A Core Pattern for Events

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Abstract. In our experience, the modeling of events of all sorts is often central in ontology development. Indeed, many proposals for models of events exist, some in the form of lightweight vocabulary, and some in the form elaborately axiomatized ontologies. However, there is as of now no clear, generic, and concisely described *pattern* for modeling events as part of an ontology. In this brief paper, we describe such a core, minimalistic, generic pattern, and we describe it in the way in which we would have found it useful in our own modeling activities. We do not claim a lot of originality in doing this, we are rather filling an obvious gap in the ontology design patterns landscape.

1 Introduction and Motivation

Part of a high-quality ontology modeling approach is to consider the nature of the things to be modeled, e.g., by aligning to an upper-level ontology, or by reusing corresponding ontology design patterns: Is a cooking recipe a document or a process [9]? Is a chess game a piece of art or an event [7]?

Using a modular, design pattern driven approach, it is very helpful to have a suite of well-designed ontology design pattens available which can be used for this purpose. During some of our recent modeling activities [3], however, we realized that the rather ubiquitous concept of *Event* is currently not well-represented. Of course, there exists a good number of ontologies or patterns which take on event modeling [1,2,8,10,11,12,13]. But they were not exactly suitable or concise enough for most of our modeling purposes.

One issue we found was that many of the models were rather extensive and involved, such as the Model F [10]. While it is good to have such models available, understanding them needs considerable effort, while our need may often be served by a much simpler model.

Another main issue was that most models assume that the location of an event is static. In reality, however, events may move. In fact, even their temporal extent may be discontinuous. An example for this would be the 1990 World Chess Championship Match, which took place in New York from October 8 to November 7, 1990, and in Lyons, France, from November 26 to December 30, 1990.

While events such as the one just given can be captured in some models, e.g., by describing the two separately located parts as subevents of the combined event, this approach becomes impractical when an event is clearly moving, and when the location of the event at any point in time may be of interest. We encountered this, e.g., when working on the GeoLink Modular Oceanography Ontology (GMO) [5], for which a central notion to be modeled was that of oceanographic cruise. The trajectory of a cruise may be given, for example, by a (large) sequence of auto-recorded coordinates (say, from an on-board GPS system), and it would be rather artificial to generate that many subevents.

We thus have to acknowledge that events may move, i.e. it is not always possible to separate the spatial and the temporal aspects of events. Rather, the spatiotemporal extent of an event may be a rather complex entity in its own right.

In this paper, we will focus on a minimal pattern for events. We will not provide a detailed model for spatiotemporal extent, which can be found elsewhere [4].

The plan of the remaining paper is as follows. In Section 2 we describe our core event pattern. In Section 3 we give some brief comparisons with other event ontologies or patterns from the literature. In Section 4 we conclude.

2 The Pattern

It is our intention to provide a minimalistic ontology design pattern for events.[1] It shall serve as a core model which can be used whenever a notion of event is to be used in modeling. It shall be extendable, of course, if a more involved model is required.

Our modeling solution is not based on requirements derived from some particular application scenarios, although some examples and issues illustrated in the Introduction did play a role in motivating the solution. Rather, we simply did a careful look at existing event models and identify ontological components reoccurring in them.

So, we begin with the question: what are essential aspects of events, in general? According to FrameNet,[2] "An Event takes place at a Place and Time." And indeed, spatial and temporal extents are part of any event model we have found. As discussed above, though, spatial and temporal extents cannot always be separated, but must be modeled as true spatiotemporal extents.

Furthermore, an event necessarily has participants, which may or may not be agents. Participation of entities (agents or otherwise) in an event distinguish it from the spatiotemporal extent in which it happens. In addition, it is very natural to indicate that some events may be subevents of other events. Note that the requirement analysis above could easily be rephrased as competency questions, e.g., "Where and when does an event take place?" or "Who participates in the event?"

