Enterprise Architecture Quality Management Approach

Malgorzata Pankowska
Department of Informatics
University of Economics
Katowice, Poland
email: pank@ue.katowice.pl

***Abstract*—Generally, the enterprise architecture (EA) is the discipline of designing enterprise guided with principles, frameworks, methodologies, requirements, tools, reference models, and standards. The EA is responsible for designing structures, engineering processes, developing working force, exploiting technology and creating opportunities for learning. The EA should be accessible for all the organization members to receive their acceptance as responsive to user needs. The EA modelling effectiveness and efficiency are determined by the EA elements quality. Therefore, the paper focuses on characterization of quality of enterprise architecture, consideration of key perspectives, measures and indicators.**

Keywords-enterprise architecture; quality; stakeholder; maturity model; ArchiMate.

I. INTRODUCTION

The term "enterprise" can be interpreted as an overall concept to identify a company, business organization or governmental institution. According to Robins, an enterprise is considered as a social entity, with a relatively identifiable boundaries [4]. The enterprise engineering is underpinned by two fundamental concepts, i.e., enterprise ontology and enterprise architecture.

The enterprise architecture (EA) is defined as a coherent and consistent set of principles and guidelines that guide system design [6]. Enterprise architecture is also defined as a strategic information asset base, which defines the business mission, the information and technology necessary to perform the mission, the transitional processes for implementing new technologies in response to the changing mission needs [2]. For the purpose of this paper, the enterprise architecture is a general plan or a direction of information communication technology (ICT) application in the enterprise to achieve strategic business goals. The enterprise architecture is a discipline that seeks to explain why organizations do what they do and how they can be changed to achieve a certain demanded purpose. The complete picture of the EA should include answers to the following questions: what will be done, i.e., what products, services and experiences, who will do the work, how well the work is done, who will be offered the results, why customers are expected to pay for what they receive, what technologies will be developed and applied. Firstly, the paper covers discussions on the EA quality issues included in the EA frameworks and some special approaches. Secondly, the role of stakeholders in the EA development and quality assurance is discussed. Thirdly, the proposed approach to quality of enterprise architecture (QoEA) evaluation is presented. In this approach, the stakeholder roles, EA principles and vision as well as the EA quality procedure are emphasized.

II. ENTERPRISE ARCHITECTURE AS PRODUCT AND PROCESS

ISO/IEC/IEEE 42010:2007 architecture standard is the fundamental organization, as well as the principles guiding its design and evolution. The EA can be considered as a process or as a product. The EA as a product serves to guide managers in designing business processes and system developers in building applications in a way that is in line with business objectives and policies. The EA as a process is to translate business vision and strategy into effective ICT components. It should be noticed that enterprise models are applied as a computational representation of the structure, activities, processes, information, people, goals, and constraints of a business. The EA is to ensure a holistic view of the business processes, systems, information, and technology of the enterprise [7]. The results of work of enterprise architect cover the derived IT strategies, the new and modified EA, the new and modified set of EA standards, and a roadmap describing the ICT projects for implementation of new architecture and achieving the target state, and a development plan [7].

Well architected systems can more quickly link with external business partners. The EA is to ensure the comprehensive understanding and evaluation of the current state or the desired state, as well as the interrelationships of processes, people and technology affected by ICT projects. The organization has bigger consistency of business processes and information across business units. The EA identifies opportunities for integration and reuse of ICT resources and prevents the development of inconsistent processes and low quality information. Especially important to users is the capability of integrating the information among applications and across data warehouses and data marts. The ISO/IEC/IEEE 42010: 2011 standard emphasizes the stakeholder object in the architecture description (Figure 1). Architecture description identifies stakeholders and system of interests, as well as expresses an architecture. The following stakeholders can be considered as having impact

 ISBN: 978-1-61208-478-7

on the architecture description: system users, operators, acquirers, owners, suppliers, developers, and maintainers. The stakeholders are included in the EA quality evaluation process, because they are the EA work recipients, although they have different interests, risk awareness and impact on the system.

