Evaluating Enterprise Architecture Management Initiatives – How to Measure and Control the Degree of Standardization of an IT Landscape

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Abstract: An important objective of nearly all EAM initiatives is the standardization and consolidation of the IT landscape. This can be seen on several levels, e.g. on the application landscape level, the software level, the hardware level, etc. This paper presents a stepwise approach for consolidating IT landscapes on the technology, software and hardware level which considers the specifics of large IT organizations and is implemented in one of the largest IT service providers of Germany's public civil administration. It is based on metrics which use concepts from fuzzy logic. In particular, these metrics allow measuring the degree of standardization of parts of as well as of the overall IT landscape.

1 Introduction

The steadily growing complexity of IT landscapes, the increasing speed of changes of business models, business process and organizational structures in many business sectors, and the high pressure for cost reductions in the IT area have lead to the intensification of Enterprise Architecture Management (EAM) activities in the past few years. There are numerous frameworks for EAM [Sc06], [FE09], [TO09]. However, there is relatively little literature how to evaluate the success of EAM initiatives. For this, metrics derived from the EAM objectives are needed.

A common issue in EAM is the enormous heterogeneity of the IT landscapes in many organizations. There are used a variety of IT objects (ITO): hardware platforms, database products, operating systems, application servers, development tools, programming languages, etc. A reduced set of such ITO leads to lower operation, administration and maintenance costs, improved security, reliability and development time, and more cost-effective delivery of services [IT07], [RW06], [TO09]. Therefore, standardization, or in other words the shift to a consolidated IT landscape, is an important EAM objective.

Standardization however comes at the price of fewer choices of IT solutions [RW06]. Furthermore, Gartner warns against "over-standardization", i.e. focusing too much on defining standards and neglecting business value, and the forceful top-down manner of implementing it [Ga09]. Therefore, the consolidation of ITO needs to be done in a stepwise manner and in consideration of business requirements.

In this paper we present an approach for controlling and measuring the degree of standardization of an IT landscape regarding ITO which considers the specifics of large IT organizations. The presented metric uses fuzzy logic concepts and is based on a simple conceptual model for representing IT landscapes and a stepwise standardization process for the IT landscape consolidation. The presented approach has been implemented at the Center for Information Processing and Information Technology (Zentrum für Informationsverarbeitung und Informationstechnik – ZIVIT), one of the largest IT service providers in Germany's public civil administration [ZI09]. ZIVIT is designing, hosting and maintaining more than 300 applications and 50 new application projects used in the public administration, which involves the management of an extensive IT landscape of over 2,000 ITO. The authors of this paper are practitioners – two are enterprise architects at ZIVIT and two are with BOC, a company providing EAM tools and solutions (ADOit, ADOben) and EAM consulting [BO09].

The remainder of this paper is organized as follows: In chapter 2 metrics for measuring Enterprise Architectures (EA) are discussed. Then, in chapter 3 a stepwise process for standardizing ITO is described which is based on a conceptual model for IT landscapes and a lifecycle model of ITO. Chapter 4 presents metrics for measuring the degree of standardization of an IT landscape. Chapter 5 summarizes practical experiences of applying the presented metrics. Chapter 6 concludes with an outlook for future work and research topics.

2 Related Work

In EAM there are no universally accepted metrics. Of course, in most organizations there are defined at least some EA metrics. However, there are only few publications which describe such metrics and experiences in applying EA metrics [AD05], [RG07], [Va08]. Methods how to define metrics for EA are described in [IT07], [Fr08] and [He08]. It has to be noted that there is also a research community on "very large business applications" [Gr07] which has a significant overlapping with EAM. It focuses on methods for the evolution of existing application landscapes and legacy systems. For example, in [Mu08] metrics for the so-called "Managed Evolution" of large business applications are described which are used to decide on the further development of legacy systems.

