An Information Model for Landscape Management – Discussing Temporality Aspects

Sabine Buckl, Alexander Ernst, Florian Matthes, and Christian M. Schweda

Technische Universität München, Institute for Informatics,
Boltzmannstr. 3, 85748 Garching, Germany
{buckls,ernst,matthes,schweda}@in.tum.de
http://www.systemcartography.info

Abstract. Planning, managing, and maintaining the evolution of the application landscape is a focal point of enterprise architecture (EA) management. Whereas, planning the evolution of business support provided by the business applications is understood as one challenge to be addressed in landscape management, another challenge arises in the context of traceability of management decisions, which determine the EA projects actually changing the application landscape.

This paper discusses the requirements regarding support for landscape management as risen by practitioners from industry. These requirements were gathered in an extensive survey during which the tool support for EA management was analyzed. Thereby, a lack of support for this management discipline was discovered, which is caused by the way, application landscapes are modeled in tools as well as in EA approaches from literature. We subsequently discuss how to incorporate these requirements into an information model, taking into account related modeling techniques from nearby disciplines.

Key words: Enterprise architecture management, tools, modeling, temporality, traceability, historization

1 Motivation and Introduction

Over the last years enterprise architecture (EA) management has become an important management area, many companies are currently executing or planning to introduce in the nearby future. As a consequence of the increased attention, a multitude of methods for EA management has been developed by academic communities (see e.g. [1–3]), standardization bodies (e.g. by [4]), or practitioners (see e.g. [5, 6]). Although these methods differ substantially concerning the quantity, abstractness, and granularity of the EA documentation, which is needed for performing EA management, the need for a documentation of the body of management is common. As a consequence, different methods and models for creating such a documentation as well as for maintaining its timeliness have been subjected to research, commonly attributing this documentation as a model of the EA (cf. [7]).

The methods and models developed have to cope with a set of challenges arising in the context of EA management, especially when the management of the application landscape[1] as a central task is concerned. During information gathering not only information about the as-is situation of the landscape has to be collected, but also information about future aspects, e.g. projects changing the application landscape, or future business support provided by a newly introduced business application, has to be maintained. In order to get an overview on the relationships and dependencies of the various elements of the enterprise, different kind of visualizations, which we refer to as *software maps*, are typically used. Figure 1 illustrates an exemplary process support map, utilizing positioning of symbols to show, which business processes are supported by which business applications at which organizational units. Thereby, chevrons representing a process chain, seen as a sequence of processes, make up the x-axis. The y-axis is made up of labels representing organizational units. The rectangles in the main area of the map symbolize business applications, and their positioning expresses which business process is supported by which business application at which organizational unit.

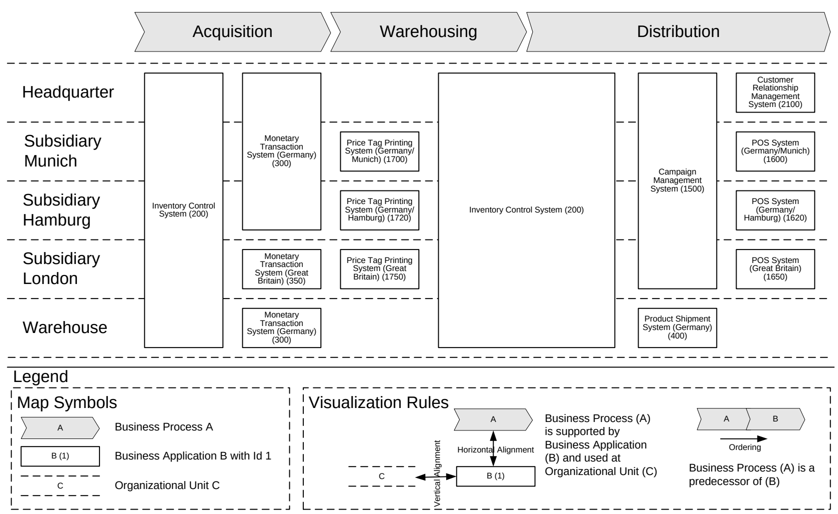

Fig. 1. Exemplary process support map

Different versions of process support maps are commonly used to document the evolution of the application landscape, illustrating either the status quo or future business supports. In order to create these documentations, the respective

[1] The term *application landscape* in this context refers to the entirety of the business applications and their relationships to other elements, e.g. business processes in a company. We abstain from using the term *application portfolio*, which we regard to a narrower focus.

data has to be stored in a repository corresponding to an information model, which defines the respective elements and the moment in time the information is related to (*planned for*).

