Business
Object
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Program

simplifying semantics

Working Paper

OP4

Ontology: Paradigms - 4

Business Object Ontology Paradigm

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OP4

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Business Object Ontology Paradigm

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OP4

ONTOLOGY: PARADIGMS - 4

BUSINESS OBJECT ONTOLOGY PARADIGM

1 Introduction

OP3—Logical Ontology Paradigm describes logical semantics. It might appear that this has all that a business objectontology needs. At an operational level this is right, but at an understanding level—the level of business modelling—it misses something. The analysis of the logical paradigm's semantics shows it is shaky for the last of the four key types of things—changes. The shift to the business object paradigm is driven by the need to give change a firm semantics.

So in this paper, we focus on the object paradigm's semantics for change. We do this in two stages. In the first part of the paper, we deal with the semantics of physical bodies, persisting through changes. In the second part, we consider the semantics of the changes themselves

We start the first part with a series of thought experiments that clarify the logical semantics for physical bodies, persisting through changes and the issues it raises. We then explore the shift to object semantics for physical bodies and see how it resolves the issues raised by logical semantics.

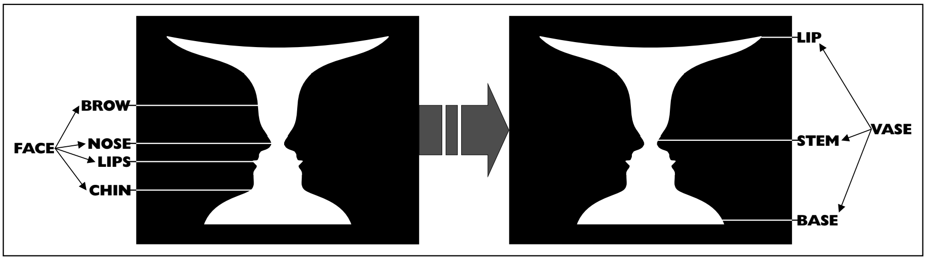
Then, we look at an example of how the new object semantics for physical bodies can transform our current notions. We see how our notion of 'stuff' is re-engineered into the semantically richer notion of stuffs as physical bodies.

Then, we re-engineer the logical notions of class and tuple objects constructed from physical bodies.

2 The logical semantics for physical bodies

The evolution from logical semantics to object semantics involves a pure shift in our understanding of what objects, whether bodies or changes, are. In *AS3—What and How we Re-engineer*, we used an ambiguous picture as an analogy for how paradigm shifts work. This is useful for explaining what happens in the shift to object semantics. In *Figure OP4–1*, when we shift from seeing two faces to seeing a vase, nothing in the underlying picture changes. In the same way, the shift to object semantics does not involve any new facts, just a new way of seeing the old facts.

Figure OP4–1
Shifting views



This new way of seeing resolves a central problem for physical bodies, explaining how identity persists through change. We have illustrated this problem before with a lepidopter. Over time it goes through various stages. We need to be able to explain why and how these different stages are, in some sense, the same object; even though, for instance, the butterfly stage of the lepidopter is so obviously different from its caterpillar stage. We saw in *OP2—Substance Ontology Paradigm* how Aristotle's substance paradigm gave a consistent explanation (illustrated in OP2's *Figure OP2–5* and *Figure OP2–6*), but one based on the now discredited notion of substance. In *OP3—Logical Ontology Paradigm*, we saw that logical semantics cannot give an explanation; that something can both be the same and different at different times is a mysterious fact.

Before we make the shift away from logical semantics, we give ourselves a context by examining our current intuitions about physical bodies' identity over time. We do this in three thought experiments:

- The wrecked car,
- The car-minus, and
- The chairman experiments.

These reveal how we determine whether physical bodies are the same at different times and how 'two' physical bodies can be the same at one time and different at another time. We gain further insight by examining how the substance paradigm deals with these thought experiments.

2.1 Wrecked car thought experiment

We instinctively use a key criterion to decide whether an object is the same at different times—this is whether it has persisted continuously through time. In everyday life, we often make the decision on the basis of how the physical body looks and feels. This first thought experiment is designed to show how seriously we take the criterion of continuity and that the look and feel of a physical body are only practical stand-ins.

Assume I buy a brand new car. Using an advanced science fiction device, supplied to me for this experiment, I make a record of the type and position of every atom in the car. I then lend my car to a friend for a week.

At the end of the week, he brings me two cars. They are the same make and model, but one is brand new and the other is a smashed up wreck. He says that one of the cars is mine and asks me which one. The smashed up car does not look at all like my original new car; everything is either bent, torn or scraped. But the other car does. I double check by using the science fiction device to get a picture of its atomic structure, which I compare with the record I made at the beginning of the week. They match perfectly. With this evidence, it would only be natural for me to assume this is the car I bought at the beginning of the week.

