Enterprise Architecture Modelling for Corporate Sustainability

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Abstract The chapter aims to validate the usability of enterprise architecture (EA) development methodologies to support enterprise sustainable development. The main thesis of the chapter is that EA modelling supports the sustainable development of business organisation as well as the sustainable governance of IT in the organisation. Therefore, the first part of the chapter covers discussion on what sustainability is, particularly in the context of EA development. The second part comprises analysis of EA modelling methods and explanations of their usefulness for sustainable development. The third part includes presentation of the EA development principles as important for corporate sustainability.

1 Introduction

In socio-economic literature, sustainable development is the practice of meeting the needs of society today without compromising the ability of future generations to meet their own needs [1]. The term in its environmental usage refers to the potential longevity of vital human ecological support systems, such as the climatic systems, systems of agriculture, industry, forestry and fisheries and the various systems, on which they depend in balance with the impacts of their unsustainable or sustainable design. In each information communication technology (ICT) project, project sponsors expect results for prolonged periods of time and expect answer to the questions of what results will be available in the future, how project beneficiaries want to ensure project results sustainability and what project results arrive after the project financial support finishes. Sustainable development is to be proactive about change.

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The move towards the enterprise engineering is usually strongly based on economic considerations, i.e. development and maintenance costs reduction, decrease of human efforts and power energy usage and improvement of the quality of the resulting EA components. The EA engineering approaches are to support the integrity, reliability, effectiveness, efficiency and actuality of the EA components as well as large-scale reuse during the systems' development.

2 Sustainability Development

Sustainability is a characteristic of a process or state than can be maintained at a certain organisational level. It is understood as the simultaneous effort of balancing economic, social and environmental goals for a corporation [2]. So, sustainability is a metaphor for describing corporate social responsibility, corporate citizenship or ethical business conduct.

In 1987, the World Commission on Environment and Development (WCED) related sustainability to corporations and the economy by defining the sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs [3, 4]. Sustainable development is proposed as a strategy to improve the quality of human life.

The etymology of "sustainable" carries interesting and important implications for the way the word is used as it includes several contradictions. The word "sustain" is derived from the Latina "sub-tenere", meaning "to uphold". This carries as passive connotation in it and gives the image of stability, persistence and balance. "Sustainable" is used in a more active sense together with "development". Development means change, progress and growth. Hence, "sustainable development" means a progress which is being uphold or defended at the same time as it implies movement and improvement [5]. The idea of "sustainable development" includes a normative and active meaning. In this sense, the sustainable development assumes a certain equilibrium among the strategic factors and available resources.

Shrivastava notices the incentives for organisations to support ecologically sustainable development activities include the following: the decrease of operating costs, creating a competitive advantage with green ICT, establishing a legitimate sustainability present with the public and stock markets, reducing the long-term risks associated with resource depletion, improving the ecosystems and community environment and positioning their organisations ahead of the regulations [6].

Corporate governance for sustainability is a setting of rules, their application and enforcement [7]. Proponents of economic liberalism prefer market mechanisms domination and they do not see the state playing a major role in supporting sustainability. Models of governance for sustainability need to concentrate more on change than stability. The existing rules, customs, practices and rights are seen more as the subject to be influenced, than as the main business of governance [8].

In this chapter, the sustainability is considered in three aspects. In economic aspect, the sustainability means long-term growth, ICT resources availability,

efficiency and minimisation of human efforts and decrease of consumption of electricity. The economic dimension of sustainability concerns the organisation's impacts on the economic conditions of its stakeholders and on economic systems at local, national and global levels. The economic indicators cover flow of capital among different stakeholders and main economic impacts of the organisation throughout society. The impact indicators comprise economic performance measures, market presence and indirect economic impact indicators.

From the environmental point of view, the sustainability means maintaining lower energy human ecosystems. The environmental dimension of sustainability concerns an organisation's impact on living and nonliving natural systems. They cover performance related to biodiversity, environmental compliance and other relevant information such as environmental expenditure and the impacts of products and services.

In the social and cultural aspect, sustainability is identified with the sociocultural diversity, including multi-stakeholder opinions, justice, equity respect and transparency of ICT systems. The social dimension of sustainability concerns the impacts an organisation has on the social systems within which it operates. Social sustainability occurs when the formal and informal processes, systems, structures and relationships actively support the capacity of current and future generations to create healthy communities [9].

