Włodarczyk André. 2013. Frames of Semantic Situation", in: Meta-informative Centering in Utterances, *John Benjamins Pub. Co*., Amsterdam, p. 21-40. First published in French "Les Cadres des situations sémantiques", *Études Cognitives / Studia Kognitywne 5*, SOW, PAN, Warsaw, p. 35-51

Frames of Semantic Situations

André WŁODARCZYK
CELTA, Université Paris-Sorbonne
wlodarczyk.andre@gmail.com

In different languages, the means of expressing a situation are shared variously between grammar and lexicon and must be represented by semantic configurations specific to a particular language (or family of languages). Situations are semantic 'nests' for several verbs which allow for the expression of a variety of aspects in the course of communication. For this reason, from a theoretical point of view, semantic situations can be seen as independent of the language in which they are expressed. Research into aspect in diverse languages showed that an aspect could not be explained without first describing the semantic situation. Thus numerous attempts have been made to classify semantic situations[1], especially after the classification proposed by Z. Vendler (1957 and 1967) for explaining aspect in English.

As verbs in natural languages normally express complex situations, semantic situations are made up of other situations, with the result that it is possible to speak of situational aggregates. In other words, situations are mixed up with one another. We maintain, however, that it is possible to separate out a number of situation types and their constituent parts by considering the possibility of classifying them from two points of view. We will hypothesise a distinction between *frame situations* and *rôle situations*. In this article we will consider *frame situations* alone. *Rôle situations* will be dealt with in a subsequent article. Some of the criteria used in our approach have been variously taken into account by different theoreticians, but most have confused the frame/rôle distinction and have thus arrived at less homogeneous classifications than our own. Looking somewhat further ahead, we think that situations can equally be classified according to their *rôle* components, which could be by showing their interactions (situations that are intransitive, transitive, convertible etc.) or their relationship with, amongst other things, centres of attention that are global (subject) or local (object), or again, the nature, countable or otherwise, of the participants, but we will not be dealing with these here.

The aim of this study is to define situations from the point of view of their "internal construction" (i.e. without taking into account modality, tense, aspect etc.) It is indeed desirable (1) to put forward a coherent system of classifying situations based on a small group of well defined primitives and (2) to show the way in which different verbal expressions, used in context, may inherit characteristics from partially organised (hierarchised) situations, taking into account the primitives that have been identified.

1. THE STRUCTURE OF SEMANTIC SITUATIONS

1 François J. and Denhiere G. (eds; 1997, p. 125) list – from 1967 to 1994 – 34 different proposals for the conceptual classification of verbal predicates; amongst which are the works of W. Chafe, S. Dick, Ch. Fillmore, J. François, R. Jackendoff, R. Martin, Z. Vendler, A.R. Verkuyl etc. In the domain of Slavonic linguistics alone one may cite amongst many others, Bulygina T.V. (1982), Laskowski R. (1998), Piernikarski C. (1967), Sémon J.P. (1979) etc.

This research on semantic situations follows on from our work based on the hypothesis of parallel processes which are supposed to characterise linguistic and cognitive operations. Furthermore, as a working hypothesis, we postulate that semantic situations (i.e. situations expressed by linguistic means) have a discrete character (as indeed does everything that we perceive) in spite of the fact that epistemic agents give the impression that they capture the continuum. We also propose (as is frequently put forward) that it must be possible to classify all situations by using as small a group of primitives as possible, and that these, as such, do not directly represent any situation.

Definition 1: A "situation' is any state or course of events contained within limits called "frames".

1.1 Space

Definition 2: There are two types of situation: **static** (the state of things) and **dynamic** (the course of events or actions).

All situations have this in common, that they are located in space (their properties are plotted in three-dimensional space), and that they are distinctive in the way in which they are concerned with time. State is distinguished from the three other kinds of situation known generically as *action situations* (c.f. hereafter) by the criterion of dynamism, that is, by the fact that the passing of time brings about change therein.

Definition 3: The constituent elements of a static situation are its "place" (in the universe of entities) and its "periphery" (places of untimed transition[2])

1.2 Time

All situations (static and dynamic) are surrounded in time by neighbouring situations: preceding or subsequent. As we will see later, neighbouring situations act as transitions for the situations in question.

Proposition: Dynamic semantic situations are structured.

Definition 4: The constituent elements of a **dynamic situation** are its "moments" (timed transitions) and its "stages" (the interval from one transition to the next).

From a conceptual point of view, all situations should only be characteristic. A situation can be said to be characteristic when all the moments and all the stages of its "life cycle" are taken into account, although semanticians often emphasise that languages rarely express characteristic situations without selecting within them any moment or stage (for example, in French, the verb "bouger" would represent the characteristic situation expressing the abstract concept of "movement"), while the language vocabularies are made up of more words which contain aspectual semes[3] (for example, the French verb "arriver" would express the final phrase of the characteristic situation "bouger", or more precisely, of one of its hyponyms "se déplacer"). Thus certain utterances express what we will call *whole* situations, whereas others present situations that are analysed into *moments* and / or *stages*.

Not only are situations analysed – as we have said – into "internal" moments and stages, but they are also related to neighbouring situations that are often taken into account in linguistic expression. Indeed, what happens in the world is never perceived "in a vacuum" but in relation to what comes before and follows on afterwards. Many linguists consider that situations can be seen as subject to "life cycles" with the result that within them we can see the following three - *inner* - stages: "the starting stage" (*begin*), "the middle stage" (*run*) and the "final stage" (*end*). It is to these three fundamental stages in particular that we add two segments, one on either side, representing the preceding neighbouring situation, (*before*) and the following neighbouring

2 Transition is here used as it is understood in the network of bipartite graphs, known as "Petri nets", see later, in the section on representation and formalisation.

3 In fact the categories of tense and aspect in a given language involve semantic situations; they allow the user, by diverse inflectional, derivational or syntactical means, to choose different ways of looking at semantic situations.

situation, (*after*). These two preceding and following situations must be considered as outer stages of the situation in question; they are therefore its immediate preparation and consequence[4].