The issue of standardization of IT landscapes is not widely treated in the literature. Its cost-cutting benefits are briefly discussed in TOGAF [TO09] and in the IT Infrastructure Library (ITIL) [IT07]. In [RW06] "standardized technology" is considered the second stage of architecture maturity readily embraced by companies due to its many benefits as presented in the introduction of this paper. However, the authors are not aware of any publications on how to measure and control the degree of standardization of an IT landscape. ITIL defines technology metrics, which however refer to the performance and availability of components and not to standardization [IT07]. The concept of standardization is based on the reuse of ITO in different applications and is thus related to the area of reuse management. [MC07] provides a literature review of reuse metrics and a report of their application in industrial studies, which are however focused on reuse in software development. Of course, most organizations have "technology lists" which define which software and hardware products shall be used. There often exist nevertheless neither defined processes how these technology lists are updated in a controlled manner, nor metrics which measure compliance. With the approach presented in the following chapters we aim to overcome these deficits.

3 Process for Standardizing ITO

One of the main competencies of ZIVIT is the design and maintenance of new applications used in the public administration. In this respect, assuring that these applications use only standardized ITO, i.e. ITO which are considered "standard" within the organization, is an important objective of EAM at ZIVIT. Before the standardization process and the standardization degree metrics can be discussed, it is necessary to present the used conceptual model for IT landscapes and a lifecycle concept for ITO.

3.1 Conceptual Model

Figure 1 depicts the conceptual model used at ZIVIT upon which the standardization metric is based. Applications use ITO – we distinguish between software, hardware and technology types of ITO. In the literature, software and hardware are often considered sub-elements of technology. However, the concept of "technology" how it is used here allows representing software architecture patterns. Additionally, there are guidelines in Germany's public administration (see below) which can be described best by introducing an additional concept to software and hardware.

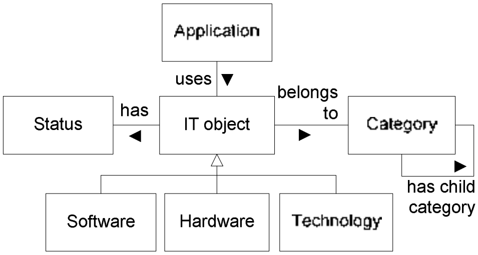

Figure 1: Conceptual model of IT landscapes

By software we mean system software such as operating systems, database products, compilers, en-/decryption software, application servers, etc. Hardware refers to physical components such as servers, workstations and storage devices. By technology we understand software architecture patterns (2/3 tier application, web application, etc.) and standards such as application protocols, digital preservation formats (e.g. XML), graphic formats, technology for information processing (e.g. HTML, XSL, JSP), programming languages (e.g. COBOL, PL/SQL), etc. Germany's public administration has for example defined a list of architecture patterns and technologies which shall be used in e-Government applications (SAGA, Standards and Architectures for e-Government Applications) [BM08].

Each type of ITO contains an unsorted set of elements. This set is broken down into function-oriented categories (subsets) which can be further refined into child categories. Each refinement step creates a new category level in the tree. Through this decomposition ITO can be represented as the leaves – at the lowest level – of a tree of categories. Figure 2 shows an example for the software category DBMS. Examples for ITO are products such as Oracle 9i, Oracle 10g, Oracle 11g, SQL Server 2005 etc.

