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# Analysis of the current State of Enterprise Architecture Evaluation Methods and Practices

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**Abstract:** Today, more and more organizations adopt enterprise architecture (EA) processes to cope with the changing environment and to improve their performance and competitiveness. However, the evaluation of EA regarding its quality and benefits is rather difficult. The studies of previous research resulted in the recognition that there is no methodology for enabling the EA evaluation by considering the whole EA. Therefore, this paper presents and analyses the current state of methods and practices to evaluate EA from different viewpoints. The introduced approaches focus especially on performing an assessment mainly based on architectural descriptions. All methods, standards, and measures address EA related concerns and evaluation needs regarding business, information, systems, and technology. All of the presented techniques have been developed or tested and validated in a practical environment.

**Keywords:** Enterprise Architecture evaluation, evaluation methods, analysis

## 1. Introduction

Enterprise Architecture (EA) is an approach for supporting the management and development of an organization through a set of architectural models, usually including the viewpoints of business, information, information systems and technology. These views should transfer knowledge about the organization towards involved stakeholder roles. Furthermore, they give a guideline for the necessary architectural descriptions of the current architecture and also a future one.

The enterprise architecture is focusing on the realisation of the organization's goals and vision though fulfilling so called *needs*. A need captures those stakeholder's concerns that will drive key decisions by the architect, such as decisions pertaining to performance, technology or cost drivers (Hilliard, Kurland et al. 1997). The architecture must be assessed regarding the fulfilment of these needs which are also called *evaluation needs*.

The evaluation results are a useful basis for the system's improvement concerning the achievement of the organization's goals and vision. Furthermore, the evaluation supports the definition of the target EA.

This paper aims at presenting the current possibilities to evaluate EA and focusing especially on performing an assessment mainly based on the descriptions of architectural decisions and solutions. The essential research questions investigated in this paper are:

- What kind of methods for EA evaluation exists?
- What are the strengths of these methods?
- What evaluation needs are addressed by these methods?

The research for this study was conducted in four steps:

1. Review of Literature to identify the current state of EA evaluation methods and practices
2. Identification of evaluation needs based on the study of (Niina Hämäläinen 2007)
3. Investigation and analysis of modelling standards and quality evaluation methods from business process, data modelling and software architecture research areas
4. Selection of techniques which could be applied on the identified evaluation needs

The studies of previous research resulted in the recognition that currently used evaluation approaches mainly assess the EA management and development processes but there is no methodology for enabling the EA evaluation by considering the architectural decisions and solutions.
Therefore, methods, standards and measures for the assessment of certain architectural concerns of enterprise architecture are presented. The presented techniques address the concerns of business, information, systems and technology separately. All of the introduced techniques have been developed or tested and validated in a practical environment.

The paper is structured as follows. The second section describes the currently wide-spread EA evaluation approaches *enterprise maturity models* and *IT-Business-alignment*. In the third section, methods which can be applied to evaluate the architectural decisions and solutions are presented and their strengths and application areas are introduced. Finally, the fourth section concludes the paper.

**3. Current State of EA Evaluation**

In this section, the current state of EA evaluation and especially methods which can be applied to carry out an EA evaluation are discussed.

Existing EA assessment techniques basically focus on the improvement of enterprise architecture management and the management process which means that new EA development targets are identified and development priorities are set. Therefore, enterprise maturity models and IT-Business-alignment evaluation are utilized.

One of the first capability maturity models, Capability Maturity Model for Software (CMM), was developed by the Software Engineering Institute, Carnegie Mellon. It enables the assessment and the control of IT-related processes as well as the assessment of organization's development competence. According to (Paulk 1993), architecture maturity involves an organization's ability to organization-wide manage the development, implementation and maintenance of architectures on various levels – e.g. business, information, applications and infrastructure.