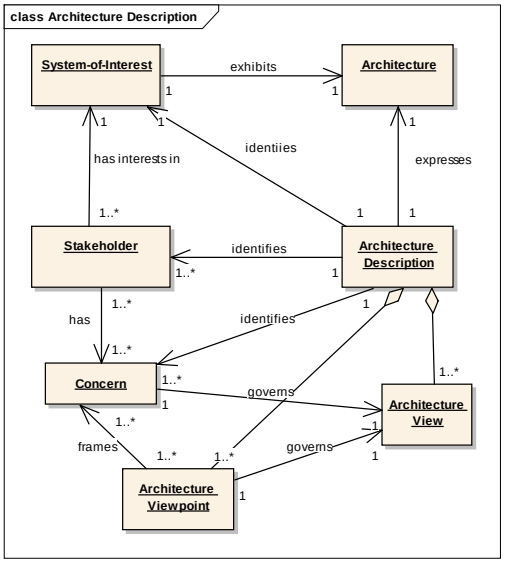

Figure 1. Enterprise Architecture in IS0/IEC/IEEE 42010:2011.

Architecture viewpoints establish the conventions for the construction, interpretation and use of architecture views to respect specific concerns. Architecture view expresses the architecture of the system from the perspectives of specific system concerns. Architecture views are the main categories that are evaluated in the aspect of quality of the EA. They are strongly dependent on EA stakeholders, whose qualifications for the EA process should also be evaluated. Architecture principles as general rules and guidelines are included in the EA views, and they guide how a chosen area of goal-oriented and efficient endeavor must be exploited and explored. Quality discussion should also concern the approval of the principles by users, and the principles development for better EA development.

III. RELATED WORKS ON EA QUALITY

A. Enterprise Architecture evaluation problems

The enterprise architecture as a process of translating business vision and strategy into effective enterprise can be viewed in many different aspects:

- business aspect - highlighting what business is conducted by the organization, what are its products and services,
- information aspect - providing the information engineering perspective of business solution architecture,
- work aspect - expressing in terms of work activities, associated resources, work locations and its optimal techniques, and needed information,
- application aspect - defining the automated business activities and business supporting software,
- technology aspect - focusing on the technology needed to facilitate other components of the architecture [8].

Evaluating refers to systematic activities undertaken to decide on a quality of particular phenomena and visualize them in a structural and formal way. The enterprise architecture evaluation is to decide on the value-in-use of EA objectives, activities, information resources, processes, actors, products, requirements and the relationships between these entities. The enterprise architecture evaluation can be used in different ways. Generally, it improves organization's work, allows the organizational members to review the enterprise and to design and implement business processes, to change the business structure and to increase the efficiency of the business reengineering and business strategy realization. Nowadays, the EA evaluation approaches do not offer mutually agreed languages, techniques and measures. The EA usually has many stakeholders, who establish their own techniques, schemas and measures. Although the EA is to provide a holistic approach to the enterprise information technology (IT) development, the quality of the EA requires different measurement methods depending on the stakeholder knowledge, competencies and activities. The EA frameworks' developers separate EA evaluation from EA implementation. They focus on analyzing the architecture models, languages, modeling techniques and propose methods for the evaluation of these artifacts. They notice in a pre-implementation analysis the necessity to ensure coherence among different models, they analyze the convergence of proposed models, their scalability, openness, agility, sustainability and ability to ensure security. The question on the EA quality is not popular in the EA engineering methodologies. However, in BIZBOK [1], beyond questions provided in Zachman Framework, there is a unique question on how well the EA is developed, and what metrics and measures are to be applied.

