Initial Experiences in Developing a Reference Enterprise Architecture for Small and Medium-Sized Utilities

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Abstract. In the last decades, numerous developments and legal changes moved the utility industry towards a liberalized market. Utility enterprises have to stay competitive and reduce costs while managing more complex IT systems. The authors of this work see special demand for aligning business and IT for small and medium-sized enterprises (SME) in this industry and identify the development of a reference enterprise architecture (R-EA) as a key for this issue. This work investigates how to develop such a reference model, which comprises data acquisition as well as validation methods.

Keywords: Enterprise Architecture Management, Reference Modeling, Utility Industry, Small and Medium-Sized Enterprises, Reference Enterprise Architecture

1 Introduction

Enterprises need to be aware of the relations among their strategy, business processes, applications, information infrastructures and roles to be able to rapidly react on changing demands in the market and within their organization. Enterprise Architecture Management (EAM) contributes to this purpose by providing methods and tools to establish a more holistic perspective on enterprises [1, 2], which includes to systematically capture and develop the different architectural layers of an enterprise (e.g. business, application and technology architecture).

In recent decades, the European utility industry faced significant changes caused by developments and regulations like market liberalization and the diversification of energy sources [3]. Numerous new market roles and business opportunities created by changes in regulations resulted in an increased competition. Therefore, utility enterprises are forced to adapt their business models to the changing market situations, which also requires adaptation in the enterprise architecture. Especially SMEs have to overcome this increasing complexity by adjusting both their business and information systems [4].

In this context, EAM is expected to be important for supporting change processes and developing competitive business capabilities [5]. Current research lacks in

S. España J. Ralyté, P. Soffer, J. Zdravkovic and Ó. Pastor (Eds.):
PoEM 2015 Short and Doctoral Consortium Papers, pp. 31-40, 2015.

investigating the exploitation of EAM in the frame of SMEs [6]. A survey within German SME utilities revealed that there is a demand for a reference EA. In the frame of the ECLORA Project such a R-EA is developed, which is configurable dependent on the respective application case. This work illustrates how to collect data in order to develop and validate such a reference EA. Therefore, the paper first points out developments in the utility industry, clarifies its understanding of SMEs, discusses the current state of EAM in this area as well as approaches how to develop reference models. Section 3 introduces the ECLORA project, its methodology and recent results, before the approach of data acquisition for R-EA development is presented in section 4. Finally, a conclusion and further outlook is given in section 5.

2 Theoretical Background

Over the last two decades, the European energy market has faced fundamental structural changes [3]. Next to increasing the energy efficiency, the European Union also aims to raise the share of renewable energy sources by 20%. The German government even steps further by intending to cover 35% of the electricity demand with renewables by 2020 and 80% by 2050 [7]. In addition, within the German EnWG law (Energy Industry Act) the industry transformed from a few monopolistic supply-side players to numerous supply-side enterprises, while customers gained more power in their role as an electricity consumer [8]. Next to this, also technical improvements increased competition, which forced utility enterprises to improve their efficiency and effectiveness [9, 10]. The Germany Federal Association of the Energy and Water Industry categorizes nine market roles such as energy retailer, balance grid coordinator or metering service provider [11]. Several roles can be taken by one utility enterprise. This development enabled the emergence of new business models combining several roles as well as offering new services.

The energy turnaround faces several major challenges according to [12]. The integration of renewable energy sources, whose generation is difficult to predict, faces a mismatch between times of supply and demand. Moreover, the production of these energy sources implicates unpopular energy storage installations and the transport of new plants for renewable energy brings along a massive expansion of the electricity grid. Also small energy producers with more flexible generation frequencies need to improve the energy production in comparison to the demanded energy in the grid [8].

The above stated developments and challenges have critical influences on utilities' operative and strategic business. Most of the public utilities in Germany can be categorized as small and medium-sized enterprises (SME). Thus, they are facing major obstacles these days restructuring their organizations while staying competitive and still complying with complex national and international regulations. According to [13] more than 99% of European enterprises operate as an SME, globally between 40% and 50% of gross domestic product is accounted to them. This paper uses the definition of the German institute for SME research, here enterprises are considered medium-sized with less than 500 employees [14].

