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RESEARCH ARTICLE

Specification of the Fundamental Concepts in the Ontology of Processes; Event, Process, Activity

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Abstract: The topic of analysis of processes and events is becoming increasingly widespread not only in analytical philosophy but also in computer science, particularly in the field of artificial intelligence. Different philosophical approaches to conceptualizing events and processes are compared to obtain the basic concepts, their specification, and interrelationships in this contribution. A conceptual framework for process ontology is proposed, close to natural language and based on John Sowa's approach and the linguistic theory of verb valency frames.

Keywords: Event; process; valency frames; activity; ontology; natural language.

1. Introduction

Alfred North Whitehead (1929) made processes the primary entities in his ontology. According to his approach, the world is composed of deeply interdependent processes and events, and we can look at all the objects from a process point of view, as they undergo changes. However, in the predicate

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logic, processes are predominantly treated as relations between more stable things called objects. John Sowa (2000, 206) shows how the typical mapping of the sentence 'Brutus stabbed Caesar' is the following formula of predicate calculus: stabbed(Brutus, Caesar). He notes that this reglementation ignores many details implicit in the natural language sentence. For instance, we are using different tenses in natural language to reflect that processes are temporal phenomena. It also does not allow further relations to be linked to the verb, such as an adverb 'violently', or a prepositional phrase 'with a shiny knife'. It also cannot support cross references from other sentences, such as 'The stabbing was violent'. To be able to conceptualize all the features of processes relevant in terms of logical consequences became particularly crucial in the logical analysis of natural language.

The problem of appropriate conceptualization of processes also concerns the analytical philosophy. Rowland Stout (2018) points out that there has been a philosophical upheaval recently in our understanding of the metaphysics of the mind. The philosophy of mind and action has traditionally ignored the category of an ongoing process. However, a proper understanding of processes is required to understand subjective experience and agency. He highlights the problem that only ongoing processes can be present to a subject in the way required for conscious experience and practical self-knowledge. The conceptualization of processes and events currently represents a challenge not only for logic and the philosophy of mind but also for computer science, particularly in the field of artificial intelligence, where the reasoning of intelligent agents has temporal aspects and agents have to deal with the changes in their environment.[1] Genesereth and Nillson (1987) pointed out that the intelligent behavior of agents or applications of artificial intelligence (AI) substantially depends on an entity's knowledge of its environment. Much of this knowledge is descriptive and can be expressed in a declarative form. The formalization of knowledge in a declarative form begins with a conceptualization based on concepts and the relationships among them. The problem of appropriate conceptualization is, therefore, crucial for any representation of knowledge and involves interdisciplinary cooperation between philosophy, logic, linguistics, and computer science.

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[1] More about multi-agent systems can be seen, for example, in (Wooldridge 2009).

This paper compares different approaches to processes and events specification from the philosophy of mind and computer science to propose a framework for process ontology, which is close to natural language and based on John Sowa's approach and the linguistic theory of verb valency frames. In this respect, the paper contributes to the logical analysis of natural language.

The paper is organized as follows. First, the general problem of conceptual analysis, ontology, and the related concepts are introduced in the informatics context in section 2. To obtain basic concepts for process ontology and their specifications, certain representative logical and philosophical approaches to process and event conceptualization are compared in section 3. The paper suggests that ontologies may be linguistically based, as they intend to be shared. An event is often indicated by a verb in natural language. It, therefore, seems to be appropriate to make use of the results of the linguistic analysis of verbs, specifically of the theory of verb valency frames, which is introduced in section 4. According to this theory, almost every verb is inherently connected with the so-called verb valency participants. They are parameters of the activity denoted by the verb, such as the agent of the activity (who), the objects that the activity operates on, the resources of the activity, etc. Verb valency frames roughly correspond to the senses of verbs, and through their exploitation, one obtains a fine-grained specification of an activity. John Sowa proposed a linguistically oriented approach to process specification based on his *thematic roles*, which are participants in the verb valency frame. I proceed from John Sowa's thematic roles and the theory of verb valency frames to propose the general conceptual framework for process ontology, introduced in section 5. This general framework has been successfully applied to automated natural language processing cases and agent communication in multi-agent systems.