Furthermore, landscape management is closely connected to project portfolio management, as the selected project portfolio determines the future development of the application landscape in the next planning cycle. Regarding the state of the art in the context of project portfolio management, most decisions about project portfolios are currently based on *gut feel*, not on information, which is derived from a comparison of different *variants* of the landscape regarding quantitative or qualitative aspects (cf. [8]). The landscape variants therein should be related to the project portfolios, they result from. These variants have to be stored in the tool in order to facilitate comparisons and therefore be used to provide decision support, also in project portfolio management.

EA management and especially landscape management are understood to be endeavors following a typical management cycle consisting of the phases Plan - Do - Check - Act (cf. [9, 10]). Thereby, the traceability[2] of management decisions taken in the *Plan* phase and implemented in the *Do* phase, must be ensured to control the achievement of objectives (*Check*). An exemplary question in this context could be: Is the status of the planned landscape reached within the planned time frame or has the plan been changed? This information is subsequently used to prepare the next management cycle (*Act*). Consequently, a third type of information has to be stored in an information model for landscape management besides the *planned for* and the *variant* information as mentioned before: the moment in time the landscape was actually modeled (*modeled at*). From this discussion the following research question has been derived:

How should an information model for landscape management be designed to incorporate both business and technical aspects, and to support future planning and traceability of management decisions?

This question has especially to take the aspects of *temporality* as connected to landscape management into account. Therein, especially different versions of the landscape are of importance: the *current*, *planned*, and *target* version. Thereby, the current landscape represents the status quo of the landscape *as is*, modeled at a certain time. The planned landscape represents a future state of the landscape as *to be* at a specific time in the future[3]. This state is modeled by an architect at a certain time, emphasizing e. g. the changes performed by projects up to that specific future date. As a long term perspective the target landscape shows the architecture of the application landscape as envisioned at a certain time following the strategies and goals defined by the enterprise. Thereby,

[2] In the context of a management cycle traceability of decisions can be achieved by storing previous states of the managed objects. The respective technique is mostly referred to as *historization*.

[3] In some publications on landscape management (cf. e.g. [6, 14]), the terms *as-is* and *to-be* are used to indicate the respective landscape version. We abstain from re-using this terminology, as especially the term *to-be* is often used ambiguously for both planned and target landscapes.

there is no need to have projects defined transforming the current or planned landscape into the target one. Furthermore, the target landscape does not specify deployed business applications but refers to envisioned future support providers.

Summarizing, the traceability aspects of landscape management lead to three different *time-related* dimensions:

- firstly, a landscape is *planned for* a specific time,
- secondly, a landscape has been *modeled at* a certain time, and
- thirdly, different *variants* of a planned landscape may exist.

Figure 2 illustrates the relationships between current, planned, and target landscape as well as the different dimensions relevant for landscape management.

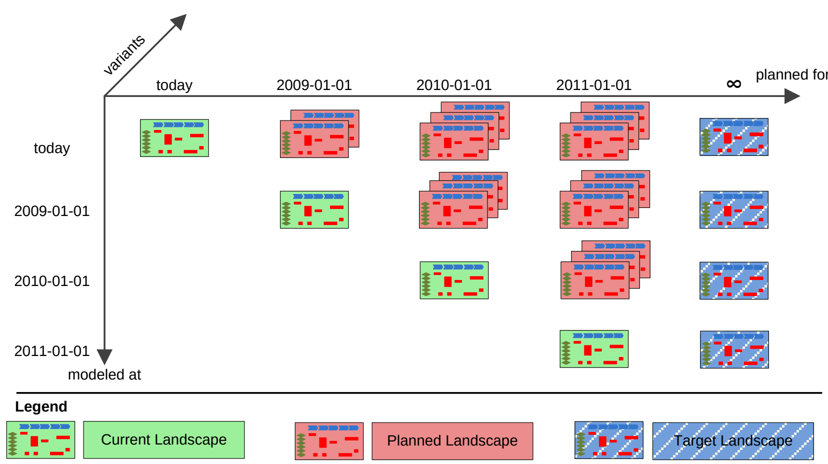

Fig. 2. Current, planned, and target landscape

The research question, as alluded to above, is approached in this article as follows: Section 2 gives an overview on current approaches to landscape management as described by researchers and practitioners in this field. Further, requirements – especially time-related ones – for an information model for landscape management are introduced. Thereby, a framework for the analysis of the support for landscape management is established. Alongside this framework an analysis of the current tool support for landscape management is performed in Section 3. Section 4 discusses ideas, which could be used to create an information model for landscape management fulfilling all the aforementioned requirements. Therein, especially solutions originating from related modeling disciplines are taken into account. Finally, Section 5 hints to further areas of research in the context of EA management and in particular landscape management.