Proposition: Dynamic semantic situations are complex. This complexity results from the fact that situations do not exist without participants or without the rôles they play.

Given that we are for the time being only dealing with situation frames, these may seem to be simple (i.e. representing one single process). In this case, by representing the situation frame as a straight line (following the linear time model), we obtain the distribution of the elements that make up situations as in figure 1. Each of the constituent elements is here represented by points (showing *moments*) and by intervals limited by markers (showing *stages*). The same linear time model is normally sufficient when representing parallel processes, thus it can also be used for complex situations, since the straight line in figure 1 represents the course of events in a complete situation and is not a measure of time.

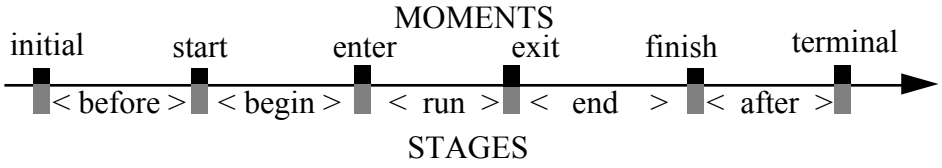


Fig. 1: Distribution of the constituent elements of simple dynamic situations.

Our definitions of semantic situations are cognitive in nature (and not ontological or phenomenological). We distinguish between the four different situations: (1) *states*, (2) *events*, (3) *ordinary processes* and (4) *refined processes*. It should be remembered that despite certain similarities, these terms are either used with *different* meanings in other theories (*states, events, processes*) or are our own terms (*ordinary processes / refined processes*).

In dynamic situations, entities undergo changes as a result of the fourth dimension (time). All dynamic situations develop or progress (a) **by *moments***: *start, enter, exit* and *finish* and (b) by ***stages*** (ordinary and refined processes have three distinct stages: *begin, run* and *end*.) The middle stage (*run*) does not appear in *events* where the beginning is immediately followed by the end, because *events* are perceived without internal duration.

1.3 Progression

Ordinary and refined processes are characterised not only by time but also by progression[5], which is defined as the *movement* from one stage to another. Although time is here a necessary condition, progression must be understood as a succession of stages. Mazurkiewicz A. (2000) sees progression as "continuous change" which is added to the interpretation of states and events[6]. The problems of progression (as well as those of regression) are widely discussed in the *theory* of situation calculus, by both logisticians and roboticists[7]

1.4 Granularity

The fourth concept (but the sixth dimension) which we feel we must bring into the situations model concerns the cognitive *granularity*[8] of stages. Here we must ascertain (clarify)

4 According to the triple of sequential processes (Hoare C.C.R., 1969), operations are preceded by conditions (known as "preconditions") and followed by consequences (known as "postconditions").

5 cf. Mazurkiewics A. (2000).

6 cf. Mazurkiewics A. (1986)

7 cf. Reiter R. (2001)

8 The author of the metaphor "a granule of knowledge" was Zadeh L. (1996. 1997). This concept, first reinterpreted within the framework of the theory of rough sets by Pawlak Z. (1981, 1982, 1991), was then generalised by Polkowski L. and Skowron A. (1999).

the way in which progressions evolve. Granularity can be defined as a conjunction of selectors of semantic features (such as intensity, speed, size, weight, strength etc.). For example, for situations where the granules involve the speed of development, the semantic features can be either *acceleration* ($t_i = v_j$ & $t_{i+1} = v_{j+1}$, c.-to-d.: in t_i time, speed is v_j and in time t_{i+1} speed is increased and is equal to v_{j+1}) or *deceleration* ($t_i = v_j$ & $t_{i-1} = v_{j-1}$, c.-to-d.: in t_i time, speed is v_j and in time t_{i+1} speed is decreased and is equal to v_{j-1}). Most situations with granulated stages are dual pairs of selectors of semantic features concerning (a) the orientation of physical movement (left/right[9], up/down[10], forwards/backwards), and (b) the orientation of psychological movement (movement of the spirit), polarity (yes/no[11], more/less) and intensity (strong/weak[12]) etc. Although the concept of granularity is close to that of discreteness, we will take care not to confuse them.

2. THE PARTIAL ORDERING OF SEMANTIC SITUATIONS.

The regularity of the defining differences between *state* and *actions* (*event, ordinary and refined process*) can be represented in a table showing their position in a hierarchy: the more complex a situation, the more defining features it has. The hierarchical relationships thus elucidated can be compared to the order of classic logic where propositional logic is zero order (order 0), predicate logic is first order (order 1) etc. In the same way, states (static situations) can be seen as being order 0, events, and ordinary and refined processes are successive orders. Thus different situations are included within one another and organise themselves in the following way:

Situation = State ⊆ Event ⊆ Ordinary Process ⊆ Refined Process

This formula reads as: "Situations are ordered: state ⊆ event ⊆ ordinary process ⊆ refined process, from the smallest to the largest". Interlocked situations make up a hierarchical order where each kind of situation inherits the properties of the one that precedes it. The inclusions that we propose in order to define the hierarchical order of types of situations are only concerned with their properties (dimensions).

SITUATIONS				
Characteristic properties (dimensions)	**Static situations**	**Dynamic situations (ACTIONS)**		
	STATE	**EVENT**	**ORDINARY PROCESS**	**REFINED PROCESS**
Space (3D)	+	+	+	+
Time	-	+	+	+
Progression	-	-	+	+
Granularity	-	-	-	+

Table 1: The hierarchy of semantic situations (tabular lay-out)

This table brings to mind certain existing classifications of verbs into semantic groups. As both Vendler Z. (1967) and his successors realised, semantic situations are not notions expressed by verbs alone. The problem is a little more complex since we are here dealing with *semantic types* which sometimes have no direct equivalent in the form of a linguistic expression, but which can be found amongst the semes contained in (a) verbs themselves, (b) verbal periphrases, (c) presuppositions, (d) communicative acts, (e) knowledge etc. Verbs are not therefore necessarily being dealt with for their properties as lexemes, but as verbs employed in

9 e.g. In French "se balancer" is used for a pendulum, but "en avant / en arrière" for a child's swing.

