Ontology based Linkage between Enterprise Architecture, Processes, and Time

Marite Kirikova, Ludmila Penicina, Andrejs Gaidukovs

Institute of Applied Computer Systems, Riga Technical University, Latvia
{marite.kirikova, ludmila.penicina, andrejs.gaidukovs}@rtu.lv

Abstract. In an highly dynamic social and business environment time becomes one of the most treasured recourses of companies and individuals. However, there are no many research works devoted to explicit analysis of time issues. Therefore, despite of a large number of enterprise and business process representation and analysis tools, it is still impossible to address time to full extent in systems modeling and analysis. This position paper proposes linkage between enterprise architecture, process, and time models to promote development of methods for managing time issues in systems development, maintenance and change management. The linkage roots in Bunge's systems ontology and concerns time ontology edited by Hobbs and Pan.

Keywords: Upper Ontology, Enterprise Architecture, Business Process, Time Ontology

1 Introduction

Time is one of the most treasured resources in highly dynamic business environment. Therefore time becomes an important issue in development of different information technology solutions, because their impact on users' time shall be considered. For instance, in development of information systems for administrative purposes the time of administration is saved, however the time of other employees might be misused to such an extent that the new administrative information systems causes losses instead of benefits in the company in terms of financial resources, job satisfaction, and ability to serve the customers of the company. On the other hand, the business in the world is run on the global scale and companies from different time zones have to cooperate in providing services and products to their customers. This means that their business process management systems must be supported by information technology solutions that can easily calculate the process parameters taking into consideration time zone differences with respect to the current geographical location of the companies and temporal locations of their employees. We assume that, to ensure good possibility to analyze time issues, it is necessary to develop the following two approaches:

- The approach how to model time as one of the sub-models of enterprise architectures

- The approach how to relate time to other models of the enterprise architecture, especially to the business process model.

In this position paper we discuss time model proposed in [1] and time ontology [2] with respect to possibilities to model time, and we propose to relate time, enterprise architecture, and business processes via Bunge's Wand and Weber information systems ontology (BWW model) [3], which is based on Bunge's systems ontology [4].

The paper is structured as follows. The related work is discussed in Section 2. The proposed approach of linkage between enterprise architecture, business process model and time model is presented in Section 3. Brief conclusions are given in Section 4.

2 Related Work

In this section we describe related work in modeling of time, inclusion of time in enterprise architecture and business process models as well as linkage between the enterprise architecture and business process models to set the ground for the approach for linking time, enterprise architecture, and business process models.

2.1 Time Model and Time Ontology

Taking into consideration different usages of time in information logistics and databases, the time model was proposed in [1]. On the basis of the code of general time ontology [5] this model (transferred into the form of ontology) was manually compared to the publically available W3C time ontology [2] (see Fig. 1).

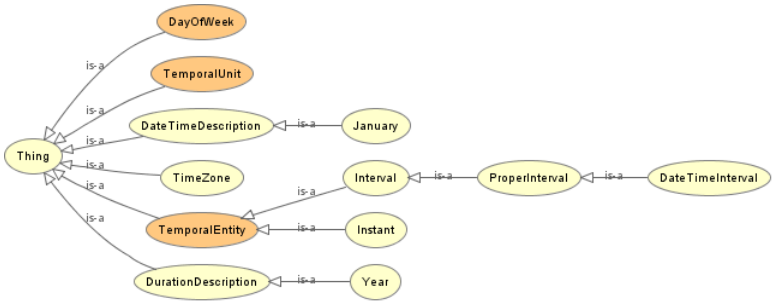

Fig. 1 Representation of W3C time ontology [2] which was used for comparison (simplified).

In this paper, on the basis of: (1) above-mentioned comparison, and (2) taking into consideration other related works discussed in Section 2.3, new time model is proposed, which amalgamates the issues reflected in the previous version of the time model [1] and W3C time ontology [2]. Additionally it includes sequencing elements *Next* and *Last* (Fig. 2). The model covers all time issues referred to in Sections 2.2 and 2.3 of this paper; however, some duration variations, dependencies and constraints discussed in [6] are not included in the model.