Now my friend introduces me to a camera crew who have been filming my car over the last week. They show me their film. It starts at the beginning of the week and follows, without a break, everything that happens to the car and ends up with my friend bringing the two cars in to me. In the film, I see my car going through a number of accidents until it is the smashed up wreck that is before me now. Now I realise that the smashed up car is, in fact, mine. Now I am not, and you wouldn't be, tempted to say that the new car is mine.

Why is this? It is because there is a continuous link between the car at the two times. This takes precedence over any evidence about how the car looks and feels. Continuity is the key criterion. It is the ultimate basis for our judgements on whether things are the same at different times. But it does not explain why they are the same.

2.2 Car-minus thought experiment

At any one time, two objects must either be the same or different. In this thought experiment, we see that the same is not true over time. Sameness can change over time; two objects can be different at one time and then the same at a later time.

Assume, again, that I bought a new car last week. An object is an extension, so I can construct an object by specifying an extension. Assume that I did this when I bought my car; assume I chose an extension, consisting of the car minus its back seats—and called it car-minus. Car-minus is obviously different from my car; they have different extensions. Car and car-minus are also both physical bodies that persist through time.

Now, assume that today I take the back seats out of my car and destroy them. Then, my car has changed; it is now without any back seats. But car-minus has not changed; the back seats were never part of it. It would appear that car and car-minus now have exactly the same extension; my car minus its back seats.

Under logical semantics, this means they must be the same object. Because physical bodies are instantaneous extensions, at a particular time, one can determine whether they are the same or different by seeing whether they occupy the same extension. We cannot meaningfully ask this question in the same way about physical bodies at different times. Because they change position, shape and size, their extension is not a reliable guide.

2.3 Chairman thought experiment

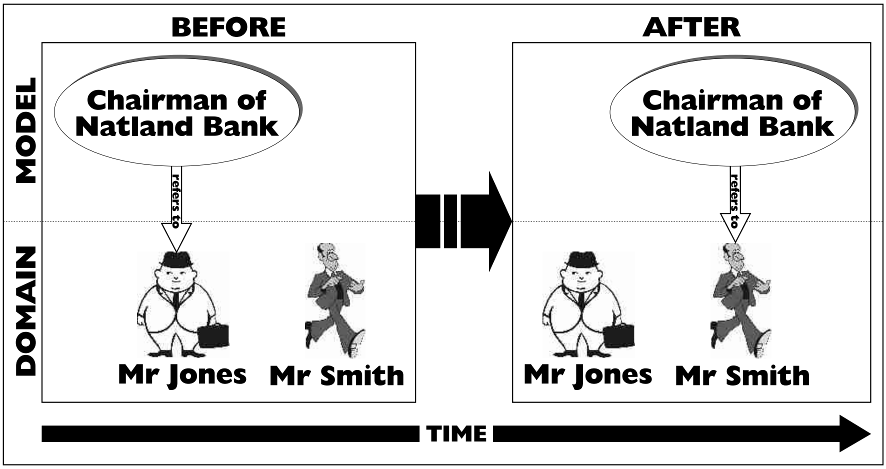
The car-minus experiment is contrived. It was meant to be, so that we could see the situation clearly. Because it is academic, I'm sure some (probably most) of you are tempted to dismiss it as irrelevant to anything commercial. But you should not. Any physical body could end up in a similar situation. We can see this in the following thought experiment that uses a modern version of an ancient puzzle; one that was known well before Aristotle's time. The puzzle was often expressed as a question—can two things be in the same place at once?

Consider Mr. Jones, the Chairman of NatLand Bank. Under logical semantics, if the concept 'Chairman of NatLand Bank' is legitimate it must refer to an object, similarly for the concept 'Mr. Jones'. In fact, we know they are both concepts and refer to the same object.

Technically speaking, under logical semantics, objects are extension. And if what appears to be two objects share the same extension (in other words, have the same height, width and depth), they are really the same object. Two objects *cannot* have the same extension at the same time. Because we know that the concepts 'Chairman of NatLand Bank' and 'Mr. Jones' refer to the same extension, they must, by the logical semantics' definition, refer to the same object.

We now move on a week or two. Mr. Jones has resigned his chairmanship and Mr. Smith has been appointed the new chairman. From logical semantics' perspective, the concept 'Chairman of NatLand Bank' now points to the same extension as the concept 'Mr. Smith' (shown in *Figure OP4–2*).