[1] OWL encoding is at `http://krisnadhi.github.io/onto/event.owl`. ODP Portal submission is at `http://ontologydesignpatterns.org/wiki/Submissions:EventCore`

[2] `https://framenet2.icsi.berkeley.edu/fnReports/data/frameIndex.xml?frame=Event`

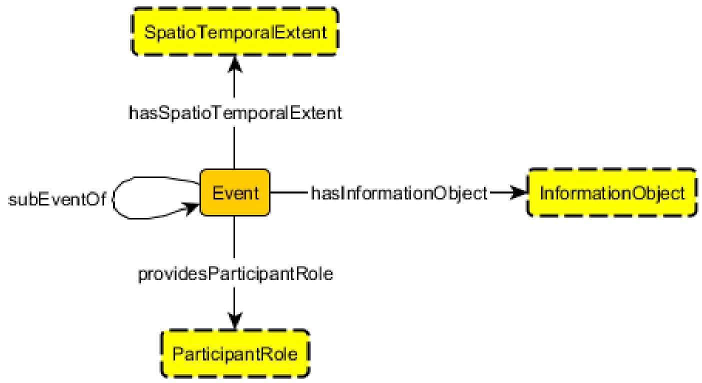

Fig. 1. Core Pattern for Events

These three, *spatiotemporal extent*, *participants*, and *subevent relationship*, already constitute what we consider a core pattern for events. We will discuss these in more detail below. Additionally, one sometimes wish to attach some additional descriptive information to events, such as textual description, labeling, etc., and thus, following good modeling practice, we will also add an InformationObject to support it.

Of course, other aspects of events are frequently required in modeling. Results of events, including causal relationships between events, but also reports on events such as logbooks, minutes, or press coverage, are often included. However, results such as reports do not seem essential to the notion of event, in contrast to, say, the notion of process which much more clearly suggests that resutls are produced. It seems more natural to think of the source event as part of the provenance of such results, i.e. a provenance model or pattern could be used for this. Likewise, causality seems a rather complex notion which calls for a model in its own right. These and other aspects we do not model. If a more complex model is called for, then any of the referenced more sophisticated event models may be worth while consulting.

A class diagram for our core pattern for events is given in Fig. 1. The dashed classes indicate external patterns, which are at the discretion of the user of the pattern.

SpatioTemporalExtent: We have already discussed, in the Introduction, the need to capture true spatiotemporal extents, including moving events, and discontinuous temporal extents. Spatiotemporal extent is a complex notion to model in this generality. One example of a model for this notion – we refer the reader to [4] for more detail – is based on a particular trajectory (i.e., partial ordering) of spatiotemporal points, which is distinguished due to having particular meaning. Of course, if the spatial extent of events to be modeled are static or near-static, then a simpler approach than [4], e.g., one which simply provides both a temporal and a spatial extent, may be sufficient.

In terms of axioms, every event does have a spatiotemporal extent, and we also specify the range of the property:

$$\begin{aligned} \mathsf{Event} &\sqsubseteq \exists \mathsf{hasSpatioTemporalExtent}.\mathsf{SpatioTemporalExtent} \\ \top &\sqsubseteq \forall \mathsf{hasSpatioTemporalExtent}.\mathsf{SpatioTemporalExtent} \end{aligned}$$

We note here that by using SpatioTemporalExtent, the Event pattern is slightly more general than TimeIndexedSituation pattern.[3] The latter models a situation with a particular time interval as temporal extent, and does not facilitate spatial information.

ParticipantRole: Participants in the event – which can be agents or inanimate objects such as a volcano in a volcano eruption – are related to the event using participant roles. A volcano could, for instance, be an erupting volcano in a natural disaster. However, it could also be the site of a plane crash, and as such be a participant in a plane crash event. The modeling of participant roles (or of agent or object roles) is rather standard and has also been described elsewhere.[4] Modelers could choose whatever model that suits their purpose.