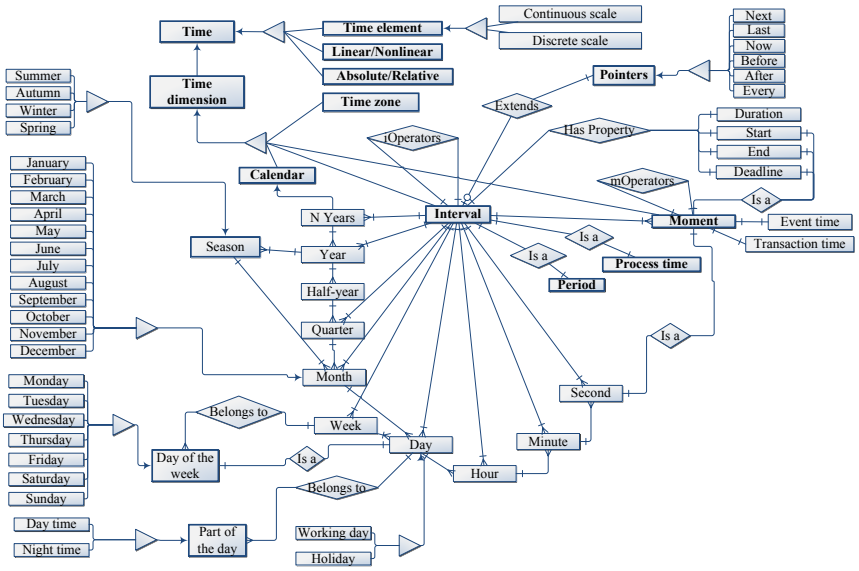

Fig. 2 New version of the time model presented in [1] (simplified).

2.2 Time in Enterprise Architecture Frameworks and Tools

In the field of Enterprise Architecture, time is considered in two ways. In the most cases it is related to the enterprise architecture development and points to the states of enterprise architecture, such as as-is and to-be. In few cases, in enterprise architecture frameworks and tools, time is incorporated inside the models forming the enterprise architecture.

TOGAF framework's [7] subsection 5.5.3 “Time period” operates with only two discrete states of time: present situation (as-is) and future state (to-be). The Zachman Framework (ZF) of Enterprise Architecture [8] implements “When” section to deal with time dimension. In the section “When” the approaches how to model time variables from long-term strategic to short-term every day periods are described. However, no models or examples of ZF “When” implementations can be found in scientific databases or in public sources. DODAF [9] and FEAF [10] implement two discrete states (as-is and to-be), and also the project plan is described as a transition from as-is to to-be state. Project plan usually is implemented as Gantt diagram. Enterprise architecture modeling language ArchiMate [11] does not support time attributes.

Enterprise architecture tools differ one from another regarding time features available in them. For instance, ADOit supports Gantt diagram. ARIS supports BPMN and EPC standards, where BPMN ensures particular temporal features [12]. There is the research work reported that aims to update ARIS EPC meta-model with time concepts using Unified Foundational Ontology [13]. Cameo Enterprise Architect [14] supports several enterprise architecture frameworks but only ZF has expanded modeling capabilities for time constraints. Cameo Enterprise Architect supports ZF “When” section using UML activity and sequence diagrams.

2.3 Time in Business Process Models

BPMN implements only Time Event entity for temporal constraints modeling. In many cases this is sufficient. However, BPMN lacks such important temporal constraints as minimum and maximum time [15], and it is not possible to define time when tasks cannot be done [16]. There are difficulties to map time constraints and other resources in BPMN [16]. There are two possible solutions in this situation. One approach is to define time constraints using existing BPM tools. For instance, delay and wait constraints can be incorporated in the tools [17]. Another approach is to add new tools for BPMN, like many temporal constraints are offered in [16].

There are few offers [15], [16], [18] that extend BPMN standard with additional graphical elements visualizing temporal constraints. Before verifying, the models with the extensions must be transformed into formal representations (Petri nets or timed automata). Additionally, there is a possibility to model temporal constraints directly using Petri nets [19], [20] or automata [21], [22]. In this case there is no need for additional transformation, but such models have specific visualization not so common as BPMN.

2.4 BWW based Linkage between Enterprise Architecture and Business Processes

The previous research [23] has shown the gap between business process models and state spaces of structural elements in business process models. In this paper mainly BPMN is considered as a notation for business processes modeling and ArchiMate - as a language for enterprise architecture modeling due to reasons described in [23].

Existing modelling languages BPMN and ArchiMate lack elements for capturing states of structural elements [23]. This gap hinders ensuring compliance between states of objects in business process models and other enterprise architecture elements. The gap could be closed by using BWW model [3] and linking structural elements of BPMN and ArchiMate using the following BWW elements [24]:

- States - properties define their states of the elements.
- Conceivable State Space - is a set of all states elements can assume.
- Lawful State Space – is a set of states that are lawful for elements.
- History - is the chronologically-ordered states of elements.
- Events - event is a change in state of elements.
- Conceivable Event Space - is a set of all events that can occur to elements.
- Lawful Event Space - is a set of all events that are lawful to elements.

