Proposal of Development of an Ontological Framework for Events as Transitions among Situations

Fabrício Henrique Rodrigues[1], Joel Luís Carbonera[1], Mara Abel[1]

[1]Instituto de Informática – Universidade Federal do Rio Grande do Sul (UFRGS)
Caixa Postal 15.064 – 91.501-970 – Porto Alegre – RS – Brazil

{fabricio.rodrigues,joel.carbonera,marabel}@inf.ufrgs.br

Abstract. *This paper introduces an ongoing research towards the development of an ontological framework for events considered as transitions among situations. This framework is based on the idea that systems as the invariant element shared by each of the successive situations in the course of an event. With that, we intend to establish a criteria to determine which successions of situations correspond to genuine events and what participates in an event at each time. Moreover, from the application of such criteria we intend to derive types of event to help in the tasks of build, assessing, and fixing models of events.*

1. Introduction

In Computer Science, an ontology can be regarded as a specification of a system of categories accounting for a certain view of the world that describes the set of all possible state of affairs considered admissible in a given domain [Guarino, 1998][Guizzardi, 2005, p.82]. Besides categories for *continuants*, i.e., things that *are* in time, being wholly present at any time point they are present (e.g., a person, the height of a building), ontologies may also have categories for *events*, i.e., things that *happen* in time, being only partially present at any time point they are present (e.g., a trip, a concert) [Casati, Varzi, 2015].

Events are usually defined as things that happen in time involving continuants as participants, as well as often described, in some way or another, as transitions between states of the world [Rodrigues, Abel, 2019] (which we will call the *transition view*). Accordingly, current ontologies offer means to build a great variety of models following to this account of event, including several additional aspects of this type of entity (such as mereology, temporal relation, causation, roles for participants, e.g., agent) [Rodrigues, Abel, 2019]. In contrast, they are not so rich in offering criteria to assess which of such models correspond to genuine events and which do not.

Particularly, there is a lack of what we will call *cohesion criteria*, i.e., the criteria to decide whether or not a succession of situations corresponds to a genuine event over and above the such situations, and to determine the participants of an event at a given instant. This lack of cohesion criteria makes it harder to establish guidelines for analyzing, building, assessing, and fixing models for events, analogously to the support we have for continuants (e.g., the OntoClean methodology [Guarino, Welty, 2004]). Additionally, if we only have loose constraints, each user may interpret models based on her/his own implicit view of reality. Finally, it is harder to identify patterns of occurrence to characterize events and to individuate them in the continuous unfolding of reality without a backbone of constraints to rely on. In view of that, we believe that establishing good cohesion criteria can help in advance the ontological account of events.

Thus, in this proposal we propose using the notion of system to provide such cohesion criteria and exploring the consequences of their application to articulate an ontological framework for analysis and modeling of events. In section 2 presents some background notions we employ in this work, section 3 briefly reviews some related work, section 4 briefly describes our goals and approach, section 5 summarizes our current results, and section 6 brings our concluding remarks.

2. Background Notions

In this section we briefly introduce some notions needed to convey the ideas that support this proposal. First, we divided continuants in *objects* (i.e., existentially independent continuants) and *particularized properties* or simply *properties* (i.e., existentially dependent continuants that inhere in objects). Properties can be either *intrinsic properties* (i.e., those that are existentially dependent on a single object, e.g., the weight of a rock) or *relationships* (i.e., those that existentially depend on a plurality of objects, e.g., a contract between two people).

Material Constitution is the relation between something and what it is made of. For [Baker, 2007], when an object *c* constitutes an object *x* we say that *c* is in favorable circumstances so that *x* can exist, being co-localized with *c*. With that we say that *x* is in a higher ontological level than *c*.

In this work, we consider *situation* as an instantaneous, particular configuration of a portion of reality that is understood as a whole and that is determined by a snapshot of a collection of objects (i.e., a set of attributions referring to the properties the objects exhibit and the relationships in which they stand) [Barwise, 1989][Herre, 2010][Guizzardi et al, 2013]. If a situation *s* is a snapshot of a collection of objects which includes the object *x*, we say that *x is present at s* and that *s includes o*.

We use the term s*ystem* to refer to what is called *concrete system* [Bunge, 1979], i.e., a complex object composed of a collection of interrelated material components, forming an integrated whole (with no independent subcollections within it), rather than a mere aggregate of loose things. Its components are linked by what is called *connections*, i.e., relations through which (at least) one of the relata affects the way the other relata will behave given certain circumstances. A system is also characterized by its *environment* (i.e., the collection of entities that are not components of the system, but that are connected to its components).