Sustainability of an ICT activity is strongly influenced by the technology used. Despite the current emphasis on economic sustainability, it is too difficult to determine sustainability criteria for ICT projects. Although many such projects use cost-recovery mechanisms, mostly they declare that project results will be exploited for the established project duration period according to the predetermined plans. Sustainability in the context of ICT is addressed through the Green IT approach. However, ICT specialists have got a certain dilemma. On one side, they create an environment of IT that is sustainable in itself (sustainable ICT), and on the other side, they foster the sustainability throughout the organisation (sustainable through ICT) that requires the integration, stability and communication inside and outside an organisation [10, 11].

In this chapter, sustainability is perceived to provide added value to the entire information system life cycle by establishing architecture to enable its implementation and rules for ownership and usage, resulting in benefits to the end user. Particularly, the enterprise architecture has abilities to ensure transparency, credibility, comprehensiveness and consistency for corporate sustainability. Transparency is enabled in the processes of the EA modelling and execution, based on scientific methods or international conventions and standards. Credibility is verified by the end users and stakeholders of the EA development. The enterprise architecture is communicated to the entire company. The focus of the communication is rather on new mutual insights and action orientation. Comprehensiveness refers to the consideration of all aspects i.e. economic, social and environmental, as well as to the identification of potential benefits. Only the enterprise architecture is able to ensure the comprehensive view, which is so important for the corporate sustainability. Consistency concerns the harmony among all parts of the process.

3 Enterprise Architecture Modelling

The main aim of the modelling exercise is to go beyond the concrete description and to fetch the abstract view of a modelled object. Modelling refers to systematic activities undertaken to describe and visualise abstract phenomena in a structured or formal way. The enterprise modelling is to describe enterprise objectives, activities, information resources, processes, actors, products, requirements and the relationships between those entities [12].

Although the enterprise architecture development is expected to convey semantic unification, nowadays the enterprise modelling approaches do not offer mutually agreed languages. Therefore, the lack of unified approaches prevents from providing meaningful information outside the scope of the enterprise. Unfortunately, every EA framework establishes its own techniques, artefacts, schemes and vocabularies. Companies have to customise and adapt recognised EA frameworks to meet their requirements, so perhaps they have no opportunities to reduce costs, efforts, and work time. Eventually, there is lack of transparency and credibility of EA.

In American National Standards Institute and Institute of Electrical and Electronics Engineers (ANSI/IEEE) Standard 1471–2000, an architecture is the fundamental organisation of a system, embodied in its components, their relationships to each other and the environment and the principles governing its design and evolution. The architectural framework is a specification of how to organise and present architectural models. Because the EA is an all-encompassing discipline, and because the enterprises it describes are often large, it can result in very complex models. The extension of the conceptual framework of IEEE 1471 is presented in Fig. 1.

The IEEE 1471 definition explains that architecture is described by one or more architecture descriptions, which are composed of one or more stakeholders, viewpoints, views and models. The architectural framework is a conceptual structure related to a certain system type and consisting of areas of concern and a necessary and sufficient set of design domains. In the extension of the ANSI/IEEE definition, the business strategy and sustainability are included. A strategy is perceived as something an organisation needs or uses in order to win or establish its legitimacy in a world of rivalry [13, 14]. Strategy is both a plan for the future and a pattern from the past; it is the match an organisation makes between its internal resources and skills and the opportunities and risks created by its external environment [15–17].

The historian Alfred Chandler has formulated the thesis that structure follows strategy [18]. He described strategy as the determination of long-term goals, the adoption of courses of action and associated allocation of resources required to achieve strategic goals. He defined structure as the design of the organisation through which strategy is managed. Changes in an organisational strategy lead to new enterprise architecture (see Fig. 1). Therefore, the sustainability strategy formulation must be followed by enterprise engineering and utilisation of feedback for the strategy reformulation. The business strategy can be identified with a selected way of ensuring corporate sustainability and creating a fit between external environment, internal resources and capabilities (see Fig. 1). In this context, ICT strategy is