B. Stakeholders and Quality issues in EA Frameworks

Nowadays, the EA is considered as the discipline of describing enterprises guided with principles, frameworks, methodologies, requirements, tools, reference models and standards. There are many frameworks that support the EA modeling and development, e.g., Zachman Framework (ZF), the Open Groups Architecture Framework (TOGAF), the Generic Enterprise Reference Architecture and Methodology (GERAM), the Purdue Enterprise Reference Architecture (PERA), Computer Integrated Manufacturing Open System Architecture (CIMOSA), the Lightweight Enterprise Architecture (LEA), Nolan Norton Framework (NNF), the Extended Enterprise Architecture Framework (E2AF), Enterprise Architecture Planning (EAP), the Federal Enterprise Architecture Framework (FEAF), Treasury Enterprise Architecture Framework (TEAF) [6], [7], [11]. However, the frameworks mentioned above are product oriented and the quality issues are not well discussed in their general descriptions. Only some of them, i.e., ZF, TOGAF,

FEAF, CIMOSA and MODAF emphasize the role of stakeholders in the EA development process.

The ZF provides a basic structure for organizing a business architecture through dimensions, such as data, function, network, people, time and motivation [13]. Zachman describes the ontology for the creation of EA through negotiations among several actors. The ZF presents various views and aspects of the enterprise architecture in a highly structured and clear form. Zachman differentiates between the levels: Scope (contextual, planner view), Enterprise Model (conceptual, owner view), System Model (logical, designer view), Technology Model (physical, builder model), Detailed Representation (out-of-context, subcontractor), and Functioning Enterprise (user view). Each of these views is presented as a row in the matrix. The lower the row, the greater the degree of detail of the level represented. The model works with six aspects of the enterprise architecture: Data (what?), Function (how?), Network (where?), People (who?), Time (when?), and Motivation (why?). Each view (i.e., column) interrogates the architecture from a particular perspective. Taken together, all the views create a complete picture of the enterprise. In this enterprise ontology there is no place for quality considerations.

Since 1999, the FEAF components of an enterprise architecture cover architecture drivers, strategic direction, current architecture, target architectures, transitional processes, architectural components, architectural models, and standards. The architect has a responsibility for ensuring the completeness of the architecture, in terms of adequately addressing all the concerns of all the various views, satisfactorily reconciling the conflicts among different stakeholders. The framework emphasizes the role of planner, owner, designer, builder and subcontractor in the EA development process. The FEAF is derived from the Zachman Framework, however, the user of the realized architecture is not included in the development team. In FEAF, the Performance Reference Model (PRM) is a standardized framework to measure the performance of major IT investments and their contribution to program performance. Within that model the customer service quality, process and activity quality, and technology quality are measured [7].

The Ministry of Defense Architectural Framework (MODAF) is the UK Government specification for architectural frameworks for the defense industry [9]. The MODAF covers 7 viewpoints, i.e., All View, Acquisition, Strategic, Operational, System, Service, and Technical. The All View viewpoint is created to define the generic, high-level information that applies to all the other viewpoints. In this approach, the architect role is hidden in the particular viewpoints. The Acquisition viewpoint is used to identify programmes and projects that are relevant to the framework and that will be executed to deliver the capabilities that have been identified in the strategy views. The Strategic viewpoint defines views that support the analysis and the optimization of a domain capability. The intention is to capture long-term missions, goals and visions, and to define what capabilities are required to realize them. The Operational viewpoint contains views that describe the operational elements required to meet the capabilities defined in the strategic views. This is achieved by considering a number of high-level scenarios, and then defining the element sorts existing in the scenarios. The operational views are solution-independent and do not describe an actual solution. These views are available to suppliers and form the basis of evaluating the System views that are provided as the supplier's proposed solution. The Service viewpoint concerns views that allow the solution to be described in terms of its services. This allows a solution to be specified as a complete service-oriented architecture. The Technical viewpoint contains two views that allow all the relevant standards to be defined. This is split into two categories: current standards and predicted future standard [9].

The CIMOSA framework is based on four abstract views (function, information, resource and organization views) and three modeling levels (i.e., requirements definition, design specification, and implementation description) [10]. The four modeling views are provided to manage the integrated enterprise model (covering the design, manipulation and access). For the management of views, CIMOSA assumes a hierarchy of business units that are grouped into divisions and plants. The TOGAF standard takes a holistic approach to the enterprise architecture. TOGAF divides the EA into four categories of architecture, i.e., business, application, data and technology. Similarly to the ISO/IEC/IEEE 42010:2007 standard, in TOGAF the minimum set of stakeholders for a system covers users, system and software engineers, operators, administrators, managers and acquirers. Beyond that there are other stakeholders:

- the executive management, who defines strategic goals,
- the client, who is responsible for the allocated budget, with regard to the expected goals,
- the provider, who delivers the component elements of the architecture,
- the sponsors, who drive and guide the work,
- the enterprise architects, who turn business goals into reality within the structure of its system.