2 Requirements for and current Approaches to Landscape Management

Due to the importance of managing the application landscape as a constituent of EA management, a number of different ways to approach this task have been proposed both in practice and academia. Subsequently, we give an overview on these approaches with an emphasis on the aspect of temporality.

In [11] the application landscape is referred to as a concept specifying the enterprise's business applications and their interdependencies. This information is reflected in the information model of [11] via *interfaces* utilized to interconnect the *applications* and/or their inner *components*. References from these application level concepts (on the *application layer* as in the notion of [11]) to business level entities, e.g. the different types of *business processes* (on the *organizational layer* of the model) are present and can be used to explicate the way, how business support is provided. More sophisticated considerations are not directly supported, e.g. the question at which organizational unit which business process is supported, by which business application, cannot be answered based on the information model. The aspect of temporality is also only partially addressed by [11], while the models contain ways to store life cycle states of applications, it does neither support planning transitions between life cycle states nor does it take projects into account.

In [12] the business applications as well as their relationships to other constituents of the EA are considered an important information asset, which should be presented to managers in an appropriate way to provide decision support. As presentation form of choice, they introduce a type of visualizations, called *landscape maps*, in which the business applications are related to business functions and products. This relationship is referred to in [12] as a ternary one, which could also be established between applications and two other concepts, although such considerations are not detailed in the article. Temporal aspects are not part of the approach, while ways to use the landscape map visualizations for interacting and changing the data in the underlying models are explicitly stated. Additionally, [12] focuses on the application landscape, not on the EA as a whole, i.e. projects are not considered in the approach.

A slightly different focus on managing the application landscape is taken in [13]. Therein, especially the aspect of the interfaces connecting the business applications is put under research. The number of interfaces associated to a business application is considered an important impact factor, e.g. when changes to the application landscape are considered. In this context, [13] puts special emphasis on documenting and analyzing the current application landscape. This information is used as input to coordinate potential change processes affecting the landscape – especially concerning risks associated to these processes. While [13] take a rather detailed look on the business applications and their interconnections, relationships to business related concepts of the EA are not presented in the paper. Whereas, the topic of the evolution of the application landscape is indicated, actual planning of future states or transformation projects is not in the focus of the paper.

Beside the academic community, as alluded to above, also practitioners address the field of landscape management. In [5] the overall architecture of the application landscape is considered an important topic to be addressed in managing the EA, exerting strong influence on the overall success of the company. Detailing the important aspects of landscape management, [5] emphasizes on the relationships of the applications to the business processes, they support, as well as to logical structuring principles, e.g. organizational units or products. Further, the importance of application landscape planning is referred to, by complementing the current landscape by a target landscape, not solely consisting of business applications but also of more abstract *providers of support* for business processes. Issues of how to transform from the current to the target landscape are additionally discussed in [5], although for them no continuous method via planned landscapes is introduced. Further topics, e.g. traceability of management decisions, are not considered therein.

In [6] a pragmatic approach to landscape management, called *application portfolio management*, is given. Thereby, this portfolio is regarded to be subject of a continuous management cycle of 1) documenting and controlling the current landscape, 2) developing a target landscape, and 3) executing projects to get from current to target. Concerning the amount of data on the landscape employed in these activities, [6] emphasizes the difficulties related to gathering extensive landscape information. Therefore, he proposes different *stages of extension* concerning landscape documentation and planning, ranging from a coarse description of the applications and their business relationships to highly detailed modeling of their inner architecture and interface usages. In creating target landscapes, the same stages of extension apply. Further, information on the relationships between these landscapes and the projects leading to them is deemed important, although no way to model these dependencies is shown.