2.1 Current State of EAM in SME Utilities

From information systems (IS) perspective today's utility enterprises have more complex requirements towards its information systems. In [10] the authors identified more than 80 different information sources that have to be used in order to develop an appropriate information system for the utility industry. Although there is a plethora of literature regarding the challenges in the utility industry, a paucity of literature with concrete focus on IS is identified. Additionally, most literature addresses the context of environmental sustainability but lacks in investigating the implications for utilities' IS and its role in the current developments [15].

The authors of this work determine EAM as an approach facilitating business and IT compliance on the one, and optimization of organizational structures on the other side. The emerging objectives to align business and IT, to overcome IT complexity, and to reduce costs for sustain competitiveness can be reached by implementing EAM [1]. An approach towards EAM initiatives has to be tailored to the context of SME utilities since their organizations models, decision processes as well as their understanding of the importance of strategic planning differ to more complex organizations [17]. So far there has been little research activity, which concretely addresses EAM as a mean to overcome the stated challenges in the utility industry. Most research focuses on parts of EAM's scope. For instance, [10] identified 11 reference models for information systems development in utility industry and proposed a catalogue for reference models in order to agree on a common terminology [18]. In the frame of an EU Mandate the Smart Grids Architecture Model framework was developed [19]. Within this framework the topic of smart metering emerges, addressing the enhancement of the Smart Grids' operational efficiency. Therefore, approaches to develop a smart metering architecture can be identified trying to manage the massive relevant data necessary to offer effective meter data management [20]. To cope the issue of complex and flexible energy input, load management and demand response are investigated [16] and customer-centric networks are created in order to reduce peak load by dint of dynamic tariff models utilities could use [21].

All these research activities address issues a utility enterprise nowadays has to consider not only in their business but also in their information systems. The stated literature investigates this at a relative granular level. A holistic approach like EAM cannot be identified. As a summary the authors derive a lack of current research regarding EAM initiatives in the utility industry [5].

2.2 Reference Modeling

This work identifies reference modeling as an approach capable of closing the gap of EAM within the utility industry. Reference models are information models developed for an abstract class of application and entitled to universality in this class. Thus, their purpose is to be reused by mechanisms of adjustment and extension according to a special application case. The reuse of a reference model is intended to increase both efficiency and effectivity of an enterprise's information systems and their change management [22]. The process of reference modeling comprises both the construction and the application of the model [23]. For both phases Schütte defines a procedure model defining certain modeling activities. The application phase is understood as an integrated process in the model construction since it may trigger the extension of the reference model [24]. Further, Schlagheck introduces the object-oriented paradigm into the construction and application of reference models. This enhances the models' reusability, configurability and comprehensibility [25]. Becker et al. identify a dilemma in reference modeling among the models general validity during construction and the effort of adjusting the model while its application. Their approach suggests solving this conflict by developing configurative reference models, which defines rules to determine model adjustments according to the problem class' characteristics. Each value of predefined configuration parameters triggers the instantiation of an appropriate model variant in a certain point of the reference model [26]. This approach integrates the application aspects into the construction phase of reference modeling.

3 ECLORA Project

ECLORA aims to develop a model description of complex enterprise architecture for the utility industry. This intention is facilitated by dint of reference modeling. The R-EA is developed and described based on specific architecture layers according to TOGAF (technical, applications, data and business) [29]. These architectural components can be used to refine and evaluate the usage of IT in utility enterprises in the context of their corporate strategies. Grounded on our experiences in EAM and a sound analysis of methods and techniques, we decided for a research design which comprises the use of the DSR approach as well as the Configurative Modeling.

3.1 Research Design

The research method used for ECLORA is design science for information systems research proposed by Hevner et al. [27]. Design science is a problem-solving paradigm that reacts on an identified organizational problem by creating and analyzing IT artifacts. In the case of ECLORA the resulting artifact is the reference EA for small and medium-sized public utility enterprises. ECLORA applies DSR using technical action research approach by Wieringa and Moralı as validation design [28]. This serves as a methodological framework, illustrated in Fig. 1.