Similarly to [Guizzardi et al, 2013], we regard an event as an entity that links a collection of two or more temporally successive situations (which we will call the *course of the event*), being a time-ordered transition among them. We say that the initial situation in the course of an event *triggers* the event and that the situations that succeed the initial one are *brought about* by the event. An object *x participates in* an event *e* (and then *e involves x*) iff *x* is *present at* some situation in the course of *e*, and what participates in *e* at time *t* is what is present in the situation in the course of *e* that obtains at *t*.

Still following [Guizzardi et al, 2013], we complementarily regard events as manifestations of dispositions (i.e., particularized properties that exhibit characteristic manifestations under some stimulus conditions, determining the behavior of their bearers under certain circumstances [Choi, Fara, 2018][Röhl, Jansen, 2011]). In this sense, the situations an event brings about are new configurations of the involved participants after the manifestation of certain dispositions of them that were activated in previous situations

that gathered the required stimulus conditions.

3. Related Work

Several ontologies cover the notion of event, usually with some degree of commitment to the transition view. In some cases it is more implicit, defining events as accumulating temporal parts or stages (e.g., SUMO [Niles, Pease, 2001], DOLCE [Gangemi et al, 202], BFO [Grenon, Smith, 2004], YAMATO [Mizoguchi, 2010]). Others explicitly refer to transitions among states of the world (e.g., UFO [Guizzardi et al, 2013], GFO [Herre, 2010], [Bennett, Galton, 2001]).

Some works establish some sort of cohesion criterion concerning the situations in the course of the event. One approach consists in establishing that certain causal-like relations must hold between each pair of successive situations in the course of the event. In YAMATO, events are constituted of processes and each successive phase of a causal process must be caused by earlier phases. In GFO, any pair of successive snapshots of an event (*coinciding presentials of a process*, in their terms) must be causally connected. Another approach is establishing that there must be some invariant element shared by the situations in the course of the event, restricting it to what happens to, for instance, a single object [Lombard, 1998], a set of focal qualities [Guarino, Guizzardi, 2016], or a portion of reality [Guizzardi et al, 2013]. This approach also provides some delimitation regarding what participates in the event in a given instant (e.g., the single object, the bearers of the focal qualities, the stuff that the chosen portion of reality comprises).

However, there are some limitations in those approaches. Considering that successive situations must be causally linked can unify a succession of situations as the course of an event, but it is not clear how it would constrain what can be said to participate in the event. On the other hand, the approach of selecting an invariant element that must be kept throughout the event works both for unifying the course of the event as well as for determining the participants of the event at each time. Nevertheless, the current proposals of invariant element face some difficulties. Restricting an event to what happens to a single object excludes the possibility of events involving multiple participants. Considering an event as what happens to a set of properties allows events with multiple participants, but cannot deal with events involving a varying group of participants (e.g., with participants coming and going or being created or destroyed) since the set of properties that an event affects is necessarily dependent on the involved participants. Finally, constraining an event to what happens to a portion of reality solves the mentioned issues, but introduces a remarkable vagueness on how to delimit such a portion of reality.

4. Goals and Approach

The main goal of our proposal is developing an ontological framework for dealing with events as transitions among situations. Besides that, there are two major secondary goals on the way to achieve our main goal. One of them is elaborating cohesion criteria to unify a succession of situations as the course of an event and to unify a collection of objects as the comprehensive list of participants of an event at a given instant. The other is deriving types of event from the application of the mentioned cohesion criteria to restrict the possible models of event. Moreover, we intend these types to allow additional inferences about properties other than those used to classify the instances.

To achieve that, we adopt the approach of establishing an invariant element that must be shared by the situations in the course of an event in order to both integrate such situations and determine the participants of an event at each instant (i.e., determining what is present in each of the situations in the course of the event). From that, we go on exploring general patterns of variation among situations with respect to the objects they include. We consider both variations on the properties that a given object exhibits in different situations it is present as well as variation on the collection of objects that different situation include (i.e., checking whether the situations include the same objects or some situations include objects that others do not).

As a guiding intuition underlying our work, we make the assumption that a (bona fide) event represents a coherent development following certain tracks that reality itself imposes, rather than being simply the fluctuation on any set of aspects we choose to observe. Thus, we adopted the notion of *system* to characterize the invariant element that gives cohesion to an event, with the components of the system at a given instant being the participants of the event at that instant. With that, we intend to materialize the referred intuition by considering that something that *happens* (i.e., an event) is in fact the delimited by a collection of interacting objects.