In [14] the application landscape is presented as management subject embedded in the context of business and technical concepts, ranging from business processes to technical platform modules. The current landscape should, accordingly, be documented with references to these aspects, especially the technical ones. Complementing the current landscape, a so called *ideal landscape*[4] should be defined as part of a landscape management endeavor, incorporating technical visions of the landscape. Mediating between current and ideal, different *to-be landscapes*[5] should be developed, each of these landscapes is assigned to a set of projects, which must be executed to actually realize the respective to-be landscape. Here, a strong relationship between the projects and the to-be landscapes should be maintained in an underlying model, nevertheless means for tracing back the evolution of a to-be landscape are not incorporated.

Subsuming the state-of-the-art in managing application landscapes as presented in literature, many common aspects can be seen, although different approaches are employed especially concerning the aspect of temporality. Nevertheless, creating an information model of the application landscape is a widely

[4] *Target* landscape in the terms used throughout this paper.
[5] In this paper, these landscape are called *planned* ones.

accepted prerequisite employed in landscape management. In some of the papers, presented above, information models are provided, which introduce the concepts necessary for performing landscape management. These information models differ widely regarding the concepts introduced and the relationships as well as regarding their complexity, because, among others, no common terminology for the concepts employed has been established. We regard, notwithstanding, such a model to be mandatory to approach landscape management as a whole and the important aspect of temporality in special.

Due to great interest from industry partners in information about EA management tools and especially their capabilities to address the concerns arising in the context of landscape management, an extensive survey – the *Enterprise Architecture Management Tool Survey 2008* – was conducted [15]. The survey pursues a threefold evaluation approach, relying on two distinct sets of scenarios together with an online questionnaire. The survey was developed in cooperation with 30 industry partners (among others Allianz Group IT, sd&m – software design & management, Siemens IT Solutions and Services, Munich Re, O2 Germany, BMW Group, Nokia Siemens Networks). Thereby, the first set of scenarios focuses on specific functionality, an EA management tool should provide, without connecting these functionalities to the execution of a typical EA management task, e.g. *1) flexibility of the information model*, *2) creating visualizations,* or *3) impact analysis and reporting*. The EA management tools are further evaluated by the scenarios of the second set, which reflect tasks that have been identified as essential constituents of many EA management endeavors, e.g. *1) business object management, 2) IT architecture management,* or *3) SOA transformation management*. One of the most prominent scenarios of the second part is the scenario *landscape management*, which is concerned with the managed evolution of the application landscape [16]. The concern of the scenario was described by the industry partners as follows:

Information about the application landscape should be stored in a tool. Starting with the information about the current landscape potential development variants should be modeled. The information about the current application landscape and future states should be historicized to enable comparisons. [15]

Subsequently, a catalog of typical questions in the context of landscape management as raised by the industry partners is given:

- What does the current application landscape look like today? Which business applications currently support which business process at which organizational unit?
- How is, according to the current plan, the application landscape going to look like in January 2010? Which future support providers support which business process at which organizational unit?
- What was, according to the plan of 01-01-2008, the application landscape going to look like in January 2010?
- How does the target application landscape do look like?
- What are the differences between the current landscape and the planned landscape, according to the current plan? What are the differences' reasons?

- What are the differences between the planned landscape according to the plan of 01-01-2008 and the current plan?
- What projects have to be initiated in order to change from the planned landscape (according to the current plan) to the target landscape? What planning scenarios can be envisioned and how do they look like?

Based on the questions from the industry partners and the different dimensions relevant for landscape management, the following requirements regarding an information model can be derived. An information model suitable for landscape management must:

(R1) contain a ternary relationship in order to support analyses regarding current and future business support (which business processes are supported by which business applications at which organizational units),

(R2) provide the possibility to specify envisioned business support providers in order to facilitate target landscape planning without having to specify implementation details of the business support,

(R3) support the deduction of future landscapes from the project tasks, which execute the transition from the current to the future business support,

(R4) foster the creation of landscape variance based on distinct project portfolios in order to tightly integrate project portfolio management activities, and

(R5) ensure the traceability of management decisions by storing historic information of past planning states. This information may be interesting especially if complemented with information on the rationale for the decisions.

From these requirements, we subsequently evaluate the support for landscape management as provided in the approaches from literature (see Table 1).

	[11]	[12]	[13]	[5]	[6]	[14]	Tool 1	Tool 2	Tool 3
R1	○	●	○	●	◑	●	○	●	●
R2	◑	◑	◑	●	●	●	●	●	●
R3	○	○	○	◑	◑	●	○	◑	●
R4	○	○	◑	○	◑	◑	◑	○	●
R5	○	○	○	○	○	○	○	○	○

Table 1. Existing Approaches and Tools and their Fulfillment of the identified Requirements

Thereby, the support provided by the different approaches is indicated by different symbols ranging from complete fulfillment of the requirement (●) via partial fulfillment (◑) to approaches, which completely lack support for the analyzed requirement (○). In addition, an overview on the support provided by exemplary tools, which were analyzed during an extensive survey [15], is shown in Table 1. A detailed discussion of the used information models shipped with the respective tools is given in the following section.