Most of the assessment models have been developed by consulting firms such as Gartner (Gartner 2002) and METAGroup (META Group Inc. 2000), and federal agencies or organizations, such as the US Office of Management and Budget (OMB) (OMB 2004), the US department of commerce (DoC) (DoC 2003), and the National Association of State Chief Information Officers (NASCIO) (NASCIO 2003). These models generally work the same way as the early CMM. Basically, they use a number of criteria to assess architecture maturity. Typical criteria are, for example, process, governance, communication, technology, and business alignment. For each criterion five maturity levels exist and they are provided with a description of aspects. The maturity models differ in the amount of criteria which are investigated. However, no matter which model is applied, they all support the identification of insufficiencies and areas of improvement in the enterprise architecture development process.

Another approach to assess the EA management and development processes is IT-Business alignment. There is a general agreement what alignment entails: the fit between business strategy, IT strategy, organizational structures and processes, and IT structures and processes (Luftman 2000). The aim of alignment is for IT activities to support those of the entire business (Chan 2002).

One well-known model is Luftman's strategic alignment assessment model which presents an approach for determining a company's business-IT alignment based on six criteria: communications, competency/value measurements, governance, partnership, skills, as well as scope and architecture (Luftman 2000). This last criterion is used to evaluate IT maturity. According to (Luftman 2000), each of these six variables is assigned five levels of alignment. The model provides a short description of the aspects of each level.

**3 The Evaluation of Architectural Decisions in EA Context**

The evaluation of the architecture is rather challenging because there seems to be no coherent view on enterprise architecture. Many different concepts, modelling techniques, tools, and visualisation techniques are utilized (Jonkers 2003). Sometimes the architectural decisions are not even documented at all. Moreover, predicting the fulfilment of goals through certain architectural decision in a changing and highly-dynamic environment is difficult. The literature review in the area of architecture evaluation methods resulted in the recognition that obviously there seems to be a lack of evaluation methodologies. While there are many approaches for the assessment of software architecture (Clements, Kazman et al. 2001), (A. V. Corry 2005), (H. Grahn 2003) (Bosch 2005), (Bosch and Molin 1999)) there is nothing equivalent for the EA domain. According to (Hilliard, Kurland et al. 1997), an architecture evaluation methodology must include the following tasks:

- Analysis of Needs, Goals and Vision
- Gather relevant documents and other artefacts related to the architecture
- Evaluate documentation against measures and score results
- Interpret results and identify architecture-related risks

- Documentation of results.

So far there is no method which fulfils these tasks for the entire EA. That is why we decided to follow the structure given by most of the enterprise architecture frameworks (Zachman 1987), (The Open Group 2006), (CIO Council 1999), (Defense 2003) and analysed techniques that could be applied to evaluate the different views of EA: business architecture, information architecture, systems architecture, technology architecture. All presented assessment techniques are either based on standards or are developed or validated in a practical environment.

Many of the introduced techniques rely on conceptual modelling to improve the architectural knowledge among different stakeholders from different domains such as managers, business analysts, and developers. These conceptual modelling standards enhance the architectural understanding, knowledge sharing and the analysis of the structure and behaviour of the organization, are also considered as evaluation approaches. Furthermore, review methods, simulation approaches, and measures for assessing quality attributes are presented. In the following, the suggested approaches are briefly introduced.

### 3.1 Business Architecture Evaluation

According to TOGAF (The Open Group 2006), the Business Architecture embodies the descriptions of business goals and objectives, business functions, business processes, business roles, and business data model. They all have to be documented in an appropriate manner which enables the analysis and evaluation. Since the business architecture transfers this essential knowledge about the organization to all kinds of stakeholders like business users, business analysts, and technical developers it is strongly relying on conceptual modelling to be understandable for people from different domains. In the following approaches for the Business Architecture evaluation are presented. These approaches are also described regarding their strengths and the evaluation needs which they address in Table 1.

