EDOC2011 PhD Student Symposium Proceedings

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Message from the EDOC2011 General Chair

Welcome to the 15th IEEE International EDOC Conference in Helsinki! It is a great pleasure for us to host the leading Enterprise Computing conference, bringing together researchers and practitioners to discuss problems, solutions and experiences related to enterprise computing.

The IEEE EDOC Conference addresses the key challenges in the creation, operation and evolution of enterprise computing systems. From its beginning in 1997, EDOC has provided a platform to discuss innovations that make enterprise systems more flexible, more dependable, and easier to develop and maintain, despite the broad spectrum of vertical domains and industry segments covered. The wide range of methods, models, tools and technologies for enterprise applications are again addressed at this year's EDOC program.

The success of EDOC 2011 is due primarily to the work of many people who have given their time and worked hard to make this conference possible. First of all, I would like to thank our program chairs, Chi-Hung Chi and Pontus Johnson who took responsibility for the main conference's technical program. They have led the selection process for an excellent list of papers.

I would also like to thank our workshops chair Georg Grossmann, who has done a great job in managing our workshops program. This year we have six workshops covering special topics of enterprise computing, including model-driven methods, quality of service management, business processes, SOA and enterprise engineering, ontologies, and enterprise architecture trends.

Likewise, I would like to thank all the workshop chairs for contributing to EDOC. For the third year, we have together implemented a "roll-out process" in which papers that cannot be accommodated at the main conference are forwarded to our workshops for consideration. This requires close coordination between program chairs and workshop chairs, and thus extra work for all involved; Georg has provided instrumental support in getting this done successfully.

Essential for us all was the support of the program committee, all members of which I want to send my sincere thanks. Further, there can be no conference without author contribution and participation: I would like to express my deep gratitude to all who contributed with their insights to make our conference and workshop programs interesting and all those who come to Helsinki to make EDOC lively.

I would also like to thank our local organization committee, student volunteers and our publicity chairs Axel Korthaus and Alex Liu for their efforts in bringing the word out about EDOC 2011. I also thank the EDOC's steering committee, who entrusted me with the responsibility of another EDOC event and provided useful suggestions.

I want to express my gratitude to our sponsors, the IEEE Communications Society and the IEEE Computer Society, and all persons at IEEE involved in the sponsorship and publication process. Their continuous institutional support is very important for the EDOC conference series. Further, I would also like to thank ACM SIGSOFT and SIGAPP, OMG and The Open Group for their support. Our patrons should be acknowledged for financial support which is essential to our meeting.

We are glad to host this year three renowned keynote speakers: Mike Papazoglou (Tilburg University, Netherlands), Terry Halpin (LogicBlox, USA) and Richard Hull (IBM Research, USA). I would like to thank them for joining us in Helsinki.

I hope you will enjoy your stay in Helsinki. I hope you will find the conference productive and inspiring and will return home with the prospect of new collaborations and interesting ideas for future work.

Lea Kutvonen
University of Helsinki
IEEE EDOC 2011 General Chair

Special Message to EDOC PhD Students

In discussions with senior EDOC program committee members and young researchers submitting to the EDOC series, it has become evident that the community of junior EDOCers is searching for a way of reaching each other, in a less formal way.

Therefore, in 2011 we have tried a form of EDOC PhD symposium. We succeeded in getting the attention of a few students, but will continue searching for other forms of community enablement as well.

I want to thank PhD Alex Norta and PhD student Sini Ruohomaa for their hard work in preparing this activity.

Lea Kutvonen
University of Helsinki

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Leadership by Architecture? Enterprise Architecture as a Means for Coherency Management – a Finnish Public Administration Case Study

Position Paper

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Abstract— **Organization without leadership has no direction. It has been claimed that enterprise architecture (EA) for coherency management provides a means to define a clear direction, an assured implementation, and an agile re-direction for an organization in any situation. For this to be accomplished, we claim that the EA framework is to support the business architecture (BA) dimensions of the enterprise by expanding the BA concerns as more than one viewpoint. Secondly, for the proper adoption of the EA at different decision levels of a diversified organization, the adoption and adaptation of an EA framework should be resulting in a set of aligned frameworks for all sub-organizations. This view is based on review of an on-going case study about EA framework engineering and adaptation for coherency management in Finnish Public Administration.**

Keywords - enterprise architecture; coherency management business architecture; public administration

I. INTRODUCTION

Enterprise Architecture (EA) has been evolving from being 'a blueprint of systems, data and technology [21]' into a discipline that aims at embedding EA in general management practice as 'design and management approach essential for organizational coherence leading to alignment, agility and assurance [3]'. Enterprise has many parts, like customers, stakeholders, strategy, employees, processes, information, systems, and technology. *Organizational coherence* refers to a logical, orderly, and consistent relation of parts to the whole [3]. *Alignment* is the ability of the organization to head one-minded towards a common shared vision [3]. *Assurance* is ability to ensure the reaching of this vision in practice [3]. *Agility,* on the other hand, means ability to re-direct the organization flexibly [3].

Organization without leadership has no direction. At its worst, the organization can be running by the power of the organizational momentum that has been gained along the time by adding more roles or duties, so that each part is finally doing its own thing. John Zachman, one of the originators of the EA discipline, summarized this problem nicely in the foreword of [3]: 'how do you intend to "assure" that the Enterprise as implemented is "aligned" with the intent of the Executive Leadership and "agile" to accommodate the dynamics of the external environment?' Incoherent parts of the organization produce incoherent information, which is called 'institutional amnesia' [3].

Architecture is about structure (e.g., in [12]). Understanding the interplay of the parts of the organization is gained through modeling the parts, their structure and inter-dependencies, thus making the EA visible. EA is a central concept to align the parts of an enterprise coherently [3][26]. Typically, an *EA framework* is used in practice, to provide a mechanism for linking the various parts of an enterprise together [3]. In the famous Zachman Framework [28] the organizational concerns (in columns) are interconnected with stakeholders (in rows) [3]. If EA is used in proper way for coherency management, it will support the leadership to head the organization to one direction [3]. How to do this more specifically, is however yet to be discovered for the most parts. Doucet et al. have gathered an anthology about the role of EA in improving organizational coherence [3]. Innovations on EA methods, practices, and leadership roles for coherency management are presented. However, the authors emphasize that to realize the idea, 'plenty of hard work will be needed by writers and practitioners to evolve this idea into a mature discipline based on the successes and lessons-learned [3]'.

We have targeted to add to this asset in a case study of Finnish public administration (PA), by building an EA framework and its adaptation model for coherency management there. Based on these constructions and their reflection in [5][23][25][26][27], we conclude as follows. Firstly, in order to direct the organization toward common goals with assured implementation, and to re-direct it in any situation, EA framework is to support the business architecture (BA) concerns of the enterprise more widely, possibly expanding BA in further columns, in order to support the work of various functional management roles and to provide a common framework for general and information management functions. Secondly, for the proper adoption of the EA at different decision levels of a diversified organization, the adoption and adaptation of an EA framework should be planned with an adaptation model, resulting in a set of aligned frameworks for all sub-organizations, with situationally specified roles for each.

Next, we will give a short review of the intermediary results of the Finnish PA case study. This shows an on-going dissertation work of Finnish Government EA framework engineering and adaptation. The aim of the presentation is to get feedback of the on-going work. The validity and reliability of the results are limited due to the on-going process. In the second chapter, the basic EA concepts used

are explained. Third chapter presents Finnish PA as the case. Fourthly, the methodology for the dissertation work is outlined shortly. Fifthly, we review the intermediary results [5][23][25][26][27] summarizing and clarifying their main contributions. Finally, the conclusions follow.

II. ENTERPRISE ARCHITECTURE CONCEPTS

Enterprise Architecture (EA) is constructed through deploying an *EA method* consisting of an EA framework, a modeling process, techniques, and roles [8]. An *EA grid* signifies here an EA framework in the matrix form. EA grids present abstraction levels typically as rows, and architectural viewpoints typically as columns. Architectural concerns [3], viewpoints [13] or dimensions [14], synonymously, are in most frameworks those of the business, information, systems and technology architectures [14][13], abbreviated as BA, IA, SA, TA, respectively. The framework further organizes the EA models and descriptions in these sub-architectures. The framework provides a central tool for EA planning. [26]

Grasping enterprise-wide whole of the parts is especially necessary for diversified organizations [12] like large corporations or public administrations (PA). Consciousness of the parts of the organization provides alignment, assurance, and agility, for the directing, ensuring the implementation, or re-directing the organization respectively [3]. EA is recently seen as a necessary tool for *coherency management*. In coherency management EA is used for three different purposes in parallel: as *foundation architecture* (in the sense of [17]), as *extended architecture* for change management, and for *embedded architecture* to leverage everyday governance practices [3].

III. THE CASE – FINNISH PUBLIC ADMINISTRATION

A government organization covers multiple service sectors, and is commonly organized as diversified, deeply hierarchical units offering tangible services, often non-IT critical and rather dependent on human resources [27]. Strategic political steering is expected to direct better administrations better in Finland [22]. Strategic changes are evaluated rather in terms of costs and human resources than of IS architecture [27]. New Public Management (NPM, [2]) presumes better design and management of operations models [27]. Administrative organizations produce often similar statutory services and deploy IS in relatively similar processes, thus enabling acts for harmonization [25].