10 e.g. In Polish "machać ręką" (to wave one's hand) but in Japan the gesture designated by the expression "te wo furu" is oriented left / right.

11 e.g. In French "hésiter" between a positive or a negative decision or between a range of decisions.

12 e.g. In French "clignoter" or in Polish, "migotać".

utterances for the purpose of designating situations. Depending on the context[13] in which it is used, the same verb can express different kinds of semantic situations.

2.1. The Hierarchy of types of situation.

One can equally well represent situation types by binary opposition (figure 2).

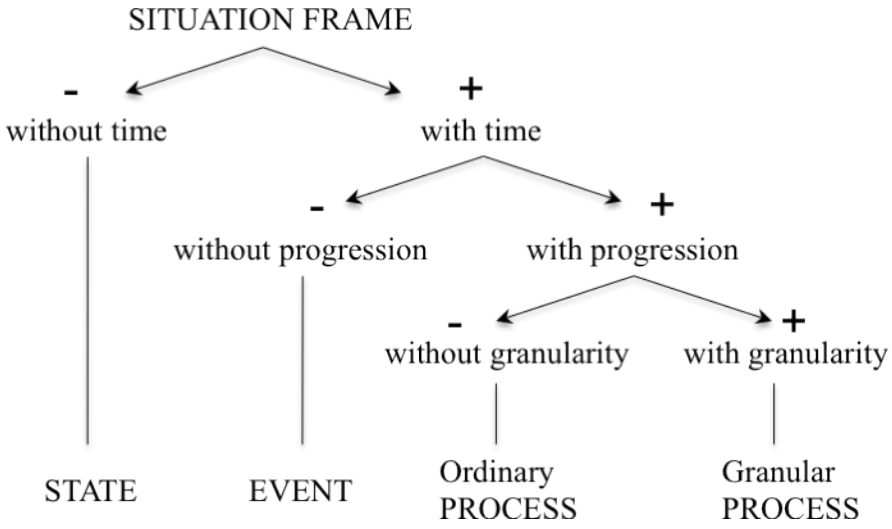


Fig. 2. Hierarchy of semantic situation frames (flow chart)

It goes without saying that the inclusion relationships which we have shown between the different kinds of semantic situations, allow situations to be formed in two ways: successively or in parallel. When one situation follows another, their make-up follows the law of transitivity in inclusion relationships. Winston M. E., Chaffin R., Hermann D.J. (1987) identify the inclusion relationship of classes which precedes the inclusion relationship of composition in the hierarchy, and this in turn precedes the spatial (topographical) inclusion relationship. These authors observed that mixed inclusion relationships are valid if, and only if, the conclusion expresses the weakest relationship in the sense of the hierarchical order existing between these inclusion relationships.

This formal property of inclusion relationships has an interesting application in the description of semantic situations expressed in languages. In the case that we are dealing with here, concrete verbs, even when they express situations of an identical type (e.g. processes), must obey the transitivity of inclusion if their lexical meanings refer to inclusion of different sorts. The weakest inclusion is: *state* ⊆ *refined process.* That is why *states* often follow *processes* or, to put it another way, *processes* are often in a composition relationship with *states* (c.f. result aspect) but in the case of the inclusion *state* ⊆ *event*, it is obvious that it is *events* which should be composed with *states*.

2.2. The situation frames model.

Our model of semantic situation frames is, by its very nature, cognitive. For example, the granules of progression allow us to look at the cognitive refinement with which certain situations (refined processes) can develop (not only nuances of expression). Thus we define a situation as a quadruple containing (1) the name of the situation, (2) its type, (3) its frame and (4) its rôles.

Situation = **{** Name, Type, Frame, Rôles **}**

Names are the names of the verbs (or adjectives) and verbal (or adjectival) phrases. There are four types: states and events, ordinary and refined processes. So as to comply with the

13 By context, we mean not just the aspect-temporal inflections of a verb, but also the actants and the anchors with which it is used.

theorising tradition in linguistics, however, we also distinguish between static situations (states) and dynamic situations (actions: events and processes).

Situation frames have dimensions which determine their type, to which the parameters "moment" and "stage" are added.

Situation Frame = { Dimension, Moment, Stage }

Figure 3 shows the situation frame seen as a "whole situation" or analysed by "moments" and "stages".

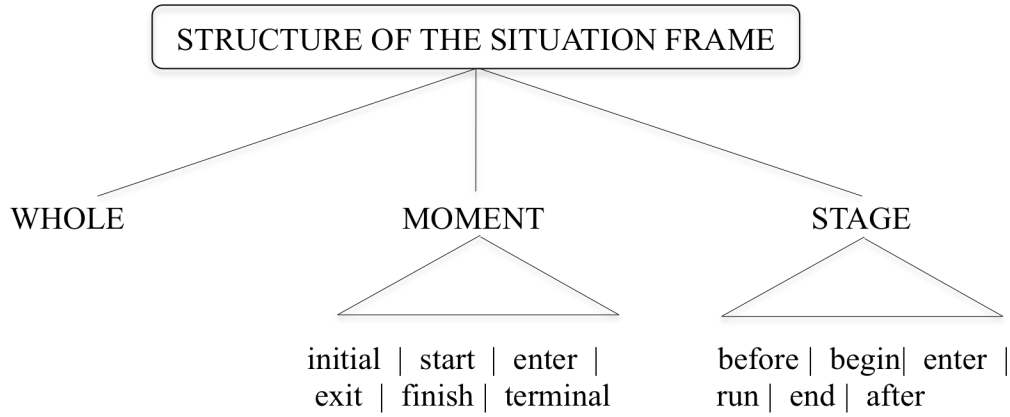


Fig.3. Internal structure of the situation frame

States only have the "space" dimension, they are states of things but they can be transformed into events or even processes. *Events* are characterised by the fact that they have no "middle" element, and as a result, no "run" stage. *Processes* show all moments and all stages, but *Ordinary processes* are distinguished from *Refined processes* by the absence of granularity in their progression. The order of the different types of situation frames can be seen in table 2.