#### *3.1.1 Business Motivation Modelling*

Vision, goals, objectives are the motivation behind an organization's strategies which result into actions to transform the enterprise's as-is status into the desired to-be status. Since this motivation is the foundation for the organizational structures, processes and behaviour it should be documented within the models describing EA. Usually, enterprises only capture the means to achieve goals in models (E. Yu 2006). That makes the traceability, analysis and evaluation of goals rather difficult.

Modelling the corporate governance would bring several benefits to the organization:

- Vision, goals, objectives are made explicit
- Transparency of transformation drivers (E. Yu 2006)
- Tracing of decisions and responsibilities
- Conflicts, points of improvement, and level of fulfilment become clearer though visualization
- Basis for planning and changing strategies and processes (linking *why*-knowledge to *how* (E. Yu 2006) )

One of the few notations that can be used for modelling the business governance is the Business Motivation Model (BMM). It is a meta-model of concepts for modelling the business governance. It has been standardized by the Object Management Group (OMG) in August 2006.

#### *3.1.2 Business Process Modelling and Simulation*

A quite common means to gain a competitive advantage, regarding costs or innovation, is the optimization of an organization's business processes. The optimization embodies the assessment of necessary infrastructure and applications, and comparison of expected benefits (D. I. Vidovic 2003). Business process modelling and simulation are the approaches to achieve the optimization of processes (Ali Bahrami 1998).
Business process modelling is the visualization of processes regarding relationships, dependencies, and effects between processes and their activities and resources. This visualization increases the understanding about the processes and supports the validation and improvement for many stakeholders (Ali Bahrami 1998). Business process modelling aims at clarifying the organization's

processes to its employees. Usually, even the documentation of processes discloses redundancies and points of improvement. According to (D. I. Vidovic 2003), 80% of process advancements are achieved by modelling the current status. There is several business process modelling approaches available. Three wide-spread approaches are:

1. Event-Driven Process Chain (EPC)
2. Business Process Modeling Notation (BPMN)
3. Unified Modeling Language (UML)

While modelling is the visualization of business processes, simulation brings them alive. On the one hand, it is possible to evaluate the current processes (*as-is* state) regarding costs, performance and to analyse the simulation data referring optimization. On the other hand, dynamic simulation is a way to analyze *what-if* scenarios, obtain cost and performance predictions, and validate processes (Ali Bahrami 1998). The predictions, gained from the simulation, support the decision making regarding organizational change and future investments. Naturally, simulation requires high effort on architectural documentation which is rather cost and time consuming.

### 3.2 Information Architecture Evaluation

The Information Architecture is a high-level model of information which an organization needs in order to make decision referring the future and required changes and also to perform its operative processes (Halttunen 2002). The organization's data is organized in a *corporate data model* (D. L. Goodhue 1992) which is a conceptual and structured data model.

The quality of the Information Architecture depends on the conceptual data models' quality. However, there is a lack of quantitative methods to assess the quality of data models. Several frameworks for evaluating a data model's quality have been suggested in (O. Lindland 1994), (D. L. Moody 1994), (Kesh 1995), (R. Schuette 1998). However, most of these frameworks suggest criteria that may be used to evaluate the quality of data models but an evaluation that is based only on criteria is quite difficult because criteria may be interpreted differently (D.L. Moody 1998). While studying the previous research, only the *Moody's Framework* for the evaluation of the quality of data models (Entity-Relationship diagrams) was found.

The Moody's Framework was developed in practice and has been applied on a wide range of organizations (D.L. Moody 1998). The evaluation framework defines necessary quality factors which are illustrated in Figure 1. Furthermore, the assigned stakeholder roles are shown for each of the quality factors. To assess these quality factors the framework embodies a number of evaluation methods, which in some cases are measures (e.g. data model complexity) and in other cases are processes for carrying out the evaluation (e.g. user reviews). The strength and addressed evaluation needs of the Moody's Framework are presented in Table 1.

