process step. These are in turn linked to each other by edges. Via these edges, the outgoing information is passed on to the neighboring nodes, which thus represent the incoming information there. More detailed definitions of a node are in turn represented in subordinate levels. Each node thus represents a process step in its abstraction level.

The modelling method was used in both CD&E projects as a method for data collection & information gathering. In the first of the two projects, data collection & information gathering took place in four workshops, some of which lasted several days, and was facilitated by one of the authors of the paper. Figure 2 shows a picture of the method used during a workshop in the CD&E project.

Figure 2: Application Modelling Method CiA

Each application of CiA in a workshop served as a separate cycle according to the specifications of the ADR ("Build", "Intervent", "Evaluate") [5]. The knowledge gained from this was incorporated into the further development of the modelling method. In the process, models were created and expanded with the help of the CiA modelling method (analogue application using maps). Data was collected by means of participant observation [33] and interviews with the participants at the end of each workshop, related to the application of the modelling method. From this, derivations for adaptations of the modelling method with regard to the requirements shown in Table 1 were formulated. The adaptations were examined in the following cycle.

In the second CD&E project, the modelling method was used without being accompanied by one of the authors of the paper. It was used in a workshop lasting several days by a person responsible for the method. Data collection was carried out by means of interviews with the person responsible for the method. The content of the interview was questions about the application of the modelling method, user-friendliness, problems with the application and its usefulness from the point of view of the person responsible for the method.

4.3 Tool CiA: Automated Creation of Operational NAF Architectures

The automated creation of operational NAF architectures was defined as an important factor in solving the identified problem (cf. Table 1 A5). For this purpose, all necessary information should be extracted from the models created by means of the modelling method of CiA, following methods of process mining [12], [13], with the help of a tool and an operational architecture should be created.

First of all, this requires the analogue models to be converted into a form that al-lows computer-aided processing. The overcoming of this media break was realized by means of the software yEd. This software offers the possibility of mapping the elements of the modelling method exactly, so that there is no difference between the form of representation of the analogue application by means of maps and the representation in the software. Thus, a digitization of analogue models is possible intuitively, without special knowledge and skills.

In order to automatically create an operational architecture from this model, a tool was developed that is also part of CiA.

The digitization of the models created with CiA and the use of the tool were also investigated in both CD&E projects: In order to make the digitization process intuitive and simple, the so-called co-discovery method was used by the experts [34]. In this method, two users are asked to work on a problem together and discuss how to proceed. In doing so, knowledge is gathered regarding the user-friendliness of a system.

From the perspective of the domain expert, the tool simply reads the digitized model and outputs a file. This can be imported into the software specified by the organization (Sparx EA, cf. 4.1). The file created by the tool corresponds to the specifications of the Sparx EA interface for importing operational architectures. When the file is imported, an operational NAF architecture is thus automatically created in the Sparx EA according to the organization's specifications.

In both CD&E projects, an operational architecture (NOV-2 and NOV-5) was automatically created from the analogue models after their digitization. These were checked for correct implementation of the specifications by the responsible departments

of the Bundeswehr in the area of operational architectures. Any deviation from the organization's specifications led to an adjustment of the tool until all specifications regarding operational architectures were correctly implemented in accordance with the NAF.

4.4 Impact CiA

The observations of the first CD&E project showed that the domain experts were already able to use the method after a brief introduction. Errors in the application of the method were recognized and corrected by the experts themselves. This observation was confirmed by the person responsible for the method in the second CD&E project. In the interviews, the domain experts emphasized the analogue application and the ease of learning the modelling method as positive. With regard to the suitability of the modelling method, the technical experts stated that it was more suitable for their work in a CD&E project than methods they were familiar with.
They were given the opportunity to present their expert knowledge by means of an easy-to-learn and intuitively applicable modelling method.

The co-discovery method showed that digitization of the created models by the domain experts could be done without difficulty. The import of the created file into the software specified by the organization was also possible without errors. This was confirmed in the interview with the person responsible for the methods in the second CD&E project, who took over the part of digitization and import.

The operational architectures created automatically in the process included both NOV-2 and NOV-5, which were divided into 26 and 14 different diagrams respectively in the projects. Both operational architectures were examined by the responsible expert units of the organization with regard to the specifications according to regulations and the correct implementation was confirmed.

Data on the further use of the operational architecture was collected by participatory observation [33] over a period of three months in various workshops (several days) or meetings (online, 2-4h). Discussions of the experts at these events referred to content-related aspects of the operational architectures. The syntax of the models was not questioned at any time. The experts confirmed the recognition value of the analogue process model they had created using CiA and the automatically created operational architecture. This enabled the domain experts to carry out quality assurance of the content and to use the operational architectures for further work, thus extending the involvement of the domain experts to all phases of the established approach. Figure 3 shows the use of CiA and the involvement of the domain experts in all three phases of the established approach.