	DIMENSION				**MOMENT**						**STAGE**				
TYPES	SPACE	TIME	PROGRESSION	GRANULARITY	INITIAL	START	ENTER	EXIT	FINISH	TERMINAL	BEFORE	BEGIN	RUN	END	AFTER
STATE	+	-	-	-	+			+			+	-	-	-	+
EVENT	+	+	-	-	+	+	-	+	+	+	+	+	-	+	+
ORDINARY PROCESS	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
REFINED PROCESS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 2: Distinctive features of semantic situation frames

It is important to note that in spite of the presence of the parameters necessary for the representation of aspect (understood as including "modes of action"), the structure of the situation does not *in itself* show any characteristics of aspect. It corresponds to the semantic nest which is the idealised meaning of a family of verbs or adjectives (or indeed verbal or adjectival expressions). At the level of usage, expressions containing the same verbs or adjectives can correspond to different semantic nests in turn, thanks to those mechanisms (the addition of adverbs, prefixes etc.) which allow a choice between the different parameters.

3. EXAMPLES OF TYPES OF SEMANTIC SITUATIONS

The dimensions which we have noted (space, time, progression and granularity) have allowed us to identify four kinds of situations and we will subsequently give some language examples of these. Our article on the aspect parameters (in collaboration with Włodarczyk H., in the same volume) gives many more examples from different languages. In particular, we show that certain aspect procedures (prefixes, conjugated forms, syntactical constructions) allow us to change the association of a verb from one semantic type to another, for example a verb can be changed in this way from a verb of process into a verb of event. In this article, we will simply give some examples without going into the details of the problem of links between aspect parameters and semantic types. We must nonetheless emphasise the fact that the situation structures that we have defined, in particular moments and stages, whilst remaining theoretical, must, independently of aspectualisation, be considered inherent to the situations.

3.1. States

STATE is the simplest kind of situation, and is defined as a situation in space which lasts for a greater or lesser period of time but which is not affected by the passing of time since it remains identical throughout. We therefore consider that the *time* parameter is not applicable to states. In a state, it is not possible to distinguish between successive stages. Although states can have a duration, we do not make any distinction between the state-moment and the state-duration.

Mary is feeling bad.

Marie se sent mal.

Maria czuję sie niedobrze.

At that time all inhabitants of the district were in their beds.

A cette heure-là tous les habitants du quartier étaient couchés.

O tej porze wszyscy mieszkańcy tej dzielnicy leżeli w łożku.

It is possible to consider the start of a state (viewed as another situation preceding it) or the end of a state (considered as another situation following it). Languages have various means of expressing these different ways of looking at states.

3.2. Events

An EVENT, which is a momentary dynamic situation (that is, without progression), has a "start" and a "finish" that are so close that it is not possible to distinguish a run stage between them. Indeed, even if, in reality, nothing can happen without occupying an interval of time, however minimal that may be, in linguistic representation man conceives of events as instantaneous and does not take into account the real time interval which they occupy. On the other hand, *events* can be used to express the start or finish moment of a *state*, an *ordinary process* or a *refined process.*

Depending upon the situation which precedes or follows an event, it is possible to identify three kinds of event. A type E1 event occurs and vanishes with no relationship to a preceding or subsequent event, and can be thought of as a very short moment of time within a state, no sooner starting than finishing**.**

Nagle ***wrzasnął.***

Soudain il poussa un hurlement.

Suddenly he shouted.

A type E2 event precedes a state or an ordinary process the duration of which is not stated, and it can therefore be thought of as a starting point.

*Piotr wczoraj **zachorował**.*

Pierre est tombé malade hier.

Yesterday Peter fell ill.

A type E3 event ends a state or an ordinary process: it can be seen as a terminal point.

Piotre przestał być dokuczliwym.

Pierre a cessé d'être énervant.

Peter stopped being irritating.

3.3. Ordinary Processes

PROCESSES are defined by progression and can therefore be analysed in three stages (start, middle and end). An ORDINARY PROCESS is defined as a situation located in space and it develops with the passage of time (progression). Three stages can be seen in an ordinary process: initial, intermediate and final.

A dark shape was approaching in their direction.

*Jakaś ciemna sylwetka coraz wyraźniej **zbliżała się** w ich stronę.*

Une silhouette sombre s'approchait d'eux de plus en plus nettement.

3.4. Refined Processses

Processes which contain a supplementary parameter, granularity, which repeats itself during progression, are defined as refined processes.

***Machali** do przejeżdżających rękami, **krzyczeli** coś.*

***Ils agitaient les mains** en direction des voyageurs, **criaient** quelque chose.*

***They were waving** at passing travellers and **were shouting** something.*

The semantic features of the granules in certain refined processes can be quantitative in nature. Because of the variation in the size of these features, it is possible to subdivide these processes into three phases[14] which make up their "life cycle" (fig. 4)

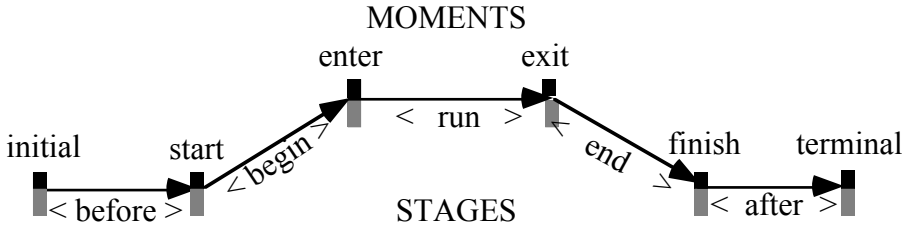


Fig. 4. Diagram of the life cycle of one specific case of a refined process.