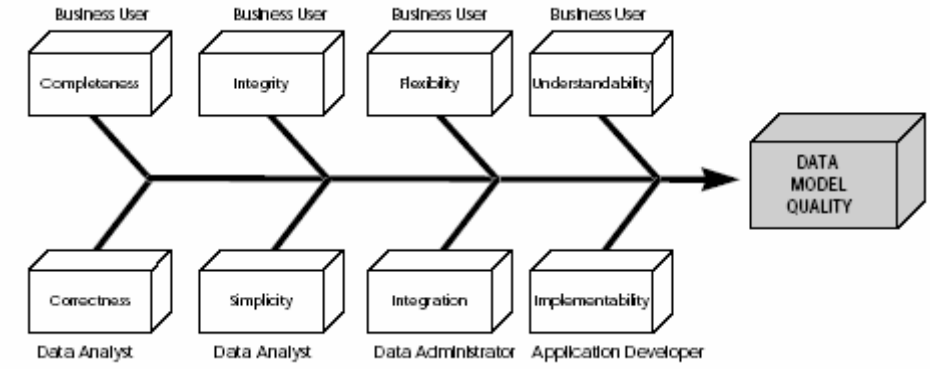


**Figure 1:** Data Model Quality Factors (D.L. Moody 1998)

### 3.3 Evaluation of utilized ICT

The ICT infrastructure includes the used systems and technology which are described through the system/application architecture and the technology architecture. The systems/application Architecture defines the software systems which is necessary to process the data and support the business. The software system is described by the *software architecture*. The software architecture basically must describe the software system's components. That means their structure as well as their behaviour and

interaction with each other because the whole software system's behaviour results from its components' behaviour and interaction (Bass, Clements et al. 2003).

Since the technology which allows the deployment of software applications is also part of the software system, it can be evaluated within the software architecture evaluation. The methods concerning the software system evaluation enable predictions regarding the whole system life cycle. Especially, characteristics, such as performance, cost, reliability and maintenance are essential characteristics in the enterprise architecture context. Methods for evaluating the software architecture are:

- Questionnaires and checklists
- Scenario-based methods
- Architectural metrics
- Mathematical modelling
- Simulation and prototyping

These methods are only applied if within the EA software systems are used which have to be developed inside the organization. A selection of scenario-based methods for the evaluation of software architecture and the benchmarking approach are presented concerning their strengths and addressed evaluation needs in Table 1. The presented scenario-based methods have been chosen because they seem to be the most effective in the early evaluation of the software architecture.

Components used within ICT infrastructure are quite often commercial-of-the-shelf (COTS) components and their quality characteristics are described by the supplier. However, it is necessary to integrate different components with each other and different implementations have different behaviour concerning runtime characteristics. Therefore the infrastructure can be evaluated by using benchmarking.

Benchmarking primary evaluates performance, scalability and reliability of the used infrastructure. The evaluation results gained from benchmarking can be compared to the expected costs which are connected to different COTS components. That cost/benefit consideration supports decision making regarding the questions which COTS components suit best the organization’s software systems. Benchmarking is also described in Table 1.

**3.4 Financial methods for assessing the business value of IT investments**

The financial measures costs and benefits of ICT related investment decisions should be evaluated to make and justify those decisions.
Organizations use several measures to assess business value, such as return on invest (ROI), net present value (NPV), internal rate of return (IRR), payback period, and economic value added (EVA). According to (Symons 2006), these measures have five main disadvantages regarding their utilization to measure the business value of IT.

- There are too many measures available and within a single organization different groups use different measures; furthermore, some measures have multiple interpretations which lead to inconsistency.
- These measures generate a value which leads to a wrong credibility because the value is actually based on assumptions and the value itself is only a prediction for the estimated benefit.
- These measures do not take intangible benefits, such as customer satisfaction, into account. Since it is difficult to measure intangible benefits they are completely ignored.
- The financial measures only estimate the direct benefit of an investment but they are not able to calculate further future benefits or opportunities.
- Perhaps the biggest flaw in most financial measurements is the underestimation of risks or even the failure to incorporate any risk at all.