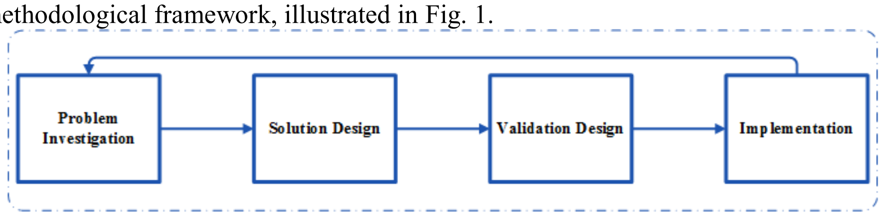

Fig. 1. Instantiating Design Science in ECLORA

As depicted the Configurative Reference Modeling approach is utilized for Solution Design within ECLORA. This approach proposed by Becker et al. addresses the reference modeling's dilemma among general validity and effort of adjustments.

3.2 Recent Results and Implications

As stated before, current research does not address industrial needs in terms of managing a flexible IT architecture utility SMEs. A survey with stakeholders from the public utility sector was conducted ascertaining industry's attitude, experience and need for EAM. The examination of the survey revealed several findings that are listed below and can be found in [4].

1. *High Diversification of Market Roles*: 25 combinations of market roles were identified. This implies that utility's EA depends on the market roles it takes.
2. *EA Frameworks too complex and expensive*: Although numerous EA Frameworks are available, there is a lack of frameworks tailored to SME utilities. They do not feel supported by them.
3. *Validation of the demand for a Reference EA*: The survey identified factors that let utilities' EA grow complex. Next to fusions and outsourcing strategies, especially rules and regulations require an advanced flexibility.
4. *Optimization of Communication between IT and business*: Although the identified core processes were supported, the majority of respondents neither felt sufficiently delivered with information nor was satisfied with the IT support. This reveals insufficient Business-IT-Alignment.
5. *Business Process Outsourcing in Utility Industry*: Especially in Energy Data Management and Billing the enterprises utilized outsourcing strategies.

These results of this survey have special implications for the ECLORA project regarding its reference enterprise architecture. The findings listed above will also influence the way ECLORA defines how to apply the reference EA to a SME utility.

3.3 Development of an initial R-EA

In order to develop an initial R-EA, data was collected by means of quantitative and qualitative methods. A survey was conducted to analyze the current situation and identify common practices and needs for improvements in utility enterprises [4]. For the development of our initial reference architecture, we merged the findings from a literature analysis, branch literature, expert interviews and the survey's analysis.

The development of the initial R-EA bases on The Open Group Architecture Framework (TOGAF), which comprises three layers: business architecture, information architecture, technical architecture [29]. Since this approach is primarily addressed towards big enterprises, an objective was to tailor the concepts of TOGAF towards SME utilities. Therefore, several perspectives for a R-EA were developed, e.g. the cooperation of actors and roles, which considers the branch-specific influences of federal agencies and EU authorities. Initial stakeholders and dependencies were identified and depicted. Specific elements were figured out, especially for the business architecture (BA). The BA consists of five functional divisions of utilities with several hierarchical levels. Fig. 2 shows the breakdown for *Energy Data Management*, which is one of the functional divisions and a characteristic part of utility industries. Roles and dependencies are pictured as well. The developed architecture layer and business processes were validated by branch experts within an internal workshop.