3 Tool support for landscape management

The solutions of nine major players in the market of EA management tools were analyzed regarding the information models, which they come shipped with. Three different exemplary approaches as taken by the different tools are subsequently explicated to provide an overview about the current operationalizations of landscape management. The attributes are thereby not shown to improve readability but are mentioned in the description, if necessary for understanding. Due to reasons of confidentiality the names of the tools analyzed are omitted.

Prior to discussing the different approaches taken by the tools, the core concepts of landscape management, which are most likely to be represented as classes in the information models, are briefly introduced (for details see [1]):

BusinessProcess: A business process can, according to Krcmar [17], be defined as a sequence of logical individual functions with connections between them. The process here should not be identified with single process steps or individual functions, but with high-level processes at a level similar to the one used in value chains, which are(at least partially) ordered sequences of processes. Thus, a process can have a predecessor process and a successor process, expressed by a respective relationship.

DeployedBusinessApplication: A deployed business application is a software system, which is part of an information system of an organization. The term refers to an actual deployment. In landscape management, business applications are restricted to applications that at least support one business process of the respective organization.

FutureSupportProvider: A future support provider poses a sort of envisioned planning object, to be used instead of an actual deployed business application in a target landscape to define a business support.

OrganizationalUnit: An organizational unit represents a subdivision of the organization according to its internal structure, e. g. the entities showing up in an organigram can be used as organizational units.

Project: Adaptations of the application landscape are performed by projects, which each hold different attributes with temporal information, e.g. for their *startDate* and *endDate*[6]. Additionally, a project is *plannedAt* and *removedAt* referring to the planning time of its creation and of its deletion – effectively resulting in a time interval of validity, which is assigned to each project. A relationship between the project and the concepts affected by it, e.g. deployed business applications exists.

SupportProvider: A support provider is an abstract concept, representing an entity, which can provide support for a business process at a specific organizational unit. In the context of the information model, actually deployed application systems can be used as *SupportProvider* instances as can future business applications.

[6] If more detailed modeling of projects should be performed, the temporal information could be extended to contain starting and ending dates for different phases of the project, e.g. *planning* and *development*.

SupportRelationship: This concept represents the support of a specific business process by a specific support provider at a specific organizational unit.

Starting with a basic approach to landscape management tool 1 presents an information model containing landscape management related concepts, as shown in Figure 3. Here, the business process is connected with the organizational unit via the support provider – an abstract base class used to support target landscape planning (cf. **R2**). Whereas data gathered according to this information model can be used to generally analyze the business support for a business process, the relationship to the organizational unit, where the support takes place, is not derivable unambiguously (cf. **R1**).

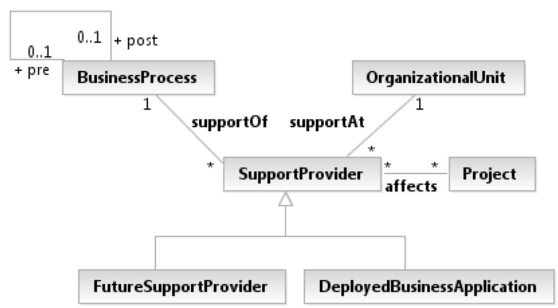

Fig. 3. Information model of tool 1

Figure 4 shows exemplary data instantiating the information model from Figure 3. Analyzing this data, a statement, which business process is supported by the *Inventory Control System* at the *Subsidiary Munich* cannot be made.

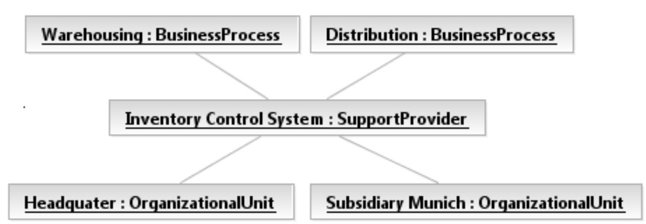

Fig. 4. Instance data corresponding to information model of tool 1

Besides the missing ternary relationship between business process, organizational unit, and support provider, the only concept carrying temporal information – the project – is connected to the support provider via the relationship *affects*. Due to the missing ternary relationship no time information for the business support provided can be stored (cf. **R3**). In addition, planning variants of the landscape can only be built based on the support providers instead of the business support provided (cf. **R4**). Consequently, tool 1 only rudimentarily supports the management of current, planned, and target landscapes. While such information might be sufficient for future planning in a one dimensional manner, the requirements as risen by the industry partners concerning traceability and versioning cannot be addressed (cf. **R5**), too.