Under these forcing drivers, Finnish Government has proceeded systematically towards process, data and systems integration among administrative organizations, by launching several Government statements, such as Finland's Government Policy Decisions on the development of IT management in 2006, in 2009, and finally launched the Information Management law in 2011. The work has been coordinated by the Ministry of Finance, especially by its two central departments, the State IT Development Unit (ValtIT) and Municipality IT Development Unit (KuntaIT). The division into the two departments is due to the municipal self-government in Finland, whence local governments in Finland have been independent concerning the organization of information management and e-government [9]. The new

information management law, however, will presume EA modeling efforts by public organizations including municipalities [9]. Finnish Government has engineered several design tools for Government Enterprise Architecture (GEA) work, including a method for GEA planning and development, called the *GEA method* [10], and *GEA governance model* [11], in 2007. The tools were originally built for the State Administration, but the previous has recently been refined into a national standard for Finnish municipalities [7]. It considers the EA as a hierarchy of sub-EA's for designing and modeling a local government at different decision making levels as advised in [24][25].

IV. RESEARCH METHODOLOGY

This post graduate study on EA has been launched in 2006. Like EA has been evolving as discipline to concern organizational issues, also the foci of this study has changed from the more specific purposes of EA to more general ones. The quest in the dissertation has been to find out, what kind of EA method, especially framework, is needed to support coherency management, and how to adapt it for a set of organizational actors within a diversified organization? As prerequisites, we have asked, what are the requirements of the Government EA (GEA) framework, and how to support PA business architecture re-engineering methodically better. The answers are supposed to help to better direct or re-direct an administration, or a diversified organization, and to better organize the resources or the parts of the organization for an assured implementation.

The research concerns the engineering, adaptation and adoption of the Finnish GEA method using action design research (ADR) principles. ADR cross-fertilizes two constructive scientific rigors, action research (AR) and design research (DR) [19]. In AR, the researchers work as designers with other employees intervening with the purpose of a new course in contextual social processes [16]. In DR, an IT artifact is constructed and evaluated for organizational needs [4]. The action taking phase of AR is enhanced by inducing building of a design artifact into the AR cycle in ADR [19]. The ADR framework presented in [19] has been here specified for this research case in Figure 1.

The IT artifact is the Finnish GEA grid with its EA descriptions. In fig. 1, the life-cycle of the GEA grids is denoted in the bottom line. First, the GEA grid [10] was engineered in 2007 by the State administration. Next, the research team provided a GEA grid adaptation model (Geagam [24]) to guide the use and adaptation of the GEA grid in State Administration. After that, the adaptation model has been specified for the local government of Kouvola City (Kouvola Geagam, in 2009 and 2010). The contribution to knowledge is denoted in fig. 1 in the top row by listing the reflection results of the research.

Figure 1 is divided in two parts: the studies in State Administration, and later in a local government of Kouvola City. The former includes participant observations of the GEA method engineering as a member of the engineering project team and consequent evaluation and instruction of the grid by building an adaptation model for it. The end-users in State Administration consisted of leaders, practitioners and

private EA consultancies. The research project team was at the University of Jyväskylä (cf. [20]).
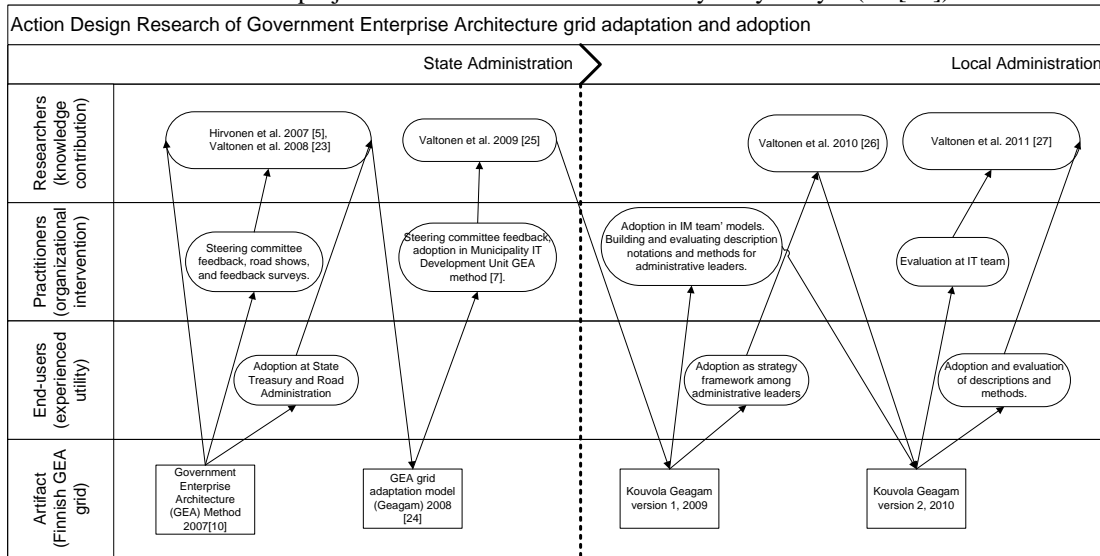

Figure 1.   Review of the presented work in ADR method framework. Bottom-line denotes the life-cycle of the IT artifact. Second and third row denote end-users and practitioners group at each time point. Top-row enlists the knowledge contribution by the researchers.

In the latter period, the author has been working in the strategy management of Kouvola City, bringing especially strategy perspective to EA adoption in a local government. The EA research efforts presented from that time are aiming at EA serving as a tool for both general and information management. The first version of the Kouvola Geagam 2009 was constructed in February 2009, the second in June 2010. Meanwhile, the strategy, process and service blueprinting practices were designed and implemented for GM purposes. The EA capabilities, EA governance, and SOA platform development were the central foci of the IT team in their respective EA efforts. The presented research focused especially on the general management interests, where the end users consisted of leaders and middle managers of the local government. The practitioners were the financial and strategy management (FSM) unit employees including CIO and her IT team. The research group consisted FSM managers and researchers of the University of Jyväskylä.

V.   RESULTS

Next, the main results of the [5][23][25][26][27] are summarized, and clarified with some generalizations. Firstly in [5], we described the Finnish Government Enterprise Architecture (GEA) Method Engineering project, outlining the special requirements for a GEA framework as follows. It was to 1. provide a *place for standards* in administration, 2. *support different decision making levels*, 3. *be simple* and easy to understand, 4. *support communication* to different stakeholders, 5. *include development methodology*, 6. *support continuous development* and long term planning, 7. *support interoperability*, and 8. *be public* [5].

Secondly, in [23], we explained, as an evaluation of the Finnish GEA method engineering work, how the government BA planning should be better facilitated by a GEA method [23] on three areas. *1. Visioning the services portfolio and their presentation to the customers:* we quested for more advised way for comparing possible (e-)business models, and further for deciding on the to-be (e-)business model or on a modification of one. *2. Deciding on the customer principles to be applied:* we gave some suggestions of customer principles, and analyzed their effect on the process architecture. *3. Deciding on the relevant operation model with suitable levels of standardization and integration:* we gave some insight concerning process standardization and integration solutions of the to-be business model, especially for cross-organizational processes were to be implemented.

Thirdly, in [25], we suggested how different decision levels of a diversified organization can be supported by an adaptation model. A GEA adaptation model (Geagam) was tailored for a hierarchical and complex multi-agent public organization [25]. Geagam 'exemplifies adaptation of a layered EA grid in a hierarchical set of organizations. The inherent ideas in the Geagam model can thus be applied with other layered EA grids. [25]' We claimed the following main benefits of such a layered adaptation:

- it helps perceiving a set of organizations as a whole, and presenting the "big picture",
- it provides a tool to plan and manage administrative (or management and strategy) changes coherently,
- it helps in the transformation process of an administration or a diversified organization, and
- it enhances the overall interoperability through methodical consistency among sub-organizations.

Forth and fifthly, in [26] and [27], we adapted the Finnish GEA grid in a Finnish local government, in the City of Kouvola, by exploiting the Geagam. The goals were to enhance the change management in merging six local governments to one, to form a new NPM related operation model, to lead the strategic political objectives, and to leverage on the information usability produced in everyday governance practices [26]. We suggested 'the application of

the EA method as a framework for *strategic planning of an entire enterprise* [26]'.

The *strategic planning in an organization* was considered as a dimensional sub-architecture (strategy architecture) of the EA, providing a set of hierarchical descriptions of the future goals in the organization. Both the strategy management and information management were considered as a part of the larger picture. The BA description viewpoints were expanded for this purpose in [26] and iteratively elaborated in [27]. The expanded BA viewpoints were thereafter populated with local government specific enterprise descriptions in [27]. The resulting viewpoints are below with the remark of their relationship to the commonly used dimensions of BA, IA, SA, and TA:

- *Environment:* external conditions and the strategies of the organization about how to react on external conditions *(represent concerns in BA).*
- *Service & Customer:* descriptions about services purchased or provided to customer *(BA).*
- *Information & Data:* basically IA and its descriptions *(IA).*
- *Personnel:* employees, their capabilities, locations, roles, etc., *(BA).*
- *Systems & Technology:* combining SA and TA viewpoints and descriptions *(SA & TA).*
- *Finance:* cost and budgeting architectures *(BA).*

VI.   DISCUSSION

Next, we summarize the claimed benefits and challenges of the embedded architecture use from [26] and [27]. By using a common framework of enterprise information among different management functions, and embedding the blueprinting practices in governance practice [27], it could be promoted: A) The coherency of the architectural dimensions, B) The government and leadership abilities, and C) The enterprise architecting methodologies.