2. Conceptualization, ontology, and knowledge representation

The topic of ontology is becoming increasingly widespread in computer science, particularly in artificial intelligence. The word ontology was taken from philosophy and then introduced to computer science. It is currently acquiring a specific role in artificial intelligence and database theory. Emilia Currás (2014, 93) notes that

> … it was at the height of the 20th century that the term ontology was first applied to design of classification systems of a certain complexity. Computer specialists consequently turned to philosophers in order to adopt an appropriate term, the main subject matter of which was classification based on the abstraction.

Sowa (1991a, 3–4) argues that the term ontology is often used as a synonym for a taxonomy that classifies the categories or concept types in a knowledge base on the principle of generalization. In that case of generalization, the taxonomy would be a generalization hierarchy, more often called a type or subsumption hierarchy. Gruber (1995, 908) defines ontology as "an explicit specification of a conceptualization". Building on Gruber's definition, the concept of ontology is often interchanged with the result of conceptual analysis that is the basis for knowledge inference. Conceptual analysis should precede the formation of a physical model of any application, and it results from a logical analysis of a respective problem in an AI. Is there any difference, however, between ontology and conceptualization?

Borst (1997, 23) defines ontology as "a formal specification of a shared conceptualization". The main purpose of ontology building is then to capture the described area so it can be shared by a broader community of interested users. Agnieszka Konys (2018) also views ontology as a kind of knowledge conceptualization. She notes that we use the results of knowledge engineering to make gathered knowledge publicly available and reusable, especially in terms of the interoperability of the collected knowledge. Ontologies are therefore shared and mostly formalized knowledge models supporting a correct modeling of reality, semantic inter-operability and automatic derivation in software applications.

It is apparent from the above-mentioned that ontology is connected with logical analysis and conceptualization of the domain of interest. Including linguistic research in the development of ontology is very important for the possibility of proposed ontologies being shared and interoperated. Guarino (1998, 3-4) has pointed out that, in certain cases, the term ontology is:

> … just a fancy name denoting the result of familiar activities like conceptual analysis and domain modeling, carried out by means of standard methodologies. In many cases, however, so-called ontologies present their own methodological and architectural peculiarities. On the methodological side, the main peculiarity is the adoption of a highly interdisciplinary approach, where philosophy and linguistics play a fundamental role in analyzing the structure of a given reality at a high level of generality and in formulating a clear and rigorous vocabulary. On the architectural side, the most interesting aspect is the centrality of the role that an ontology can play in an information system, leading to the perspective of ontology-driven information systems.

Guarino mentions the fundamental role of linguistics in finding appropriate (rigorous and clear) terms for ontological concepts. An appropriate designation of a term is mostly based on the common use of natural language and respects the meaning that the term has in common use. This approach is very close to the analysis of the meaning of words within analytic philosophy approaches. Currás (2014, 89) also points out the fundamental role of linguistics based on the fact that "ontology is structured like a system in which the principal and primary node is the word".

To summarize the above, ontology is based on abstraction and depicts the basic concepts of the domain of interest, their properties and attributes, and the crucial relations between them. Ontologies can be more easily shared if we respect the role of concepts in natural language. However, ontological commitments and conceptualization carried out by ontology also depend on the goals and purposes of the respective application. In this sense, ontology design is also an engineering matter. Gruber (1995, 909) points out on this matter that

> … formal ontologies are designed. When we choose how to represent something in an ontology, we are making design decisions. To guide and evaluate our designs, we need objective criteria that are founded on the purpose of the resulting artifact, rather than based on *a priori* notions of naturalness of Truth.

When designing an ontology, it is very important to find a balance between the fact that the ontology is designed to achieve the goals of the application and the ability to share such an ontology in the broader context, thus also outside of the interested team that created it. A necessary condition for an ontology to be shared is to respect the role of conceptualized terms in natural language. Moreover, when looking for the main concepts and their relations to ontology, it is also necessary to consider already established standards and existing approaches. For this reason, before proposing a general conceptual framework for process ontology, fundamental approaches will be compared in the next section.

