The Role of Architecture Evaluations in ICT-companies

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ABSTRACT

Architecture evaluation is a way to get answers to organisation's information needs and problems relating to its business and ICT. Companies' needs to move towards business value driven ICT-development and pressures to improve the cost-effectiveness of ICT are some of the reasons for the increasing interest in the evaluations and measurements of architectures. However, the role and the meaning which architecture evaluation may have in companies is not clearly identified or defined. For example, needs and triggers for architectural evaluations do not seem to be identified in previous studies. The aim of this study is to gain understanding of roles and meanings, which architecture evaluation and measurement may have in companies. Triggers for evaluations and measurements were identified and analyzed. Practitioners from five ICT user and service provider organisations were interviewed in this study. This study reveals that the role of architecture evaluation may be to enhance the understanding of company's business and ICT-environments from financial and structural viewpoints. In addition, it can be used as a tool in change management, quality assurance, process planning, IT cost management and architectural choice making.

Keywords

Architecture evaluation, enterprise architecture, software architecture

INTRODUCTION

Companies' needs to move towards business value driven ICT-development and to improve the cost-effectiveness of ICT are illustrative of contemporary development pressures. These, among others, pressures drive companies to improve the understanding of their business- and ICT-environments. Architectures and architectural descriptions (enterprise and software architectures) are used to enhance

understanding of the company's environments. However, architectural descriptions and documents do not directly answer all business and ICT related questions and information needs.

Stakeholders in a company have various information needs, questions and topics of concern relating to the company's business and ICT. One way to seek answers to these questions and information needs is the execution of architecture evaluations. Lately, interest in carrying out such evaluations of architectures has increased in companies. In addition, experts also highlight the importance of evaluations of architectures and architecture processes (e.g. [25, 26]). The methods and practices for architecture evaluations and measurement are studied and developed by many organisations as well. However, the role of architecture evaluation in companies and its meaning for them is not yet clearly defined or identified, suggesting that real evaluation needs or triggers for evaluations are not identified and gathered from practitioners and specialist in ICT companies.

The aim of this study is to gain understanding of the meanings and roles, which architecture evaluation and measurement may have in companies. This study identifies and analyses companies' triggers for architecture evaluations. Our research involved reviewing five ICT-companies' practitioners' experiences on and conceptions of triggers for enterprise and software architecture evaluations. Triggers for architecture evaluations are problems, questions, topics of concerns and information needs which initiate the evaluation work.

This study consists of the following sections. Firstly, general evaluation concepts and architecture evaluation related concepts and architectural viewpoints are considered. Secondly, the research method used in this study is presented. Thirdly, the triggers for architecture evaluations identified and categorised in this study are presented. Finally, these triggers are analysed and suggestions for roles and meanings of architecture evaluations are given. The areas for further examination are also presented.

ARCHITECTURE EVALUATION CONCEPTS

It seems that there is no commonly accepted evaluation and measurement theory. Nevertheless, many sources and research areas in several domains define evaluation and measurement concepts as well as present methods and practices for it. For example, evaluation and measurement concepts are defined in the domains of program evaluation (e.g. [6, 29, 34, 37, 38]), quality management (e.g. [15], [16]) and software engineering (e.g. [19], [11], [4]). Research and development work on evaluation methods and practices is ongoing in the context of enterprise and software architecture management (e.g. relating EA [9, 27]). However, evaluation theory (e.g. concepts and practices) does not yet seem to be established in this context.

Enterprise and Software Architecture Definitions

IEEE 1471 Standard [12] defines architecture as the fundamental organization of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution. In one instance enterprise architecture is defined by Kaisler et al. [18] as " *the main components of the organization, its information systems, the ways in which these components work together in order to achieve defined business objectives, and the way in which the information systems support the business processes of the organization*". These components include staff, business processes, technology, information, financial and other resources, etc. A definition of software architecture is provided by Bass et. al [5]: "*The software architecture of a program or computing system is the structure or*

*structures of the system, which comprise software elements, the externally visible
properties of those elements, and the relationships among them."*

Stakeholders

Architecture work has a group of stakeholders. These stakeholders have varying topics
of concern, information needs and questions relating to company's business and ICT.
These stakeholders have thus different perspectives on architectures. Therefore, they
have different questions and concerns relating to architectures. On one hand,
enterprise architecture related stakeholders may include the ICT and the business
organisations, management, the architecture group, the investment board, ICT
maintenance and security groups (e.g. [1, 33]). On the other hand, software
architecture related stakeholders may include acquirers, developers, architects, users,
maintainers, suppliers, testers, assessors, communicators, system administrators and
support staff [28].