Figure OP4–2
Changing reference

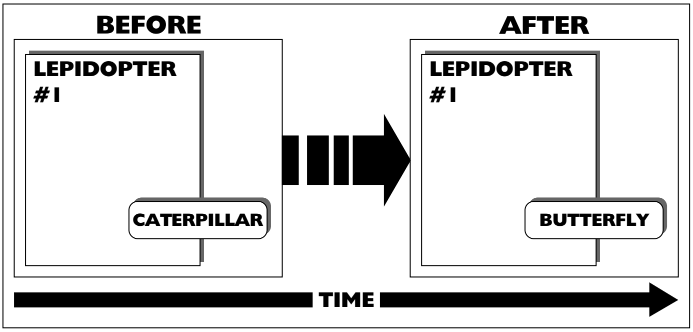


It is plain that the concept 'Chairman of NatLand Bank' has changed its reference and now points to Mr. Smith. And this is not a special situation with an obscure case; it occurs in every business with every position, from tea boy up to managing director.

2.4 Aristotle's explanation of the experiments

These questions about how sameness over time works are ancient. In *OP2—Substance Ontology Paradigm*, we saw how Aristotle developed his notion of substance in a way that, as far as he was concerned, gave a clear explanation. We illustrated this with the example of the stages in a lepidopter's life. In the substance paradigm, the caterpillar and butterfly stages of the lepidopter were the same because they had the same substance. The reason they looked and felt so different is that they had different attributes (shown in *Figure OP4–3*). For Aristotle, one of substance's main purposes was to explain sameness over time. When logical semantics replaced the notion of primary substance, it could no longer use Aristotle's explanation.

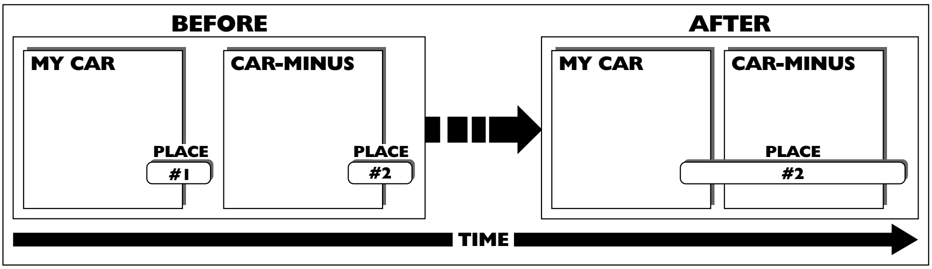
Figure OP4–3
A lepidopter substance—caterpillar and butterfly attributes



Faced with the three thought experiments, Aristotle could use substance to give clear answers. In the wrecked car experiment, he would say that the two cars were the same because, like the lepidopter, they had the same substance.

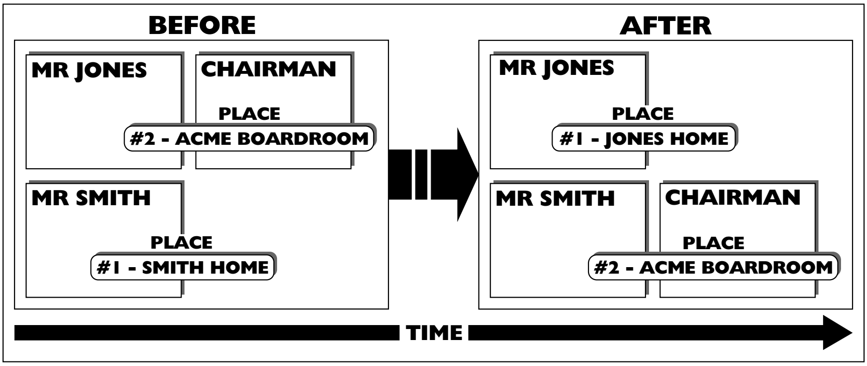
In the car-minus thought experiment, Aristotle would say that my car and car-minus (if he accepted that car-minus existed) are different substances. He would explain what happened when I took the back seats out of my car as two substances starting to share the same place (shown in Figure OP4–4) where place is the Aristotelian equivalent of extension.

Figure OP4–4
My car and car-minus sharing a place attribute



Aristotle would have offered a similar explanation to the Chairman of NatLand Bank thought experiment. He would have suggested that there is a third substance, the Chairman of NatLand Bank, in addition to the Mr. Jones and Mr. Smith substances. This shares a place attribute with the other two substances at different times (shown in Figure OP4–5).

Figure OP4–5
Chairmen sharing place predicates



3 The shift to object semantics

Aristotle's explanations of the three thought experiments show the benefits, when capturing change patterns, of having place (his version of extension) as an attribute category rather than a foundation for physical bodies. However, we should not be tempted to retreat back to substance. Object semantics' shift to a new particle for physical bodies provides us with a much better tool for capturing these change patterns.