3. Continuants, occurrents, and two approaches to processes

Whitehead (1920) distinguished enduring objects, which have a relatively stable identity over some period of time, from the constantly perishing occasions, whose successive stages may not resemble one another. However, according to Whitehead, the reality itself consists of interrelation of continuously developing processes, and it is a structure of evolving processes. Following Whitehead's approach, Sowa (2000, 71) distinguishes the dichotomy of enduring objects called *continuants* and processes or events, which do not have enduring characteristics, called *occurrents*. He defines them from the logical point of view in the following way:

> A *continuant* has stable attributes or characteristics that enable its various appearances at different times to be recognized as the same individual. An *occurrent* is in a state of flux that prevents it from being recognized by a stable set of attributes. Instead, it can only be identified by its location in some region of space-time.

Huang (2016, 16) notes that the continuant/occurrent dichotomy in philosophy corresponds to the endurant/perdurant dichotomy of top-level ontologies in computer science. This dichotomy relies crucially on the relevance of time. *Endurant* is a concept that can be defined independently of time. On the other hand, *perdurant* is a concept that must be defined dependently on time. Huang points out that it is not the shape or other perceivable physical properties, but rather the entity’s continuity of existence in time that plays a central role in the conceptual classification of our knowledge systems.[2]

Hanzal, Svátek, and Vacura (2016, 192-193) provide a general survey of ontologies for modeling events and demonstrate how the dichotomy of *continuants* (entities that persist through time as wholes) and *occurrents* (entities that are not wholly present at every moment) is incorporated into several well-known foundational ontologies. They survey KR Ontology, the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE), PURO, and certain other chosen ontologies based on Web Ontological Language (OWL):[3] The Event Ontology, The Simple Event Model Ontology (SEM), Linking Open Descriptions of Events (LODE). They summarize that in all approaches is central the class of *events* whose instances have time properties and are connected to other entities – place, agents, etc. In the case of SEM there are some additions to this basic model, for example, the modeling of different views. Hanzal, Svátek, and Vacura suggest that classes of different things dispersed in different models are merely subsumed under the common class of events. This creates a relatively flat hierarchy, and they propose more particular classes. Below, there is their tentative classification of events into four categories to remedy the problem of a rather flat hierarchy:

- *C1 - Actions.* They assume an explicit or implicit deliberate agent performing them.
- *C2 - Happenings.* They cover the situations when "something happened", without being initiated by a deliberate agent.
- *C3 - Planned "social" events.* Besides being planned, they typically put emphasis on the spatio-temporal frame rather than on concrete participants.

[2] Endurant/perdurant dichotomy is also present in Sowa's Ontology, Basic Formal Ontology (BFO), see (Smith, 2012), Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE), see (Borgo et al, 2006, 3), The Suggested Upper Merged Ontology (SUMO), see (Niles and Pease, 2001), and many others ontologies.

[3] The Web Ontology Language (OWL) is a family of knowledge representation languages for authoring ontologies. They are built upon the World Wide Web Consortium's (W3C) XML standard for objects called the Resource Description Framework (RDF).

- *C4 - Structural components of temporal entities*. This, possibly less salient, type is inspired by the Audio Features Ontology, which has a common creator with the Event Ontology. These events are "more arbitrary" than those falling under other categories and can be viewed as "regions", however, as merely temporal (and not spatio-temporal) ones. (Hanzal, Svátek and Vacura 2016, 193).

In section 5, I follow their distinction between *action* and *happening*. I distinguish between two types of activities: activities as actions that are performed by the deliberate agent, and activities as happenings that make something happen without being initiated by a deliberate agent.

If we are concerned with the conceptualization of processes, there are two ways of approaching processes in philosophy and logic. John Sowa (2000, 213-214) distinguishes between *continuous* and *discrete* processes. In the discrete process, changes occur in discrete steps called *events*, interleaved with periods of inactivity called *states*. According to Sowa, an event is part of the discrete process where some change is realized and leads from one state to another.