The information model of tool 2 (see Figure 5) incorporates the ternary relationship between the business processes, the organizational units, and the support providers by introducing a dedicated class and respective associations (cf. **R1**). The association *supportBy* is further assigned life cycle parameters using a mechanism similar to an association class in UML. Thus, it is possible to indicate that the business support provided by a specific instance of class *SupportProvider* is at a certain point in time in a specific life cycle phase, e.g. *planned* or *active* (cf. **R2**). This notion of life cycle is nevertheless disconnected from the concept of the project, which is independently associated to the class realizing the ternary relationship. While this association allows to model, that the support for a specific business process executed at a specific location is affected by a project, no mechanism to indicate, which *SupportProvider* actually is changed by the project, is present (cf.**R3** and **R4**)[7]. Further, the model does not support the creation of different landscape scenarios, as it is not possible to make projects or providers of business support belong together in one scenario. A mechanism for marking a *SupportProvider* an element of a target landscape is nevertheless provided via a flag attribute *target* in the association class *supportBy*. Historization of planned application landscapes is not supported (cf. **R5**) as no means for versioning instances corresponding to the model are given.

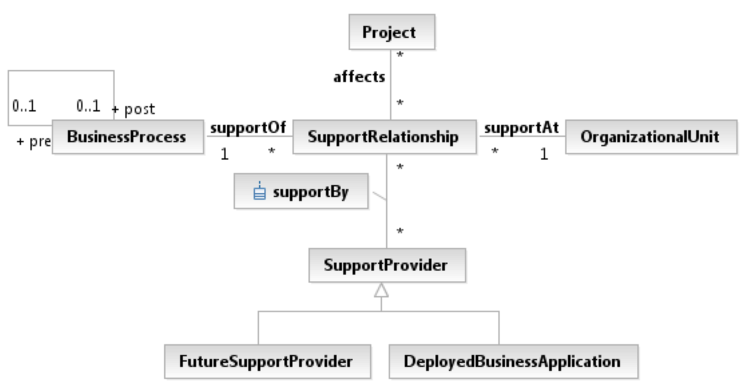

Fig. 5. Information model of tool 2

[7] This fact is caused by the `*` multiplicity on the `SupportProvider` end of the `supportBy` association. Therefore, an unambigous mapping from projects to affected support providers is not possible.

Finally, the information model of tool 3 is presented (cf. Figure 6), which is only slightly different from the model of tool 2, provides additional support for application landscape management – future state considerations are supported similarly as in tool 2 (cf. **R2**). The information model contains a support relationship, which supports analyses regarding the business support provided for a business process by a business application at an organizational unit (cf. **R1**). Nevertheless, the information model as proposed by tool 3 also implements temporality in a one dimensional manner by the project concept (cf. **R3** and **R4**), which affects the support relationship and contains temporal information, e.g. start and end dates. Such information might be sufficient for planning the evolution of the EA, but is somewhat limited concerning traceability of changes to the plans (cf. **R5**), which would demand support for *bitemporal* modeling. As an example, one might think of a plan for the EA regarding the year 2010, which might look different as-of begin 2008 respectively begin 2009.

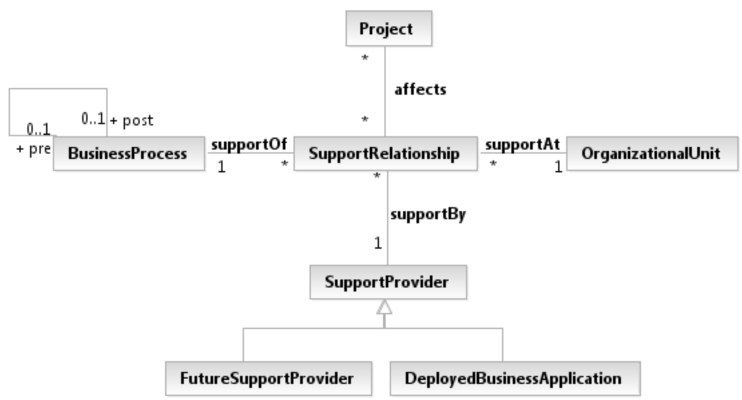

Fig. 6. Information model of tool 3

Summarizing, Table 1 provides an overview about the evaluation results of the current tool support regarding landscape management in general and temporality aspects in special. In order to discuss the constituents of an information model fulfilling the requirements as identified in Section 2 we subsequently detail on related modeling techniques.

