The Time Dimension in Information Logistics

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Abstract. The purpose of information logistics is to ensure that the right information, which is necessary in accomplishment of business tasks, is available in the right location, in the right time, and in the right quality. Different combinations of models have been suggested for supporting this purpose. However, none of them includes the model that corresponds to the time dimension of information logistics. Taking into consideration that the right time is an essential goal that corresponds to the purpose of information logistics, this paper takes a closer look at the time dimension and suggests extending the set of related models of information logistics with the time dimension model.

Keywords: information logistics, time dimension, information demand model

1 Introduction

Information Logistics is a branch of research that addresses concepts, methods, technologies, and solutions that help to ensure situation sensitive availability of high quality information for individuals or groups with respect to their information needs, time, location, and user-friendly form of representation [1]. As revealed in [2] the notion of Information Logistics was coined in 1978. According to data available in scientific repository SCOPUS, the number of papers on information logistics has gradually increased from one paper in 1982 [3] to more than 40 papers per year during 2009-2012.

Information logistics usually is organized around the following four main dimensions [4]:

- *Personalization*: each person or group has particular information needs that depend on their knowledge and experience
- *Time*: information has to be available or delivered in a particular time when it is actually needed
- *Communication*: information has to be available (or represented) in the form that is convenient for its users
- *Context*: information has to be deliverable regarding the location and situation, in which it is used in a particular moment of time

One more dimension – the *quality* dimension of information logistics is suggested in [1].

Most of the research in the information logistics has been devoted to the context dimension, e.g., [5], [6], [7], and [8]. Usually the time dimension is considered from the point of view of sequence of time moments or intervals in which particular items of information are needed. The intervals can be relative, e.g., “four weeks before a particular time moment”, “six weeks before a particular time moment” and so forth. The moments and start and end points of the intervals are represented on a scalar time axis. Thus, while such issues as roles, tasks, information items, and quality parameters are addressed in specific interrelated models, the time dimension has not been considered as a separate information logistics model so far.

The goal of this paper is to analyze the time dimension in depth and propose the model of the time dimension that would enhance possibility to represent and analyze information needs and information availability and delivery patterns more accurately.

The paper is organized as follows: In Section 2 features of the time dimension are discussed. In Section 3 conceptual modeling of time dimension is considered and the model of the time dimension is presented. In Section 4 the time dimension is put in the context of information demand modeling. In Section 5 the practical applicability of the time dimension model is discussed. Brief conclusions are stated in Section 5.

2 Features of Time Dimension

In this section the discussion of the time dimension is pragmatically oriented; it is mainly based on research reflected in [9] and [10] and does not concern philosophical considerations of time dimension.

The features of time can be structured as reflected in Fig 1.

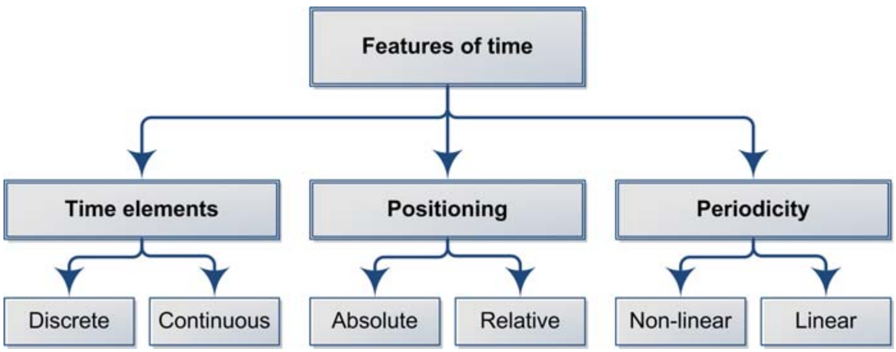

Fig. 1 Features of time

Time can be considered as discrete items or as a continuous phenomenon. In information technology context it is mainly considered as discrete items. It can be positioned as absolute time referring to a chosen “clock” or as a relative time (e.g., “one year ago”). An essential feature of time is “periodicity” or frequency of intervals that can be reflected using linear or non-linear scales. It is essential that users are free to define time periods by themselves. In related work one can find the following types or aspects of the time dimension:

- Calendar granularity (N years, Year, Half-year, Quarter, Month, Week, Day, Hour, Minute, Second)
- Monthly (January, February, March, April, May, June, July, August, September, October, November, December)
- Daily (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday)
- Part of the day (Day time, Night time)
- Seasonal (Spring, Summer, Autumn, Winter)
- Arbitrary time intervals (periods)
- Arbitrary time moments
- Time zone
- Process time (Start time, Duration, End time, Deadline)
- Relative pointers (Before, After, Now, Every)
- Time types (systems time, real time, see e.g. ISO SQL:2011 standard [11])

The model of the time dimension, which is proposed in the next section, includes most of above-listed time dimension types.