A.   The coherency of the architectural concerns

The most important benefits for different organizational concerns, and among them, were: *1. Systematic service system re-engineering.* Especially in NPM related changes where management processes or even ownership of functions, organizations, or part of them may change [27], systematic support is needed to assure a coherent transition into to-be service operations model [27]. *2. Better resource alignment of strategic requirements to different resources* whether capital, human, IT, rooms etc. [27]. *3. Transparent information flows* among different organizational actors providing shared awareness, usage and deployment of enterprise information [27]. *4. Digitization of the information interface,* and *5. interoperability of the systems [27].*

The alignment of different concerns like environmental requirements, strategic goals, personnel capabilities, financial resources, systems, processes, etc., means prioritized work towards a common vision, and if necessary, the re-direction of the work. EA as a concept has the capacity to model and structure various aspects of an organization, within and for the benefit of various stakeholders. Dynamic

understanding of the dependencies of an organization is available to all who can 'read the figures'. This may on the hand cause tensions between IT management and general management (cf. e.g., [6]). Even tool and equipment ownership may be the issue: who owns the EA as a tool and can control the access to the figures (cf. [18]). Access to the source of innovation, however, does enhance the innovation on the area of all organization concerns (cf. e.g., [1]) if access and training is fostered.

B.   Government or leadership benefits and challenges:

The embedded architecture benefits and challenges the leadership roles in many ways: *1.* using the systematic modeling practices of EA planning provide *a holistic model of the business and strategy* [26]. *2.* This enhances *holistic consideration* as a leadership capability and commitment [26], and *3. provide better decisions* based on better understanding of the underlying structure [27]. *4.* The adaptation model advices *how to analyze the descriptions* vertically and horizontally [26] and *5. how to organize the discussions* in decision making. *6. As pre-requisites*, however, meta-level capabilities are presumed from change agents, leaders [27], and other stakeholders, as well as having enough resources for proper modeling and discussions efforts required for the EA consciousness to birth [26]. *8.* Static and 'ancient' information *management styles* and thinking are other hindrances [26].

EA can challenges leadership in many ways: beyond the top-down conversations, into collecting information of the pieces, into bottom-up discussions, into decisions about the direction, and the subsequent delegation for implementation. As such, it is an essential tool for leadership. Courage, to take the lead towards the vision and the coherent organization is presumed, however.

C.   The enterprise architecting methodologies

As users and even providers of the embedded EA models, there should be general and middle managers. A common framework facilitates innovations on methods, techniques, tools, repositories as: *1. providing comparability* through common methods and tools [27]. *2. Supporting a larger variety of corporate descriptions* [26]. However, many aspects of organizations are not covered by standardized notations and models. *3. Innovating new kinds of dependence descriptions* between EA dimensions [27]. *4. Tools and repositories.* The set of grids can advise the developing of the user interface for the descriptions [26]. IS support for EA information is presumed with high usability for top and middle managers [26]. E.g., the structured data should be automatically visualized as blueprints [27]. However, there is not yet such a tool which would automatize structured data and represent it in a visualized and comparable way concerning all organizational information. Also capturing the socio-organizational requirements [27] in EA repository is challenging.

We also presented a few *practical implications* how to embed the architecture. Architectural terminology and modeling practices were suggested to be implemented step by step, e.g., one dimension or description type at time [27].

Proclaiming the GEA as library [27] was recommended, so that anyone producing descriptions would be aware of adding to shared asset [27]. Adapting and adopting the EA grid was advised to be done gradually [27], such that in a complex government or corporate there would be different timings for adaptors. Proceeding should be ensured with success stories [27]. An EA grid as more than one instance was advised to support the coherency management of several organizational actors within a diversified organization [26].

VII. CONCLUSIONS

We presented intermediary results of an on-going dissertation to receive feedback of the work. We reviewed the engineering and adaptation of the government enterprise architecture (GEA) method for coherency management in Finnish public administration. The intermediary results included GEA method requirements, methodical support of BA planning, GEA grid adaptation in a diversified organization, and GEA grid structure for coherency management use. Based on these constructions and their reflection, we conclude as follows. Firstly, in order to direct the organization toward a common vision with assured implementation, and to re-direct it in any situation, EA framework has to support the business architecture (BA) dimensions of the enterprise by expanding the BA concerns as more than one viewpoint. Secondly, for the adoption of the EA at different decision levels of a diversified organization, the adaptation of the EA framework should be resulting in a set of aligned frameworks for the sub-organizations with their roles as situationally specified rows.

To complete the dissertation thesis, the future research steps are planned as follows: 1. Describing and evaluating the adopted strategy architecture. 2. Analysis of the EA description dependencies and reflections of it on EA governance requirements for coherency management. The anticipated interventions in the local government are to facilitate active and participative leadership practices by blueprints, and in long term, to develop of a more systematic governance model for the diversified local government.

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Supporting enterprise performance management with organization-specific indicators

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Abstract—The high complexity of the enterprise architecture (EA) management calls for decision support by organization-specific indicators for performance measurement. Many EA management frameworks and approaches were presented in last few years to support enterprise architects with the development of their EA management. Some of these approaches became well-accepted and defacto-standards in this field over the years. Nevertheless, enterprise architects still lack decision support by relevant KPIs for performance measurement in these frameworks. In this article, we outline the research questions arising, when organization-specific KPIs for concrete EA management goals are to be defined. We further sketch a possible solution for this problem as firstly outlining a development of a practice-proven KPI catalog for the measurement of EA management goals. Secondly, a so-called performance indicator definition language (PIDL), representing practice-proven computations, is introduced and concrete performance indicator definitions (PIDs) are derived from the developed KPI collection. These PIDs are then finally integrated with the building blocks for enterprise architecture management solutions approach of Buckl et al. to support the definition of organization-specific performance measurement.

Keywords-Enterprise Architecture (EA), EA management, organization-specific indicator, metrics, measurement, key performance indicator (KPI), performance indicator definition language (PIDL), performance indicator definition (PID)

I. MOTIVATION

In the last decade, Enterprise Architecture (EA) and its management have received considerable attention from academics, practitioners, consultants and tool vendors. EA management targets the enterprise in an embracing manner and seeks to evolve the enterprise to facilitate the alignment of business and of information technology (IT). Therefore, EA management provides individual EA products - enterprise architectures. These architectures describe *"the fundamental organization of [the enterprise] embodied in its components, their relationships to each other, and to the environment"* [9].

Being a management discipline itself, EA management defines and pursues goals. Buckl et al. present in [3] a list of the key EA management goals, e. g., *reduce operating costs*, *ensure compliance*, *increase homogeneity* identified in a literature review in this field. Goals take an important role in the existing EA management frameworks (cf. Section II). For example, according to BEAMS [3], the development of an organization-specific EA management function requires concrete EA management goals as part of the input for this approach. In TOGAF [17], goals are also an important part of the required input for the ADM phases A and B. However, a link to related indicators or measures for the measurement of the achievement of EA management goals is missing in the existing frameworks (cf. Section II). This thesis is supported by the findings of Lucke et al. in [14].

According to many practitioners, the ability to measure the achievement of defined goals is becoming more and more important for existing EA management initiatives. The practitioners lack KPIs for a successful EA management. In particular, following two aspects are very important for the practitioners:

- Enterprise architects are currently taking decisions instinctively regarding the question how to ensure the achievement of their EA management goals.
- Involved stakeholder require clear defined, easy to understand and well-proven KPIs for communicating the performance, the current status and the future development of EA management initiatives.

In related management fields, e.g. IT project management (cf. [2], [11], [12]), IT risk management (cf. [11], [12], [13], [15]), practice-proven KPIs for common goals are well-known and widely accepted. Future EA management has to provide better information regarding the measurement of EA management goal achievement. Following research question question is to be answered:

RQ: How to support enterprise performance management with organization-specific indicators?

To ensure, that the complexity of the main research question remains manageable, following five sub research question are to be answered:

- *rq1:* What are best-practice KPIs for common EA management goals?
- *rq2:* What mathematical functions are used for computing these KPIs?
- *rq3:* Which data is required for these computations?
- *rq4:* How to ensure that required data is available?
- *rq5:* How to link KPIs with concrete EA management tasks?

Thus, the answer of research question RQ depends on the solutions of the five sub research question, i.e.,

$$RQ = rq1 + rq2 + rq3 + rq4 + rq5.$$

The reminder of this article is structured as follows. Section II outlines related frameworks and approaches in the fields of EA management and IT control. Section III provides an insight in our ongoing research activities regarding the aforementioned research questions. The last section IV concludes the paper with a short discussion and an outlook.

II. RELATED WORK

In the last ten years, many different EA management frameworks and approaches were developed and presented. Starting in 1987, John Zachman was one of the first to understand the "*bigger whole*" in which information system architecture and its development is embedded. His work, "*A framework for information systems architecture*" (cf. [20]), is the probably most well-known framework for EA (the Zachman Framework). However, the question "*How EA management goals are to be measured?*" is not explicitly treated by this framework.

The EA management approach developed at KTH Stockholm (cf. [7]) aims at providing decision support for IT management in enterprises, in particular for the CIO (chief information officer), as key responsible for the strategic IT-related decisions. In the first step of this approach, relevant business and IT goals for EA management are selected, and are linked in the second step to relevant stakeholders. In the third step appropriate viewpoints for the EA management function are selected and are linked then to the underlying information model. This approach provides a couple of concrete measurement for some of the related EA management goals, however a complete indicator catalog for the measurement of all relevant EA management goals is not provided by the framework.