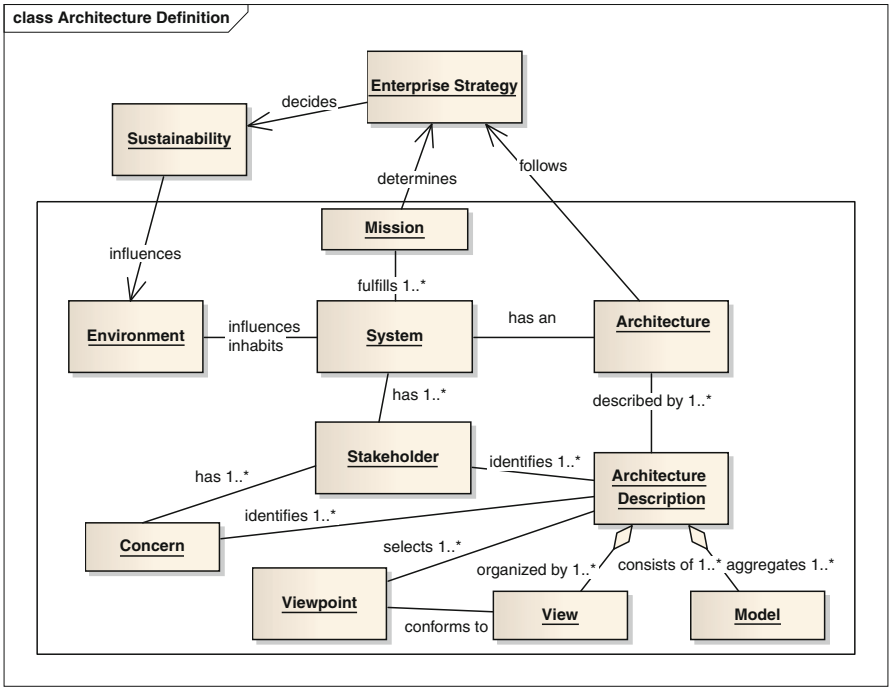

Fig. 1 Extension of the conceptual framework of IEEE 1471

a general plan or a direction of IT application in the enterprise to achieve strategic business goals. ICT strategy is a discipline that seeks to explain why organisations do what they do and how they can be changed to achieve a certain demanded purpose. The EA's role for organisation strategic development is presented in literature [19].

In this chapter, the EA model is clearly a communication tool. The EA model communicates a compelling vision of usage of ICT within an organisation and within its contacts with the business environment, to coordinate organisational strengths with environmental opportunities, to guide and coordinate supporting activities, to generate more benefits than costs and to explore new opportunities and respond to new user requirements. The same as above, questions are formulated in the EA framework e.g. Zachman Framework. Ross et al. [20] argue that strategy and architecture are relatively analogous terms. However, an architecture is often thought more of as a static picture, and a strategy is more like putting the architecture into motion, defining not only what is to be accomplished but how it is going to be achieved.

The EA as a strategic management discipline creates a holistic view of the business processes, systems, information and technology of the enterprise. As such, it is a manifestation of an organisation's mission and enables that mission (see Fig. 1). The EA consisting of ICT systems is to ensure adaptability and agility of the enterprise to respond more adequately to the dynamics of the business environment.

The EA is expected to give faster delivery of new functionalities and modifications of the legacy systems, as well as an easier access to higher quality, more consistent and more reliable information. The business organisation should eventually have a bigger consistency of business processes and information across business units. The enterprise architecture is to identify opportunities for integration of inconsistent processes and information and support the reuse of them.

Unfortunately, there are no clear and transparent guidelines that enterprise architecture framework is to support the corporate sustainability.

3.1 The Open Group Architecture Framework

In The Open Group Architecture Framework (TOGAF), architecture has two meanings:

- A formal description of a system, or a detailed plan of the system at component level to guide its implementation
- The structure of components, their interrelationships and the principles and guidelines governing their design and evolution over time [21, 22]

There are four architecture domains:

- The business architecture that defines the business strategy, governance, organisation and key business processes
- The data architecture that describes the structure of an organisation's logical and physical data assets and data management resources
- The application architecture that provides a scheme of the individual application, their interactions and their relations to the core business processes
- The technology architecture that describes the logical software and hardware capabilities that are required to support the deployment of business, data and applications services

The purpose of enterprise architecture is to optimise across the enterprise legacy systems into an integrated environment that can be responsive to business strategy and corporate sustainability through reduction of ICT resources incompatibilities and costs. The EA development is to ensure lower business operation costs, more agile organisation, lower change management costs and improved business productivity. Although it is not clearly defined in this method, improvement of interoperability, reduced complexity of the business processes and the ability to procure heterogeneous, multi-vendor open systems are the ways to ensure environmental and economic sustainability of the enterprise. With TOGAF the sustainable development of the enterprise is supported by the major components within an Architecture Repository that are as follows:

- The Architecture Metamodel describing the organisationally tailored application of an architecture framework
- The Architecture Capability defining the parameters, structures and processes that support governance of the Architecture Repository

- The Architecture Landscape which is the architectural representation of assets deployed within the modelled enterprise [22]

TOGAF guides the selection and integration of specific services to create an architecture useful for building reusable solutions across a wide number of relevant domains. The reuse of building components is a typical activity for sustainable development of EA and for corporate sustainability.