Since, measuring the value of IT-enabled business change will be critical to almost every organization as technology becomes embedded in virtually every business process (Symons 2006), more efficient measurement tools are needed. Four methodologies which have been developed to overcome the problems of the standard financial measures are:

1. Business Value Index (BVI)

2. Total Economic Impact (TEI)
3. Val IT
4. Applied Information Economics (AIE)

The techniques are described regarding their strengths and addressed evaluation needs in Table 1.

**Table 1:** Overview of EA Evaluation Methods

| Method Name | Technique | Strengths | Addressed Evaluation Needs |
|---|---|---|---|
| *Business Architecture* | | | |
| Governance Modelling | conceptual modelling and review | - vision, goals, objectives are made explicit<br>- transparency of transformation drivers<br>- tracing of decisions and responsibilities<br>- basis for analysis and evaluation (conflicts, improvement, level of fulfilment)<br>- basis for planning and changing strategies and processes | - observation that ICT-architecture do not correspond to company's business's requirements<br>- enhances the understanding of company's business/ICT<br>- enhances the understanding of responsibilities in the company<br>- make sure that organisational choices are suitable<br>- An effort towards long-term technical solutions and need to argue for the long-term technical solutions |
| Business Process Modelling | conceptual modelling and review | - visualization of processes regarding relationships, dependencies, and effects between processes and their activities and resources<br>- visualization increases the understanding about the processes and supports the validation and improvement for many stakeholders<br>- 80% of process advancements are achieved by modelling the current status | - change need in the business or ICT (e.g. a need to move from one solution to another)<br>- observation that ICT-architecture do not correspond to company's business's requirements<br>- enhances the understanding of company's business/ICT<br>- enhances the understanding of responsibilities in the company<br>- make sure that organisational choices are suitable<br>- distribution of work<br>- Business process planning<br>- need to find the best possible system solution and a need to understand the aspects relating the solution<br>- An effort towards long-term technical solutions and need to argue for the long-term technical solutions |
| Business Process Simulation | simulation | - the current processes (*as-is* state) regarding costs, performance<br>- analyze *what-if* scenarios, obtain cost and performance predictions, and validate processes<br>- support the decision making regarding organizational change and future investments | - change need in the business or ICT (e.g. a need to move from one solution to another)<br>- observation that ICT-architecture do not correspond to company's business's requirements<br>- make sure that organisational choices are suitable<br>- Business process planning<br>- need to find the best possible system solution and a need to understand the aspects relating the solution<br>- An effort towards long-term |

| Method Name | Technique | Strengths | Addressed Evaluation Needs |
|---|---|---|---|
| | | | technical solutions and need to argue for the long-term technical solutions |
| *Information Architecture* | | | |
| Moody's Framework | reviews and metrics | - evaluates data model's quality<br>- provides quantitative measures<br>- coverage of many data model quality aspects | - information / data models of good quality<br>- understanding information managed in company |
| *Software Systems Architecture* | | | |
| SAAM | scenario-based review aims on scenario validation | - knowledge transfer about architectural decisions<br>- identification of areas of high potential complexity | - understanding the state of the company's application portfolio<br>- understand the current state of technical infrastructure<br>- need to find the best possible system solution and a need to understand the aspects relating the solution |
| ATAM | - scenario-based review<br>- regarding system's quality attributes<br>- including scenario validation, trade-off and risk identification | - identifies risks and points of trade-off<br>- enables evaluation of structural and behavioural system characteristics<br>- improves architectural knowledge sharing | - change need in the business or ICT (e.g. a need to move from one solution to another)<br>- need to enhance the understanding of company's business/ICT<br>- understanding the state of the company's application portfolio<br>- understanding quality aspects relating to the company's application portfolio<br>- understanding the current state of technical infrastructure<br>- need to find the best possible system solution and a need to understand the aspects relating the solution<br>- An effort towards long-term technical solutions and need to argue for the long-term technical solutions |
| CBAM | scenario-based review with focus on cost and benefits | - measurement of design decisions with cost and benefit metric<br>- makes uncertainty explicit associated with the estimates | - change need in the business or ICT (e.g. a need to move from one solution to another)<br>- understanding quality aspects relating to the company's application portfolio<br>- effort to drive investments to follow up architectural principles<br>- An effort towards long-term technical solutions and need to argue for the long-term technical solutions |
| *Technology/Infrastructure Architecture* | | | |
| Benchmarking | Measures performance, reliability, and cost | - enables the collection of metrics regarding the system's performance, reliability | - understanding the current state of technical infrastructure |