At the university of St. Gallen, Winter and Fischer discuss in [19] a layered framework for the EA. In their understanding EA seeks to provide a "*cross-layer view of aggregate artifacts*" in order to address challenges that are not confined to a single layer. In particular, following three main aims of EA management are described by the authors: support business/IT alignment, support business development and support maintenance. In [16], Schelp and Stutz show how the balanced scorecard mechanism can be adopted in this framework to support the measurement of related EA management goals. However, no concrete KPIs or measurements are suggested by this framework.

Buckl et al. present in [3] a building block approach for enterprise architecture management solutions (BEAMS) for the development of an organization-specific EA management function. In particular, they elicit a PDCA-like structure that an EA management function typically commits to, defining four phases - describe, implement, analyze, and adapt. EA management goals play an important role during the describe phase in BEAMS. However no information regarding the measurement of these goals is provided by the framework.

The Open Group is a vendor and technology-neutral consortium published the current version 9.0 of their TOGAF framework for EA management in October 2009 [17]. TOGAF is based on the terminology introduced in the ISO Standard 42010 [10] and provides a method and supporting models and techniques for the development of enterprise architectures. This framework is well-known and widely-used in practice. The probably most-known part of TOGAF is the ADM, which describes an iterative process consisting of eight phases, which are complemented by a preliminary preparation phase and the central activity of requirements management. However no additional information is provided by this framework regarding the question "*How defined EA management goals are to be measured?*".

The CobiT framework [11] from the IT Governance Institute is a well-known IT governance framework in the practice. CobiT focuses on the controlling of IT processes. For every IT process defined in this framework, a link to related stakeholders is created. Then concrete goals are presented and corresponding metrics for their measurement are provided by this framework. In particular, CobiT distinguishes between three types of goals – activity goals, process goals and IT goals. However, a link to EA management as well as a link between the suggested metrics and the required data in the underlying information model for the computation of these metrics is missing.

Basili et al. present in [1] the Goal Question Metric (GQM) approach as a mechanism for defining software measurements. The GQM introduces a measurement model on following three levels:

- *Conceptual level (goal):* a goal is defined for a concrete object due to variety of reasons, with respect to various models of quality, from various points of view and relative to a particular environment. Examples for objects of measurement are products, processes, resources, etc.
- *Operational level (question):* a set of questions is used to define models of the measured object and then focuses on that object to characterize the assessment or achievement of a specific goal.
- *Quantitative level (metric):* a set of metrics, based on the developed models, is associated with every defined question to provide measurable answers.

This approach can be easily adopted in the field of EA management enabling the enterprise architects to define organization-specific performance measurements (cf. [5]). However, currently no concrete KPIs are provided by this approach. Furthermore, no link between metrics and related data, stakeholders and task is provided.

This literature review on the fields of EA management and IT controlling supports our finding, that enterprise architects receive insufficient support for the measurement of their goals from the existing frameworks and approaches. It further shows that promising approaches exist in related disciplines.

III. SOLUTION

In this section we describe our current research stream in the field of the development of organization-specific indicators for enterprise performance measurement. Firstly, we outline our current progress in the development of a practice-proven

KPI catalog for the measurement of concrete EA management goals. Then we introduce the concept of a performance indicator definition language (PIDL), which allows the development of concrete performance indicator definitions (PIDs) representing the practice-proven knowledge collected in the KPI catalog. Finally, we sketch how these PIDs are integrated in the BEAMS approach by Buckl et al [3].

A. Development of a practice-proven KPI catalog for EA management goal measurement

Originating from social science, Grounded Theory (GT) is an approach to evaluate primarily qualitative data (e.g. interview transcripts or observation minutes) to generate theories. According to Glaser and Strauss [8], socalled grounded theories relating to a certain phenomenon can be discovered, elaborated, and preliminarily confirmed by systematical collection and evaluation of data. Furthermore, both researchers propose theoretical sampling as a method for comparative analysis. The idea is to analyze a collection of independent pieces of information by selecting a set of cases according to their potential to reveal new insights and findings, while a representative character has less priority. In our research, we followed a structured approach consisting of three sequential steps: literature study, expert interviews, and data evaluation.

To address the problem of missing KPIs for BEAMS, we are currently working in the first step on an initial version of a corresponding KPI catalog for the measurement of EA management goals. Therefore we are performing a literature review to identify concrete KPIs in related literature (cf. section II). This review is structured and performed according to the approach of [18]. In addition, based on our finding, we seek to link these KPIs to concrete EA management goals, tasks and roles as long as such information is available. For example, the CobiT framework provides over 200 concrete metrics for the different type of goals defined by this framework.

After creating the initial version of the KPI catalog, we plan in the second step of our approach to perform a series of semi-structured interviews with enterprise architects from different industry sectors to evaluate our KPI collection. We hope to improve existing KPIs and to identify new KPIs for our catalog based on the input of the participating practitioners.

During the third step, the collected data will be analyzed and consolidated. The information regarding the used mathematical functions and required data for the computation will be documented in an uniform manner. This catalog will provide the answers to the research questions rq1, rq2 and rq3 (cf. Section I).

B. Performance indicator definition language

Applying the idea of patterns to the context of EA management Buckl et al. [4] introduced a new way to structure the domain of EA management. Based on this idea, the authors present in [3] a building block approach for enterprise architecture management solutions (BEAMS). The framework provides following types of building blocks:

- *method building block (MBB):* describing who has to perform which tasks in order to address a problem in a situated context, and
- *language building block (LBB)* referring to which EA-related information is necessary to perform the tasks and how it can be visualized. BEAMS actually differentiates between two subtypes of the LBBs - information model building blocks (IBBs) and viewpoint building blocks (VBBs). An IBB is used to define the syntax and semantics of the EA description language, and a VBB is used to describe the language's notation, i.e., the way the EA-related information is visualized.

Figure 1 illustrates the conceptual framework of an EA according to BEAMS. This conceptual model contains architectural layers, abstraction layers and cross-cutting aspects, which are defined as follows:

- *Architectural layer:* an architectural layer mirrors the overall business-to-infrastructure structure of the organizations's EA ranging from logic concepts on the business and organization level, which are independent of the technical realization, over application level concepts that describe the IT realization of these logic concepts, down to infrastructure, i.e. hardware-related facilities.
- *Abstraction layer:* each abstraction layer complements an architectural layer with a customer-oriented perspective. Hence, an abstraction layer describes the EA concepts on the corresponding architectural layer in an abstract way focused on the provided functionalities, whereas details of the actual realization of the functionalities are suppressed.
- *Cross-cutting aspect:* a cross-cutting aspect covers concepts that are not directly part of the static EA structure but may be linked to any element in a layer.
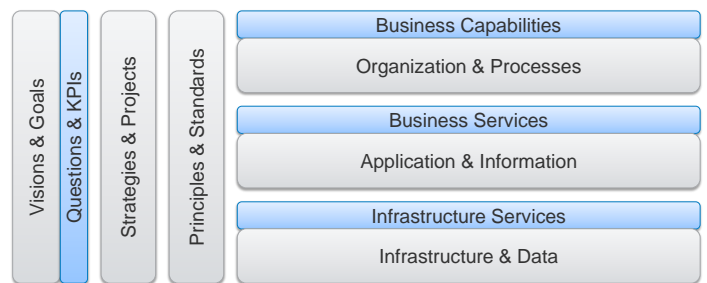

Fig. 1. Architectural layers, abstraction layers, and cross-cutting aspects

According to BEAMS, complementing the aspect of visions & goals, the aspect questions & KPIs establishes means to quantify aspects of importance. Most preferably, a measure or KPI is introduced to quantify the fulfillment of an objective and is hence added to the architectural concept that this objective aims at. However, the framework does not provide any concrete KPIs or measurements for relevant EA management goals. Thus, the research questions rq1-rq5 remain unanswered by BEAMS so far.

To close this gap, we introduce the concept of a *performance indicator definition language (PIDL)*. The PIDL language is used to define concrete *performance indicator definitions (PIDs)*, e.g., sum, product, median. The PIDL is similar to the object constraint language OCL (cf. [6]), and is in particular:

- recursive,
- set-oriented,
- functional, and
- structured.

An example of a concrete PID is provided in section III-C.

The concept of PIDs, representing the practice-proven knowledge collected in our KPI catalog, can be integrated in the existing BEAMS approach. This allows us to link PIDs to concrete EA information models and EA management tasks. Firstly, every PID has to be linked to concrete information models to ensure, that the data required for the computation is available in the underlying information model. Secondly, every PID requires a link to a concrete information model in order to store the computed data (using derived attributes). Linking PIDs to concrete methods provides information about related EA management tasks and actors for the measurement.

According to Figure 1, PIDs can be applied on all three architectural layers – organization & processes, application & information, and infrastructure & data. Furthermore, PIDs can be used to enable aggregation of measurement results from one architectural layer to another. For example, the costs of used hardware resources on infrastructure & data layer can be propagated to the using business applications on the application & information layer. The costs of used business applications on the application & information (containing the aggregated cost from the layer infrastructure & data) can be propagated to the supported business process on the organization & processes layer.

Using this understanding of EA management indicators, enterprise architects will be able to easily recognize dependencies between different EA management task and goals. Concrete EA management task can be then linked to concrete roles or actors and personnel goals with corresponding measurements can be defined. In this way, the enterprise performance measurement can be made more transparent to the interested stakeholders and can help to identify performance bottlenecks in the architecture.

By extending BEAMS with practice-proven PIDs, we combine well established answers for research questions rq1-rq3 (KPI catalog) with an established method targeting research questions rq4-rq5 (BEAMS). In the next section III-C an example for a PID is provided.