3.2 Zachman Framework

According to Zachman, his framework is a model or ontology for understanding and managing a change of enterprise [23]. Zachman assumes that architecture is the result of work of several actors, who present diverse interests and have to negotiate the final state of the enterprise architecture. So, the EA is an integrated and transparent representation of all enterprise interests. The Zachman Framework (ZF) brings attention to stakeholders' integration, transparency of their opinions and alignment challenges associated with the EA. The Zachman's model provides deep insights into the descriptions of EA and interrelationships among them. The Zachman enterprise architecture framework promotes a top-down approach to development. Within the framework, the considerations are conducted on six levels. The ZF differentiates between the levels: scope model (contextual, planner view), enterprise model (conceptual, owner view), system model (logical, designer view), technology model (physical, builder model) and detailed representation (subcontractor, user model). 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 (column) interrogates the architecture from a particular perspective. Taken together, the matrix cells create a complete image of the enterprise. Such holistic visualisation allows for establishing a certain equilibrium among the views of different stakeholders. The ZF establishes a common vocabulary and set of perspectives for defining and describing complex enterprise systems. The key role is that of the business enterprise architect, who is responsible for documenting, analysing and designing the business processes and functions, products, business units and interactions among them. Governance approach towards the EA development is to understand the business better, to provide an overview of all the units within the enterprise described from different viewpoints, to ensure collaboration between all the units and to add value to the users through continuous enhancement of business processes.

3.3 Federal Enterprise Architecture Framework

The Federal Enterprise Architecture Framework (FEAF) promotes interoperability and sharing of information among US federal agencies and other governmental

entities [24]. The FEAF components of an enterprise architecture are as follows: architecture drivers, strategic direction, current architecture, target architecture, transitional processes, architectural segments, architectural models and standards. The FEAF supports the establishment of the scope of the enterprise architecture similarly as it is in the Zachman Framework. The FEAF method also accepts the actor-oriented approach, including Planner, Owner, Designer, Builder and Subcontractor Perspective and demanding analysis of Data, Application and Technology Architecture from that five viewpoints. So, the holistic model of EA is the result of negotiations and compromises of the different stakeholders.

3.4 C4ISR Architecture Framework

The Command, Control, Computers, Communications (C4), Intelligence, Surveillance, and Reconnaissance (ISR) framework covers three views [25]. The operational view describes and integrates the operational elements, tasks and activities and information flows required to accomplish mission operations. The system view describes systems and their performance to the operational view. The technical view describes the minimal set of rules governing the arrangement and interdependences of system components. The framework aims to ensure that the architecture is the description, from different perspectives, of the integrated, interoperable and cost-effective capabilities in the field.

3.5 Treasury Enterprise Architecture Framework

The Treasury Enterprise Architecture Framework (TEAF) provides guidance and template for development and evolution of information systems architecture. The TEAF's functional, information and organisational architecture views allow for modelling the organisation's processes and business operations. The enterprise architecture description is a matrix, with columns being views (functional, information, organizational and infrastructure) and rows being perspectives (planner, owner, designer and builder) [21]. The matrix supports the realisation of the transition strategy to new environment and the establishment of the sustainability of the enterprise and its architecture.

3.6 The Ministry of Defense Architectural Framework

The Ministry of Defense Architectural Framework (MODAF) is the UK Government specification for architectural frameworks for the defence industry.

The framework consists of seven viewpoints, i.e. acquisition, strategic, operational, system, service-oriented, technical and all view viewpoint [26]. All these viewpoints are interrelated and integrated to ensure long-term balance of the EA components and further improvements within the assumed scopes.

3.7 CIMOSA Framework

The Computer Integrated Manufacturing Open System Architecture (CIMOSA) is assumed to produce a formal, executable model that may be used to simulate and operate the enterprise [25]. The CIMOSA framework emphasises the necessity to transfer the executable model from the enterprise engineering environment to the operational environment. The use of two separate environments supports the implementation of parallel and concurrent processes of the EA development. The CIMOSA modelling framework is based on four abstract views (function, information, resource and organisation views) and three modelling levels (requirements definition, design specification and implementation description). The four modelling views are provided to manage the integrated enterprise model [27]. The argument for the enterprise sustainability is that CIMOSA considers enterprise integration to be a continuous process, which requires that the enterprise modelling activities should be realised simultaneously with the normal operation of the enterprise. Beyond that, the CIMOSA guidelines include building block selection from a catalogue, customisation of selected building blocks, adding variables at execution time to reduce costs and efforts of the EA development.