3 The Model of the Time Dimension

While there is rarely specific time model available in the related work, time has been included in different conceptual models. Ten of such models are surveyed in [9]:

- *Infologistic data model* by Langefors, presented in 1973 [12]. In this model the time (moment or period) is an attribute of the elementary fact, belonging to its built-in context. E.g., *O(p)* is a set of objects with property p, $O_t(p)$ is a set of objects which have property *p* during time period *t*.
- *Conceptual Information Model* [13] distinguishes between extrinsic time automatically set by the software system and intrinsic time (a part of the fact that refers to real time when the fact is true). Here the time is considered as a component of the relationship. In its later modifications the distinction between time moments and time intervals is taken into consideration.
- *The time extended Entity Relationship Model – TERM* [14] focuses on historical structure of data, where each attribute, role, or relationship has historical property. This is achieved by specific basic, derived, or inductive historical operations.
- *Logic based model* proposed by Lundberg [15], which argues that, despite of continues nature of time, in information systems it is to be represented as a discrete phenomenon.
- *INFOLOG* [16] model maintains time dimension as a set of temporal operators. This model ignores future and focuses only on past and present issues of facts.
- *DMILT* [17] model is based on specific temporal logic that addresses process network, where processes exchange messages via the temporal database of the information system.

- *The Entity, Relationship, Attribute, Event (ERAE)* [18] model distinguishes between past, present and future of individual data entities or groups of entities. Time is represented as a specific data type.
- *The Conceptual Modeling Language (CML)* [19]. This language has object-oriented structure. It considers discrete time reflected as time intervals using such predicates as *meets*, *equals*, *during/over*, *before/after*, *startsbefore/startsafter*, *endsbefore/endsafter*, *overlaps*, *costarts*, and *coends*. This language includes also two constants, namely, *Alltime* and *Now*.
- *TEMPORA* [20] consists of two types of models such as Entity Relationship Time (ERT) model and Conceptual Rule Language (CRL). Time is reflected as time stamps of entities and relationships in ERT. CRL includes different predicates that allow reflecting various time based situations. Time moments and time intervals are considered (for events – only time moments). Modeling time and real time are considered, as well as historical relationship is presented.

While above-listed methods have been developed quite a time ago and time is an essential issue in contemporary business and information systems environment, there are not many research works available that would consider conceptual modeling aspects of the time dimension. We can distinguish between the following main areas where time issues are currently discussed:

- *Neuropsychology*
- *Simulation*
- *Data Warehouses*
- *Business Intelligence*
- *Ontology Engineering*

In neuropsychology, simulation, data warehouses, and business intelligence only some aspects of the time dimension are considered [21], [22], [23], [24]. The broadest scope of the aspects is analyzed in the research on the time ontology [25], [26].

The fact that recently issued SQL:2012 standard [11] considers only some aspects (calendar granularity, real time, and systems time) of the time dimension, shows that it is necessary to further research the time dimension to better understand its features and incorporate it into models of information logistics.

In this paper we present the first version of the time dimension model that has been developed, mainly, by amalgamating various aspects of the time dimension in a single model. This was done with the purpose to obtain a generic view on different aspects of time relevant in information logistics and to have a possibility to control relationships between these aspects in the time dimension model. The simplified version of the proposed model is presented in Fig. 2. The model presented in Fig. 2 has been obtained independently of the time ontology presented in [26]. While the proposed model has many similarities with the time ontology, such as inclusion of parts of the year, time zones, etc; still there are some essential differences how periodicity and time moments are handled. The model in Fig. 2 distinguishes between periods and intervals as separate entities since both the length of transactions (intervals) and the periods of time showing repetitive execution of transactions are important in information logistics. More detailed comparison of the time ontology and proposed time dimension model is beyond of the scope of this paper.