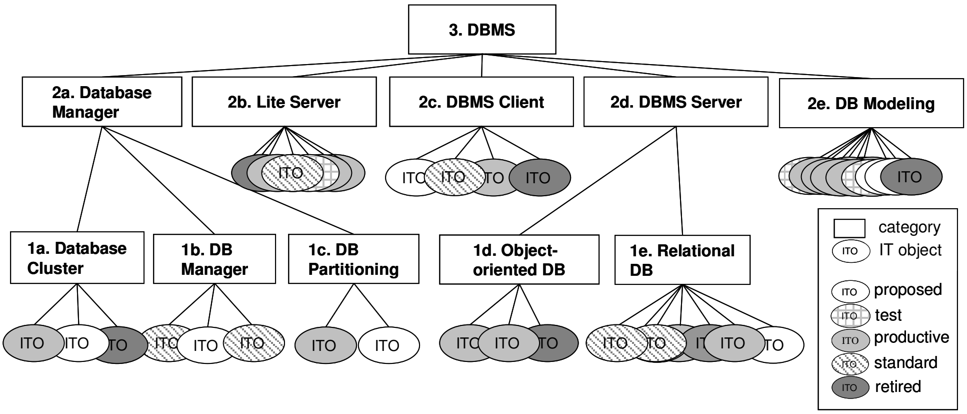

Figure 2: Category tree – Example for software

Each ITO has a status which describes in which phase of its lifecycle it is located. There are five statuses defined at ZIVIT explained in the following subsection.

3.2 Lifecycle of an ITO

In order to understand the concept of standard ITO upon which the calculation of the standardization metrics is based, it is important to describe the lifecycle of ITO at ZIVIT. The possible transitions between the five defined statuses are visualized in figure 3 and subsequently explained in the description of the standardization process.

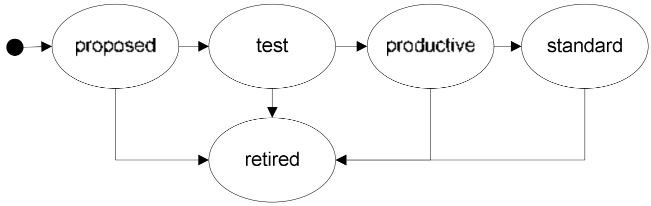

Figure 3: Transition between ITO statuses

Proposed: The status "proposed" suggests that it has been assessed that an existing ITO within a category does not meet completely the requirements or that a new ITO is available which promises advantages in comparison to existing ones. Alternatively, there might be seen the need for a new category with new ITO.

Test: After a proposal has been approved, the ITO enters the test phase. Depending on the test results the ITO with status "test" can either be admitted to production (status "productive") or rejected (status "retired").

Productive: Once an ITO enters into use in an application, it obtains the status "productive". Productive ITO are such that have successfully completed the test phase and are considered necessary or appropriate for one or more applications. A productive ITO can either be promoted to status "standard" or can be retired if it does not fit the long-term IT strategy of the organization or could not prove itself in production. The status "productive" has been introduced due to the size of ZIVIT and its IT landscape. In other organizations it might be common to transition directly from "test" to "standard" respectively to "retired".

Standard: If the benefits of an ITO and its alignment with the IT strategy could be proven in production, the ITO is promoted to standard. ITO with status "standard" are officially released and made available for all applications. Standard ITO are approved as such by the management and are obligatory in applications with the same requirements.

Retired: This status can be obtained after all possible statuses but only at the discretion of the management body (except in the case when a proposed ITO is rejected). Retired ITO are not to be used in new applications. In existing applications they can continue to be used but need to be reviewed at the time of the next release. ITO with status "proposed" or "test" which are rejected receive directly the status "retired". In such cases is necessary to maintain documentation of such rejected proposals in order to prevent redundant evaluations of ITO in the future. Rarely it happens that a new version of rejected ITO has to be reevaluated, e.g. due to market changes. Then, there is created a new ITO (with status "proposed").

3.3 Standardization Process

In order to ensure the involvement of different organizational roles in the standardization process and thus secure their acceptance, a standardization process has been established at ZIVIT which controls the transitions between the life-cycle statuses of ITO and is depicted in figure 4. From our experience well-governed IT organizations have similar processes in place.

The standardization process at ZIVIT is activated when a trigger such as new IT trends, customer requirements, changes to management strategy, etc. leads to a request for a new ITO in a written form submitted along with a statement of motivation to the enterprise architects. Such a change request can be submitted by any organizational role. After the proposal has been acknowledged by the enterprise architects, the ITO receives the status "proposed".