Evaluation Perspectives

Due to this variety of stakeholders and their information needs, different evaluation
approaches are needed. A classification of evaluation approaches is proposed by
Worthen et. al [38] in the context of program evaluation. The adaptation of this
classification to the architecture context is presented in the next table.

**Table 1. Evaluation approaches
(adapted to the architecture evaluation context from Worthen et al. [38]).**

Evaluation approach	General purpose of evaluation
objective-oriented evaluation	determining the extent to which goals are achieved
management-oriented evaluation	providing useful information to aid in making decisions
consumer-oriented evaluation	providing information about products to aid in making decisions about purchases or adoptions
expertise-oriented evaluation	providing professional judgments of quality
adversary-oriented evaluation	providing a balanced examination of all sides of controversial issues, highlighting both strengths and weaknesses
participant-oriented evaluation	understanding and portraying the complexities of a architecture, responding to an audience's requirements for information

Architecture Evaluation Concepts

Fundamental evaluation concepts are described, for example, by Marta Lopez in the
examination of one architecture evaluation method (ATAM) [23]. These concepts are:

- *target*: the object under evaluation
- *criteria*: the characteristics of the target that are to be evaluated
- *yardstick or standard*: the ideal target against with the real target is to be
  compared

- *data-gathering techniques*: the techniques needed to obtain data to analyze each criterion
- *synthesis techniques*: techniques used to judge each criterion and, in general, to judge the target, obtaining the results of the evaluation
- *evaluation process*: series of activities and tasks by means of which an evaluation is performed.

Data gathering and synthesis techniques and evaluation process for architectures are largely not defined separately. Rather, these are defined by and included in the architecture evaluation methods. In addition, evaluation methods support different evaluation approaches. An array of methods is also being developed for evaluation of enterprise and software architectures. These methods are evaluated and compared in some studies (e.g. [3], [8], [13]).

ARCHITECTURAL VIEWPOINTS

This study focuses on examining architecture evaluations which are based on information included partly or totally in architecture descriptions and documents. Architectural descriptions related concepts are considered in this chapter.

Architectural Descriptions

Both enterprise and software architectures are described by architectural descriptions. The architectural descriptions may be baseline and/or target architecture descriptions. IEEE 1471 defines a couple of concepts relating to architecture descriptions. IEEE 1471 concepts seem to be accepted both in the SA and in the EA domain (EA domain adaptations for example relating to Togaf Framework [10] and by Steen et. al. [32]). Concepts defined by IEEE 1471 [12] are especially the following:

- *Architectural description*: A set of views (which consist of architectural models) and additional architectural information.
- *View*: A set of model representing enterprise or system from the perspective of a related set of concerns.
- *Model*: A particular diagram and description constructed following the method defined in a viewpoint.
- *Viewpoint*: The conventions for creating, depicting and analyzing a view.

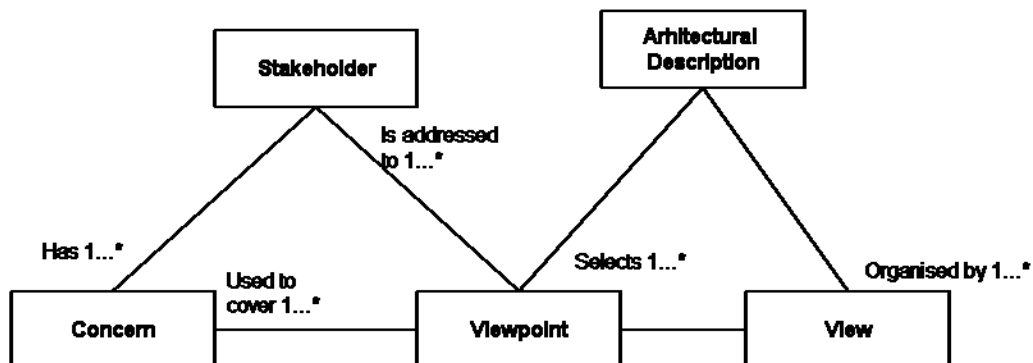Relationships between these concepts are presented in figure 1.