More generally, the "begin" stage is thus the phase in which the specific size is increasing (represented by a rising segment), the "run" - the phase where the specific size seems to reach equilibrium (represented by a horizontal segment) and the end stage – the phase where the specific size decreases to the end point of the process (represented by a falling segment). For example, a situation such as "the door is opening" could be analysed in this way in three phases: (a) the initial speed of the progression granule being equal to zero, in the course of the "begin" stage this speed increases, (b) in the "run" stage it is stabilised, then (c) it decreases during the

14 A diagram of this kind is used in numerous works on aspect, e.g. Sémon 1986, Barentsen 1995.

"end" stage.

4. REPRESENTATIONS AND FORMALISATION.

The primary source of inspiration for defining the internal stages of a semantic situation was for us algorithmic in nature. In the course of working out the order of situations, however, we thought it useful to consult theories of modal logic: (1) of **action** (von Wright G.H., 1967), (2) of the **structure of events** (Winskel G., 1982 & 1983; Kowalski R.A. & Sergot M.J., 1986) and (3) of **situations** (McCarthy J. & Hayes P.J., 1969). It was above all the relationship of these theories to computer science which seemed to us to be able to contribute to the development of theories of meaning in linguistics. This continuing dialogue between logic and computer science is, moreover, equally profitable to logic itself. As far as the contribution of logic and computer science to linguistics is concerned, it is barely necessary to point out that generative linguistics owes its appearance to the development of computer science techniques (in particular, to the intensive research carried out on formal languages, including "Chomsky's hierarchy of languages"), and that since then, a great deal of research on natural language processing has been inspired either directly by logic or by theories in the area of computer science on the treatment of symbols.

In order to construct our concept of *situation structure*, however, we relied above all on *sequence structure* as defined by Hoare C. A. R. (1969). It was no doubt this same concept which inspired Moens (1987), and then Moens & Steedman (1988), to propose the "tripartite structure of events" called "nucleus". This nucleus was then adopted by theoreticians of discourse representation: Kamp and Reyle (1993), and other specialists of *modes of action* (Aktionsarten): Blackburn et al. (1993) and Gagnon and Lapalme (1995).

As a result of the intensive use in computer science of both (1) **Petri nets** and (2) the **Event Structures**[15] of Winskel G. (1982 and 1983), and because these two representations are useful for describing parallel structures[16], we can compare the results of our research on situation with the research in this area prompted by Petri nets and event structures. Petri nets were first applied to linguistic analysis by Mazurkiewicz A. (1986, 2000). As we will see, however, our use of the Petri model differs from that of Mazurkiewicz A. (1986) in that we do not deal with inter-situational relationships (i.e. involving multiple situations), and from that of Mazurkiewicz A. (2000) in that we identify two levels of analysis: micro-structural (lower) and macro-structural (higher). In order to present macro-structural concepts we will also use the formalism of "event structures". Nevertheless, the latter will be augmented in the following ways: (a) by adding the time component[17] and (b) by completing the structure of "events" ("semantic situations" in our terminology) with the "terminal moment" and thus, with the "after" stage.

4.1. Semantic situations and Petri nets.

There are at least three different ways of introducing the Petri net system (set-theoretical, graphic and algebraic). We are using the graphic method because of its visual quality. For our current needs we will limit ourselves to a shortened version of Petri nets, known as "ordinary nets", which are made up of the pair (place, transition) and an set of links running from *places* to *transitions* and from *transitions* to *places*. *Places* are represented by circles and transitions by squares. A study of the different interpretations of Petri's axioms (Banaszak Z. & al. 1993, Suraj Z & Szpyrka M. 1999, Grafcet 1979) shows that **places** are often interpreted not only as "states" but also as "positions", "conditions", "local states" or "stages" and **transitions** as "events", "operations" or "actions".

---

15 The semantics of event structures was formulated by Winskel G. for the CCS – Calculus of Communicating Systems of Milner R.A. (1980).

16 We consider that interpretations are parallel processes (Wlodarczyk A. 2002, to be published).

17 Winkowski J. (1992).

By interpreting places as "states" and transitions as "events", Mazurkiewicz A. (1986) showed a direct correspondence between situations and Petri primitives, based on the idea that all semantic situations could be reduced to just *two* categories (states and events). If we consider the situation model used from 1986 to 2000, following Mazurkiewicz A, by Koseka-Toszewa V. (1986) and others (e.g. Laskowski R. or Bojar B.), we first of all see that this model, based upon the classic Petri nets computation (i.e. without any enrichment of a temporal or stochastic kind for example), does not distinguish between (1) the micro-structural level (lower subconceptual level) and (2) the macro-structural level (higher conceptual level). In a Petri net, a place is always followed or preceded by a transition and a transition by a place, in other words two places or two transitions never follow one another. This formal constraint imposes the order of succession (precedence) at the lower level which, taken at the higher level, led Mazurkiewicz A. (1986, p.10) to consider that there might be a natural order characterising the relationship between places (interpreted as "states") and transitions (interpreted as "events").

In our opinion, it is above all the assimilation of the primary concepts of Petri nets with semantic situations (expressed by languages) which leads Mazurkiewicz to propose a relationship of succession (precedence) at the higher level (though removed at the lower level) and to conclude that this generates order (this relationship would be above all transitive and asymmetric) at the higher level also. To realise that this is not in fact the case, one only has to remember that the relationships (of succession or even of concurrence) between semantic situations (in daily life) in fact depend upon expression or are simply unforeseeable[18].

A "transition" in Petri nets is not in itself a dynamic situation. In order to make transitions dynamic, computer scientists proposed extended Petri nets (Murata 1989). In addition, and by this time through the study of aspect in languages, researchers at Berkeley[19] proposed introducing more enrichments into the initial formalism: *"our extensions to the basic Petri Net formalism include typed arcs, hierarchical control, durative transitions, parametrization, typed (individual) tokens and stochasticity"*.