In TOGAF, the holistic approach to the EA quality management is possible through the application of the Architecture Maturity Model (AMM), which is based upon capability maturity models as formal ways to gain control over and improve architecture processes as well as to assess the organization's development competence. Van Den Berg and Van Steenbergen consider eighteen key areas of architecture maturity, which can be included in the EA evaluation process [12]. They are as follows: architecture development, use of architecture, alignment with business, alignment with the development process, alignment with operations, suitability of the architecture, roles and responsibilities, coordination of development, monitoring, quality management, architectural process maintenance, maintenance of architectural deliverables, commitment and motivation, architectural roles and training, use of architectural roles and training, use of an architectural method, consultation, architectural tools, budgeting and planning. The development of architecture should be

budgeted and planned, however, in such a wide spectrum of variables included in the evaluation process, there is a question of who is the beneficiary of the multicriteria evaluation and what priorities have been established for these criteria. In TOGAF 9.1, the enterprise architecture process maturity levels are as follows:

- Level 0: No enterprise architecture program,
- Level 1: Informal enterprise architecture process underway,
- Level 2: Enterprise architecture process under development,
- Level 3: Defined enterprise architecture including detailed written procedures, Technical Reference Model (TRM) and Standards Profile framework,
- Level 4: Managed and measured enterprise architecture process,
- Level 5: Continuous improvement of enterprise architecture process.

That model is a result of the Enterprise Architecture Capability Maturity Model delivered by DoC (US Department of Commerce) [3].

IV. STAKEHOLDERS AND VISIONS AS FUNDAMENTAL OF EA QUALITY MANAGEMENT

Stakeholders are the individuals who have a stake in the success or failure of a business. They are people, for whom the value is created, who are beneficiaries of the EA development decision. Among others, a particularly important role belongs to enterprise architect, whose competencies should be planned and addressed at two levels: the enterprise and the personal level. An enterprise competence is an integrated complex of enterprise skills, knowledge and technology. To a considerable extent, enterprises competencies rest on the competencies of employees, i.e., the competencies at the personal level. Competencies are defined in measurable behavior characteristics that determine the ability to function successfully - knowledge, skills, craftsmanship, attitudes, social skills, and personal traits. The competencies cover the abilities to cooperate, to take initiative, or show user-orientation and decision making skills [4]. The important for the enterprise architect knowledge aspects cover system thinking, business and organization, information, information technology, enterprise development, and its change. The enterprise architects should be able to translate the strategic initiatives and areas of concerns into a particular enterprise design. Usually, the enterprise architects are responsible for documenting, analyzing, and designing the business processes, business functions, business objects, and the interactions among them. By the analysis of the entire organization model, the architects are able to uncover the points where there is a need for action and the potential of optimization. There is a necessity to ensure the cohesion among roles: application managers, project managers, process architects, business analysts, organization consultants, infrastructure acquirers, project portfolio components' controllers, ICT strategists, IT managers, security representatives, risk managers and quality managers.

The enterprise architect is placed in a network of stakeholders. As actors in network, they achieve their significance by being in relations with other actors. The position of the architect in the enterprise determines the associated controls of the EA development activities. Techniques used frequently to clarify responsibilities are RACI and RAEW [12]. RACI model includes the following characteristics: Responsible (i.e., the individual delivering the end result), Accountable (i.e., the person bearing the ultimate responsibility for the result), Consulting (i.e., the person providing input to reach the result), Informed (i.e., the individuals informed about the result) (see Table I). In RAEW model, the enterprise architect should be the person of Responsibility, Authority, Expertise and Work. Assuming that EA quality depends on the stakeholders' qualifications, the stakeholder network quality problem could be analyzed through the detail specification and evaluation of stakeholders' competencies.