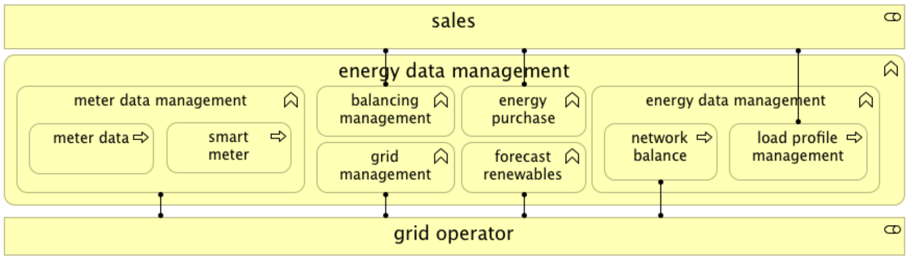

Fig. 2: Business Architecture of Energy Data Management

4 Preparing the Validation Cycle

4.1 Capturing the R-EA at the Utility's

The initial R-EA serves as a basis for conducting workshops at the utility SMEs. As the implications from the survey show, the awareness of EAM's importance in utility industry increases in conformity with one's knowledge of this discipline. Still, the results of the survey reveal that the majority of the consulted utilities is inexperienced in the field of EAM [4]. Since it cannot be assumed that the utilities' participants at the workshops understand the concepts and views of EAM, it seems inappropriate to it as a means to collect all relevant data during the workshops.

Thus, the obstacle was to elaborate means how to collect data in the workshops without the necessity to train participants in terms of EAM. Concluding the results of the survey, practitioners are not supposed to understand modeling notation and hence, would not be able to add value to the models with their domain expertise. For this reason, illustrations with a higher level of abstraction were developed to compress the information relevant for the workshop. Hence, the presentation of the R-EA only contains functional divisions and first subsections as well as related roles. This seemed to be a reasonable approach to drive discussions with the domain experts, which was validated by the experts of the industrial project partner.

A next issue was to capture the information and technology perspective on the utilities, their interrelations between each other and with the business architecture. It was decided to use business processes typical for the utility industry. Furthermore, the right participants and workshop design had to be discussed as well as tools and auxiliaries used during the workshops. Decisions and experiences regarding these issues are discussed in the following sections.

4.2 Business Processes to Capture the Current State

Business processes are used, which are known by the participants and which are representative for the utility industry. While the processes *meter data collection* and *consumption billing* are of a standardized nature, utilities differ in the performance of the *customer acquisition* process as well as *domestic connection*. The decision to use these processes was taken in collaboration with the experts from the industrial partner. They were assessed appropriate in order to gather information for developing a R-EA.

Analyzing these business processes intends to gather information according to different process realizations and contributes to understand the interactions between the different architectural layers. Therefore, *meter data collection* is used here for illustration purposes. It focuses on the data transfer from a meter to the processing system of the utility industry and therewith contains elements of data architecture, information flows as well as integrated technology like smart meter. Despite that, the process itself is easy to understand because it might be reasonably assumed that every employee of the utility industry is a client of this industry as well. The process starts with the order to collect meter data, placed by the supplier. Even though there are different reasons for triggering this action, the subsequent activities are the same. This order is settled by a network operator, by either remote meter reading or on-side reading. Meter data are transferred to the supplier, who imports and validates the incoming data in his IT and therewith generates accounting data. Even though this handling is expected to be similar within the utility industry, it permits little variations like the usage of smart metering or the on-side reading executed by clients itself and affects all layers of the reference architecture. The process illustrated in Fig. 3. is validated by experts of the industrial partner.

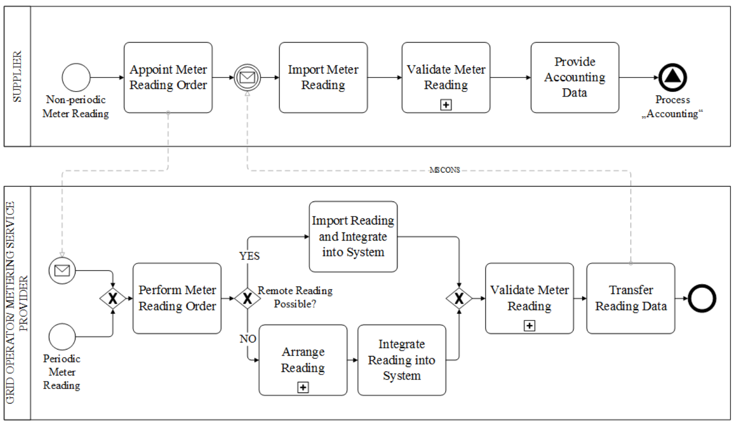

Fig. 3 Meter Data Collection

Regarding the data collection at the utilities' there are some aspect to be considered beforehand. We want to develop the remaining processes from the scratch together with the participants, only specifying the beginning and end point. This procedure minimizes the risk of merely nodding through fully pictured processes. Participants shall reflect their everyday activities without being influenced by our predefined elements.