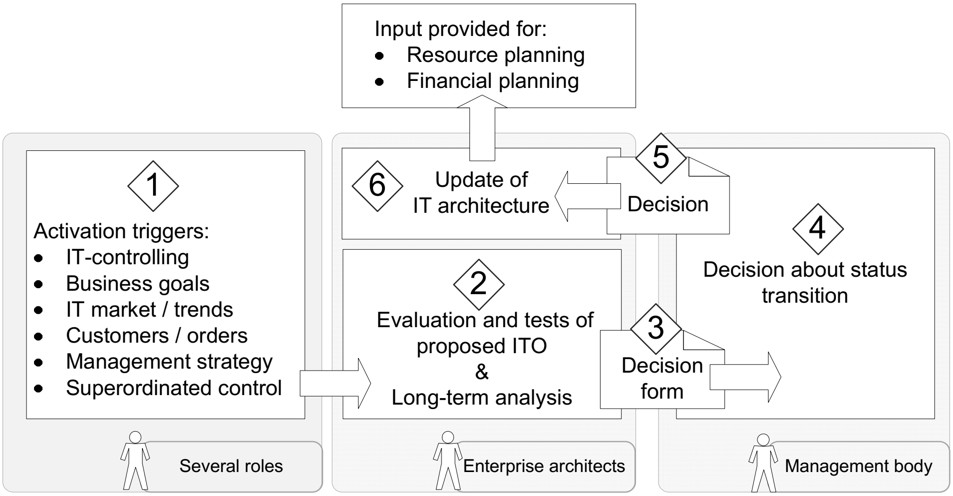

Figure 4: Standardization process

The main part of the process is the analysis phase in which the expected long-term effects of decisions are evaluated and tested. The following questions are considered: Is there an actual need for a new ITO or can the demands be met by an already existing object or is the request of a strategic importance, e.g. is the new ITO expected to have far-reaching consequences for the entire EA? The proposed object is reviewed by the enterprise architects and can be either marked as relevant which changes its status to "test" or is rejected leading to the status "retired". The proposed ITO, along with alternatives when required, are tested and evaluated with the help of a test results template.

After tests are completed, a decision form is created and submitted to the management body by the enterprise architects. Each status transition after the test phase is to be determined in the decision-making process. In case of positive test results, the selected ITO applies for a status "productive". If tests fail, the ITO is recommended for rejection - status "retired".

If the ITO has proven itself – for this, there is a detailed list of criteria –, it is promoted to status "standard", again with a decision form. If an ITO is no longer supported or maintained by its vendor or due to some reason such as obsolescence is no longer to be further used in new applications, a decision form is used to request the new status "retired" for this ITO.

Each time that a decision has been made by the management body based on the information provided as input by the analysis phase and communicated back to the enterprise architects, the IT architecture is updated and the update is documented in the repository. It is important that changes to the IT architecture further provide input for and are evaluated in terms of their effects on the resource and financial planning.

4 Metrics for the Standardization Degree

As specified in the conceptual model explained in section 3.1, ITO are grouped in categories which are further broken down in child categories (see figure 2). In order to propagate the standard status of ITO to the category level a number of conditions need to be introduced:

Postulate 1: There is no mixing of ITO and categories as children of a single category.

Postulate 2: A hierarchy of categories is built upon the level of the ITO. This hierarchy is described with the category tree as presented in section 3.1

These two postulates imply:

Corollary 1: ITO are located always at the lowest level of the category hierarchy. The ITO are the leaves of the category tree.

The hierarchical categorization of ITO allows determining the standardization degree metric for each category in the tree based on its elements. If this metric is applied to the root category, one would obtain the standardization degree for an entire type (i.e. software, hardware, technology). Calculating the standardization degree requires applying the concept of standardization to the category tree. The further standardization of elements of the category tree is defined in the following section 4.1.

4.1 Definition of Standardization

Definition 1: A category K containing ITO is called <u>standardized</u> if and only if the number of child ITO with status "standard" is one or two, i.e.:

$$1 \leq \#\{ITO \in K \mid st(ITO) = \text{"standard"}\} \leq 2$$

with $st()$ being the function which returns the status of an ITO (or category).