For the illustration of EA quality considerations, the e-healthcare system architecture is presented in Figure 2. The project was supported by the National Centre of Science, grant number 4100/B/H03/2011/40. Stakeholders of the e-healthcare system contribute to the three kinds of architecture (i.e., Business, Application and Technology Infrastructure) in a consistent way. Architects in each of the architectural areas influence each other's decisions. Software architects designing for software reliability need the design support of system architects as well as knowledge brokers and end users.

For e-healthcare architecture modeling, the ArchiMate language is applied to emphasize the stakeholders in a suitable manner to support business agility. In Figure 2, a system architecture model in ArchiMate presents the whole complexity of EA e-healthcare and as such should be considered, although it is organized into some basic layers:

- BUSINESS containing the following elements: actor (i.e., Patient), role (i.e., e-Healthcare Service Recipient, Knowledge Broker), process (i.e., e-Healthcare Consultation Process covering 7 subprocesses), service (i.e., e-Healthcare Service Information Browsing, e-Healthcare Service Conceptualization, e-Healthcare Service Knowledge Component Registration, e-Healthcare Service Knowledge Components' Catalogue, e-Healthcare Service Knowledge Components' Management). In this paper, the e-healthcare knowledge management is component-oriented. Therefore, each service consists of some knowledge components, which are designed, constructed and selected to provide optimal advice to patients and their guardians. The knowledge components can be further designed as learning objects for education of end users and for their community considered as organization of learning good medical practices.
- APPLICATION covering elements, such as Financial Application, Knowledge Component Management System, Portal to External Sources of Knowledge (e.g., libraries, journals, document repositories), Service Management System, Knowledge Broker- Patient

Relation System, e-Healthcare Service Politics and Regulations, Risk Evaluation, IT Support.

- TECHNOLOGY including elements, such as Data Server, Application Server.
- MOTIVATION containing the following elements: drivers (i.e., e-Healthcare Consultation Needs), principles (i.e., e-Healthcare Knowledge Development Principles), assessment (i.e., e-Healthcare Consultation Evaluation), goals (i.e., Patient Satisfaction, Efficient and Effective Response for Patient), requirements (i.e., Patient e-Healthcare Requests), stakeholders (e.g., Patients and their Guardians).

In Table I, proposed e-Healthcare organizational structure covers the most important stakeholders, i.e., Patients and their Guardians (PG), Medical Staff (MS), Institutional Investors (II), Knowledge Brokers (KB), Information System Developers (ISD), Information Technology Architects (ITA), Public Healthcare Managers (PHM).

TABLE I. RACI CHART FOR E-HEALTHCARE

Key Management Practices	PG	MS	II	KB	ISD	ITA	PHM
e-Healthcare Strategic Planning	I	C	R	C	R	R	C
e-Healthcare Knowledge Brokering	C	C	R	A	R	R	C
e-Healthcare Vision Development	R	C	C	R	I	I	C
Cultural Environment Capabilities & Performance	A	R	R	R	R	A	C
IT Capabilities Development	C	C	R	C	A	A	C
The ICT Investment Development & Project Planning	R	R	A	R	R	C	C

Their activities are further precisely specified and verified in particular projects. However, at the pre-implementation stage each person can be evaluated according to the following criteria:

- Reliability: capability to maintain a level of performance under stated conditions for a stated period of time,
- Efficiency: ability to work properly to the amount of resources used under stated conditions,
- Suitability: ability to meet stated and implied needs,
- Agility: capability to receive required effects in stated time,
- Compliance: complying with laws, regulations and contractual agreements.

At the EA development, quality can be evaluated as the conformance to the requirements. Every EA product or service has a requirement, i.e., a description of what the service recipient needs. When a particular product meets that requirement, it has achieved quality. The requirements are formulated for information, applications, and services. TECHNOLOGY layer components are strongly standardized and their quality can be evaluated through IT benchmarking.