Here we can make an analogy with objects (inspired in [Hirsch, 1992]) by taking the case of a car that is half inside and half outside a garage and calling *outcar* the portion of the car that is outside the garage. We can certainly identify the boundaries of *outcar*, which may even be useful, e.g., to recognize that, as time passes, the color of *outcar* is growing fader than that of the other half of the car. Even so, we tend to refrain from considering *outcar* as a genuine, bona fide object. Analogously, even though we can surely track the modification in time of certain object(s) regarding certain properties, it does not necessarily mean that this succession of states of this object (or sum of objects) is a genuine event. Instead, it may simply be a collection of successive outcomes of something that is happening involving these objects.

Moreover, with the notion of system we seem to be able to overcome the limitations that other approaches present. First, an event delimited by a system can have multiple simultaneous participants. Also, being integrated wholes rather than simply mereological sums of objects, systems can survive the change of their components (e.g., a human body remains the same as time passes by, even though the collection of cells that compose it constantly changes). Thus, the participants of an event that is delimited by a system can vary during its occurrence. Additionally, given that a system is composed of objects connected via a special type of relation, we have a fairly strict criterion to delimit the portion of reality over which an event operates. Yet, although it may not be specific enough to account for the particularities of every case, it provides a general guideline for such specialized criteria.

Finally, we employ the notion of constitution to explore the patterns of variation among the situations in the course of an event. With that, besides the account for qualitative changes in the participants of an event, we can also make sense of existential changes (e.g., an object *x* coming into existence in virtue of some other object being put on certain favorable circumstances that make it constitute *x*).

5. Preliminary Results

Exploring the consequences of the notion of constitution, in [Rodrigues, Carbonera, Abel,

2020] we arrived at the position that that every individual object is either a constituted object or an amounts of *basic ontological substrate* (or *substrate* for short), i.e., a type of object on the lowest ontological level, whose instances are the ultimate constituents of the instances of every other type of object. Based on that and assuming that the basic ontological substrate can be neither created, nor destroyed, we elaborated the *principle of ontological conservation*, which states that "*given a closed system, the basic ontological substrate is conserved along time*".

Then, we elaborated the notions of *open* and *closed system* with respect to the exchange of substrate with the environment (either by the entry/exit of components or by the assimilation/release of substrate by components of the system). With that, we defined two types of event: *open events* and *closed events* (i.e., events that are delimited by open and closed systems, respectively). Applying the principle of ontological conservation to them, we derive some further properties.

The substrate involved in a closed event (i.e., the sum of the amounts of substrate that ultimately constitute each of the participants) remains the same throughout the event. Thus, such an event simply corresponds to a rearrangement of the involved substrate with respect to the properties it exhibits. Thus, we derived 5 types of event: *stasis* (i.e., event in which nothing is changed), *qualitative change* (i.e., participants are changed, but remain the numerically the same during the event), *creation* (i.e., an object acquires the favorable circumstances to constitute a new object), *destruction* (i.e., an object loses the properties that made it constitute another object, so that the latter goes out of existence), and *identity change* (i.e., some essential property of an individual object is changed, so that it goes out of existence and simultaneously another individual of the same type comes into existence).

In the case of open events, there is no requirement of invariance of the underlying substrate since part of it can be exchanged with the environment. However, each of those exchanges corresponds to the happening of an *entry event* (i.e., an event in which an object becomes a component of the system that delimits the main, open event or in which some amount of substrate is assimilated by an existing component of the system) or an *exit event* (i.e., an event in which an object ceases to be a component of the system that delimits the main event or in which some component of the system releases some amount of substrate).

6. Concluding Remarks

It is still an open question how general is the account of events on which we are working (i.e., what share of the intended models of event it covers). Still, the idea that what delimits an event is a (possibly varying) collection of interacting objects has some explanatory power for a series of events. For instance, the manufacturing of a product could be characterized by a system of coordinated people, tools, and materials, with several events of entry and exit of participants (e.g., new components being added at each stage of the production). A civil lawsuit also involves a system of interacting people and documents, with entry of participants (e.g., a party appointing an attorney, an attorney filling a new document, a party withdrawing the case). Some natural processes also seem to fit this account (e.g., turbidity currents, which are characterized by a system of water and suspended sediment flowing a slope, with new sediment entering and leaving the system via erosion and deposition events).

We intend to validate the work by applying the resulting framework over case studies and evaluating two aspects. We will assess how well it fits existing descriptions

(i.e., providing means to classify the entities already employed in such descriptions). Besides that, we will evaluate the ability of the framework in revealing participants, events, and relations among events that are implicit in current descriptions of events (e.g., revealing a hidden entry event to justify the appearance of a new participant in the course of an open event).

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