Allowing two standard ITO within a category has its justification. Very often a single product cannot fulfill the particular requirements of all applications which use an ITO of this category. Furthermore, variability in the costs of the ITO (license costs, maintenance costs) could lead to differing economic efficiency in different applications. For example, in the category of signature methods products affirmed by the law regarding electronic signatures in Germany (SiG) [BJ09] are needed for qualified digital signatures, whereas for technical signatures JAVA components are sufficient. Nevertheless, the decision to allow two standard ITO within a category is ZIVIT-specific and might be different in other IT organizations.

Definition 2: A category K^n on level n containing categories K^{n-1} of level n-1 is called standardized if and only if its child categories of level n-1 are standardized, i.e.:

$$\#\{K^{n-1} \in K^n\} = \#\{K^{n-1} \in K^n \mid st(K^{n-1}) = \text{"standard"}\}$$

The notation K^n signifies the level at which a category K is located, i.e. the categories from level *n*-1 are elements of the categories of level *n*.

4.2 Standardization Degree of Categories

The standardization degree is a value between 0 and 1, similar to the fuzzy logic concept according to which variables can have an intermediate membership value [Za65]. The rationale behind the definitions introduced below is the following: Even if a category is standardized, ITO with status "productive" can weaken this standardization if these ITO are used in "too many" applications.

Definition 3: The standardization degree *SD(K)* of a category *K* containing ITO is defined as follows:

$$SD(K) := \begin{cases} \dfrac{\sum\limits_{ITO \in K} g_{ITO}\delta_{ITO}}{ST_{Sub} + Prod_{Sub}}, & \text{if } 1 \leq ST_{Sub} \leq 2 \\ 0, & \text{otherwise} \end{cases}$$

where $ST_{SUB} := \#\{ITO \in K \mid st(ITO) = \text{"}standard\text{"}\}$ and

$$Prod_{SUB} := \#\{ITO \in K \mid st(ITO) = \text{"}productive\text{"} \; and \; gp_{ITO} > 0\}$$

The parameter δ_{ITO} is defined for each ITO of the category *K* such that:

$$\delta_{ITO} := \begin{cases} 1, \text{ if } st(ITO) = "standard" \text{ } or \text{ } st(ITO) = "productive" \\ 0, \text{ otherwise} \end{cases}$$

The factor δ_{ITO} retrieves simply the status of an ITO and is equal to 0 for all objects which are with status "proposed", "test" or "retired". The reasoning behind the decision for not including them in the metric calculation is that ITO with these statuses have no direct effect on standardization or the transition between statuses "productive" and "standard". Hence, "standard" and "productive" are the only statuses which are of importance for the usage of an ITO in operations.

The parameter g_{ITO} is defined for each ITO as follows:

$$g_{ITO} := \begin{cases} 1, \text{ if } st(ITO) = "standard" \\ gp_{ITO}, \text{ if } st(ITO) = "productive" \end{cases}$$

The parameter gp_{ITO} is defined for each productive ITO as follows:

$$gp_{ITO} := \begin{cases} 0, \text{ if } \frac{\#\{applications | ITO \in application\}}{\#\{applications\}} \leq \text{TV} \\ \frac{\#\{applications | ITO \in application\}}{\#\{applications\}}, \text{ otherwise} \end{cases}$$

TV is a threshold value above which an ITO with status "productive" enters into the calculation as it means that the ITO is in use in a relatively high number of applications of the overall IT landscape and can be considered quasi-standard. The value of TV is set based on the business requirements, advisably by the enterprise architects. We use the value 0.05.

The factor g_{ITO} determines whether the contribution of an ITO is full – when its status is "standard" – or fractional when "productive". Productive ITO which are not used in more than a certain percentage of the total number of applications within the overall IT landscape are not considered, i.e. g_{ITO} is 0. For productive ITO which are considered as quasi-standard due to their extensive usage g_{ITO} is the percentage of applications of the overall IT landscape in which these productive ITO are used.