Independently of this, Mazurkiewicz A. (2000) also proposed the extension of Petri nets by introducing the concept of "progression" (represented by a triangle) which allowed him to time transitions. Hence the need to identify the following four kinds of *progression*: (1) open progression [$state_1$ → progression → $state_2$], (2) closed progression [$event_1$ → progression → $event_2$], (3) progression closed from behind [event → progression → state], (4) progression closed in front [state → progression → event][20]. Mazurkiewicz's proposal has, however, profound consequences for the very structure of Petri nets, in particular the need to introduce a third graph, that of triangles. Thus extended, Petri nets would no longer be systems of transitions and places (bipartite graphs[21]), but of systems of transitions, places and progressions (tripartite graphs). Unless the **progression** defined by Mazurkiewicz A. (2000) is a "macro-stage" (cf. Grafcet) and consequently has a semantic interpretation based on the idea of the continuity of operations which define change.

Since we are dealing with languages (including natural languages) the semantic content of which has to do with the "expression" of situations and not their "execution", each kind of situation must be modelled (at the higher level) by using formulae which make it discrete (lower level). The distinction between the macroscopic (higher) and microscopic (lower) levels is capital when one has to compile languages. Thus, if we wanted to represent our situations model, the model proposed by Mazurkiewicz in 1986 (which is based upon a minimum net made up of

---

18 This observation has already been made by Bojar B. (1986, p. 85)

19 Chang N. (1997), Narayanan S. (1997), Chang N., Gildea D. and Narayanan S. (1998)

20 N.B. [state ⟶ progression ⟶ event] ≡ [event ⟵ progression ⟵ state].

21 Following the explanation given by Sowa J. (2000), Petri Nets are a fusion of Flow Chart and State Machine structures, each of which can be represented by a graph. In particular, it is the way in which this fusion was carried out which makes us think of bipartite graphs.

places and transitions) would not be sufficient, because our model is in fact macroscopic. We would therefore need to define a certain number of macro-objects which would be the elementary units of our net. This would entail distinguishing between untimed transitions (t_1, t_2,...t_n) and timed ones (m_1, m_2,...m_n)[22] Timed transitions, called moments, depend on the timing system, a fact which makes them dynamic.

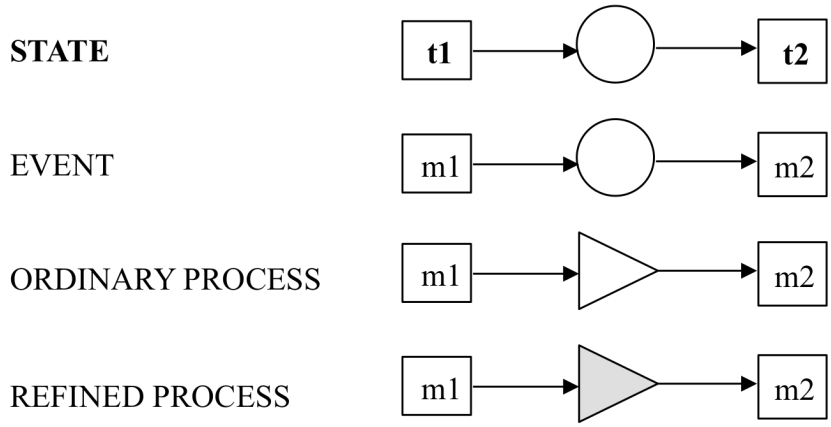


Fig. 5. Four kinds of situation represented by an extended Petri formalism.

In figure 5, state is represented as a "place" between two transitions (untimed) and event as a "place" between two timed transitions. The two kinds of process (ordinary and refined) are characterised by progression represented by a triangle, which here is intended to be a synthesis of the four kinds of progression defined by Mazurkiewicz A. (2000). In the refined process, granularity is represented by the lines subdividing the progression triangle.

Even the representations that we have just proposed, however, are too schematic to take account of the situations model that we described informally in sections 1 – 3 above. Figure 6 represents in an intuitive way a complex situation[23] in which the arrows correspond to paths (in time), some of which are parallel. These parallels reflect the idea that situations contain rôles which, once played, can develop in times that are relative to one another, and all of this is contained within the internal time frame of each situation.

22 "... any time Petri net can be translated by a t-timed net. Formally, a duration of sensitization $d_i = [d_i \text{ min}; d_i \text{ max}]$ is associated with each t_i transition in the net". "In the case of t-timed nets, the interval associated with the transitions characterises their duration. It is the time during which the place tokens on entry are no longer present (they are reserved) but during which the tokens produced are not yet visible in the place of exit" (Pradin-Chézalviel B. et Valette R. - 2000).

23 In the context of organic programming (GAEA system), complex situations are also defined as being made up of primitive situations (Nakashima H. - 1998). cf. also Nakashima H., Ohsawa I. and Kinoshita Y. (1991) and Harada Y. & Nakashima H. (1995).