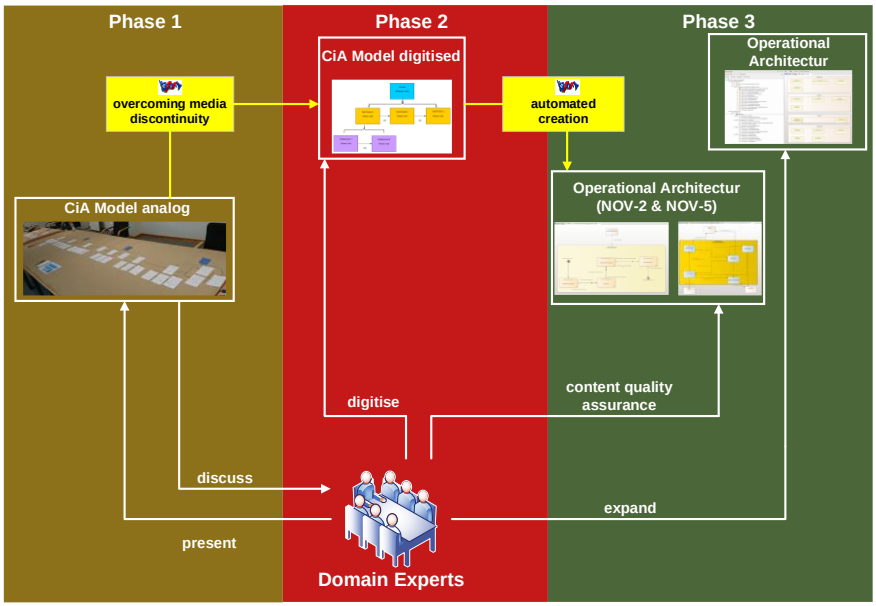

Figure 3: Method CiA

5 Main Contributions – Conclusion

Through CiA, the experts could present their knowledge and discuss this issue. The analogue models could be digitized by the experts. From these digital models, operational architectures could be created automatically by CiA. The recognition value between the analogue models and the automatically created operational architectures enabled the experts to ensure the quality of the content and the further use of the operational architectures.

The modelling method of CiA was easy to apply and all contents could be presented in an understandable way. In this way, existing knowledge was presented and a discussion about the presented facts was made possible, which can be seen as evidence for the comprehensibility [35]. The adoption of best practice is an important factor for the acceptance of the method by the users. Since the development of CiA focused on the later application domain, this is also an important indicator of user acceptance [36].

The optimization of the established approach results from the automated creation of operational architectures and their further use by the domain experts. In this way, they can find the knowledge they have gained through the CiA modelling method in the automatically created operational architecture, check it for correctness of content and use it for further work. The basis for this is the design of the modelling method, which gives the transformed model (operational architecture) a strong recognition value.

In both CD&E projects, the use of CiA led to a better integration of domain experts and the integration of their expert knowledge in the creation of operational architectures, as they were able to use the automatically created operational architectures and were thus integrated in all three phases of the established approach. Thus, CiA contributes to the solution of the identified, practice-relevant problem. The advantages of CiA result from the following characteristics:

- Easy to learn and use

- Integration of best practice of the organization (analogue application)
- Consideration of organizational specifications (NAF, Sparx EA)
- Automated creation of operational architectures

The focus on the creation of operational architectures according to the specifications of the organization and the construction of a semi-formal language for modelling, combined with a tool for the automated creation of operational architectures according to NAF, provides an innovative conceptual contribution as a holistic view of task-human-computer, in the field of information acquisition for the modelling of processes [37]. The implementation of artefacts as instantiation already provides an innovative contribution [38], [39].

CiA makes it possible to integrate "non-modelers" (domain experts) in the creation of EA of an organization and thus makes a contribution in the field of grass-roots modelling [23]. Thereby, we expand the work of Gonçalves et al.. [17] and Simões et al. [7].

The organization-centered modelling method uses story telling approaches, following the work of Gonçalves et al. [16] and Simões et al. [8], to enable group work and to provide information on a subject to be presented without having modelling knowledge. The automated creation of operational architectures on the basis of the process models created with the modelling method, by means of a tool specially developed for this purpose, uses principles of process mining [12], [13], in the sense of the automated creation of models from existing data.

Due to the focus of CiA on an existing organization, the artefacts cannot be used in a different environment without adaptation. Therefore, adapting CiA to a different organizational setting provides opportunities for further work. The adaptation and use of CiA thus serves to investigate whether the principle of providing a simple modelling method geared to the context of the organization, which provides the data basis for an automated creation of models, can be applied to similar practice-relevant problems.

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