4 Discussing an information model for landscape management

The question, how to incorporate aspects of time in a database system has been repeatedly discussed in scientific literature (see e.g. [18, 19]). A simple approach is to introduce a time stamp attribute to the table, which should be enriched with temporal information. This allows to specify that an entry of the table is valid since the point in time specified by the time stamp. The approach has the disadvantage that it is not possible to specify that the information stored in the table row is valid for a certain period of time. In order to resolve this problem another attribute can be introduced to define up to which point in time the values of the appropriate table are valid, thereby capturing the history of a changing reality.

If traceability should also be considered a so called *transaction time* has to be specified additionally to the *valid time*, which has been described before. According to [19] this can be done by introducing two additional attributes defining a time interval for capturing the sequence of states of a changing table. Such a table is than called a bitemporal table.

Similar discussions have taken place for object-oriented models. From these discussions, a few design patterns, of which [20] gives a good overview, have emerged – reflecting temporality in different ways. In addition, [20] introduces basic time concepts: event, time interval, and duration, of which the latter ones can be considered of special importance for our design issue, e.g. for modeling life cycle information of business applications.

Additionally useful in the context of creating temporality aware object-oriented models are the temporal (design) patterns presented in [21]. The concept of the temporal property introduced there can be utilized to model, that an instance of a class can hold multiple different values for the same attribute during its lifetime, i.e. must retain information when the value has been changed. The pattern realizes this functionality by externalizing the corresponding temporal attribute as a referenced class, additionally holding a relationship to a time interval indicating the period of validity. A similar concept for associations, the temporal association pattern, is also introduced in [21]. Thereby, it can be modeled, that the objects referenced in association can change over time. The actual realization of the pattern is similar to the one of the temporal property, i.e. the association is explicated as an independent class retaining a relationship to a validity interval. Other design patterns for addressing temporality exist, e.g. the edition [21], but are not discussed here.

In order to fulfill the requirements as mentioned in Section 2, especially **R4** and **R5**, which have not been well addressed by the majority of tools, temporal patterns or bitemporal tables, as alluded to above, could be utilized. This challenge can be met by a central relationship of the landscape management models – the ternary one relating support providers, business processes, and organizational units, which is explicated as an independent class, the *SupportRelationship*. Thereby, the pattern of the *temporal association* [21] could be incorporated – the associated projects could help to supply periods of validity for the *SupportRelationship* instances, i.e. the referenced *SupportRelationship* becomes valid, once the *endDate* of the project is reached.

If landscape plans for the same point in time created at different times should be compared to each other (cf. **R5**), the information concerning the point, when the project has been planned at, had to be considered. Consistently, the temporal pattern *edition* (cf. [21]) could be used to implemented this mechanism.

5 Outlook

In this article, we discussed time-related issues of application landscape management and how they relate to other tasks in EA management, especially project portfolio management. Section 2 showed different approaches to landscape management as found in literature. Further, we discussed requirements for a landscape management method, as gathered from EA management practitioners during an extensive survey, and finally compared the findings from literature and practice. Subsequently, section 3 discussed the tool support for landscape management with an emphasis on the underlying information models. From this, the drawbacks of the different approaches were highlighted and explained. Related fields of modeling were taken into account in Section 4 discussing, how an information model could be created to fulfill the respective requirements. Therein, especially the field of *temporal patterns* for object oriented models proved to be very promising.

Two interesting directions of research result in continuation of the discussions undertaken in this paper. At first, the ideas for constructing a temporal information model for landscape management have yet not been validated. This would nevertheless be an important step in research, although not an easy one. First, the creation of such a model is likely to comprise additional difficulties, especially if considered in the context of a larger EA information model. Second, a temporal information model is due to its inherent complexity likely to be usable only via an appropriate tool. This is especially true considering the temporal relationships to be maintained by a user – constrastingly, currently no tool capable of managing such an information model in a convenient way exists.