C. Example

For the measurement of the EA management goal *reduce operating cost*, following calculation is performed. As defined by the underlying information model (cf. Figure 1), a platform service is supported by many physical technology components.
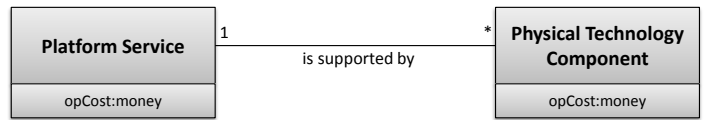

Fig. 2. An information model

Every physical technology component, as well as every platform service has fixed operational costs – *opCost*. According to this information model, a platform service derives its operational cost from the physical technology components used. This value is computed as the sum of the operational costs from all used physical technology components and stored in the derived attribute *derivedOpCost*. The total operation costs are computed as the sum of the derived costs from the used platform components and the fixed cost of the platform service. The result is stored thereafter within the derived attribute *totalOpCost*.

Thinking in PIDs, we identify the PID *sum* in these measurements. This PID computes the sum of a set of attribute values and presents the result of this computation as the value of a derived attribute as shown in Figure 3. In our example, the PID sum is used twice for computing the given KPI.
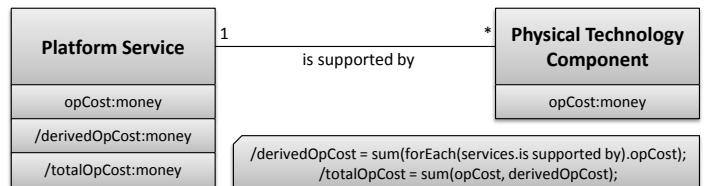

Fig. 3. Interplay between the PID *sum* and a concrete information model

This short example illustrates how PIDs can be identified from practice-proven KPIs and how PIDs can be embedded into concrete information models. The example also illustrates how PIDs can be interlinked to support more complex computations.

IV. CONCLUSION AND OUTLOOK

In this article following two ideas for the field of EA management are presented:

1) A best-practice KPI catalog for the measurement of EA management goals.
2) Extension of the BEAMS approach by Buckl et al. [3] by the concept of performance indicator definition (PID) and a corresponding performance indicator definition language (PIDS) to support organization-specific measurement of EA management goals based on best-practice measurements.

After evaluating the developed KPI catalog in workshops with practitioners, computation building block have to be identified and defined in a first step. Then, the developed CBBs are to be refined and integrated in the existing MBBs and IBBs

of BEAMS. Finally, the extended BEAMS approach is applied and evaluated in practice. Last but not least a future research challenge in the context of software engineering will be the implementation of this approach in a corresponding tool.

V. ACKNOWLEDGEMENTS

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Human Intervention on Trust Decisions for Inter-Enterprise Collaborations

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Abstract—Trust is an important factor in the success of inter-enterprise collaborations. Trust decisions are made based on whether the incentives to participate in a collaboration outweigh the risks involved. Supporting these decisions is a central activity in inter-enterprise trust management. In this paper, we review factors affecting human trust decision making in online environments and apply them to the domain of inter-enterprise collaborations. To validate their applicability, we evaluate how the Pilarcos collaboration management toolset, and particularly its trust management system, can be mapped to them.

Index Terms—inter-enterprise collaborations, trust decisions, trust development, Pilarcos trust management system

I. INTRODUCTION

Inter-enterprise collaborations are the drivers of the European economy, as the majority of the economy is constituted of small and medium-sized enterprises [1], [2]. Due to limited resources such as money, manpower, hardware and software, they need to collaborate with other enterprises in order to expand their business and attain a competitive edge in fields dominated by large enterprises [3], [4].

Inter-enterprise collaborations are defined as networks of autonomous enterprises providing a composed service to the end-users. The success of the inter-enterprise collaborations relies on their efficient establishment in dynamically evolving open service ecosystems, which support opportunistic selection of collaboration partners beyond the enterprises' slowly evolving strategic networks. The open nature of these ecosystems, combined with the autonomy of the enterprises involved, makes trust management a challenge.

Trust decision making is a core activity in the trust management process in the domain of inter-enterprise collaborations. Trust decisions are made during the establishment and the continuation of the inter-enterprise collaborations. They measure the subjective willingness of the enterprise to participate in the collaboration, given the risks and incentives involved [4]. The goal of automated support for these trust decisions is to help protect enterprise assets, which are endangered by uncertain and risky situations. Therefore, trust decisions play a crucial role in the establishment and operation of inter-enterprise collaborations.

The establishment of inter-enterprise collaborations should be efficient in terms of cost and time. For this purpose, routine decisions are automated. Human intervention is still needed, however, whenever the available supporting information is insufficient or the risks and stakes are too high for the decision to be trusted to the automated system. Due to this, it becomes necessary to study human preferences for trust decision making in risky and uncertain situations.

The overall objective of the research is to resolve how to support human interventions for semi-automated trust decision making in the domain of inter-enterprise collaborations. To support this goal, the main research question of this paper is how human preferences regarding trust decision making in the research literature, focusing on the business-to-consumer (B2C) setting, can be applied to the field of inter-enterprise collaboration. We address this research question by (i) studying human preferences in context of the process of trust decision making with previously unknown or little known enterprises, and (ii) validating the applicability of the identified factors by comparing them against the Pilarcos collaboration management framework, particularly its trust management system.

Studying human preferences to trust decision making in the domain of inter-enterprise collaborations serves three purposes. First, it helps in understanding the phenomenom of human trust decision making in the domain of inter-enterprise collaborations. Second, understanding human preferences will contribute to the development of future automated or semi-automated trust management systems that can satisfy human needs, which in turn leads to better usability and helps users entrust their routine decision making to these tools. Lastly, it provides a basis for evaluating existing trust management systems for further improvements. Some of these purposes tie into future work, which we will return to later in this paper.

The rest of the paper is organized as follows. Section II discusses human preferences on trust decision making applicable in the domain of inter-enterprise collaborations. Section III presents the Pilarcos middleware tools and trust management system, and maps the concepts from the previous section to Pilarcos in order to evaluate their applicability. Section IV presents the conclusions and future work.

II. HUMAN PREFERENCES FOR TRUST DECISION MAKING

This section presents the human preferences for trust decision making in terms of: (A) approaches to human trust development and (B) qualitative and quantitative criteria affecting trust decision making. The approaches to trust development

are correlated with different criteria for trust decision making. This is because movement between different stages and cycles of trust development requires trust decision making which is, in turn, dependent on different criteria.

So far, few studies address the problem of human intervention regarding trust decision making, particularly with previously unknown or little known enterprises in the domain of inter-enterprise collaborations. On the other hand, human trust decision making in risky situations has been researched in the domain of B2C e-commerce. Considering the findings in existing literature and the involvement of human users in the problem under consideration, we believe that findings from the literature in the domain of B2C can be mapped to the field of inter-enterprise collaborations with some adaption.

A. Approaches to Human Trust Development

Two approaches to human trust development can be identified in the existing literature: the cyclic and the staged approach [5].

The **cyclic trust development approach** is based on the satisfaction of prior expectations about behavioral outcomes. The satisfaction gained builds the confidence of the trustor, whereas continuous dissatisfaction at any stage lowers the existing trust level.

Fung et al. [6] introduce a cyclic approach to trust development in the domain of B2C e-commerce. Their model of cyclic approach lists information quality, interface design and reputation as factors contributing to initial trust formation. On the other hand, Deelman et al. [7] have proposed an elaborated model, also representing the cyclic approach to trust development, based on the model of Fung et al. The model of Deelman et al. addresses trust development in the domain of inter-enterprise e-commerce through factors such as willingness to trust, estimation of the trustworthiness of the trustee enterprise, evaluation of past experiences, situation and risk inherent in the current situation.

Both Deelman et al. and Fung et al. mainly focus on the cyclic nature of trust development. Deelman et al. [7] have modified the list of factors affecting initial trust development from the factors given by Fung et al. [6] based on the domain of their research. However, the list of factors given by both the models is insufficient in context with the domain of inter-enterprise collaborations. There are other factors, such as contracts, shared beliefs, legal terms and conditions, playing a significant role in the trust development during initial stages. Furthermore, the models also do not clearly state the criteria behind distrust or dropping out of further transactions. Both models are of the view that negative evaluations generate distrust and, through that, dropping out of the trust relationship. They do not clearly state, however, whether only one negative evaluation or continued negative evaluations results in dropping out. We believe that this is, in fact, determined by the effect the negative evaluations have on the enterprise. For example, if only one transaction creates huge losses for the enterprise, drop out will occur immediately. On the other hand, if the effect is trivial, then continuity and persistence of

the negative evaluations becomes the basis for dropping out. In addition, the model given by Deelman et al. states that the factor list is followed in the given fixed sequential order, but we do not agree as the following of the order depends on the subjective preference of human users.

The **staged trust development approach** works on the assumption that the development of online trust takes place in different stages. Shapiro et al. [8] and Ba et al. [9] have proposed three-staged trust development models. The three stages given by the model of Shapiro et al. are deterrence-based, knowledge-based and identification-based. In turn, Ba et al. have given calculus-based, information-based and transference-based stages to trust development. Both these models have weak points, when considered against inter-enterprise collaboration. First, they do not show the effect of opportunistic behavior or deviations on the trust levels at any stage. Second, they assume a limited view of the collaboration, as they are of the viewpoint that knowledge/information-based trust becomes dominant during the second stage, after a series of direct interactions. We believe that it can also be used during the first stage, based on the information gained from the reputation networks in addition to calculus-based trust. Furthermore, the model of Shapiro et al. considers deterrence-based trust as the first stage, whereas we assume that calculus-based trust, which employs weighing of potential gains versus risks, to be the more influential in the case of trust development with the previously unknown, little known and even known enterprises.