3.1 The origins of object semantics

We start the re-engineering by looking at its origins in a new way of seeing developed in physics. The role model for this way of seeing was Albert Einstein's amalgamation of space and time to space-time in his theory of relativity. This is not normally applied in everyday life, to ordinary people-sized objects. However, a number of people (including one of today's leading philosophers, Willard Van Orman Quine) saw how Einstein's notion of space-time can be used to resolve the problems of identity of people-sized physical bodies. As Quine says:

> *Our ordinary language shows a tiresome bias in its treatment of time.*

This 'tiresome bias' is treating time as something completely separate from space. His answer is to follow Einstein and treat time as another dimension on a par with space's three. One of the benefits of this shift was that the patterns for space and time were amalgamated into general patterns for space-time. As we shall see, this proved particularly fruitful for whole–part patterns. The key shift we focus on here is in the central notion of extension; from space-based and three-dimensional to space-time based and four-dimensional.

3.2 Explaining our intuitions

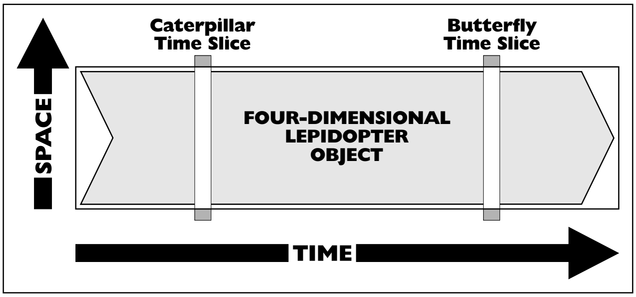
This shift takes some getting used to. However, once we do, it seems natural; it appears to be an explicit explanation of what we have already grasped intuitively. It certainly fits in neatly with many of our intuitions. For instance, it not only respects our intuition that continuity is a key factor in identity, but explains why by giving continuity a physical embodiment.

3.2.1 A four-dimensional lepidopter

We can see how this works with an example. In logical semantics, individual physical bodies are extensions and extension is three-dimensional; height, width and depth. A lepidopter in a caterpillar state is a physical body with a three-dimensional extension. Similarly when a caterpillar metamorphoses into a butterfly, it is also an object and so is also a three-dimensional extension, but a different one. What makes these two extensions the same object is that there is a continuous link of time-stages between the caterpillar and the butterfly.

The new object semantics follows Quine and Einstein's lead and assumes extension is four dimensional: space's three dimensions and the time dimension. In it, the lepidopter is one four-dimensional object. The two, three-dimensional objects from logical semantics are now just slices in time of the new four-dimensional object as illustrated in *Figure OP4–6*.

Figure OP4-6
A four-dimensional lepidopter



In this four-dimensional way of looking at things, continuity across time is now the same as continuity across space. We can look up and down a lepidopter in space or backward and forward in time along it. The continuity in time that we merely intuitively grasped before is now transformed into something as physical and tangible as continuity across space.

3.2.2 The general trend away from egocentricity

We can see this shift to space-time is part of a general trend—a trend from an egocentric to a more 'objective' view of the universe. When children are young, they see the world revolving around themselves. As they grow up, they begin to realise it does not. In some ways, adults still retain an element of that egocentric attitude. For instance, most of us half believe in a variation of Murphy's law—that things happen when they are most inconvenient for us. So, we half suspect that it is raining because we forgot our umbrella or because we were going out to play tennis. Whereas, 'objectively' we know that the weather is not influenced by our future plans.

We can see a similar egocentric attitude in the earth-centred theory of early astronomy. This assumed that because people see the earth standing still and things moving in the skies, the earth must be standing still and the planets and stars moving. When, in the 15th century, Copernicus suggested the earth was just another planet moving around the sun, he was suggesting a less egocentric view of the cosmos. One in which humans lost their special position at the centre of the universe.

Copernicus' theory overturned an egocentric view of space. Quine and Albert Einstein's theories take this one step further and overthrow an egocentric view of time. We assume that, because we are at a particular point in time, our position must be special. This is egocentric. Why should the point in time that we inhabit (called the present) have a special quality? Most people do not think, when walking down a path, that that point on the path is special because they are there. The present is much like any other point in time. In fact, all points in time have been, or will be, at some time the present.

We tend to think of space and time as different because our experiences of them are so different. But we are interested in the things in themselves, not how we experience them. Just because something looks different, does not mean it is different. This is particularly clear when we can use two senses to 'perceive' the same type of object. When we touch one banana and taste another we get very different feelings; but we have no problems in recognising them as belonging to the same type of thing. We should think about perceiving time and space in the same way; that we are perceiving the same type of thing with different senses.

3.2.3 How business models have anticipated this shift

In one way, business modellers have already recognised the similarity of the space and time dimensions. They intuitively and instinctively translate the time dimension into a spatial dimension in their models.