In terms of axioms, we posit that every event does have at least one participant. We also specify the range of the property:

$$\begin{aligned} \mathsf{Event} &\sqsubseteq \exists \mathsf{providesParticipantRole}.\mathsf{ParticipantRole} \\ \top &\sqsubseteq \forall \mathsf{providesParticipantRole}.\mathsf{ParticipantRole} \end{aligned}$$

SubEvent: The subevent relationship is of course declared transitive, and both domain and range are events:

$$\begin{aligned} \mathsf{subEventOf} \circ \mathsf{subEventOf} &\sqsubseteq \mathsf{subEventOf} \\ \exists \mathsf{subEventOf}.\top &\sqsubseteq \mathsf{Event} \\ \top &\sqsubseteq \forall \mathsf{subEventOf}.\mathsf{Event} \end{aligned}$$

Inheritance along subEventOf is a bit more tricky. Clearly, every participant in a subevent is also a participant of the event. We can express this as a rule as

$$\begin{aligned} &\mathsf{Event}(x) \wedge \mathsf{providesParticipantRole}(x,p) \wedge \mathsf{subEventOf}(x,y) \\ &\qquad \rightarrow \mathsf{providesParticipantRole}(y,p). \end{aligned}$$

This rule can be converted into OWL DL, using a conversion technique known as *rolification* [6]. The idea is to introduce a new property[5] for the class Event,

[3] `http://ontologydesignpatterns.org/wiki/Submissions:TimeIndexedSituation`

[4] E.g., `http://ontologydesignpatterns.org/wiki/Submissions:ParticipantRole`, `http://ontologydesignpatterns.org/wiki/Submissions:Objectrole`, or `http://ontologydesignpatterns.org/wiki/Submissions:Nary_Participation`.

[5] In DL literature, properties are traditionally called roles, hence the term *rolification*

which is not occurring elsewhere in the ontology. This property, say R_{Event}, can then be used as a binary predicate in the rule in place of the unary predicate Event, and as a result, the rule can be readily written as a property chain axiom, while the correspondence between Event and R_{Event} is expressed in an axiom with a Self-restriction. In this particular case, the conversion also requires the use of an inverse property, i.e. this cannot be done, e.g., in the OWL EL profile. The resulting axioms are as follows.

$$\mathsf{Event} \equiv \exists R_{\mathsf{Event}}.\mathsf{Self}$$

$$\mathsf{subEventOf}^{-} \circ R_{\mathsf{Event}} \circ \mathsf{providesParticipantRole} \sqsubseteq \mathsf{providesParticipantRole}$$

In addition, we would need axioms governing the relationships between the spatiotemporal extents of an event and its subevents. The exact nature of these axioms would depend on the details of the SpatioTemporalExtent pattern used, and may involve temporal and spatial reasoning. However, let us assume for the moment that two spatiotemporal extents can be related using a subSpatioTemporalExtentOf relationship, which we abbreviate as subSTEOf: Specifying $\mathsf{subSTEOf}(x, y)$, for two spatiotemporal extents x and y means that at any point in time for which x is given, the spatial extent of x must be contained within the spatial extent of y. Given this, we can add the rule

$$\begin{aligned} &\mathsf{Event}(x) \wedge \mathsf{hasSpatioTemporalExtent}(x, w) \wedge \mathsf{subEventOf}(x, y) \\ &\quad \wedge \mathsf{Event}(y) \wedge \mathsf{hasSpatioTemporalExtent}(y, z) \rightarrow \mathsf{subSTEOf}(w, z) \end{aligned}$$

which can be rolified, using R_{Event} as above, into

$$\begin{aligned} &\mathsf{hasSpatioTemporalExtent}^{-} \circ R_{\mathsf{Event}} \circ \mathsf{subEventOf} \circ R_{\mathsf{Event}} \\ &\quad \circ \mathsf{hasSpatioTemporalExtent} \sqsubseteq \mathsf{subSTEOf}. \end{aligned}$$

InformationObject: Following established practice, we use an information object to group non-essential information such as names, URIs, textual descriptions, etc. Concrete instantiations of this pattern can be adjusted from the literature, e.g. from [5]. As the only axiom, we indicate a range restriction:

$$\top \sqsubseteq \forall \mathsf{hasInformationObject}.\mathsf{InformationObject}$$

Class Disjointness: Finally, we assert pairwise disjointness between any of the classes in Fig. 1:

`AllDisjointClasses`(Event, SpatioTemporalExtent, ParticipantRole, InformationObject)

3 Comparisons

We briefly compare our core pattern for events with some other proposals in the literature.