4.3 Workshop Design

This work presents an approach to collect data regarding the several TOGAF layers presented, taking into account that domain experts may not be familiar with EAM. Table 1 depicts the schedule that serves as a proposal and contains information about the timescales, main parts, their assumed duration as well as brief description of the topics. The workshop lasts two days, with a maximum of eight hours a day.

Table 1. Workshop Agenda

Duration	Focus	Topic
7-8 hours (Day 1)	Enterprise Architecture	Comprises all TOGAF layers, whereby **business layer** is the baseline of consideration. E.g. energy data management, technical network operation.
	Business Process I *Meter Data Collection*	Meter Data is transferred into your system. By whom, how, when and why?
7-8 hours (Day 2)	**Business Process II** *Customer Acquisition*	When a potential customer becomes a customer: What tasks have to be accomplished when a customer enquires a contract with the energy supplier?
	Business Process III *Domestic Connection*	A new property was built: Which information is required and what actions have to be performed in order to integrate the consumption point?
	Business Process IV *Consumption Billing*	All data for billing are in your system: What has to be done in order to send the invoice to the customer?

After introducing the team, topic and goals, the R-EA is presented. Further, each layer and its content is explained by dint of the meter data collection example. A simplified R-EA model is used. To gain more insights into the information and technology layer and to validate the business architecture layer as well, we predefine purposeful questions, open-ended questions and ask for improvement suggestions. This ensures to systematically extend the R-EA within every workshop. At the end of the day, the R-EA is discussed and probably enriched or adjusted with information, objects or links between existing elements.

The second day focuses on the business processes. They will be created by using the approach of participatory modeling [30]. To create them we determine the beginning and end point wherein the participants are tagging each step they have to do to achieve the end. Using different shapes of cards allows specifying if there is an activity (rectangular card) or an object, e.g. a document (oval shape) requested. All members of the ECLORA-team will document the workshop, except the moderator. This ensures the maximum perception of information, which will be compared and compiled afterwards. During the reworking new objects are reflected upon the R-EA. New insights and their generalizability will be discussed before adjusting the architecture, bearing in mind that those workshops are company-specific, whereas deviating steps within the processes will be integrated for covering a wide spectrum of variants.

5 Conclusion

The aim of EAM is to master the complexity of IT and to align it to the enterprise's objectives, its business and other aspects like laws or regulations [1]. Especially utility industry is expected to be a beneficiary of the integration of EAM since laws such as market liberalization require utilities to act competitive [12]. In the frame of the

ECLORA project, a R-EA is developed, which applies reference modelling in order to provide a universal solution for EAM integration in utility industry. Therefore, this work examined how a R-EA is developed in the frame of the project by conducting workshops with several German utilities. In advance, a survey was conducted in order to validate the industry's needs towards such a reference model and to develop an initial R-EA. Although the respondents assess EAM as a mean to handle current challenges for utilities in the changing industry, the general approach and its terms are unknown to the majority [4]. This challenges the elicitation of appropriate data for the stated project ECLORA.

This paper proposes how to conduct workshops at the utilities' in order to gather this relevant data necessary for developing a R-EA. The authors understand a first focus on the business architecture as an appropriate mean to get an overview about the enterprise at hand. The remaining EA layers can be captured by taking typical business processes of the utility industry as a base of discussion, i.e. the meter data collection. Having the domain experts participating at the workshop ensures the correctness of the collected data. Pointed questions enable the processes' relation to information and technology architecture of the utility. The final outcome is a workshop design, which will be applied in future actions of ECLORA.

The workshop design presented is a suggestion that was developed in cooperation with both academic and industrial partners of the project. It will be validated and further enhanced by applying at several German utilities'. At the moment the authors see room for improvement regarding the level of details of the information presented during the workshop as well as the concrete scheduling and documentation of the results. Nevertheless, a first test run revealed that the current design helps to gather promising information and seems to deliver its intended outcome.

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