BWW model [3] that roots in Bunge's systems ontology [4] allows straightforwardly to address the lawful and conceivable state spaces of elements in business process models. BWW linkage with BPMN and ArchiMate potentially has a capacity to support compliance of business process models with other enterprise architecture elements or external regulations that define legal states of business process elements.

However, BWW, BPMN and ArchiMate lack temporal concepts that are required to analyse state transition and history of business process objects for compliance purposes.

Temporal concepts are required to describe temporal content in business process models, such as data objects and changes of their states, and temporal properties of objects. Defining temporal concepts in business process models will provide a capacity for defining history of states and events for further analysis. Ability to capture temporal concepts of business process will support monitoring business process compliance regarding temporal restrictions during the run-time, and analysing executed business process models for bottlenecks and other deficiencies, e.g., recognizing business objects in not allowed states for not allowed period of time, events that happen at not allowed time, objects that are idle, etc. The model for linking time to the enterprise architecture and business processes, which themselves are linked via BWW model based on Bunge's ontology, is proposed in the next section.

3 Linking Time to Business Process Models and Enterprise Architecture

Business processes always contain temporal information – time of order placement, time of error, time of received message, intended delay of the process, unintended delay, specific date to start a business process, etc. However, BPMN, ArchiMate, and BWW lack a vocabulary for expressing facts about time. W3 Time Ontology [2] provides a set of temporal concepts for expressing facts about topological relations among instants and intervals, together with information about durations, and about date-time information. Basically, W3 Time Ontology defines two subclasses of temporal concept: Instant and Interval. Intervals are things with extent and instants are point-like in that they have no interior points [2].

We propose to think that Events correspond to instants and States correspond to intervals. Event is a happening that instantly triggers a state transformation, however, objects are in a particular state for a particular interval of time, e.g., message is received on Monday at 6 am (Event), and Message is in a State *Received* for an interval of time since of receipt till it is read. Fig 3 shows the proposed linkage between BWW states and events, ArchiMate and BPMN structural elements, and W3 time ontology. This linkage applies also to time model reflected in Fig. 2. In case of time model *Period* stays instead of *Interval* and *Moment* stays instead of *Instant.*

The following issues are considered in Fig. 3:

- BPMN and ArchiMate elements representing the structure elements having BWW States.
- BWW States are changed in the case of a happening of an Event. The happening of any Event has a particular point in time, but since BWW model does not include the concept of time, we propose to use W3C Time Ontology Instant concept (or in time model - Moment), which will record the time of Event occurrence.
- BWW States have BWW History – chronologically ordered States of structural elements, but since BWW model does not include the concept of time, we propose to use W3C Time Ontology Interval concept (or in time model - Period), which will record the period of being in a particular State and History of States.

Table 1 describes in detail the relationships between BWW, BPMN, ArchiMate, and W3C Time ontology.

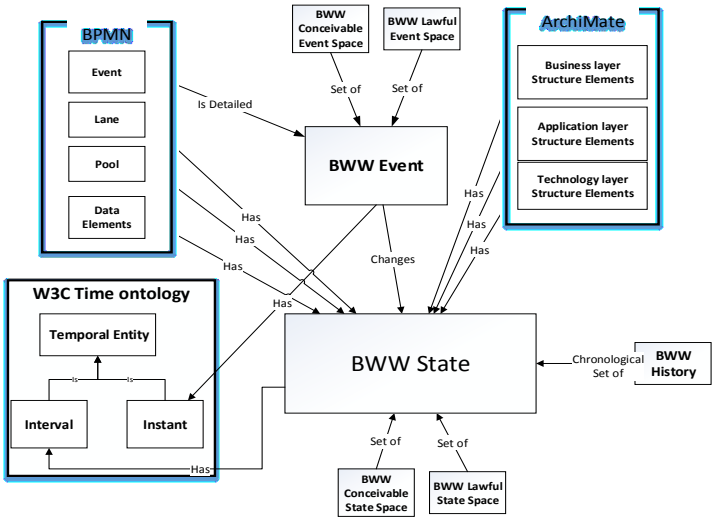

Fig. 3 The model for linking time, enterprise architecture and business processes

Table 1. Detailed relationships between BWW, BPMN, ArchiMate, and W3C Time Ontology