In addition to the two models above, Kim et al. [10] and McKnight et al. [11] have both proposed two-staged models of trust development. The different stages in their models are the initial or exploratory, and commitment stage. The model proposed by Kim et al. does not clearly state the criteria behind a shift from initial trust to the robust trust of the commitment stage, or departure. For example, in the case of inter-enterprise collaborations, the occurrence of significant deviations from the accepted terms and conditions have been identified as criteria behind departure from the collaboration [3], [12]. The model also does not provide a precise list of factors affecting trust formation during the initial and committed stage. In contrast, the model proposed by McKnight et al. does not address the notion of departure from the trust relationship at any stage. This is unrealistic, as the priorities of the enterprises can change at any time.

B. Criteria for Trust Decision Making

The criteria for trust decision making are defined as different qualitative and quantitative characteristics or standards required for decision making in an uncertain and risky situation [13], [14], [5]. In the domain of inter-enterprise collaborations, different criteria for trust decision making are specific to the trustor, trustee, context and/or collaboration being considered.

Trustor criteria, such as propensity to trust, emotions and culture, have direct impact on the trust decision making. **Propensity to trust** is the human behavioral trait referring

to the trustor's general expectations or attitude about trusting humanity. It reflects their willingness to extend trust to any trustee, purely based on their inherent willingness to trust others and independent of any information about a trustee's characteristics [14]. **Emotions** are defined as the cognitive approach to trust decision making which are also independent of the trustee or the situation [15], [16]. They dominate trust decision making by facilitating the formulation of perceptions about the available information and the situation at hand. **Culture** is defined as a personality trait of the trustor, influencing their attitude in perceiving the available information for trust decision making [15].

Trustee criteria refer to reputation information on the trustee, affecting the process of trust decision making. Reputation information is defined as the knowledge about the past and present behavior of the trustee, aiding the assessment of their trustworthiness [3], [13], [17]. It also provides a basis for trying to predict the future behavior of the trustee. Trustworthiness is defined in terms of three high-level classes: ability, benevolence and integrity [14]. With previously unknown enterprises, third-party reputation networks are the main source of reputation information during the initial stages of trust development. On the other hand, information gained from past direct experiences of the trustor with the target enterprises act as the main source of reputation information during the committed stage.

Contextual criteria represent information that changes depending on the current situation. It comprises three aspects: system trust, a user interface to aid decision making, and external environmental factors. McKnight et al. [18] introduce structural assurances and situational normality as components of **system trust**, and Pavlou [19] has later added facilitating factors to the list. **Structural assurances** refer to the impersonal structures which help in generating trustworthiness when dealing with uncertain situations [18], [5], such as guarantees, safety nets, legal contracts and regulations. **Situational normality** refers to the trustor's belief or assumption that the situation at hand is safe and positive for gaining the desired benefits [18], [5]. **Facilitating factors** [19] are defined as non-governing factors referring to the perception about the trustee's integrity or adherence to the general and unanimously established rules and commitments regarding the collaboration, such as shared standards, goals and beliefs between the collaborators. The **user interface** of the trust management system is responsible for presenting the information required for trust decision making regarding inter-enterprise collaboration in a clear and efficient manner. **External environmental factors** refer to the contextual factors constituting social, economic and technological issues affected by the current conditions, such as a recession.

Collaboration-specific criteria refers to the collaboration objectives and perspectives affecting trust decision making [17]. The **objectives** are defined as the pre-set goals of the inter-enterprise collaboration and its participating enterprises. On the other hand, the **perspectives** which are based on the objectives represents the viewpoint of the trustor towards trust formation [17]. We identify seven different types of perspectives: organizational, economical, social, technological, behavioral, psychological and the service perspective [17], [3], [12]. The organizational perspective refers to characteristics of the enterprise, such as setup and size, whereas the competencies and abilities of the enterprise fall under the technological perspective [17], [3]. The economical perspective reflects the financial condition of the enterprise, in addition to the possibilities of monetary risks and incentives involved in the inter-enterprise collaboration [17], [3]. The social perspective represents the association of the enterprise with its external environment in general, such as the activities and contributions of the enterprises in the social context or through the consideration of contracts, monitoring and security mechanisms [17], [12]. The behavioral perspective points to the past or present behavior of the enterprise in context to inter-enterprise collaborations [3], [17], [12], whereas the psychological perspective represents the intentions of the enterprises willing to collaborate [12]. Finally, the service perspective considers the details of the service offers made by the enterprises for collaborating with other enterprises [3], [12].

III. TRUST MANAGEMENT IN PILARCOS

This section compares the concepts we have discovered in existing literature against the existing Pilarcos trust management system, with the goal of validating their applicability to inter-enterprise collaborations. Our ongoing research on resolving the problem of human intervention in the domain of inter-enterprise collaborations is ultimately tested through implementation of the concepts in the Pilarcos middleware. Firstly, Pilarcos and its trust management system are briefly presented in Section III.A before going into details in Section III.B. The main findings from the evaluation are discussed in Section III.C.

A. Pilarcos Middleware and Trust Management System

The Pilarcos middleware facilitates the establishment and operation of inter-enterprise collaboration in open and distributed environments. It provides support for automated collaboration management and ecosystem evolution processes by providing solutions to interoperability and trust management problems [3], [20]. Pilarcos defines inter-enterprise collaborations as a *"loosely-coupled, dynamic constellation of business services"* [3]. The collaborations are formed based on Business Network Models (BNM). A BNM defines the structure of the virtual enterprise in terms of the roles and interactions between them, in addition to the policies based on the legal and regulatory systems of the business domain under consideration [21]. A BNM repository in the Pilarcos middleware contains templates for the different kinds of collaborations available. Considering the scope of the paper, our focus is on the Pilarcos trust management system specifically.

In Pilarcos, trust is defined as *"the extent to which one party is willing to participate in a given action with a given partner in a given situation, considering the risks and incentives involved"* [4]. The system performs automated local

and context-aware trust decisions. The Pilarcos middleware requires trust decisions at two kinds of points: joining and continuing the collaboration, when additional resources must be committed. The trust decisions are made by producing risk estimations and comparing them to risk tolerance [3], [4]. The risk estimates are based on reputation information, whereas risk tolerance is based on the strategic importance of the collaboration to the business of the enterprise [3], [4].

The Pilarcos trust management system makes automated trust decisions according to pre-defined local policies. In addition, mutually decided shared policies are negotiated at each collaboration establishment by all the collaborating enterprises, and are encoded in contracts; these policies influence the local policy setup as well. The automated trust decisions are performed in the routine cases leading to clear acceptance or rejection. On the other hand, human users are prompted for trust decision making during cases that fall under the gray area between routine accept or reject. In these cases, a trust decision expert tool handles the required human intervention [22].

B. Comparison of Human Preferences Against Pilarcos

The correlation between the human preferences found in the existing literature and the process of trust decision making followed by the Pilarcos trust management system helps in validating their applicability of the findings in the domain of inter-enterprise collaboration. Table 1 presents the summarization of the evaluation of Pilarcos and its trust management system against the human preferences specified in Section II.

1) Approach to Trust Development: The working of the Pilarcos trust management system contains the elements of both the cyclic and the staged approach to trust formation [3], [4]. As previously mentioned, the Pilarcos trust management system triggers trust decisions both during the establishment and operation of the collaboration. For an unknown or little known collaborator, the first trust decision point is equivalent to the initial stage of trust formation marked by either no or low trust. On the other hand, the following trust decision points are equivalent to the committed stage, where decisions are made based on the experience gained by direct interaction with the collaborating enterprises. This continuation point comes whenever more resources need to be committed or significant reputation changes occur during the collaboration.

The Pilarcos middleware tracks the operation of the inter-enterprise collaboration using monitors local to each enterprise. Whenever a service detects significant deviations in terms of misbehavior and failure to comply with contractual commitments, it notifies the other participating enterprises, and joint recovery actions can be taken. If needed, the parties responsible are replaced by new partners in the inter-enterprise collaboration. The first-hand experiences gained during the collaboration constitute local reputation information. The local reputation information is fed to a reputation system during the termination phase for the short-term collaborations [4]. In the case of long-term collaborations, the local information is fed at the pre-decided checkpoints during the operational phase. This local information together with external reputation

Comparison Criteria			Pilarcos
Approach to Trust Development			Combined (Cyclic + Staged)
Human Trust Decision Criteria	Trustor Criteria	Propensity to Trust	Policies and contracts
		Emotions	Trust decision expert tool
		Culture	Business Network Model defining structure of the collaboration
	Trustee Criteria	Reputation	Experiences gained from earlier collaborations, first hand information from monitors and shared through reputation networks. The experiences are represented as the effects of actions on assets: monetary, reputation, satisfaction and control.
	Contextual Criteria	System Trust	Contract, possibility of contract negotiation, existence of interoperability measures, and monitoring
		User Interface	User interface of expert tool
		External Environmental Factors	Context repository
	Collaboration specific Criteria	Perspectives	Services, Economical, Technological, Behavioral.
		Objectives	Shared and Enterprise specific objective

TABLE I
EVALUATION OF HUMAN PREFERENCES AGAINST PILARCOS.

information is used in risk evaluations for future establishment and operation of inter-enterprise collaborations.