On the other hand, in the *continuous* process, changes take place continuously. When a continuous process has an explicit starting point, Sowa calls it an *initiation*, one with an ending point is a *cessation*, and one whose endpoints are not being considered is a *continuation*. Sowa's approach is based on the distinction between continuous and discrete change. Discrete processes are typical for computer programs[4] or idealized approximations of physical processes.

The approach to processes as continuous entities is close to the approach of Rowland Stout (2018, 1-3) in the analytical philosophy of mind. He has developed a conception of ongoing processes as dynamic continuants. He notes that the philosophy of mind and action has traditionally treated its

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4 A similar approach is applied in informatics representations for discrete processes known as state-transition diagrams and Petri nets. In state-transition diagrams, states are called uniformly. They are graphically represented as circles, while changes of states are called *transition* and are graphically represented as arrows that connect the circles. In Petri nets, states are called *places*, and changes between them are called *transitions*.

subject matter as consisting of states and events, and completely ignored the category of the ongoing processes. For example, in the functionalistic Turing machine model, the mind is treated in terms of states, and the place for mental occurrences is only as state transitions.[5] Rowland Stout comes from linguistics and distinguishes two basic occurrences: *ongoing process* and *completed event*. This distinction is based on the distinct perspectives we have when thinking about occurrences and is reflected in language by means of the linguistic aspect. To describe the ongoing process, we use a progressive aspect, and to describe the completed events, we use a perfective aspect. Compare the following two sentences:

a) 'I was delivering' a lecture this morning.
b) 'I delivered' a lecture this morning.

In sentence a), we think about the occurrence of giving a lecture as something that was happening for a certain period of time and was happening at every moment during that period. We are thinking about occurrences from the inside. We use the progressive aspect in English. In sentence b), we think about the lecture as a completed event extended over some respective period of time. We are thinking about occurrence from a temporal perspective. We use the perfective aspect in English. Stout points out that especially for the purposes of metaphysics of the mind, a proper understanding of mental processes as ongoing processes is required to understand subjective experience and agency.

Terminological ambiguities arise as in a number of approaches, the concepts of process and event overlap, and these terms are treated as synonyms. Bach (1983) called events, states and processes collectively *eventualities*, while Barwise and Perry (1983) used the term *situation* in this context. Sowa specifies events as parts of the process where one state is changing into another state. Stout suggests that in natural language, we often use the term *event* (as opposed to the term process) to mark the distinction we are after.

Whether we may describe the processes as a series of transitions and states, or as ongoing continual processes, depends on the problem to be solved via the proposed ontology. Antony Galton (2018) suggests that there

[5] Compare this approach with John F. Sowa's discrete processes.

is a possibility to share both views to process. Galton describes as an example a situation that 'Pat sets off from home to the station in 8.30 a.m. and arrives at the station 15 minutes later'.

> This situation can be presented experientially, in answer to the question 'What is Pat doing?', or historically, in answer to the question 'What did Pat do?'. The most direct answer to the question 'What is Pat doing?', if asked at any time between 8.30 and 8.45, is 'Pat is walking'. This identifies an open process WALK which Pat is currently realizing. Similarly, the most direct answer to the question 'What did Pat do?' (where the time which is being asked about is presumably implicit in the question context) is 'Pat walked'. This identifies an event which is a 'chunk' of the open process WALK: Pat started walking, walked for a while, and then stopped walking. Any realization of the process WALK must take the form of an occurrence of an event which is a chunk of that process, but in describing it in this way we are saying nothing about how that chunk is bounded, only that it must be bounded in some way. (Galton 2018, 55)

The conceptualization of processes as ongoing continuants or as discrete steps of states interleaved by the transitions of change depends on the problems to be solved by the proposed conceptualization. To avoid terminological ambiguities, I will use the term 'transition' instead of Sowa's term 'event' when describing processes as discrete steps. From a linguistic point of view, we mostly use verbs to express activities that trigger processes. If ontologies tend to be based on natural language, a closer look at the meaning of verbs is needed for conceptualization purposes. In the following section, I will introduce the theory of verb valency frames and Sowa's thematic roles in this context

4. The category of the valency participant as relations-in-intension

As stated above, ontology is based on abstraction. It depicts the basic concepts of the domain of interest, their properties and attributes, and the crucial relations. Ontologies can be more easily shared if we respect the role of concepts in natural language. These strategies for building ontologies, in general, are also relevant to process ontologies.