The other research direction is a logic consequence from the fact, that landscape management is not the only part of EA management that can be considered to have strong temporality related issues associated. Managing the infrastructure of the enterprise, among others its hardware landscape, might be also influenced by different dimensions of time. Additionally, temporal aspects addressed in one part of EA management may also exert certain influences to other parts of managing the EA, which independently might not be affected by temporality aspects. In order to address this, the information model could be organized in patterns, which keep temporality related issues contained in one fragment of a larger model, while nevertheless supporting integration with each other. A technique potentially helpful in this context is the EA management pattern approach (see [1]).

References

1. Buckl, S., Ernst, A., Lankes, J., and Matthes, F.: Enterprise Architecture Management Pattern Catalog (Version 1.0, February 2008). Technical Report TB 0801, Chair for Informatics 19, Technische Universität München, (2008)
2. Lankhorst, M. e. a.: Enterprise Architecture at Work – Modelling, Communication, and Analysis. Springer-Verlag, Berlin, Heidelberg, (2005)

3. Winter, R., Bucher, T., Fischer, R., and Kurpjuweit, S.: Analysis and Application Scenarios of Enterprise Architecture – An Exploratory Study Journal of Enterprise Architecture 3 3, 33–43 (2007)
4. The Open Group: The Open Group Architectural Framework Version 8.1.1. http://www.opengroup.org/architecture/togaf8-doc/arch/, (cited 2008-10-03)
5. Dern, G.: Management von IT Architekturen (Edition CIO). Vieweg, Wiesbaden, (2006), (in German)
6. Keller, W.: IT Unternehmensarchitekturen. dpunkt Verlag, Heidelberg, (2007). (in German).
7. Fischer, R., Aier, S., and Winter, R.: In: Enterprise Modelling and Information Systems Architectures Proceedings of the 2nd International Workshop EMISA 2007. St. Goar, Rhine, (2007)
8. Lankes, J. and Schweda, C.: Using Metrics to Evaluate Failure Propagation in Application Landscapes. In: Multikonferenz Wirtschaftsinformatik (MKWI) 2008, München, (2008)
9. Deming, W.: Out of the Crisis. Massachusetts Institute of Technology, Cambridge, (1982)
10. Shewart, W.: Statistical Method from the Viewpoint of Quality Control. Dover Publication, New York, (1986)
11. Braun, C. and Winter, R.: A Comprehensive Enterprise Architecture Metamodel and Its Implementation Using a Metamodeling Platform. In: Desel, J. and Frank, U.: Gesellschaft für Informatik 2005, Bonn (2005)
12. van der Torre, L., Lankhorst, M., ter Doest, H., Campschroer, J., and Arbab, F.: Landscape Maps for Enterprise Architctures. In CAiSE 2006, 351–366, Springer, Berlin, (2006)
13. Garg, A., Kazman, R., and Chen, H.-M.: Interface descriptions for enterprise architecture. Science of Computer Programming, 61, ELSEVIER, 4–15 (2006)
14. Engels, G., Hess, A., Humm, B., Juwig, O., Lohmann, M., Richter, J.-P. Voss, M., and Willkomm, J.: Quasar Enterprise – Anwendungslandschaften serviceorientiert gestalten. dpunkt Verlag, Heidelberg, (2008), (in German)
15. Matthes, F., Buckl, S., Leitel, J., and Schweda, C.: Enterprise Architecture Management Tool Survey 2008. TU München, Chair for Informatics 19 (sebis), Munich, (2008)
16. Aier, S. and Schönherr, M.: Enterprise Application Integration – Flexibilisierung komplexer Unternehmensarchitekturen. Gito, Berlin, (2007), (in German).
17. Krcmar, H.: Informationsmanagement. Springer, Berlin, 4 edition, (2005), (in German).
18. Date, C.: An Introduction to Database Systems. Addison Wesley, Boston, (2000)
19. Snodgrass, R.: Developing Time-Oriented Database Applications in SQL. Morgan Kaufmann Publishers, San Francisco, (2000)
20. Anderson, F.: A Collection of History Patterns. In: Harrison, N. and Foote, B. and Rohnert H. (editors): Pattern Languages of Program Design, Addison Wesley, Boston, (1999)
21. Carlson, A., Estepp, S., and Fowler, M.: Temporal Patterns. In: Harrison, N. and Foote, B. and Rohnert H. (editors): Pattern Languages of Program Design. Addison Wesley, Boston, (1999)