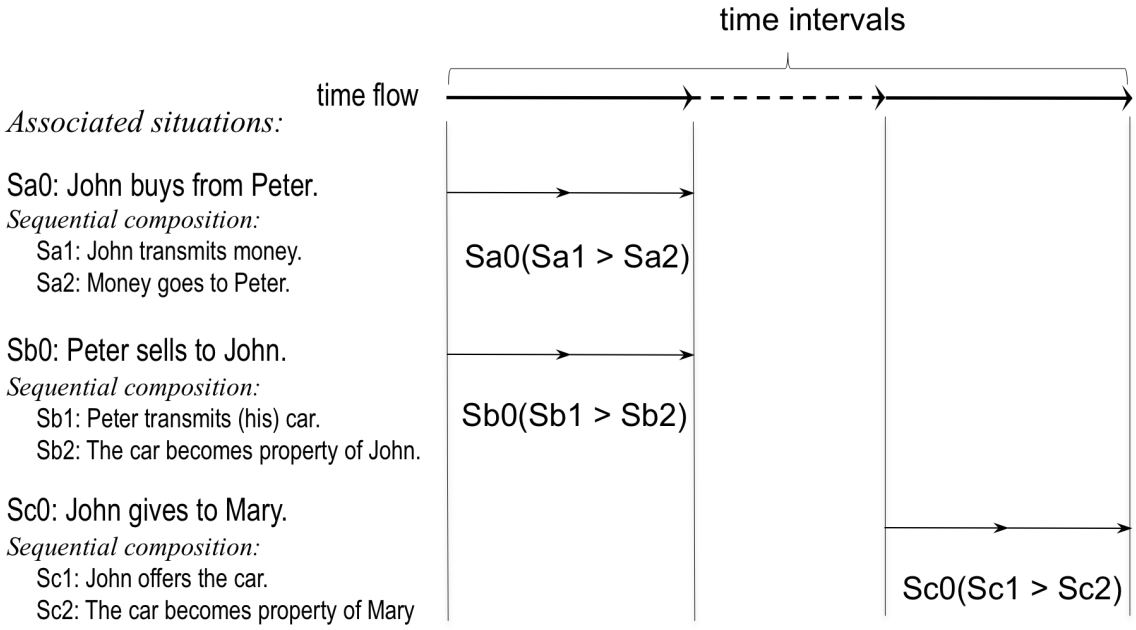


Fig 6. The distribution of elementary situations making up a complex situation following the analysis of "John bought a car (from Peter) for Mary".

The model in figure 6 compared to that in figure 1 simply adds parallels, without changing the time model itself. The internal time of a situation can be simply modelled by linear time. But this is not the case with time in inter-situational relationships. Human experience shows that to take account of these relationships we would have to use the branching model[24] (but not, for example, the circular model).

4.2. Semantic situations and "event structures and the structures of configuration of events"

Semantic situations can also be represented by the concepts of the sequential logic of Hoare C.A.R. (1969) and of extended event structures[25]. According to event structures, any action[26] which takes place in time (timed action) is a quadruple made up of:

- the action itself
- enabling time: t_0
- start time: t_1
- completion time: t_2

The three defined times are ordered: $t_0 < t_1 < t_2$. Taking inspiration from Hoare's logic of sequential processes, according to which all sequences are made up of a prefix $\{\phi\}$ (expressing preconditions), an operation α and a suffix $\{\psi\}$ (expressing postconditions or effect): $\{\phi\}\ \alpha\ \{\psi\}$, we add to the event structures a 4th time (effect or resulting time: t_3). Only those operations α whose preconditions $\{\phi\}$ are true can give results prescribed by postconditions $\{\psi\}$.

In relation to "event structures", in our model of semantic situations what we call *state* is not an event structure because the predicate of the state expresses the property of the objects or entities without the state being characterised by any internal structure. What we have described as an event can be defined in the formalism of event structures as a situation in which the enabling time t_0 coincides with the start time t_1, and the completion time t_2 coincides with the effect time t_3 (in short, $t_0 = t_1$ and $t_2 = t_3$). Thus an *event* can be defined as a particular case of

24 This important observation comes from Kayser D. (personal communication).

25 We call "extended event structures" the events structures of Winksel G. (1982 &1983) integrated into the structures and event configurations of Winkowski J. (1992).

26 In this paragraph we use the terms actions and events in their accepted sense in the "theory of event structures" and not as we define them in our typology of semantic situations.

event structures which we would call *critical situations*. *Ordinary processes*, on the other hand, can be described by event structures, on condition, however, that a middle phase is added between the start and completion times.

Translated by Rosemary Masters

References

BANASZAK Z., KUś J. & ADAMSKI M. (1993) Sieci Petriego – Modelowanie, Sterowanie i Synteza Systemów Dyskretnych, Wydawnictwo Wyższej Szkoły Inżynierskiej, Zielona Góra, Pologne.

BARENTSEN A. (1995) « Trexstupencataja model' invarianta soversennogo vida v russkom jazyke », in., Semantika i struktura slavjanskogo vida, sous la rédaction de KAROLAK St., Wydawnictwo Naukowe WSP, Kraków.

BOJAR B. (1986) « Werbalne wykladniki leksykalne relacji temporalnych w jezykach polskim i bulgarskim » (Les marqueurs lexicaux verbaux des relations temporelles en polonais et bulgare), in Studia Gramatyczne bulgarsko-polskie, Tom I: Temporalność p. 83-91)

BULYGINA T. V. (1982) « K postrojenju tipologii predikatov v russkom jazyke », Semanticeskie tipy predikatov, Moskva.

CHANG N. (1997). « A Cognitive Approach to Aspectual Composition », ICSI TR 97-034.

CHANG N., GILDEA D., NARAYANAN S. (1998). « A Dynamic Model of Aspectual Composition », Proceedings of the Twentieth Annual Meeting of the Cognitive Science Society COGSCI-98. Madison.

Collectif ADEPA, Le Grafcet, diagramme fonctionnel des automatismes séquentiels, rapport de la commision ADEPA sur la normalisation du GRAFCET, Montrouge 1979

DOWTY D. (1979) Word Meaning and Montague Grammar: The Semantics of Verbs and Times in Generative Semantics and in Montague's PTQ , Reidel, Dordrecht.

FRANCOIS J. & DENHIERE G. - éditeurs (1997) Sémantique linguistique et psychologie cognitive, Presses de l'Université de Grenoble.

HARADA Y. and NAKASHIMA H. (1995) « Situated Disambiguation with Properly Specified Representation », in Semantic Amibuity and Underspecification), eds Kees van Deemter and Stanley Peters., CSLI Publications

HOARE C. A. R., 1969. « An Axiomatic basis for computer programming » , in Comm. ACM 12: 576-583.

KOSESKA-TOSZEWA V. (1986) « O temporalności inaczej », in Studia Gramatyczne bulgarsko-polskie, Tom I: Temporalność p. 39-64)

KOWALSKI R. A. and SERGOT M. J., A (1986) « Logic-Based Calculus of Events », New Generation Computing, vol 4.

LASKOWSKI R. (1986) « System temporalno-aspektowo-modalny jezyka polskiego a sieci Petriego » (Le Système temporel, aspectuel et modal de la langue polonaise et les réseaux de Petri), in Studia Gramatyczne bulgarsko-polskie, Tom I: Temporalność p. 23-37)

LASKOWSKI R. (1998) « Uwagi o znaczeniu czasowników », in Gramatyka współczesnego języka polskiego, Morfologia, wyd. 2 zmienione, T. 1 p. 152-157, P.W.N., Warszawa.