BWW Element	*BPMN Element*	*ArchiMate Element*	*W3C Time ontology Element*
State, Conceivable State Space, Lawful State Space	Lane, Participant (Pool), Data Object, Data Store	Business actor, Business role, Business interface, Location, Business object, Contract, Product Application component, Application interface, Data object, Node, Device, Infrastructure interface, System software, Artifact	Interval (interval of time BPMN and ArchiMate elements are in particular State)
History	Lane, Participant (Pool), Data Object, Data Store	Business actor, Business role, Business interface Location, Business object, Contract, Product, Application component, Application interface, Data object, Node, Device, Infrastructure interface, System software, Artifact	Set of chronologically ordered Intervals
Event, Conceivable Event Space, Lawful Event Space	Start event, Intermediate event, End event	Business Event	Instants (a particular point of time BPMN and ArchiMate Event happens)

Table 1 shows for which BPMN and ArchiMate elements we propose to define W3C Instants or Intervals. For example, ArchiMate *Application Component* can be related to BPMN Pool, which shows in detail the process *Application Component* performs, and *Application Component* is capable of having *States*: BWW State spaces – Conceivable and Lawful, e.g., *Conceivable state* can be "Not responding (Timeout)", and Lawful

State - "Active". State of *Application Component* will change if Event that happens is in a particular point of time, thus we propose to relate Event to W3C Time Ontology Instant. Also *Application Component* is in a particular State for a particular period of time, for that we propose to relate BWW State to W3C Time Ontology Interval element.

The overall idea represented in Fig. 3 and Table 1 can be summarized as follows – ArchiMate models describe structure of business process in detail, BPMN models describe behavior (activities, events) of business process in detail, BWW model describes states in detail, and W3C Time Ontology (or time model presented in Fig. 2) describes time concepts for states.BWW model allows decomposition of a system into subsystems and composition of a system from a set of subsystems. The BWW-ArchiMate-BPMN linkage we discuss in this paper propagates also to other BWW elements, e.g., states of subsystems at particulars intervals and time instants.

4 Example

Figure 4 provides a simple example of publication archivation process at a university in which a researcher uploads her publication to university repository and can choose an option to publish her work as Open Access. If a Researcher agrees to archive her publication as Open Access, she must choose a (1) licence under which she wishes to publish her publication, (2) a version of the full text which the publisher permits to archive in the institutional repository. The possible versions of the publication's full texts are: pre-print, post-print or published version. Next, a Librarian must check the Publisher's policy for Open Access archivation in repositories. Three outcomes are possible: (1) the Publisher does not allow to archive the publication as Open Access, (2) the Publisher allows to archive the Publication as Open Access after a specific period of time (embargo period, .e.g, 6 months), or (3) the Publisher permits Open Access archivation. Uploaded publication can assume several states:

1. Publication [Registered] – publication is registered in the system.
2. Publication [Internal] – publication is available only for internal university users.
3. Publication [Confirmed Open Access] – publication is confirmed by a Librarian to be archived as Open Access.
4. Publication [EMBARGO Open Access] – publication has an embargo period before it can be published as Open Access.
5. Publication [Cancelled Open Access] – publication has been cancelled for Open Access archivation by a Librarian.

Lawful event is allowing to showing a full text of the publication publicly if the state has been changed to [Confirmed Open Access]. Unlawful event is showing a full text of the publication publicly if the state has been changed to [Cancelled Open Access]. Also, an unlawful event is showing a full text of the publication publicly when embargo period is still active. Here the time components Instant and Interval is essential to provide a mechanism for embargo period control and to change the state of publication from [EMBARGO Open Access] to [Confirmed Open Access]. Table 2 describes in detail the relationships between BWW, BPMN and W3C Time ontology for the example described above. Figure 5 shows the instance of the example process in which the

Publication follows the following State history:{Registered 15/04/2015 6:00 AM - 15/04/2015 10:00 AM; EMBARGO Open Access 15/04/2015 10:00 AM-15/07/2015 10:00 AM; Confirmed Open Access 15/07/2015 10:00 AM-15/04/2020 10:00 AM}