Event Ontology [8]: The Event Ontology is similarly minimalistic as our proposal. However, it does not provide for proper spatiotemporal extents: its spatial component is `geo:SpatialThing` from WGS84 Geo Positioning Ontology,[6] while its temporal component is `time:TemporalEntity` from the W3C OWL Time Ontology.[7] It distinguishes conceptually between active and passive participants, but does not use roles to model participation. In addition, events according to this model may produce some entity.

Linking Open Descriptions of Events (LODE) [12]: LODE is also a minimalistic model that focuses on the factual aspects of events, represented in terms of the four Ws: what happened, where and where did it happen, and who was involved, which is similar to our proposal. However, like the aforementioned Event Ontology, it does not provide proper spatiotemporal extent. In fact, LODE is defined in terms of several notions from DOLCE Ultra-Lite (DUL).[8] It separates the information about the spatial extent of an event into `dul:Place` and `geo:SpatialThing`, while the temporal extent is given by `time:TemporalEntity`. Furthermore, events in LODE illustrate something (e.g., media object, documents, etc.) and involvement of objects (`dul:Object`) or agents (`dul:Agent`) in events is not modeled through roles.

Model F [10]: Model F is very elaborate and details many aspects which we have deliberately omitted to arrive at a core pattern only. Model F does not provide for a fine-grained modeling of spatiotemporal extents, though some of it, e.g. regarding representation of moving objects participating in an event, is provided. Model F also includes elaborate modeling of ParticipantRole in the form participation pattern in a way similar to our notion of, partonomic event relation and event composition through the mereology pattern, causality relation between events through the causality pattern, and correlation between events through the correlation event. These elaborate components are either simplified or omitted entirely to simplify our pattern.

Simple Event Model (SEM) [2]: SEM has a defined core which is relatively close to our model. However, it does not provide for proper spatiotemporal extents. As opposed of axiomatizing event in a precise language like OWL, SEM is modeled purely in RDF: it contains vocabulary terms in the forms of RDF-based classes and properties, and very few axioms in the form of domain and range restrictions. Consequently, its much more loose in terms of modeling variations and not much automated reasoning can be performed with it.

[6] `http://www.w3.org/2003/01/geo/wgs84_pos`
[7] `http://www.w3.org/2006/time`
[8] `http://ontologydesignpatterns.org/wiki/Ontology:DOLCE+DnS_Ultralite`

Other models, such as the following, involve notions of events, but they have been developed for rather different, specific purposes, and are therefore not suitable as generic event patterns:

– SOUPA [1] focusses on ubiquitous computing, but a part of the ontology models events. The modeling only captures spatially static events, i.e. they do not include full spatioetmporal extents.
– Eventory [13] focuses on capturing multimedia events. Place and time, as well as participants, are of course relevant. But other parts of the model focus on the specific multimedia use case.
– The Event and Implied Situation Ontology ESO [11] was developed for the very specific purpose of extracting certain information from text. It is strongly influenced by linguistic considerations, and thus not suitable as a generic reusable pattern for events. It is also relatively elaborate, with over 50 classes.

4 Conclusions

We have provided a core pattern for events, which focuses only on the bare essentials, to be used in cases where more elaborate models are not needed. The pattern avoids ontological commitments which would prevent extension, in particular it refers to proper spatiotemporal extents rather than the simplified view often found in event models that space and time were separable.

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