According to Tichý (1980), the event is expressed in natural language in the sentence where an *episodic* verb occurs. Tichý distinguished between *episodic* and *attributive* verbs. Episodic verbs (e.g., ‘drive’, ‘tell’, etc.) express the actions of objects or people. In contrast, *attributive* verbs (e.g., ‘is dog’, ‘looks speedy’) ascribe some empirical properties to individuals. Tichý’s dichotomy of episodic/attributive verbs corresponds with the dynamic/stative dichotomy of verbs in linguistics, see for instance (Language Tool, n.d.). While *dynamic* verbs (also called action verbs or event verbs) indicate physical action (like ‘jump’ or ‘play’), *stative* verbs convey a state of being or condition (like ‘prefer’ or ‘have’). A major difference between dynamic and stative verbs is that stative verbs cannot be used in progressive (continuous) tenses in English. However, depending on the context, some verbs can be both dynamic and static.[6]

Based on the linguistic approach, the semantics of the respective verb is provided via its valency frame. If we want to base an ontology on the role of concepts in natural language, it could be useful to utilize the verb valency theory as a framework for conceptualizing processes. Verb valency is the ability of a verb to bind other formal units. It determines the number of arguments, so-called verb valency *participants*, controlled by the verbal predicate. These participants can play different roles. There are many classifications of the participants’ categories, for instance, the Czech valency dictionaries VALLEX and Verbalex.[7] John Sowa also provides his own classification and uses the term *thematic roles* for the verb valency participants.[8]

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[6] Compare the verb ‘have’ in the following two sentences: ‘I have a lot to tell you.’ / ‘I have’ as the stative verb versus ‘I am having lunch at 12 PM if you want to join.’ / ‘I am having’ as the dynamic verb.

[7] VALLEX is being developed by the Institute of Formal and Applied Linguistics, Faculty of Mathematics and Physics, Charles University Prague. Verbalex is being developed by the Natural Language Processing Centre Faculty of Informatics, Masaryk University Brno.

[8] A summary of all types of thematic roles can be found in (Sowa 2000, 506-510). Three approaches to classification, according to the two valency dictionaries for the

Sowa developed the system of conceptual graphs, which are specified in (Sowa 1991b, 157), as the system of logic for representing natural language semantics. Unlike predicate calculus, which was designed for studies in the foundations of mathematics, conceptual graphs were designed to simplify the mapping to and from natural language. They are based on a graph notation for logic first developed by the philosopher and logician C. S. Peirce. The conceptual graph is represented as a labelled bipartite graph. Apart from the graph notation, there is an equivalent linear notation where boxes for concepts are represented by square brackets, and the circles for conceptual relations are represented by parentheses. Sowa distinguishes between several types of thematic roles. Below, there are examples of thematic roles of type *Agent* (Agnt), *Destination* (Dest), and *Patient* (Ptnt):

> *Agent* as an active animate entity that voluntarily initiates an action, example: *Eve bit an apple*:
>
> [Person: Eve] ← (Agnt) ← [Bite] → (Ptnt) → [Apple],
>
> *Destination* as a goal of a spatial process, example: *Bob went to Danbury*:
>
> [Person: Bob] ← (Agnt) ← [Go] → (Dest) → [City: Danbury],
>
> *Patient* as an essential participant that undergoes some structural change as a result of event, example: *The cat swallowed a canary*:
>
> [Cat: #] ← (Agnt) ← [Swallow] → (Ptnt) → [Canary: #],
>
> and so on. For details, see Sowa (2000, 508-510).

In addition to above Sowa's participants in the example, we can distinguish other verb valency participants such as *Manner* as a manner of activity execution (example: measure, speed etc.)), *Beneficient* as somebody who has a benefit from an activity, *Direction 1* as the direction from where, *Direction 2* to describe which way, *Direction 3* to describe where to, and many others. When building an ontology, the number or the respective types of participants depends on the problems the concrete application has to solve.