We can see this by contrasting a business model with an engineer's working model of a steam engine. We expect the engineer's model to have pistons that move up and down when fuel is burnt in its combustion chamber. We judge the model by how accurately its movements reflect the movements of a real steam engine. If it did not move, we would say that it did not 'work'.

What is interesting is that a business model does not 'work' in the same way. Unlike the engineer's model, it is not expected to reflect changes in the business by moving or changing. Instead, it models one process following another in time as one process following another across a piece of paper. The changes in time are modelled by shapes in space.

Business modellers compact the four spatio-temporal dimensions onto a two-dimensional piece of paper; time is translated into space. This is analogous to the way an architect describes the three spatial dimensions of a building on a two-dimensional piece of paper—compacting three spatial dimensions into two.

There is an ancient precedent for this interchanging of time and space, one that we are all familiar with—writing. Its characters use space to describe the way speech's sounds change over time. They use a spatial dimension to represent speech's time dimension.

3.3 Re-interpreting the thought experiments

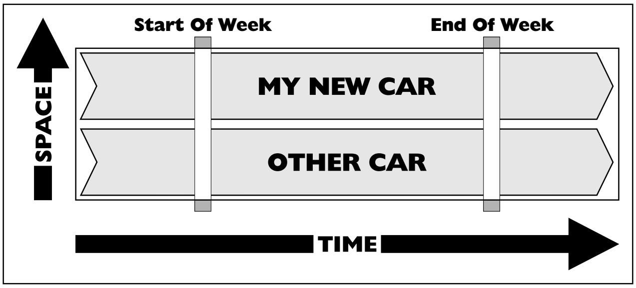
We now examine how object semantics resolves the problem of physical bodies' identity over time by looking at the earlier thought experiments through four-dimensional eyes. We need to be able to draw the four-dimensional objects that this reveals in some way. We cannot draw four-dimensions. But if we use the business modeller's technique of compressing dimensions to fit four dimensions into two, then we can draw a diagram called a space-time map. In it time, the most important dimension for us here, goes across the page and the three dimensions of space are condensed into one that goes up the page. (*Figure OP4–6's* four-dimensional lepidopter is an example.) Those people familiar with state-transition diagrams can see this as, in some ways, a simple O-O version.

3.3.1 Wrecked car thought experiment

We look at the wrecked car thought experiment first. When we did this experiment earlier, we gave a reason for seeing the two time-stages as stages of the same thing. We could trace a continuous link from the first time-stage to second. There was a continuous link between my car in its original new state at the beginning of the week, through all its mishaps during the week, to the battered wreck at the end of the week.

We now have a different way of interpreting this explanation based upon my car as a four-dimensional space-time object. The time-stage that was a brand new car at the beginning of the week is a part of the space-time object; the wreck at the end of the week is another part. The two time-stages are now slices in time of the new spatio-temporal physical body, as shown in *Figure OP4–7*.

Figure OP4–7
Space-time map of my new car

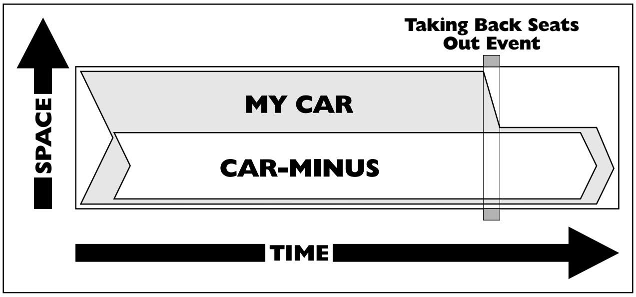


This explains quite clearly why we regard the 'continuous link through time' as far more important than an object's look and feel. It is no longer a link through time but a line along the time dimension of a four-dimensional physical body. This four-dimensionality provides a simple and tangible explanation for a physical body's identity over time.

3.3.2 Car-minus thought experiment

Object semantics also leads to a consistent re-interpretation of the car-minus thought experiment. In the original experiment, we had the odd situation of my car and car-minus starting off as different objects and ending up as the same object. Look at the space-time map of the objects in *Figure OP4–8*.

Figure OP4–8
Space-time map of my car and car-minus



We now see my car and car-minus as different objects, irrespective of time, because they occupy different bits of four-dimensional space-time. There is no temptation to see their sameness change over time. The parts of these two objects that fall inside the slice of space-time called today, occupy the same bit of space (and small slice of time). But because these objects are now four-dimensional, we see this as the result of two four-dimensional objects with overlapping extension rather than as two three-dimensional objects occupying the same extension. The object paradigm gives us a consistent, simpler and more sophisticated notion of sameness. It enables us to coherently make distinctions that are impossible in the logical paradigm.