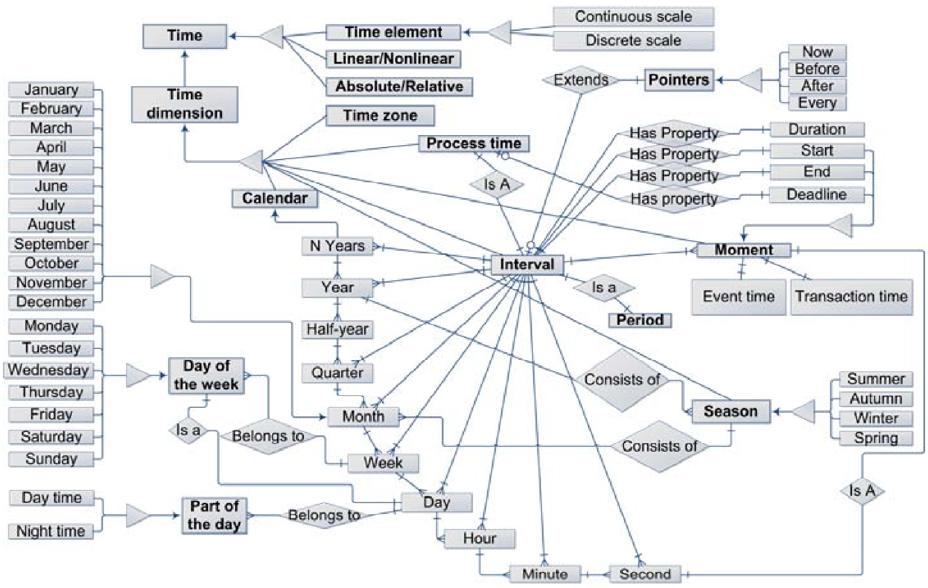

Fig. 2 Time dimension model (simplified)

Fig. 2 reflects different aspects of time that can be relevant in various tasks of information logistics (See Section 2). The positioning of the time dimension model in the context of other models of information logistics is discussed in the next section.

4 Time Dimension and Information Demand Model

For illustrating the role of the time dimension in information logistics we use Information Demand Pattern discussed in [2]. From the modeling perspective this pattern prescribes the model that consists of the following sub-models:

- Information Model that represents the items of information used in performance of tasks
- Effects Model that reflects different issues of quality of information logistics, such as economical effect, motivation, experience etc.
- Organizational Chart showing relationships between the roles in organization
- Task Model showing the architecture of the tasks.

The elements of above-listed models should be iner-related in order to show, which information is needed for which role when performing a particular task, and what effects the availability/unavailability of this information may cause. Fig. 3 illustrates how these models can be related to the time dimension model.

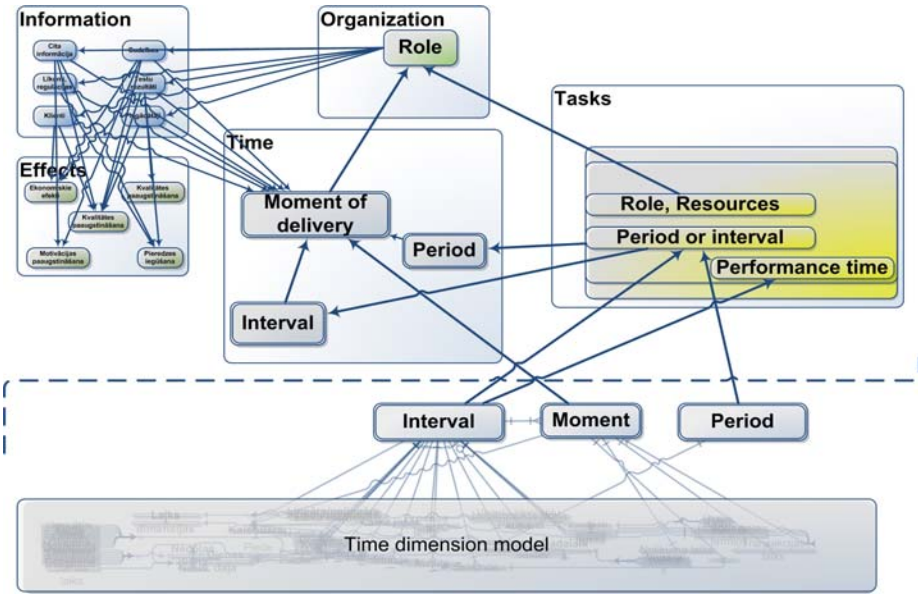

Fig. 3 Information Demand Model related to the time dimension model

At high level of abstraction Fig. 3 shows how elements of Information Demand Pattern can be related to the time dimension model. However, any element of the time dimension model reflected in Fig. 2 can be indirectly related to Information Demand Pattern. This is illustrated by the time dimension model bellow the dotted line in Fig. 3. The usage of the time dimension affects the Task Model. Each Task Model's element has to have attributes that help to characterize their duration (performance time or interval) and periodicity (period or interval of repetition of the task).