The repeated use of the information representing different criteria for trust decision making during the collaboration makes the Pilarcos trust management system cyclic in nature. On the other hand, the two kinds of decision points representing the two different stages of trust formation makes the Pilarcos trust management system staged in nature at the same time. Therefore, we conclude that Pilarcos trust follows a combined approach to trust development.

2) Criteria for Trust Decision Making: The criteria supported by the Pilarcos middleware and its trust management system are discussed below. As presented in Section II, they are divided into four groups: trustor, trustee, contextual and collaboration-spefic criteria. The **trustor criteria** include propensity to trust, emotions and culture.

Propensity to trust: The local policies and the contracts established mutually by all the collaborating enterprises during the negotiation phase represent propensity to trust in Pilarcos. The contract is not just data; it is defined as an active and distributed agent containing meta-information constituting all the rules and regulations responsible for dynamically governing the established inter-enterprise collaborations [23].

Emotions: Emotions come into play in the Pilarcos trust management system through the trust decision expert tool that handles human interventions in trust decisions. The user interface of the trust decision expert tool affects the emotions of the human users during trust decision making. Therefore, emotions play an important role in the establishment and operation of the inter-enterprise collaborations through human

intervention.

Culture: For Pilarcos, the choice of BNM for the collaboration represents its culture, for the purposes of trust decision making. As noted before, the BNM contains information about the processes, roles, interaction between roles and governing acceptable behavioral policies. The information contained in the BNM also dominates the process of automated search and selection of potential partners for the collaboration.

The **trustee criteria** consists of reputation information.

Reputation information: Pilarcos uses reputation information for calculating risk estimations [3], [4]. The main sources of reputation information are experiences gained from earlier collaborations and those shared through third-party reputation networks. Local monitors are responsible for gathering first-hand experiences during the collaboration. In addition, external reputation information shared through reputation networks is used particularly when local experiences are not readily available. Both the local and external reputation information is transformed to a uniform format of the number of experiences, each representing major negative, minor negative, no change, minor positive or major positive effects to four different assets: monetary, reputation, satisfaction and control [3].

The **contextual criteria** include system trust, user interface and external environmental factors.

System trust: The existence of legally binding contracts regulating the collaborations act as a structural assurance. The perception of situational normality is supported in multiple ways: The Pilarcos middleware provides the possibility of contract negotiation iteratively until all the collaborating enterprises are satisfied with the contents of the contract [20]. Furthermore, the existence of automated interoperability assurance between the collaborating enterprises also affects trust decision making positively [3]. The interoperability checking is performed during the selection of potential partners for the collaboration. In addition, monitoring of the collaboration to detect deviations and misbehavior also acts as a factor for observing situational normality [21]. The shared objective of the collaboration, in addition to shared technical and semantic communication standards, act as facilitating factors.

User interface: The Pilarcos trust decision expert tool handles human intervention for trust decisions [22]. The user interface of the expert tool provides the user with required information about risk, reputation, collaboration progress and context. It is designed based on the usability principles provided by Nielsen for designing user interfaces [24] and supported by a number of different cognitive strategies of user interface: cognitive fit theory, cognitive learning theory, unified theory of acceptance and use of technology and technology acceptance model [25], [26].

External environmental factors: The Pilarcos trust management system explicitly models context as one of the parameters influencing automated trust decision making. Context information comes from three sources: internal state of the system of the enterprise, state of business of the enterprise, and state of the business network the enterprise is involved in [3]. All these sources of information are affected by external environmental factors. A recession might affect the internal financial condition of the enterprise, for example, which would in turn affect the decision of the enterprise to enter into the collaboration. Therefore, contextual information provided by Pilarcos is related to the external environmental factors affecting the process of trust decision making.

Collaboration-specific criteria include objectives and perspectives.

Objectives: There are two types of objectives to consider: the shared objective of the inter-enterprise collaboration and the individual objectives of the enterprises involved. The collaboration objective is shared between the collaborating enterprises, whereas the individual goals of the enterprises can differ. Both types of objectives are present in Pilarcos. Collaboration objectives, such as monetary gains, reputation and customer satisfaction, are considered during the population process, where the selected service offers can be required to satisfy a set of criteria on e.g. their pricing [21]. On the other hand, the objectives of the enterprises come to play during the negotiation phase and contract establishment through risk tolerance policies, which can e.g. require that the probability of minor or major reputation gain is sufficiently high [4].

Perspectives: Pilarcos considers the service, economical, technological and behavioral perspectives of trust formation. The comparison of the service offer details against the requirements of the roles of the business process while selecting the potential partners for inter-enterprise collaboration provide a service perspective [20], [21]. Weighing potential benefits against possible losses and risks in trust decisions reflects the economical perspective. Interoperability checking of technical and connectivity issues ensuring reception and delivery of the messages among participating enterprises relates to the technical perspective. Use of reputation information, i.e. information about the past behavior of the enterprises, ties to the behavioral perspective on trust formation.

C. Discussion

The comparison of the criteria affecting human trust decision making against the Pilarcos system demonstrates that the concepts drawn from the domain of B2C e-commerce are applicable in the domain of inter-enterprise collaborations as well, after some necessary adjustments. While the objectives and perspectives of the collaboration have a strong influence on trust decisions in inter-enterprise collaborations, for example, they have had very little emphasis in the B2C literature, as it focuses on reasonably simple interactions between the consumer and the enterprise.

Once these adjustments have been made, the resulting criteria can be used to describe trust management in Pilarcos, i.e. the criteria used in Pilarcos map into the human decision making concepts. Further, the identified concepts all have a match in Pilarcos; in other words, Pilarcos supports the different criteria found in this work, which provides a good basis for satisfying the needs and expectations of human users.

IV. CONCLUSION AND FUTURE WORK

Trust is the prominent factor aiding the existence, feasibility and success of the inter-enterprise collaborations. The existence of trust mitigates the feeling of uncertainty and fear inherent in relying on other autonomous partners, and relaxes the need for constrictive risk mitigation methods to support the collaboration. Trust decisions measure this willingness to accept the risks involved. While routine trust decisions can be automated for efficiency, human intervention must be supported in non-routine situations. For this purpose, we have analyzed the existing literature on human trust decision making in the online environment, and applied the concepts to inter-enterprise collaborations.

Understanding the human process of trust decision making, in terms of different elements and criteria of trust decision making and the trust development process, helps resolve the overarching research question of how to support human intervention in trust decisions for inter-enterprise collaborations. In this paper, we have found that existing research on human trust decisions in the B2C domain can be applied to the domain of inter-enterprise collaborations, with some adjustments. The applicability of the identified decision criteria has been evaluated against the existing Pilarcos middleware and trust management system, demonstrating that the inter-enterprise collaboration management middleware can be described through these concepts, and that it also addresses all the identified criteria.

As a next step, we plan to populate the decision criteria and trust development model presented in this paper with different existing trust management systems within the domain of inter-enterprise collaborations in order to provide a comparative analysis of the trust management processes in related work. The study also provides input for our continued work on developing user-friendly interfaces for inter-enterprise collaboration management, which forms a second branch of our work on supporting human intervention in trust decisions for inter-enterprise collaborations; we have completed the user interface for simple trust decisions, and plan to continue the work through implementing a more flexible expert tool that allows the reconfiguration of collaborations and simulating the effects of policy changes as well.

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Optimal experience in software development – an element of developer experience

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Abstract—Software engineering and software development would benefit from further insight into human factors-related *developer experience*. In particular, how should developer experience be researched, how can process models and company-specific processes more carefully take developer experience into account, how can projects discover and address interpersonal root causes for project failure, and how can quality assurance and improvement consider human factor root causes? Understanding Free and Open Source Software and Agile software development practices require an application of psychological and social psychological insights to software engineering and software development. In particular, optimal experience in software development is of interest, as it relates to intrinsic motivation and values of software developers. Increased understanding of this topic may help select and improve development processes, methodologies, and tools, increase quality and performance of software-based products and services, and contribute to well-being in software development organisations. This paper describes a PhD project to study these issues.

Keywords-software engineering, open source software, behavioural science, mood, psychometric testing, human factors, developer experience, optimal experience

I. INTRODUCTION

The process by which software is constructed is traditionally believed to have significant impact on both the success of the project – whether it has delivered the desired software within the real-world restrictions on cost, schedule and other factors – and the quality of the end-product – whether the product performs according to specifications. As the visibility of Free and Open Source Software (FOSS) started to increase during the 1990s, the importance of following a process in the traditional sense has been increasingly questioned. FOSS instead puts emphasis on the social aspects of software engineering [1], as does Agile software development with its "individuals and interactions over processes and tools" motto [2]. Simultaneously, FOSS professionals frequently create, follow, and enhance personal and collective processes, and encode these in various software development tools, and many Agile software developers use the same tools. FOSS and Agile software development have been the subject of many research articles. However, there is currently a gap in understanding how software professionals experience their work processes, be they traditional, Agile, or FOSS, and what contributes to optimal experience in software development.

II. RELATED WORK

Software systems and service development, maintenance, and other related activities are to a large extent human-based. Aspects such as motivation, skills, satisfaction, and even more vague concepts such as psychological flow are to be considered in these activities. The importance of human aspects in software development is well known [3], [4], [5], [6], but limited evidence is available on the relevance of human factors in the development process that influence performance and quality.