Figure 1. Architectural description related concepts (IEEE 1471 [12]).

Viewpoints

Viewpoints delineate the architectural information that is presented to the stakeholders [20]. Viewpoints, on the one hand, prescribe the content and "models" to be used, and, on the other hand, indicate their intended "stakeholders" and their concerns [20].

Architecture frameworks both in enterprise architecture and in software architecture domain define a couple of viewpoints. For example, EA viewpoints are defined by Zachman's Framework for Enterprise Architecture [39], The Open Group Architecture Framework (TOGAF) [35], Archimate framework, ISO Reference Model of Open Distributed Processing (RM-ODP) [14]. SA viewpoints are defined, for example, by viewpoint models such as Kruchten "4+1" View Model [21], Software Engineering Institute (SEI) set of views [7], Siemens Four View Model [31] and Rational Architecture Description Specification (ADS).

As discovered by May [24], viewpoints defined such as defined by different Viewpoint models do not completely correspond to each other. Enterprise architecture viewpoint models seem to be similar situation. A commonly accepted set of architectural viewpoints does not thus currently exist [24, 30]. As Smolander [30] reveals the architectural viewpoints chosen by companies are rather agreements between people depending on the organizational and project environment. In practice, the selection of architectural viewpoints is, thus, based on the prevalent situation and characteristics in the company and in the project at hand.

However, different viewpoint models have similarities in the viewpoints defined by them. In the following, viewpoints that seem to be accepted on some level in the EA domain are presented firstly; secondly, viewpoints that seem to be on some level accepted in the SA domain are introduced.

Enterprise Architecture Viewpoints

Enterprise architecture viewpoints define abstractions on the set of models representing the enterprise architecture, each aimed at a particular type of stakeholder and addressing particular concerns [32]. Enterprise architecture viewpoints which are generally mentioned include: *business architecture, information and data architecture*, a*pplication (systems) architecture* and *technical (technology, infrastructure) architecture* (e.g. [17, 35, 36]). Roles these viewpoints have and examples of targets suggested to be described relating to each viewpoint are described in the table 2.

Table 2. Enterprise architecture viewpoints.

Business architecture	
Role	Defines what the enterprise must produce to satisfy its customers, compete in a market, deal with its suppliers, sustain operations, and care for its employees [36].
	An enterprise view of what the business must do today as well as in the future to accomplish particular business requirements [36].
Content examples	Key business operations and value streams for the organization [17, 18, 36], Business processes [18], Organisational structure: Organisations, units and functions and responsibilities of them, Roles/Skills [18, 36], Enterprise operating environment [36]

Information / Data architecture	
Role	*Information architecture*
	The informational needs of the enterprise in the context of core business processes and strategic goals of the enterprise [36].
	Major information entities needed to operate the business, their relationships, and how they map to business processes, units, and locations [2].
	Data architecture
	Identifies how data are maintained, accessed and utilized [17].
Content examples	*Information architecture*
	The information and data management framework and precepts [36]. Operational and decision support systems needed to support the core processes and strategic goals, where the information for those systems is located, and how this information will be management [36].
	Data architecture
	Data, at the element level, its associated relationships, in what processes they are used and in what form, and how they flow between processes [36].
Application / Systems architecture	
Role	To provide a logical portfolio of applications for supporting the various business processes of an enterprise [36].
Content examples	The application software portfolio and integration relationships; Interface specifications, tools, utilities, and in some cases approved products for applications; Application inputs and outputs; Application geographical deployment requirements; Guiding principles, standards, and design characteristics for the acquisition and the development [36].
Technical / Technology / Infrastructure architecture	
Role	To describe the technology needed to meet the business requirements, helps ground the other architecture views by making it clear that the technology exists to implement them [2].
Content examples	Supporting services, computing platforms, and internal and external interfaces the information systems need to run [2].

Software Architecture Viewpoints

May [24] has analyzed five different software architecture viewpoint models: the Kruchten "4+1" View Model, the Software Engineering Institute (SEI) set of views, the ISO Reference Model of Open Distributed Processing (RM-ODP), the Siemens Four View Model and the Rational Architecture Description Specification). The result was that the commonly accepted SA viewpoints (that these viewpoint models seem to define one way or another) are *functional*, *behavioural*, *external* and *deployment viewpoint*. In addition to these, Rozanski and Woods [28] define *information* and *operational viewpoints*. Roles of these viewpoints and examples of their content are described in the table 3.