Czech language VALLEX and VerbaLex and John Sowa's approach, are compared in detail in (Číhalová 2011).

From the logical point of view, we can deal with the category of the participant as denoting a relation-in-intension between the concept expressed by the dynamic verb and the object that plays the role of the participant. These relations should be specified as intensions because their value depends on the possible world and time.[9]

In the following section, a revised process ontology is introduced based on the theory of verb valency frames and John Sowa's approach.

5. Analysis of processes based on the verb valency frames

A proposed approach for determining the ontological category of concept is the differentiation between the *static* and *dynamic* parts of the respective domain of interest. The static part of the domain is made up of simple and non-decomposable unique objects and their characteristics, and the dynamic part is made up of the activities and their participants.

The static part comprises entities as logical individuals, characterized by their properties, attributes, and relations between them. Relations can be extensional (mathematical relations such as '1 < 2'), or intensional relationships as 'Peter is higher than Tom'). Based on the temporal aspect, it could be useful to distinguish between *substantive* and *accidental* characteristics of individuals. *Substantive* characteristics are those that individuals have nomically necessarily. This means that in the respective possible world, the individual has these characteristics (properties) during his/her/its whole existence. 'Being a person' is, for example, the substantive property of an individual. These properties in ontology usually form so-called ISA relationships, as in the example 'every apple is a fruit', 'every person is a mammal'.

In contrast, *accidental* characteristics are possessed by individuals purely contingently. The property of being a student is, for example,

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[9] In the background theory of Transparent Intensional Logic (TIL) we view α-intensions as functions mapping possible worlds (of type ω) to type β. Type β is frequently the type of chronology of the elements of type α. These α-chronologies are, in turn, functions mapping time (of type τ) to type α. Thus, α-intensions are usually mappings of type $(\omega\rightarrow(\tau\rightarrow\alpha))$, or in TIL notation $((\alpha\tau)\omega)$,$\alpha_{\tau\omega}$ for short. The foundations of TIL can be seen in (Duží et al. 2010).

accidental; one and the same person contingently becomes a student or stops being a student. Other accidental characteristics of the person-type individuals can be, for example, attributes such as ‘weight’, ‘height’, ‘age’, etc. The value of accidental characteristics is time-dependent.

The dynamic part is made up of activities, i. e. concepts linguistically detected by some special types of verbs called dynamic verbs.[10] Compare the following two sentences describing two processes: ‘Apple is turning red’, ‘Peter is running’. The phrase ‘is turning red’ express the activity of some apple. This activity is not intentional, because an apple is not a deliberative agent. On the other hand, the phrase ‘is running’ expresses an intentional action of Peter. Hazal, Svátek, and Vacura differ in these activities as *happenings* and *actions*. Hence, the activity can be a happening or an action, depending on non/deliberative agency.

Each activity has an agent (who/what is doing the activity) and can involve other objects called participants, such as *Patient*, *Manner*, *Destination*, etc. The respective type of participant expresses the role that a noun phrase plays with respect to the activity described by the governing verb. It can be specified as the relation-in-intension between an activity and the concrete object that plays the role of the respective participant. The number and the categories of the participants depend on the respective domain of interest and the functions of the application or the system of agents. [11]

In the discrete specification of process, we can define a simple process as an ordered sequence of state 1, transition, and state 2. Processes could be compounded from two or more simple processes. A state as a particular state of affairs denotes a proposition, i. e. a truth value depending on the

[10] In contrast, static verbs (e.g. ‘is dog’, ‘looks speedy’) ascribe some empirical properties to individuals. They express the accidental or substantive characteristics of individuals according to above mentioned.

[11] Note, that the static/dynamic part of domain dichotomy is not the same as the occurrent/continuant dichotomy in standard ontologies. In (Sowa 2000, 77), “occurrent categories are characterized by a predicate that depends on time or a timelike succession”. According to this approach, it is problematic to capture the fact, that the property of ‘student’, or an attribute of ‘veight’ are predicates depending on time, however their bearer is not the event. The dichotomy static/dynamic corresponds with the distinction of individuals and their activities in natural language.

possible world and time. A transition, as a change from $State_n$ to $State_{n+1}$ also denotes a proposition.[12] As a simple example, consider these two processes P1 and P2:

P1: $State_1$: Peter is standing; Transition: Peter starts running; $State_2$: Peter is running.
P2: $State_1$: Apple is green, Transition: Apple turns red, $State_2$: Apple is red.