3.8 Dynamic Architecture Model

The principles of the Dynamic Architecture (DYA) model assume that enterprise architecture aims at achieving coherence and cohesion. Architecture investments have a chance to be approved if they are an integral part of the investment necessary to attain important business objectives. By providing a clear insight into the relationships between various architectural objects (processes, information, applications) and various architectural levels (strategic, tactical and operational) within an organisation, the transparent relationships are defined and the risk of uncontrolled growth of noncompliant solutions will be reduced [28]. The enterprise software application maintenance may demand on development. The DYA model assumes clear defining of independent software components to make adaptations and implementation easier in the future. The EA internal cohesion is achieved because of the anticipative strategy and the ICT governance to coordinate the activities in such a way that they contribute towards achieving business objectives.

4 Enterprise Architecture Principles for Corporate Sustainability

Although there are much more frameworks of EA, e.g. Generic Enterprise Reference Architecture and Methodology (GERAM), Purdue Enterprise Reference Architecture (PERA), Lightweight Enterprise Architecture (LEA), Nolan Norton Framework, Extended Enterprise Architecture Framework (E2AF) or Technical Architecture Framework for Information Management (TAFIM), the role of the EA as a support factor for corporate sustainability development is not explained directly [21, 29]. However, generally, the established EA frameworks allow to develop ICT projects that are expected to be cost-effective and shared solutions that aid the enterprise in the long term. They are coherent with the standards and industry regulation compliant. The beneficiaries of ICT projects within the EA should be responsible for the correctness of financial and economic analyses, cohesion of information included in the project and the EA documentation, correctness of cost qualifications, technical, organizational, legal and financial feasibilities as well as each project and the whole EA stability and energy effectiveness of proposed ICT solutions. All the criteria are important for corporate sustainability from the ICT projects' point of view. The EA principles can be positioned as instruments to articulate an enterprise's future direction and its sustainability, while serving as a coordination and steering mechanism towards the actual transformation of the enterprise. The basic EA principles need to drive the behaviour within the enterprise. Therefore, the elements of the EA should be understandable, robust, sufficiently defined and precise to support consistent decision making, complete, consistent, and agile to accommodate changes. The EA is the bridge between the business strategy and organisational design, but it must be perceived as the normative restriction of design freedom [30].

Particularly important to users is the capability of integrating the information among software applications and across data warehouses and data marts. By understanding the enterprise architecture, they can develop a standard data dictionary and develop metadata standard to minimise data inconsistency. The EA ensures the traceability between business processes, data, user roles, applications and infrastructure. The traceability and integration support corporate ICT sustainability. Otherwise, i.e. if an organisation does not have a clear model of its business application and technical infrastructure, they are not monitored and maintained consistently in the long term. The better monitoring of ICT assets provides a greater understanding of the interrelated issues of business-ICT alignment and support electric energy and human efforts reduction. The development of the EA enables complex preparation for new technologies, smarter project realisation and the reuse of the EA components and best practices. Standardisation for the EA drives ICT procurement efficiencies, because of the opportunities of economies of scale, reduced skills maintenance and trainings.

For architecture development the conceptual integrity is an important consideration in system design [31]. Problems that enterprise integration can solve include the following: information aggregation, single point of data entry, process efficiency, web channel integration, supplier integration and supply chain optimisation.

5 Conclusion

Concluding, the EA is the principal mechanism for establishing the fundamentals in enterprise design, managing the knowledge of the enterprise and long-term integration of the technology into the enterprise. The EA implements risk-monitoring mechanisms and generates technical guidelines of how the service delivery function makes optimal use of ICT assets, thereby maximising cost-effectiveness. So far, the enterprise architecture frameworks are poorly supported by the principles and tools to control the enterprise sustainability. The EA modelling should be the formal or formalised approach for addressing the organisational complexity and sustainability and the realisation of a unified and integrated design. The corporate sustainable development should be determined by the EA that aims at ensuring the communication between users and developers, as well as at the validation and verification of implemented systems, including material for reuse repositories.

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