Many factors for software project success have been identified, including communication, characteristics of team structure, and personalities of team members [7], [3], [8], coordination processes [8], [9], [10], and interdependencies between software developers and users [11]. Previous work suggests that software developers are motivated by intrinsic factors such as the nature of the job itself [12], [13], increased responsibility [14], opportunities for advancement and growth [15], recognition [6], and senior management support [16], [17], [18].

In a university setting, both group cohesion and structure seem to correlate with team performance [19]. In industrial settings, achieving high levels of performance and capabilities may result in projects that are more time- and cost-effective, better managed, and produce higher-quality software. Clarity of team goals and trust among team members have an impact on team performance in terms of higher software quality [20]. Trust is key to a cohesive team [21]. Achieving a working team, however, is a learning process with each new project [22]. High-performance teams have been reported to be proud of their high technical competence and confidence, and they value flexibility and ability to communicate, listen, give relevant feedback, and be a good team worker [6].

Baddoo et al. [5] and Hall et al. [6] report that good performance in a high-maturity organization is a consequence of motivating developers by salary and benefits, recognition, and opportunities for achievement, technically challenging work, job security, and senior management support. Beecham et al. [15] show that software engineers are motivated by 1) their characteristics (e.g. their need for variety), 2) internal controls (e.g. personality), and 3) external moderators (e.g. career stage). Moreover, job motivators include technical challenge, problem solving, and working to benefit others [15].

All these are human factors that have been observed in professional software development environments. However, few process models, software project management practices, or other related activities place these human factors in a central position when attempting to optimize the development process. The links between these human factors and adherence to software development processes, level of project success, level of performance, and level of quality, are largely unexplored.

A. Developer experience as an essential factor of software project success

Current software engineering practice paints a complex picture of the activity of software development. The perception of success often differs between stakeholders – management, software developers, and software users. Differences in perception across industries has also been found in a study examining successful software projects and products [23]. This suggests that process models must be adapted to each case and that they may not in fact contain the most crucial elements required or be as repeatable as desired. Other factors may be far more important than development processes or methodology as they are portrayed in traditional software engineering literature. Anecdotal evidence suggests that some development teams can outperform other teams by orders of magnitude [24], [25], but reasons are not to be found in application of a standard process model or development methodology. It is likely that the reasons for this increased performance lies in social and psychological areas. As industry is becoming attentive to user experience (e.g.. [26]), it seems that the "user experience" of software development itself is also an important perspective.

Software development organisations also affect software development through various mechanisms, some of which are unintentional. Organisational structure affects the quality of the end product [27]. Architectural structure of a software product corresponds to that of the development organisation [28]. During software development, as in any collaborative human activity, the psychological state of each individual affects and is affected by the state of other individuals as they interact within a group. It is likely that the collective efforts of the software development team affect project quality and the quality of the end product.

B. Processes may not be the most important factor

Many FOSS projects appear to work well without explicit process definitions. Individuals in these projects work partly based on experience, partly by trial and error, and partly on intuition. There is no overall software engineering process in the traditional sense. The steering mechanism is one of social structure. Discussion and project-level action happen whenever needed, otherwise all resources are spent on actual work. Explicit processes may be a hindrance, and it is not surprising that "process" is so loosely defined in the FOSS universe. Where they exist, the processes of FOSS are encoded in the tools used by participants. If the process in some area is suboptimal,

a period of experimentation is followed by a tool change to enforce a new process in that area. The concept of process is then promptly forgotten, as participants again focus on the actual work. This decision is a pragmatic one, and applies just as well to non-FOSS development efforts. In a study comparing four operating system kernels – two having been developed by different kinds of FOSS projects and the other two by different kinds of non-FOSS organisations – the influence of process among these was found to be at most marginal [29].

C. Essential psychological and social psychological mechanisms

As noted, FOSS and Agile place emphasis on the social aspects of software development. The personality of individuals and how well they communicate are important elements, which influence a development team. One case study observed the difficulty in getting teams to function efficiently that are heterogeneous in ethnic, religious, and personality domains, but noted that these difficulties can be overcome if the team members are determined [30]. The study also noted that failure can arise from over-reliance on a single individual, and that this situation can be caused by the personality and ethnic mix within the team.

Successful completion of a software development project does not merely require contributions of work from each team member, it also requires the individual contributions to fit together properly. Software engineering focuses internally on architecture, modularity, code reuse, testing, and other methods. It is thought that arranging these as steps – not necessarily serial – in a repeatable process model is key to successful projects. However, little is known about how human factors determine success in software development. The influence of individual temperament, personality, knowledge, and skills on success, performance, and quality; how groups should be composed, and how they should interact taking into account issues like co-location or team distribution; how intrinsic and extrinsic motives determine the actual direction in which individuals and groups take their development projects – all of these are intuitively important factors to experienced software engineers, but the factors are detached from the theoretical knowledge in the field.

D. Optimal experience as a guide

The term *flow* or *optimal experience* describes what work or leisure experience can be at its best: "a sense of that one's skills are adequate to cope with the challenges at hand in a goal directed, rule bound action system" [31]. The state can also be experienced collectively, as described in the literature on optimal experience, which leads to the idea that software development projects could be managed using a repeatable, human factors-driven method.

This paper describes a PhD project to study developer experience with particular attention to optimal experience in software development. The general research question of the project is

RQ: *How do software development practitioners experience software development?*

This is broken down into the following sub-questions:

RQ1: *Under what conditions and in what activities do software development practitioners perceive optimal experience?*

RQ2: *What enablers and barriers for optimal experience exist in current software development methodologies?*

RQ3: *What is the relation between developer experience and performance in software development?*

RQ4: *What is the relation between developer experience and quality in software development?*

RQ5: *How could developer experience and optimal experience be used to improve the software development process?*

III. RESEARCH METHOD

The following methods and modes of execution will be used to answer the research questions. In general, the research is inspired by Grounded Theory methodology [**?**] and new research questions may arise during the interaction with field data. The research uses both quantitative and qualitative data, and can be characterized as mixed-method research.

A. RQ1: Under what conditions and in what activities do software development practitioners perceive optimal experience?

To answer this research question, the *Experience Sampling Method* (ESM) [32] will be used. This method involves subjects reporting their experiences during a limited time interval (e.g., two weeks) a certain number of times every day (e.g. randomly at certain hours or at fixed times). In this study, a sample of software developers will be examined using ESM to determine the conditions that affect developer experience and enhance the experience towards optimality. Possible influencing factors will be isolated and the sampling may be repeated to test influence of different factors.

The method will be employed both in a quasi-controlled laboratory environment and an uncontrolled field environment.

B. RQ2: What enablers and barriers for optimal experience exist in current software development methodologies?

To answer this research question, a set of modern software development methodologies will be examined analytically to determine whether they contain inherent mechanisms that could affect developer experience or enhance the experience towards optimality. Also, qualitative methods will be used to examine perceptions of software developers. In addition to this, the ESM runs in RQ1 will be used to test the mechanisms empirically where possible.

C. RQ3: What is the relation between developer experience and performance in software development?

This research question contains two separate angles: that of perceived performance, a subjective measure, and that of performance as measured by objective measurement.

To answer this research question, perceived performance will be recorded via questionnaires and interviews, and objective software performance metrics will be gathered during the same time periods as the ESM runs. Correlational analysis will be used to determine the relation.

D. RQ4: What is the relation between developer experience and quality in software development?

This research question contains two separate angles: that of perceived quality, a subjective measure, and that of quality as measured by objective measurement. To answer this research question, perceived quality will be recorded via questionnaires and interviews, and objective software quality metrics will be gathered during the same time periods as the ESM runs. Correlational analysis will be used to determine the relation.

E. RQ5: How could developer experience and optimal experience be used to improve the software development process?

To answer this research question, the results from RQ1-RQ4 will be analysed and suggestions for how developer experience and optimal experience could be used to improve the software development process will be produced. Depending on the results, these suggestions could be further tested in either laboratory or field conditions.

F. Actions and current state

Actions and current state of research are outlined in Table I.

IV. EVALUATION CRITERIA

V. CONCLUSION

The aim of this PhD study is to explore the concept of developer experience and optimal experience in software development. The study is be conducted using a Grounded Theory approach with mixed-method characteristics. Project partners from two projects are to be used in case studies and data collection.

To answer the research question, ESM will be used to empirically measure developer experience during software development. The dimensions to measure are determined by a thorough analysis of existing software development methodologies and by qualitative inquiry examining perceptions of software developers. The relation between developer experience and performance and quality are examined by measuring both subjective notions and objective measurements of these. Finally, the insights gathered will be used to suggest how developer experience could be used to improve the software development process.

VI. ACKNOWLEDGEMENT

Table I
LIST OF ACTIONS AND THEIR CURRENT STATE.

Step	Status	Documentation
Problem	80% finished	To be submitted.
State of the practice	50% finished	1st article submitted. (Grounded theory/affinity wall study.)
State of the art	10% finished	To be submitted.
Approach	1st version finished	Initial outline.
	2nd version started	Grounded theory approach. To be submitted.
	3rd version not started	Quantitative approach.
	4th version not started	Mixed-methods approach.
Evaluation	1st evaluation started	Grounded theory/affinity wall interview study. 1st version submitted.
	2nd evaluation not started	Grounded theory case study.
	3rd evaluation not started	Quantitative study.
	Further cycles as needed	
Documentation and integration	Started	Initial outline.

of TIVIT[3] (Finnish Strategic Centre for Science, Technology and Innovation in the field of ICT), and by the Department of Computer Science[4], University of Helsinki as part of the Software Factory[5] project.

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