| Method Name | Technique | Strengths | Addressed Evaluation Needs |
|---|---|---|---|
| | | and cost<br>- supports decision making | |
| *Financial methods for assessing the business value of IT investments* | | | |
| Business Value Index (BVI) | priority-based assessment of future investments | - supports the prioritization of investment options<br>- tangible and intangible value can be measured | - change need in the business or ICT (e.g. a need to move from one solution to another)<br>- effort to drive investments to follow up architectural principles<br>- change need in the business or ICT (e.g. a need to move from one solution to another)<br>- understanding quality aspects relating to the company's application portfolio |
| Total Economic Impact (TEI) | Risk-adjusted Return on Invest calculation | - measures cost, benefits, flexibility, and risk impact on business<br>- risk-adjusted ROI | |
| ValIT | Value governance, Portfolio management, and investment management | - Value governance<br>- Portfolio management<br>- Investment management | |
| Applied Information Economics (AIE) | IT investment assessment through mathematical and scientific methods | - mathematical models<br>- Developing financially-based quality assurance measures<br>- Developing a strategic plan for information systems | |

**4. In conclusion**

The evaluation of the EA is rather challenging because predicting the fulfilment of goals through certain architectural decision in a changing and highly-dynamic environment is difficult. Most of the evaluation needs in (Niina Hämäläinen 2007) are related to the enhancement of knowledge and understanding of the business and ICT concerns and to the recognition of necessary changes in the current EA.

The result of the conducted literature review was that there seems to be a lack of methodologies evaluating EA. Currently; the most wide-spread approaches are maturity models and IT-Business-Alignment assessment methods. However, they address primarily the enterprise architecture management and development process and not the evaluation of architectural decisions and solutions concerning the achievement of the organization's goals. Since there is no method for the evaluation of the entire EA we analyzed techniques from the areas of business processes, data modelling, software architecture evaluation, and benchmark testing. Furthermore, also methods to measure cost and benefits of ICT investment have been investigated. These measures are always a relevant basis for managerial decision making.

Most of the introduced evaluation techniques are based on reviews of the architectural descriptions. Therefore, EA evaluation depends strongly on conceptual models as input and the basis for analysis and discussion because they support sharing and communicating the architectural knowledge among different stakeholders from different domains. Furthermore, also more quantitative techniques like simulation and measuring can be applied but they require more detailed architectural descriptions.

One of the major advantages of all of the presented techniques is that they have been developed or tested and validated in a practical environment. All methods are summarized with their strengths and the evaluation needs which they address in Table 1. However, it is difficult to predict the extent of satisfaction for certain needs because the needs definitions in (Niina Hämäläinen 2007) are rather general. Only the application of the methods to the specific EA can answer the question how well the

suggested methods satisfy the evaluation needs of a specific organization. Furthermore, a combination of methods might be necessary to improve the fulfilment of certain needs.

Still, the complexity of enterprise architecture and the related variety of concerns complicates reaching an established overall evaluation approach. The problem of developing methodologies enabling the enterprise architecture evaluation in a coherent, efficient, and practical way should be overcome in future research and work.
So far it is only possible to apply different techniques on only single architectural views of EA. Integrating these introduced techniques into the EA evaluation process of a company might be difficult. These techniques are independent of each other and they refer to different standards, description models, and tools which are not compatible to those already used within in the organization.

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