You may have noticed that we are treating temporal (time) parts in the same way as we treat spatial parts. We are re-using the patterns we have established for spatial parts on temporal parts. The steering wheel, gear stick and dashboard are all spatial parts of my car. My car today is a temporal part of my car. Car-minus is a spatio-temporal part of my car. Because time and space dimensions are on a par, all these varieties of car parts are regarded as the same type of thing—spatio-temporal parts of my car. We naturally extend the spatial whole–part patterns to spatio-temporal whole–parts. We shall see later on in this paper (and in *MW—The BORO Methodology: Worked Examples*) that when we use object semantics; these more general, more powerful, patterns for whole–part crop up frequently. In fact, the next thought experiment uses them.

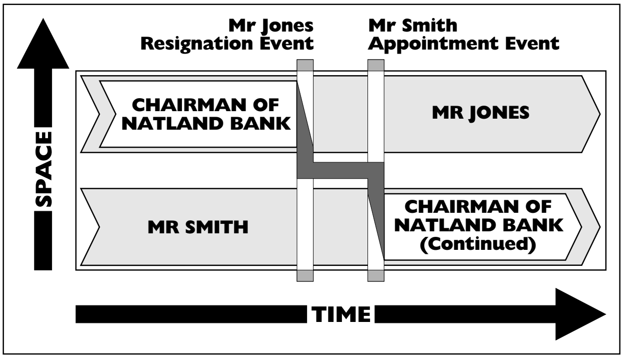
3.3.3 Chairman thought experiment

We now re-interpret the Chairman of NatLand Bank thought experiment into the new object semantics. Under logical semantics, the chairman seemed to be a physical body that changed sameness. It was the same as Mr. Jones at one time and then, later on, the same as Mr. Smith.

Now look at *Figure OP4–9*; it contains a space-time map of the four-dimensional chairman object. In this map, Mr. Smith and Mr. Jones have simple straight time-lines. The Chairman of NatLand Bank object is less simple. It is composed of temporal parts of Mr. Smith and Mr. Jones. A time-slice of Mr. Smith's time-line is his chairmanship. Similarly, a time-slice of Mr. Jones' time-line is his chairmanship. The fusion of these two chairmanships, and all the other chairmanships, is the

Chairman of NatLand Bank object. This object does not change sameness. It is never the same object as Mr. Smith and Mr. Jones. What logical semantics interpreted as sameness is now re-interpreted as overlapping.

Figure OP4–9 Space-time map of the Chairman of NatLand Bank



At first sight, this notion of a four-dimensional, multi-time-slice, chairman seems odd. It is made out of pieces of other objects and, a major sticking point, it is not continuous. For example, there is a discontinuity between Mr. Jones' resignation and Mr. Smith's appointment. We intuitively expect physical bodies to be continuous over time. However, a radical paradigm shift, such as the shift to object semantics, is bound to lead to what seem initially like counterintuitive situations.

Object semantics provides a simple and powerful explanation of how Mr. Smith and then Mr. Jones 'are' Chairman of NatLand Bank without being the same object as the Chairman of NatLand Bank. We now see that they share temporal parts (slices of their time-lines), but do not have the same overall four-dimensional extension (and, so are not the same physical body).

We originally introduced this experiment with the ancient question—can two things be in the same place at once? Within logical semantics, there are reasons for wanting to answer both yes and no. Now, after the shift to object semantics, we can see why the question is ambiguous and that we really need to divide it into two separate questions. First, can two physical bodies overlap completely for a period of time? The answer to this is obviously yes. Examples are car-minus and the Chairman of NatLand Bank. Then second, can two physical bodies overlap completely? In other words, can they have the same four-dimensional extension? The answer to this is no. If they do then they must be the same object, the same physical body.

3.4 Characteristics of object semantics

These thought experiments provide our first sight of two important characteristics of object semantics, ones that we will meet again and again. These are:

- Timelessness, and
- Whole-part patterns.

3.4.1 Timelessness

We are accustomed to using one vocabulary and set of patterns for time and another, different, set for space. However, within object semantics, there is one general set of patterns for space-time. The four-dimensional perspective of these new patterns leads to one very important difference; we talk about (and see) objects in a ‘timeless’ way. We no longer say (using the thought experiments above) that car and car-minus occupied different extensions last week and the same extensions now. We now say that the four-dimensional car and car-minus objects share temporal parts. Similarly, we now say that a temporal part of Mr. Jones is also a temporal part of the Chairman of NatLand Bank. This new way of talking (and seeing) normally takes a while to become used to (as theoretical physicists who work with space-time in Einstein’s theory of relativity will know). Making the change to this new perspective involves overriding some deeply embedded mental habits.

3.4.2 Timelessness and individual object identity

Reference and extension fit naturally into this space-time world. The breaches of the strong reference principle, which we discussed at the end of *OP3—Logical Ontology Paradigm*, disappear. Reference and extension no longer vary to explain sameness over time for physical bodies—they are timeless. Reference is now unchanging, fixed forever to a timeless four-dimensional extension. And, as the extension is the object, sameness is no longer mysterious. It is being the same four-dimensional extension.