It is obvious that the standardization degree *SD(K)* of a category *K* containing one or two ITO with status "standard" and no ITO with status "productive" is 1. The same applies if there are contained ITO with status "productive" which are only relatively rarely used in applications. The presence of quasi-standard ITO reduces the standardization degree of a category to indicate that the category contains productive ITO which are not with status "standard" but are still used by a significant number of applications.

Definition 4: The standardization degree $SD(K^n)$ of a category K^n containing categories K^{n-1} of level n-1 is defined recursively as follows:

$$SD(K^n) := \frac{\sum_{K^{n1-1} \in K^n} SD(K^{n-1})}{\#\left\{K^{n-1} \mid K^{n-1} \in K^n\right\}}$$

So, $SD(K^n)$ of a category K^n of level n containing categories K^{n-1} of level n-1 is the average of the standardization degrees of its containing categories.

It can be easily shown that $0 \le SD(K) \le 1$ for all categories K.

4.3 Further Metrics

For a complete control of the standardization process, additional metrics are needed, which are defined below.

The standardization degree does not capture how widely a standard ITO are used. Therefore we introduce the spread of an application/application landscape.

Spread of an application/application landscape: The ratio of the standard ITO of an application to the total number of ITO used in the application is called the spread of an application. A statement about the entire application landscape can be made by calculation the average spreads of the applications:

$$\frac{\sum_{i=0}^{n} \frac{\#\{ITO_S \in application_i\}}{\#\{ITO \in application_i\}}}{n}$$

where ITO_S:=ITO with status "standard" and n:=number of applications.

To measure the potential reuse rate of an ITO, we introduce the following metric:

Possible spread of an ITO: The ratio of the number of applications in which an ITO is used to the total number of the applications in which the ITO could be potentially used is called possible spread of an ITO, i.e.:

$$\frac{\text{Number of applications in which the ITO is in use}}{\text{Total number of applications in which the ITO could be used}}$$

This shows the actual usage of an ITO in relation to its possible one. Hence this metric is similar to the reuse rate presented in [MC07]. In the same way the spread of all ITO of a category can be calculated.

In particular, when introducing the standardization process, there will be probably a high number of ITO with status "productive". Therefore, it is of interest to measure how many of them are quasi-standard:

Number of quasi-standard ITO: This metric represents the number of ITO in the landscape that have a value for g_{ITO} above the defined threshold value, as it was introduced in definition 3 in section 4.2.

The number of quasi-standard ITO complements the standardization degree in measuring the success of the standardization process. Additionally, for a single quasi-standard ITO, the standardization process might be triggered (see section 5.1).

5 Example and Practical Experiences

This chapter presents first an example of the application of the standardization degree metric. Then, experiences and benefits of the application at ZIVIT are described.

5.1 Exemplary Application of the Standardization Metric

Figure 5 shows the standardization degrees for the category tree from figure 2. This means that the category "DBMS" is 47.4% standardized. This implies that the categories on the lower levels need to be investigated in order to account for the low degree of standardization. Four non-standardized categories are found – three at the lowest category level – 1a, 1c and 1d, and a fourth one at the second level – 2e. A standardization degree of 0 means that in these categories either no or more than two standard ITO are in use. An issue that comes to being here is the priority of resolution of such multiple cases. For this prioritization weights of categories as described in section 5.2 can be used.

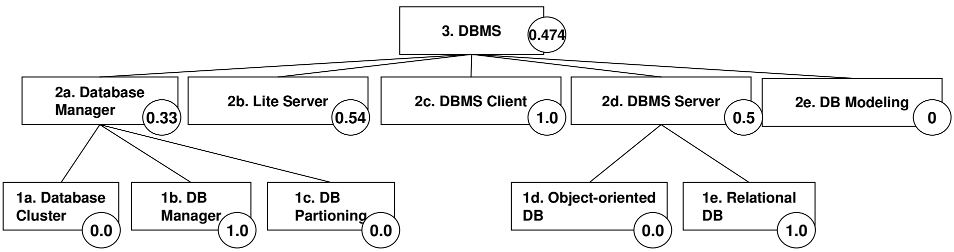

Figure 5: Application of standardization metric to a category tree

Furthermore, category 2b has the value of 0.54. The value between 0 and 1 suggests that there is at least one quasi-standard ITO. Assume, there is an ITO with status "productive" which is used in more than 5% of the total number of applications. The task of the enterprise architect in this case is to review the quasi-standard ITO and its usage in applications in order to investigate the reasons behind the fact that given that a standard ITO already exists in a category, such a high number of applications are using another non-standard ITO from this category.