MAGGIOLO-SCHETTINI A. & WINKOWSKI J. (1992) Towards an Algebra for Timed Behaviours, Report 677, Institute of Computer Science of the Polish Academy of Sciences, January 1990, and Theoretical Computet Science 103, 1992, pp. 335-36.

MAZURKIEWICZ A. (1986) « Zdarzenia i stany: elementy temporalności », (Evenements et états: éléments de temporalité), in Studia Gramatyczne bulgarsko-polskie, Tom I: Temporalność, p. 7-21.

MAZURKIEWICZ A. (2000) Communication orale sur la progression à la réunion du Groupe de recherche franco-polonais « Etudes cognitives », (Paris, LACITO, 24 novembre 2000)

McCARTHY J. & HAYES, P. J. (1969) « Some Philosophical Problems from the Standpoint of Artificial Intelligence », in Machine Intelligence 4, eds D. Michie and B. Meltzer, Edinburgh University Press.

MILNER R.A. (1980) Calculus of Communicating Systems, Springer LNCS 92

MOENS M. (1987) Tense, Aspect and Temporal Reference, PhD dissertation, University of Edinburgh.

MOENS M. and STEEDMAN M. (1988). « Temporal Ontology and Temporal Reference », in Journal of Computational Linguistics, Association for Computational Linguistics 14 (2):15-28.

MURATA T. (1989) « Petri nets: Properties, analysis, and applications », in Proc. IEEE-89, volume 77, p. 541–576.

MURATA, T. (1991). « Planning with Petri Nets », In Information and Control.

NAKASHIMA H. (1998) GAEA Version 2.3 Manual, Revision 011, Cooperative Architecture Project Team, Electrotechnical Laboratory (ETL), Japan.

NAKASHIMA H. OHSAWA I. and KINOSHITA Y. (1991) "Inference with Mental Situations", TR-91-7: a Technical Report of Electronical Laboratory, Tsukuba (http://ci.etl.go.jp/kyocho/Papers)

NAKASHIMA H., OHSAWA I. AND KINOSHITA Y. (1991) « Inference with Mental situations », TR-91-7Received in 1991-06-22, Electrotechnical Laboratory.

NARAYANAN S. (1997). « Talking The Talk Is Like Walking the Walk: A Computational Model of Verbal Aspect », Proceedings of the Nineteenth Annual Meeting of the Cognitive Science Society COGSCI-97. Stanford: Stanford University Press

PAWLAK Z. (1981) « Information Systems — Theoretical Foundations », in Informations Systems, 6, 205–218.

PAWLAK Z. (1982) « Rough sets », in International Journal of Information and Computer Science, 11, 344-356.

PAWLAK Z. (1991) Rough sets: Theoretical aspects of reasoning about data, Kluwer, Dordrecht.

PETRI C. A (1966) Kommunikation mit Automaten, Schriften des IIM Nr 2, Institut für Instrumentelle Mathematik, Bonn 1962, Traduction en anglais : Technical Report RADC-TR-65-377, Grifftiths Air Force Base, New York, Vol. 1, Suppl. 1, 1966.

POLKOWSKI L. & SKOWRON A. (1999) « Towards adaptive calculus of granules », in L. A. Zadeh and J. Kacprzyk (eds.), Computing with Words in Information /Intelligent Systems, Springer-Verlag Group (Physica-Verlag), Studies in Fuzziness and Soft Computing 30, pp. 201-228.

PRADIN-CHÉZALVIEL B., VALETTE R. (2000) « Accessibilité de marquage et logique linéaire dans un réseau de Petri t-temporel », (chezalviel@laas.fr, robert@laas.fr), IUT A, Université Paul Sabatier, Toulouse, France.

REITER R. (2001) Knowledge in Action – Logical Foundations for Specifying and Implementing Dynamical Systems, The MIT Press, Cambridge, Massachusetts, London, England.

SOWA J. F., (2000) Knowledge Representation: Logical, Philosophical, and Computational Foundations, Brooks Cole Publishing Co., Pacific Grove, CA.

http://www-ksl.stanford.edu/email-archives/srkb.index.html

SURAJ Z. & SZPYRKA M. (1999) Sieci Petriego i PN-Tools (Narzędzia do konstrukcji i analizy sieci Petriego), Wydawnictwo Wyższej Szkoły Pedagogicznej, Rzeszów, Pologne.

VENDLER Z. (1967) « Verbs and Times », in Z. Vendler, Linguistics and Philosophy, Ithaca, Ithaca, New York: Cornell University Press., pp. 97-121 (revised version of Vendler Z. « Verbs and Times », The Philosophical Review, 66 (1957), 143-160)

Von WRIGHT, G. H. (1967) « The Logic of Action : a sketch », in The Logic of Decision and Action, ed. Rescher N., University of Pittsburgh Press

WINKOWSKI J. (1992) « Modelling timed behaviours with the aid of Event and Configuration structures », ICS PAS Reports, N° 715, p. 34

WINSKEL G. (1982) « Event Structure Semantics for CCS and Related Languages », Springer LNCS 140, pp. 561-576

WINSKEL G. (1983) « Event Structure Semantics for CCS and Related Languages », Aarhus University, DAIMI PB-159, April 1983

WINSTON M. E., Chaffin R., Hermann D. J. (1987) « A Taxonomy of Part-Whole Relation », Cognitive Science , N°11, p. 417-444.

WŁODARCZYK A. (2002 à paraître) « Linguistique dynamique: évolution du discours dans le temps », Communication au Xe Colloque international romano-slave sur « Temps et temporalité » à l'Académie Pédagogique de Cracovie, sept. 2000.

ZADEH L. A. (1996) « Fuzzy logic = computing with words », IEEE Trans. On Fuzzy Systems 4, p. 103-111.

ZADEH L. A. (1997) « Toward a theory of fuzzy information granulation and its certainty in human reasoning and fuzzy logic », Fuzzy Sets and Systems 90, p. 111-127.