3.4.3 Re-using the spatial whole–part patterns in space-time

This shift to four-dimensional objects also enhances the power of the whole–part pattern. Shifting from three to four-dimensional extension extends the range of the whole–part pattern. Furthermore, the physical explanation of whole–part in terms of the extension of the whole containing the extension of the part is extended from spatial whole–parts to temporal and spatio-temporal whole–parts. The earlier thought experiments with their temporal whole–part patterns (such as Mr. Smith sharing a temporal–part with the Chairman of NatLand Bank) give us some idea of how useful this is.

Currently, most people do not see things in terms of spatio-temporal parts. If we are to feel comfortable working with object semantics, however, we need to. For instance, if my car was red last week and green this week, then we need to start instinctively seeing a red temporal part (stage) followed by a green temporal part (stage), where the temporal parts are time-slices of the whole car.

Becoming used to a pattern of temporal parts is not as hard as it might be, because the patterns for temporal parts are not really new. They are based on the familiar spatial whole–part pattern. The amalgamation of space and time into space-time means temporal parts now work under the same group of patterns as spatial parts. In other words, the patterns for spatial whole–part are now generalised to also cover temporal whole–parts—and spatio-temporal whole–parts. We are used to seeing things as spatial parts. For instance, we have no trouble recognising that a steering wheel is a (spatial) part of the car. All we need to do is learn to re-use these patterns on temporal and spatio-temporal whole–parts. *MW—The BORO Methodology: Worked Examples* contains useful worked examples of how they should be re-used.

4 Physical stuff objects

The object semantics for physical bodies does more than explain their identity through change. Through the use of the powerful whole–part patterns we have just been discussing, it also transforms some of our current notions. Here we look at one example; how it transforms our current abstract everyday notion of stuff into a down-to-earth physical body. (This explanation is drawn from the work of W.V.O. Quine. He and other philosophers have been using it for decades.)

People normally associate stuff with things. The patterns for the two are ancient and typically contrasted. For example: in standard grammar, nouns are divided into count and mass nouns. A mass noun, such as water, refers to stuff and a count noun, such as car, refers to a thing. The philosopher David Lewis has referred to the difference more light-heartedly as the hunk/gunk distinction.

What distinguishes things from stuff, hunks from gunk? A key difference seems to be that things are individuals; they stand by themselves. Whereas, stuff is more collective. If we put two bits of stuff together, then we have one bigger bit of stuff. If we divide a bit of stuff in two, then we have two smaller bits of stuff. Whereas, if we divide a thing, such as a car, in two, then all we get is two worthless pieces of junk.

The semantic problem that we set out to resolve is why a general stuff, such as milk in general, appears to be an abstract notion. Particularly, when bits of stuff are tangible and have extension. We see how object semantics' four-dimensional perspective gives general stuff a tangible physical basis.

4.1 Applying the strong reference principle to stuff

We start by applying the strong reference principle. We ask:

> What kind of object is a general stuff?

We focus in on one type of general stuff and ask:

What kind of object is general milk stuff?

We have an idea of the kind of answer we are looking for. According to object semantics, general milk stuff should be a four-dimensional extension (or, maybe, a collection of extensions). The problem is —which four-dimensional extension? A glass or a jug can both contain milk. They are different bits of milk, but both bits are still the same stuff, milk. We are looking for a four-dimensional extension that can explain this.

4.2 Disconnected objects

Before we can see the answer, we need to develop a more sophisticated notion of what a physical body is. We started with the simple notion of it as necessarily connected in space and continuous in time (or in four-dimensional terms, connected in space-time). This was the point of the wrecked car example—the brand new car was connected through both space and time to the wrecked car—there were no gaps, no discontinuities.

This connectedness helps us recognise simple individual physical objects; it is a vital part of our early understanding. But as our world grows more sophisticated, it becomes a liability if taken as a fixed rule. We want to be able to have individual physical bodies that are not connected. For example, a United States of America, that has as a physically disconnected part, Alaska.

We saw another simple example of disconnectedness in the Chairman of NatLand Bank above. The chairman physical body object was not connected in space-time—there is a temporal gap between Mr. Jones' resignation and Mr. Smith's appointment. So individual physical objects are not necessarily always spatio-temporally connected. But the spatio-temporal gap in the chairman was small and temporal. We need to be able to tolerate wider, more substantial gaps in both time and space before we can see what milk, water and other general stuffs are.