Table 3. Software architecture viewpoints.

Functional viewpoint	
Role	Business aspects of the system.
	Description of the system's functional/structural elements and their responsibilities, interfaces and primary interactions [24, 28]
Content	Functional capabilities, decomposition, uses, layered, abstraction, external interfaces, internal structure, design philosophy [24, 28]
Information viewpoint	
Role	Description of the way the system stores, manipulates, manages, and distributes information [28]
Content	Information structure and content, information flow, data ownership, transaction management and recovery, timeliness, latency, and age, references and mappings, data volumes, archives and data retention, regulation [28]
Behavioral / Concurrency	
Role	Description of the system's dynamic aspects [24]
	Description of the concurrency structure of the system, mapping functional elements to concurrency units to clearly identify the parts of the system that can execute concurrently, and showing how this is coordinated and controlled [28]
Content	Process, concurrency (task structure, mapping of functional elements to tasks, interprocess communication, state management, etc.) etc.
Development / External viewpoint	
Role	Description of system's implementation structures
Content	Code structure and dependencies, system-wide design constraints, system-wide standards to ensure technical integrity, work assignment [24, 28]
Deployment viewpoint	
Role	Description of the physical environment into which the system will be deployed, including the dependencies the system has on its runtime [28]
Content	Hardware, third-party software, network, physical constraints etc.
Operational viewpoint	
Role	Describes how the system will be operated, administrated, and supported when it is running in its production environment [28]
Content	Installation and upgrade, functional migration, data migration, operational monitoring and control, configuration management, performance monitoring, support, backup and restore [28]

RESEARCH METHOD

In order to gain understanding of meanings and roles that architecture evaluation and measurement have in companies, a series of research phases was used in this study. A semi-structured group interview with a focus group of practitioners from five ICT user and service provider organisations was organised.

Interviewees

Practitioners were managers and specialists of the management of enterprise and

software architectures in their organisations. The companies and interviewees are described in the next table.

Table 4. Interviewees in the focus group interview

Companies	Number of personnel (year 2005)	Number of interviewees	Viewpoints of interviewees
Architecture consultation company	10	2	enterprise and software architecture consultation
Banking, finance and insurance company	11 974	1	enterprise architecture
Telecommunication company	4989	1	enterprise architecture
Business & IT consulting and development organization	a part of a large international company with 329 373 employees in total	2	enterprise architecture, software architecture, marketing, business
Retail and service company	28 092	1	IT governance, enterprise architecture

The arrangements for the interview

The participants from these companies were interviewed as one group in order for group members to influence each other by responding to ideas and comments of others [22]. This use of group did have an impact, bringing out new aspects. However, some aspects may not have been brought out by the interviewees due to confidentiality reasons.

Interview

Architectural viewpoints and their definitions discussed at the beginning of this paper were presented to the participants. In addition, the main evaluation concepts and perspectives were presented. Based on practitioners' own practical experiences, practitioners were asked to name evaluation or measurement needs that relate to each architectural viewpoint. In addition, they were asked to name evaluation needs that exist relating to relationships between these viewpoints.

Data collection and analysis

The interview was tape-recorded. Notes were written during the interview session. Based on this data, a list of questions, information needs and topics of concern which may be triggers for architectural evaluations was produced. This list was reviewed by practitioners and the list was completed with comments. This list is presented in the next chapter.

TRIGGERS FOR ARCHITECTURE EVALUATIONS

In the focus group interview, it came up that from the practitioner's point of view it was difficult to directly specify evaluation needs that relate to each architectural view. Practitioners suggested that company's business and ICT related problems, questions, topics of concern and information needs may be triggers for architecture evaluations. A group of triggers which came up in the focus group interview are presented in the table below. In addition, evaluation needs which arise due to these triggers are presented.

Table 4. Triggers for architecture evaluations.