5.2 Experiences and Benefits of Applying the Standardization Metric

The presented approach has been fully implemented at ZIVIT. Of course, the implementation and operation of the standardization process required significant effort. At ZIVIT it needed two enterprise architects for one year to model the 2,000 ITO with all their attributes. ITO at ZIVIT and their hierarchical categorization are catalogued and kept up-to-date in a repository with the EAM tool ADOit [AD09], [Ju08]. For example, more than 1,500 software objects in 10 main and 150 child categories are defined. The top software categories are defined according to the different steps of the software development process, i.e. requirements engineering, functional design, technical design, build, test, deployment. This leads to categories such as requirements engineering and specification tools, development tools, run-time libraries/tools, databases, execution environments, etc.

The relation between applications and ITO is maintained by the application owners (approximately 100 at ZIVIT). To ensure that the application owners really do this maintenance well-defined processes and some organizational change management is needed. However, this effort is more than compensated by the enormous cost reductions in terms of human resources, administration effort in production, and last but not least, license and maintenance costs. Imagine for example the effect of a reduction of fictive 10 million Euros yearly maintenance costs by 5% (which is not an unrealistic reduction rate). The final aim is to achieve a standardization degree of 1 for the entire IT landscape. Of course, this is a vision which will never be reached in large IT organizations. However, on the way towards this ideal state, the historical record of the development of the value of the metric is an indication for the results of the process. Summarizing, the presented approach proved its value at ZIVIT. Actually, it was already extended by representing expiration dates of the maintenance levels of software and hardware ITO to enable proactive measures for replacing ITO.

Something we have not done yet due to the high effort required but we are seriously considering is the definition of weights for categories of ITO. A category of strategic value, e.g. database products, has a different importance than the category of text editors because the latter is most likely much easier to replace. This idea would require adapting definition 4 of section 4.2 by assigning a weight between 0 and 1 to each category, according to the effort for replacing a contained ITO by another one from this category. In this way, the standardization degree of a category would still have a value between 0 and 1. However, the standardization degrees of the contained categories will be weighed accordingly.

As mentioned in the introduction, over-standardization is a practice in EAM that should be avoided. Over-standardization should not be understood as an excessive degree of standardization of the IT landscape but as a tendency to force standards on the organization without consideration of the business needs. The introduced standardization metric contributes towards the avoidance of over-standardization through exposing quasi-standard ITO in its calculation. As defined in section 4.2, quasi-standard ITO are such that are used in a high number of applications without having the status "standard". Their presence indicates a possible discrepancy between business needs and established standards. Their revision and possible promotion to standard objects is an essential step towards aligning business needs with the IT landscape.

6 Outlook

The presented approach has been developed for large IT organizations using several hundred or even several thousand ITO. However, by adapting the parameters of the metrics the presented approach works for smaller IT organizations too. It could be defined for example that only one standard ITO per category is allowed instead of two (compare definition 1 in section 4.1). It is crucial to be aware that the application of the presented metrics relies upon the availability of always up-to-date EA data. From our experience this is one of the major obstacles for the success of EAM. Here we see a large research potential regarding EAM processes. Ideas and concepts how to design and implement EAM processes are presented for example in [Ke07] and [Mo09].

From a practitioner's point of view we see the need for more extensive research on EAM metrics. An interesting approach would be for example to apply data warehouse concepts on EA data. Additionally, we see a large potential in applying the "EAM patterns approach" [Bu08] on EAM metrics. This would allow to share experiences about EAM metrics in a convenient way by stating in which situations which metrics can (or should) be applied.

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