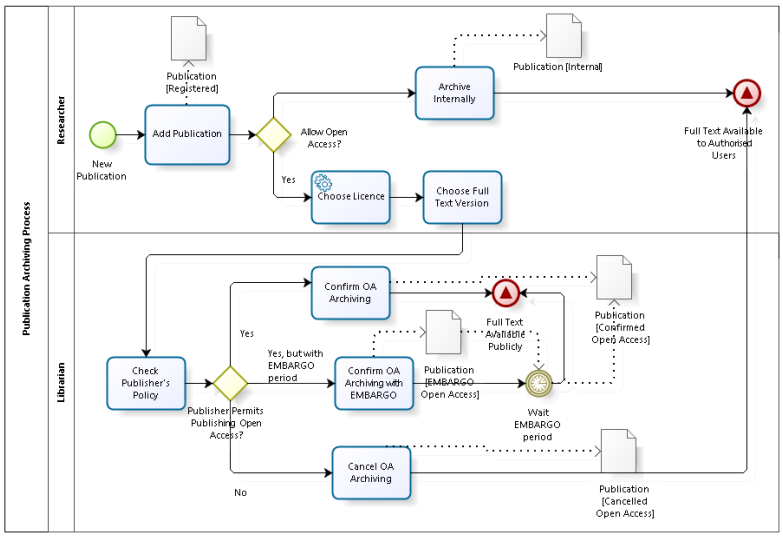

Fig. 4 Publication archivation process example.

Table 2. Relationships between BWW, BPMN, and W3C Time Ontology in Publication Archivation process.

BWW element	*BPMN element*	*W3C Time Ontology*
State space for Data Object {Registered, Internal, Confirmed Open Access, EMBARGO Open Access, Cancelled Open Access}	Data Object {Publication}	Instant - a particular moment of time to initiate a particular State of a Publication, e.g., 01/04/2015 6:00 AM [Registered] Interval - a period of time in which Publication is in a particular State, e.g., 15/04/2015 6:00 AM – 15/07/2015 10:00 AM [EMBARGO Open Access]
Event	Timer Event {Wait EMBARGO period}	Instant - a particular moment of time to start a countdown of EMBARGO period, e.g., 15/04/2015 6:00 AM However, an Event {Wait EMBARGO period} must stop the process for a period of time (embargo period), and only after that to initiate a State transition from [EMBARGO Open Access] to [Confirmed Open Access].
History	Data Object {Publication}	Chronologically ordered States for a particular instance of the process, e.g., {Registered, EMBARGO Open Access, Confirmed Open Access} A set of chronologically ordered Intervals of Publication States: {15/04/2015 6:00 AM - 15/04/2015 10:00 AM; 15/04/2015 10:00 AM-15/07/2015 10:00 AM; 15/07/2015 10:00 AM-15/04/2020 10:00 AM}

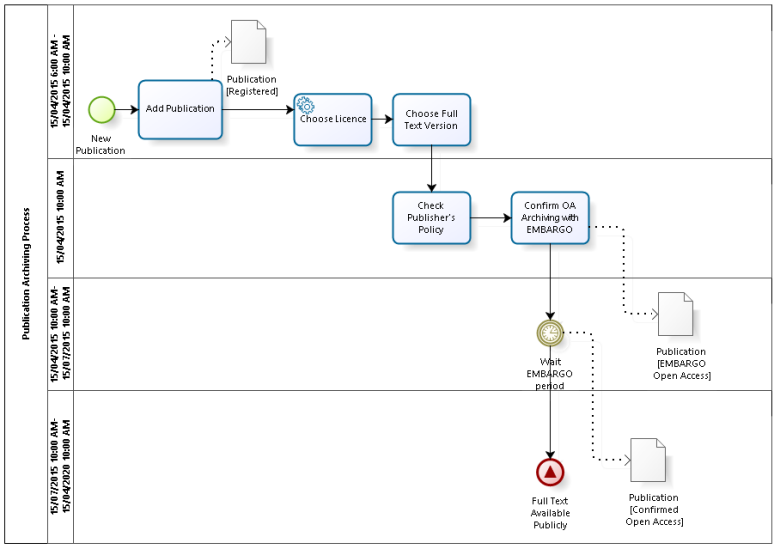

Fig. 5 Publication archivation process instance.

5 Conclusions

The paper concerns linkage between time, enterprise architecture, and business processes. This linkage is necessary to address more extensively time issues in different enterprise modeling and analysis tasks as the time becomes one of the most treasured resources of companies in highly dynamic and global business environment. The paper contributes the new version of the time model and, in the Bunge's systems ontology rooted, model for linking time to enterprise architecture and business process models via temporal entity of W3C ontology. Temporal elements of W3C ontology map to the corresponding elements in the proposed time model. Thus both (W3C ontology and the time model) can be related to the enterprise architecture and business processes.

For further experiments the inclusion of time model and time ontology in enterprise modeling tools would be helpful to ensure efficiency of modeling efforts. The development of extensions for existing tools or designing new tools and experiments with a number of different time-sensitive scenarios is the matter of further research.

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