Triggers for architecture evaluations	Evaluation needs	Evaluation Targets
A need for the documentation of good quality		
A need to produce architectural models and documentations that • can be quickly communicated and • are understandable by many different stakeholders • are cost-effectively kept up to date.	The evaluation the quality of architectural documentation. A need to evaluate: - Policy: do policies (e.g architectural framework) exist for documentation and are they followed? - Intelligibility and usability: are documents easy to understand and use? - Accuracy: are documents truthful and factual? - Cost effectiveness of maintenance: how much effort is needed to keep models and documentation up to date? - Traceability between architectural documents: is there traceability between architectural documents?	Architecture documentation (EA / SA)
A need to have organisation's business environment descriptions of good quality	The evaluation existence and quality of business descriptions (goals, strategy, company's operations) : • existence of business descriptions (e.g. goals, strategy, company's operations) • Accuracy: are the descriptions up to date?	Business architecture documentation
A need to have information / data models of good quality	The evaluation of the quality the information / data models	Information / Data architecture
Change pressures in organisation		
A change need in the business or ICT (e.g. a need to move from one solution to another)	The evaluation and identification of the places affected by a change and effects in each architectural viewpoint.	EA viewpoints
An observation that ICT-architecture do not correspond to company's business's requirements	The evaluation how the enterprise architecture should be changed by identifying what chances should be carried out in each architectural viewpoint.	EA viewpoints
The understanding of business and ICT environments		
A need to enhance the understanding of company's business/ICT	The evaluation of enterprise architecture from different aspects or against different factors e.g. the identification of overlaps.	EA viewpoints
A goal that ICT supports business	The evaluation of how business architecture is supported by other viewpoints (information, applications, infrastructure).	EA viewpoints

A need to enhance the understanding of responsibilities in the company	Identification and evaluation of responsibilities in company (for example who is responsible for customer informations).	Business architecture
A need to understand the state of the company's product portfolio and processes	The description and evaluation of business architecture related aspects.	Business architecture
A need to understand information managed in company	The description of major information entities and responsibilities in information management.	Information / Data architecture
A need to understand the state of the company's application portfolio	The description and evaluation of structures and components of application architecture.	Application architecture
A need to understand quality aspects relating to the company's application portfolio	The evaluation the application architecture against quality aspects and attributes e.g. the identification of overlaps.	Application architecture
A need to understand the current state of technical infrastructure	The description and evaluation of structures and components of technical infrastructure.	Technology architecture
Company management and process planning		
A need to make sure that organisational choices are suitable	The evaluation of organisational structures and operations: are those suitable or should those be changed.	Business architecture
The distribution of work	The evaluation of processes: identification of which tasks will be carried out by the company and which are dealt out to partners.	Business architecture
Business process planning	The evaluation of functionality of business processes: e.g. do processes correspond to company's strategy?	Business architecture
Management of architectures		
An observation that ICT-architecture does not correspond to ICT-development projects' needs	The evaluation of how architectural principles or architecture descriptions should be changed.	EA viewpoints
An effort to drive investments to follow up architectural principles	The evaluation of if the investment corresponds and is suitable to the existing architecture and architectural principles.	EA viewpoints
A need to drive technical infrastructure investments to follow the architectural principles	The evaluation of if investments correspond to the principles.	Technology architecture principles

IT cost management		
A need to understand and manage costs relating to the company's application portfolio	The evaluation of financial aspects and factors relating to application architecture	Application architec-ture
A need to understand and manage costs relating to technical infrastructure	The evaluation of financial aspects and factors relating to technical infrastructure	Technology architec-ture
Architectural choices		
A need to find the best possible system solution and a need to understand the aspects relating the solution	The evaluation of the architectural solution: e.g. evaluation of • quality aspects (evaluation against quality attributes), • flexibility of solution, • the life cycle of solution, • suitability for the situation in question (e.g is solution possible within available time, money and resources).	SA viewpoints (EA viewpoints)
An effort towards long-term technical solutions and need to argue for the long-term technical solutions	The comparison of a long-term and short-term solution.	EA / SA viewpoints

DISCUSSION

Architecture evaluation triggers and needs were identified and analysed in this study. During this study, the following observations were made.

Architecture evaluation is more trigger-based than stabilized work in companies.

This study revealed that architecture evaluations do not at least yet have a stabilized role in companies unlike, for example, requirements engineering and architecture design have. Evaluations seem not to have a fixed status in the architecture processes or in other processes in companies. Therefore, evaluations are not executed regularly.