We can distinguish between the following types of tasks:

- Meetings: project meetings, conferences, seminars
- Ordinary Tasks: performing a particular transformation

On one hand, the type of the task does not change the way how the time dimension is incorporated in Information Demand Pattern. On another hand, the experimentally obtained models, which represented particular Information Demand Pattern's (extended by the time dimension model) instances, revealed that the extended Information Demand Pattern models have slightly different outlooks of above-mentioned types of tasks. Nevertheless, in both cases there is a time interval Δt that is related to start time point t_s and end time point t_e of the task

$$\Delta t = t_e - t_s \quad (1)$$

Moment of Delivery M_d is defined as a moment in which a particular information unit is sent to the role. In most cases this moment should not occur later than the beginning of the task.

Both types of tasks can occur periodically. In this case it is necessary to define period P as the delta between two sequential starting points of tasks $t_{s.n}$ and $t_{s.n+1}$,

$$P = t_{s.n+1} - t_{s.n} \tag{2}$$

The periods can be constant and arbitrary. In case they are constant ones (e.g. handing in monthly reports), the M_d can be calculated as follows:

$$M_d = P - \Delta t \tag{3}$$

Often in information logistics the moment, when information is received, can be considered being practically equal to the moment, when information is delivered. However, there are cases, when the time of delivery has to be taken into account.

5 Experimental Application of Time Dimension Model

The time dimension model proposed in Section 2 related to Information Demand Pattern (Section 3) was applied for information demand modeling in the project proposal preparation in a public organization. Effects Model was not used in the experiment. The models illustrating the obtained information demand pattern are shown in Fig. 4.

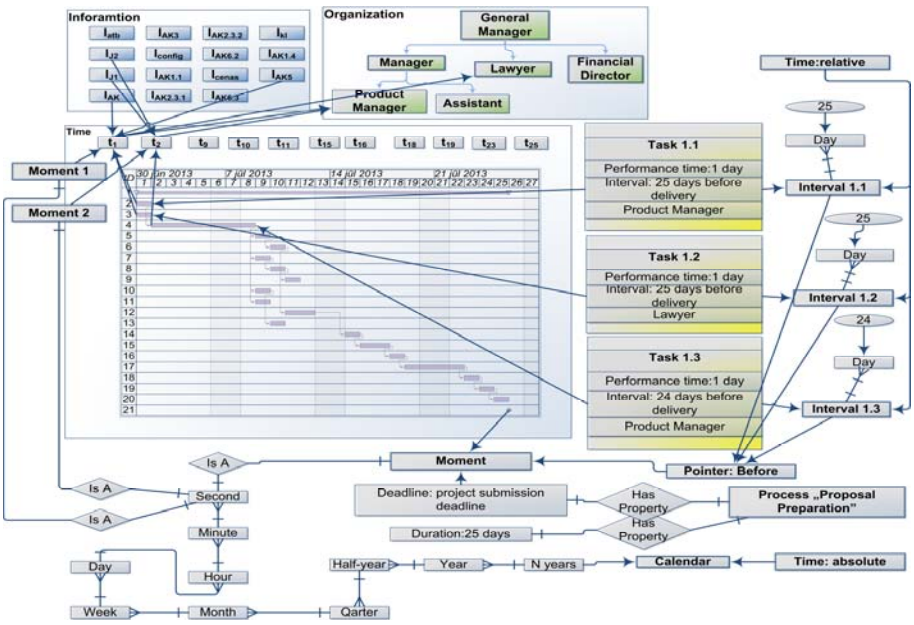

Fig. 4 Part of Information Demand Pattern models for project proposal preparation extended by the time dimension model

There were six organizational roles, nineteen tasks, and twenty five information units defined. The maximal duration of the project proposal preparation was 25 days. On the basis of the models, the information system's infrastructure and the data model were defined for supporting the tasks represented in the Task Model. The time dimension model was helpful for identification of time issues and attributes relevant for information logistics of project proposal preparation. The model helped to represent and analyze information needs and show information availability and delivery patterns more accurately.

6 Conclusions

The paper focuses on the time dimension in information logistics. It contributes the first version of the conceptual time dimension model for information logistics as well as relates well-known Information Demand Pattern to the time dimension.

First experiments with inclusion of the time dimension model in the set of inter-related information logistics models show that the time dimension model helps to represent and analyze information needs and show information availability and delivery patterns accurately. The model is useful for visualizing the tasks of roles and designing information architecture that supports the performance of the tasks.

Further research should concern tuning of the time dimension model, lager scale experiments with Information Demand Pattern extended by the time dimension model, and designing transformation algorithms that produce role oriented and information technology support oriented views on the detailed sub-models of the extended Information Demand Pattern.

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