The EA quality evaluation focuses on the evaluation of certain vision provided by a stakeholder as it is in Figure 2. Usually, the vision is supported by the set of principles, which support the EA analysis, development and implementation. The exemplar principles of EA are as follows:

- data quality is a major factor in enhancing value of e-healthcare,
- reusing existing services and knowledge components reduces the work required to implement new ones,
- real-time e-healthcare system monitoring allows immediate action to resolve failures and incidents,
- standardization of EA components help achieve economies of scale and improves flexibility,
- processes must be designed from the patient perspective,
- decision-making must take place at the lowest possible organizational level,
- patient interaction processes must have error correction capabilities,
- all knowledge must have authorizing source,
- information structure must be based on ArchiMate standards,
- patient data must be accessible to the patient.

The EA vision and principles are evaluated in the following way:

- identification of the intended stakeholders of the quality measurement results,
- determination of the post-evaluation decision-making responsibilities, decisions will be some procedures with respect to the architecture vision,
- defining the measures, e.g., :
  - accuracy : data in the EA vision correctly define the event or object which they describe,
  - completeness: all the necessary data are present,
  - validity: the data fall between acceptable ranges defined by the system architect,
  - consistency: data elements are consistently defined and understood,
  - relevance: the EA vision components support a decision that needs to be made or a task that needs to be performed,
  - presentation: the EA vision is presented in a form that makes it easily understandable
- for each measure, specification of feasible quantifiers, and if it is not possible using the "check-mark" technique for the acceptance of requirement level achievement.
- on the basis of the assessments in the step above, re-improvement of the EA vision and principles specification. The results of such evaluations of measurements will address questions related to the occurrence of the undesirable conditions, outcomes or principles. The process is also developed to reveal omissions, redundancies and any other weaknesses.