Each more detailed specification of some state or transition can contain other clause members based on the valency of verbs and nouns incorporated also in the static part of the domain. For instance, $State_1$ in the P1 can be described in more detail by other characteristics of the individual and his activity, such as in the example '30-year-old Peter is standing at the station'. The ontological categories of concepts are the following:

- '30-year-old': It is an accidental characteristic of individual Peter, from the logical point of view, it is the value of the attribute 'Age' of individual Peter.
- 'At the station': It is the characteristic of running activity, precisely a participant of type *Destination.* From the logical point of view, *Destination* is the relation-in-intension between activity 'is standing' and some x, which is the station.

$State_1$ in the P2 can be described in more detail by other characteristics, such as 'Apple on the table is green'. The ontological categories of concepts are the following:

- 'Apple': substantive characteristic, from the logical point of view it is the predicate of some x.
- 'Is green': accidental characteristic, from the logical point of view, it is the value of the attribute 'Colour' of some x.
- 'On': the relation-in-intension between x (characterized as an apple) and y (characterized as a table).

[12] The state usually has some temporal length and we can characterize it as an interval. Depending on the needs of the domain of interest, we can characterize the transition with a zero temporal length as the respective time point, or as an interval.

- 'Table' substantive characteristic of some individuals, from the logical point of view it is the predicate of some *x*.

The measure of the process's granularity depends on the aims of the application that the ontology serves. To capture the speed changes of Peter's running, we need to specify the process in more detail. Each speed change has to be captured by adding accelerate and decelerate actions to the ontology. So we can specify at first the $State_1$, where Peter is running at some speed, secondly the transition, where Peter accelerates, and finally, the $State_2$, where Peter is running at a higher speed.

Note, that not only transitions but also states can be specified by a certain activity and its participants, such as in the states '*X* is standing', '*X* is going', etc. However, states can be specified also by some entities with their accidental or substantive characteristics, such as '*X* is green', '*X* is sour apple', etc. In contrast, a necessary condition to specify a transition is some activity, i. e. action or happening. In other words, a transition is always produced by some activity.

The proposed approach is based on dividing the domain of interest into a *static* and a *dynamic* part. This dichotomy is based on some necessary idealization and may certainly be reductive. The world is too complex, however, and each conceptualization effort has to be reductive by its very nature. When performing conceptualization, we have to leave out the details which are not fundamental to our point of view and the aims of the intended application. However, for the purposes of conceptualizations based on natural language, this dichotomy had been successfully applied.

I suggested applying this ontology framework in a classification of the logical types of Wh-questions for multi-agent systems and the logical analysis of such questions in Transparent Intensional Logic (TIL). In (Číhalová, Duží, 2022), we proposed a new classification of Wh-questions that matches the logical structure of agents' knowledge and the logical types of possible direct answers to Wh-questions. To this end, we distinguished questions about static entities, dynamic activities, and their characteristics. We can raise questions about activities, their participants, about substantive and accidental characteristics of objects, and, last but not least, the agents can ask for explication (refinement) of concepts themselves and thus learn new concepts and enrich their ontology.

We also have utilized this framework to provide the rules for converting natural language text into TIL-Script, the computational variant of TIL, see (Číhalová, Menšík 2021) and (Číhalová, Menšík, to appear). This function is part of the tool, which is used for appropriate textual information sources retrieval and natural language processing.

6. Conclusion

The proposed conceptual framework is based on the concept of *activity* (action or happening) and the theory of verb valency frames. If we want to build an ontology close to natural language and involve processes, it is useful to divide the domain of interest into a *static* and *dynamic* parts. The static part includes logical individuals and their substantive or accidental characteristics, and relations. The dynamic part includes activities and their participants. For the analysis of activities, it is useful to proceed from the valency of verbs and specify the relevant types of participants as a relations-in-intension between the activity and the involved objects.

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