In this study, it came up that some kind of trigger must exist before the evaluation is executed. This trigger may be, for example, a problem, a question or a need for information relating to company's business or ICT-environment. In the figure below, the first steps before the architecture evaluation, identified in this study, are summarized.
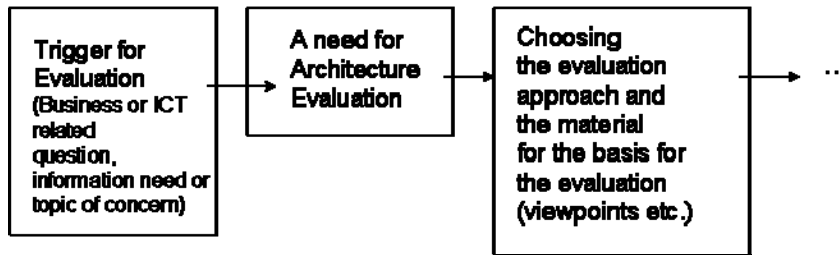
Figure 2. Starting steps for the architecture evaluation.

Architecture evaluation has several meanings and roles in companies and evaluations can thus be used for different purposes.

This study revealed a couple of triggers for architecture evaluations. These triggers can be categorised to the following categories:

- Company and business management: Support needs for organisation's structural design (e.g. business process design) and for the distribution of the work (e.g for out-sourcing).

- Holistic view: Needs to understand the current status of organisation's business and ICT-environment.

- IT cost management: Financial information needs relating to company's ICT (applications and technical infrastructure).

- Change management: Change pressures relating to architectures and architectural principles – identification of probability and nature of changes that should be made and decision making about changes.

- Quality management: Quality questions relating architectural documentation, the company's information/data structures, application and technical infrastructure, as well as systems solutions.

- Architecture management: Confirming that architecture related work meets expectations e.g. investments correspond to the architectural principles.

- Architectural choices: evaluation of architectural alternatives against quality, cost and other aspects.

We suggest that these evaluation triggers describe role and meaning that architecture evaluation may have in companies. Architecture evaluations can hence be one of the tools of quality assurance, change management, architectural planning and IT cost management. In addition, evaluations may support the organisational planning and decision making. Different evaluation approaches are needed because architecture evaluation's role varies remarkably.

A motivation for the evaluation defines the material and architectural viewpoints to be viewed.

The nature of a trigger for the evaluation drives the choosing of architectural documentation and viewpoints to be viewed in the evaluation. Sometimes it can be concentrate only on one viewpoint, but sometimes many viewpoints and their relationships can be analyzed.

The nature of evaluation and its challenges differ between viewpoints.

In the interview, practitioners brought out that business architecture seems to be the most difficult area to evaluate. The challenge relating to evaluation of information / data architectures is the lack of information and data models in companies. Currently, companies are not accustomed to actively producing information and data models.

Practitioners felt that application and technical architecture are the most understandable areas and these areas are typically evaluated in companies. The evaluation of these areas is numerical (e.g. amounts of components, cost).

One challenge in architectural evaluations is the architectural documentation.

Evaluations are based on the architectural documentation and descriptions that the company has. In the interview, practitioners brought out some challenges that relate to architectural documentation. It is not clear and easy to decide what descriptions and documentation should be produced relating to architectures. In addition, the amount of documentation produced should be limited. The quality and amount of architectural documentation may have an effect on the possibilities to execute evaluations for a company's architectures. However, the descriptions are needed for analysing and understanding architectures.

The relationship between architecture evaluations and organisation's other measurement activities

Companies already have measurement practices and metric programs (e.g. enterprise performance measurement, balanced scorecard). In the interview, it came up that a link between an organisation's existing measurement practices and architectural evaluations and measurements should be specified.

Restrictions

In this study, the EA and SA design and development specialists were interviewed. Their perspectives might reveal much more than the companies' other business and ICT stakeholders' perspectives. In addition, all the possible triggers for evaluations may not have been identified in this study. However, the results give an image of the role and meaning of architecture evaluations in companies.

CONCLUSION

This study revealed that currently architectural evaluations seem not to have a stabilized role and meaning in companies. This situation is reflected, for instance, in architecture evaluations not having stabilized place in organisations' architecture process models. It came up that a trigger for evaluation must exist. However, the reason for this may be that architecture evaluation practices are still immature in general and, therefore, we might expect to see changes in the future.

In this study, triggers for architecture evaluations in companies were identified and analysed. This study aims to enhance the definition of the role for architectural evaluation in organisations.

The future research questions, raised in this study, include the questions of what kind of stabilized role architecture evaluation could have in organisations and how architecture evaluations and measurements could be linked to an organisation's other measurement and evaluation programs and practices.

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