 ISBN: 978-1-61208-478-7

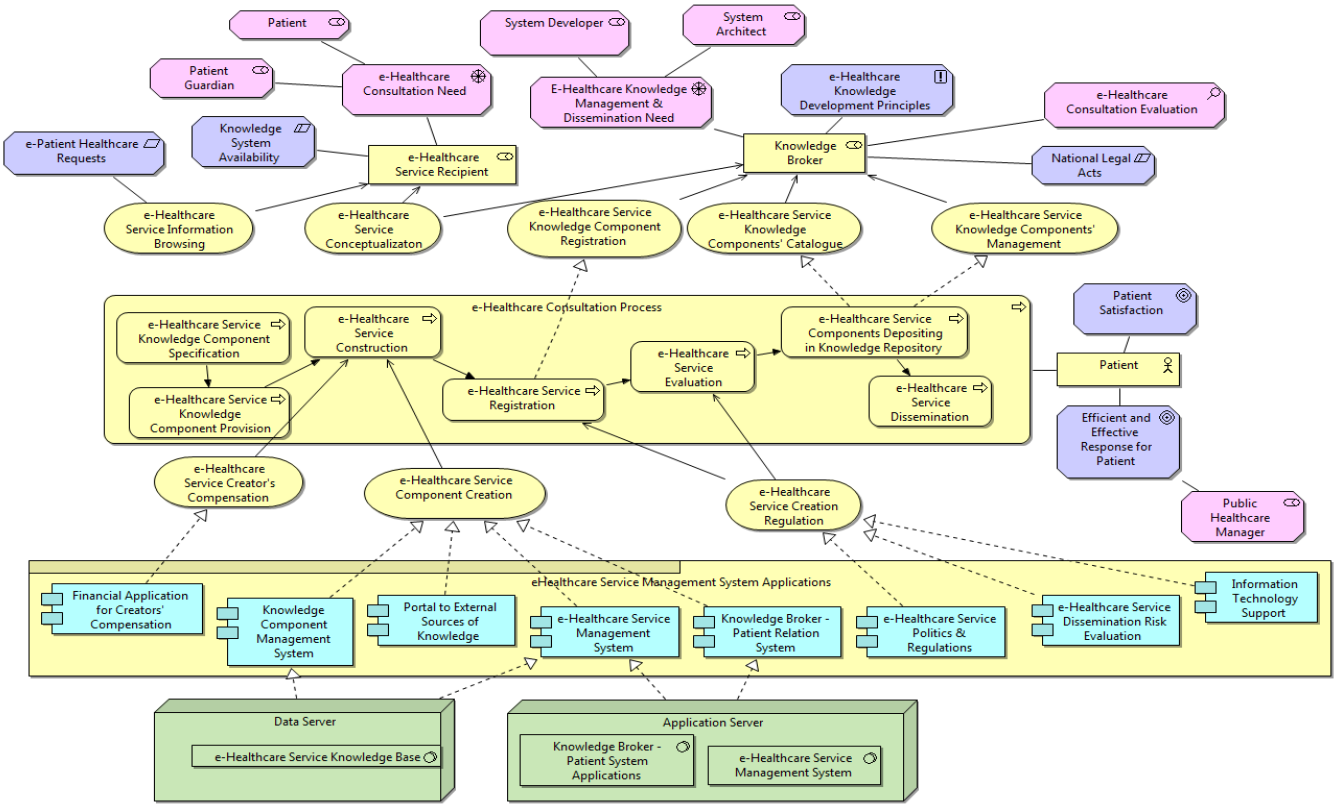

Figure 2. e-Healthcare Architecture Model.

V. CONCLUSION

Although holistic approach to the EA quality evaluation was provided in TOGAF as the Architecture Maturity Modeling, in this paper, the EA quality evaluation is a complex process. Taking into account the ISO/IE/IEEE 42010 definition, quality of each of the EA elements should be evaluated separately. Although the TOGAF framework focuses on EA process quality, this paper is to emphasize that EA stakeholders and vision are the most important in the quality evaluation process. The stakeholders as EA development beneficiaries should be the EA quality evaluators. The exemplar specification of quality measures were proposed for that EA objects.

REFERENCES

[1] BIZBOK™ guide version 4.0. [Online] Available from http://c.ymcdn.com/sites/www.businessarchitectureguild.org/resource/resmgr/BIZBOKV4IntroductiIn.pdf. 2014.10.12

[2] CIO Council, Updating the Clinger-Cohen Competencies for Enterprise Architecture, 2003, [Online] Available from http://www.cio.gov/documents/FINAL_White_Paper_on_EA_v62.doc, 2016.01.11

[3] P. Desfray and G. Raymond, "Modeling Enterprise Architecture with TOGAF A Practical Guide Using UML and BPMN," Amsterdam, Elsevier, 2014

[4] J.A.P. Hoogervorst, "Enterprise Governance and Enterprise Engineering," Berlin, Springer, 2009.

[5] ISO/IEC 42010, System and software engineering - Architecture description. International Standard, Geneva, 2011.

[6] M. Lankhorst, "Enterprise Architecture at Work," Berlin, Springer, 2005.

[7] D. Minoli, "Enterprise Architecture A to Z, Frameworks, Business Process Modeling, SOA, and Infrastructure Technology," London, CRC Press, 2008.

[8] M. Op't Land, E. Proper, M. Waage, J. Cloo, and C. Steghuis, "Enterprise Architecture, creating value by Informed Governance," Berlin, Springer, 2009.

[9] C. Perks and T. Beveridge, T., "Guide to Enterprise IT Architecture," New York, Springer, 2003.

[10] M. Spadoni and A. Abdmouleh, "Information Systems Architecture for Business Process Modelling" in Handbook of Enterprise Systems Architecture in Practice, P.Saha, Ed. Hershey, Information Science Reference, 2007, pp. 366-382,.

[11] F. Theuerkorn, "Lightweight Enterprise Architectures," London, Auerbach Applications, 2005.

[12] M. Van Den Berg and M. Van Steenbergen, "Building an Enterprise Architecture Practice, Tools, Tips, Best Practices, Ready-to-Use Insights," Sogeti, Springer, 2006.

[13] J.A. Zachman, "Frameworks Standards: What's It All About?" In The SIM Guide to Enterprise Architecture, L.A. Kappelman L.A. Eds. Boca Raton, CRC Press, 2010, pp.66-70.

 ISBN: 978-1-61208-478-7