4.3 Overall stuff

This is because milk, water, and so on are very disconnected objects. Milk, for instance, is the fusion of all the bits of milk in the world. (The fusion of two or more objects is the sum of their extensions, another extension, another physical body.) If there is a glass of milk on the table and a jug of milk in the fridge, then the fusion of these two is one physical body with part of its extension on the table and part in the fridge. The general stuff object, milk, contains all the bits of milk here and on the other side of the globe. It contains those that have been and those that will be; it stretches both back and forward in time. It is the fusion of innumerable bits of milk and so is incredibly disconnected. This is completely unlike connected physical bodies such as the one we started with, my car. I call this general stuff object an overall stuff object.

There is only one overall milk object; one overall water object; one overall brass object. Each of them are overall stuff objects. We talk about something being stuff, if it is part of the overall stuff object. So the milk stuff in a glass of milk is a part of the overall milk stuff object. And a brass statue is a (spatio-temporal) part of the overall brass stuff object.

Here, object semantics has given us a simple explanation of what stuff is. It may seem radically different from our intuitions, and in one sense it is. But it still accords with the way we talk about stuff. This notion of physical bodies of overall stuff gives an important role to the whole–part pattern. It is used to help define what counts as stuff; being stuff is being *part of* an overall stuff. So the water in my glass is water stuff because it is *part of* overall water stuff. In general, the shift to four-dimensional extension leads to an increase in the range of the whole–part pattern. We will find that it can be used to explain a number of different, previously unrelated, patterns.

5 Classes of four-dimensional objects

Looking at these patterns for physical bodies has reinforced our understanding of what one is in object semantics. This will help us understand how to re-interpret the patterns for the other types of logical object; classes and tuples. Classes are, in logical semantics, collections of objects treated as an object. Some classes are constructed from collections of physical bodies. The shift to object semantics for physical bodies affects how we see these classes. It also resolves a problem that logical semantics' classes suffer from—the familiar problem of identity over time. It will help us to understand object semantics' notion of class, if we see how its resolves logical semantics' problem.

5.1 Logical semantics' problem with a class's identity over time

Once we understand what a class is, we instinctively see individual physical objects belonging to classes. For instance, we see a car as a member of the class cars; a person as a member of the class persons. This presumes that the class cars and persons are well-understood objects. However, in logical semantics, this presumption is not warranted. There is a gap between what the semantics says is an individual physical body and what our intuitions about class says a member is.

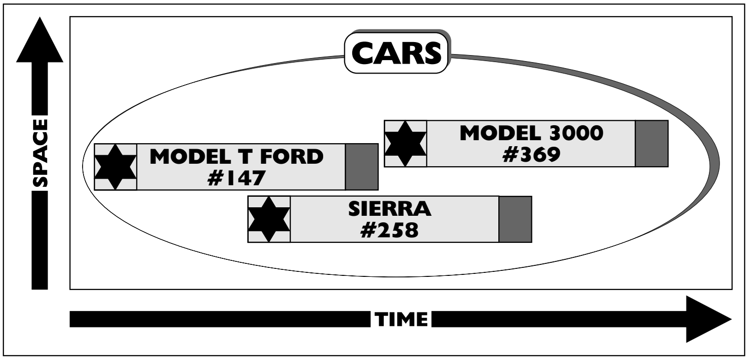
A class is a collection of objects. For example, the class cars is a collection of car objects. Car objects are physical bodies and so extensions. In logical semantics, a car object is a three-dimensional extension now and was another different three-dimensional extension yesterday and these are somehow the same car. What then is the class cars? It must be a collection of three-dimensional car extensions, but which collection? Is it all the extensions, historic and present, or only the present extensions? If we follow the lead of physical bodies and select only the present extensions, then a class (like a physical body) is continuously re-created. At each new moment of time, a new class with new members is re-created. We then have a problem explaining in what way these different classes with different members are the same. In logical semantics, classes share the same mysterious sameness over time as physical bodies.

5.2 Object semantics' view of a class's identity over time

In object semantics, we do not face this problem. A car object is a timeless four-dimensional extension. The class cars is the collection of these objects. Because they are timeless, it is timeless. This fits in well with our instinctive notion of what a class should be.

The cars class (like all classes) is timeless, it does not change. An object either is, or is not, a car (in other words, a member of the class cars)—time does not come into it. This applies to all objects wherever or whenever they exist. It includes the full four-dimensional extension of the first Model T Ford as well as all cars produced in the year 3000 AD, if there are any (illustrated in Figure OP4–10).

Figure OP4–10 Class of spatio-temporal extensions



This object shift does for classes what it did for individual objects. It fixes the reference of classes to a single extension (in this case a collection of four-dimensional extensions). This also clears up the explanation of a class's identity. Two classes are the same if, and only if, they have the same extension (in other words, if they have the same collection of extensions). We no longer have to explain how the 'same' class has a different extension at different times.

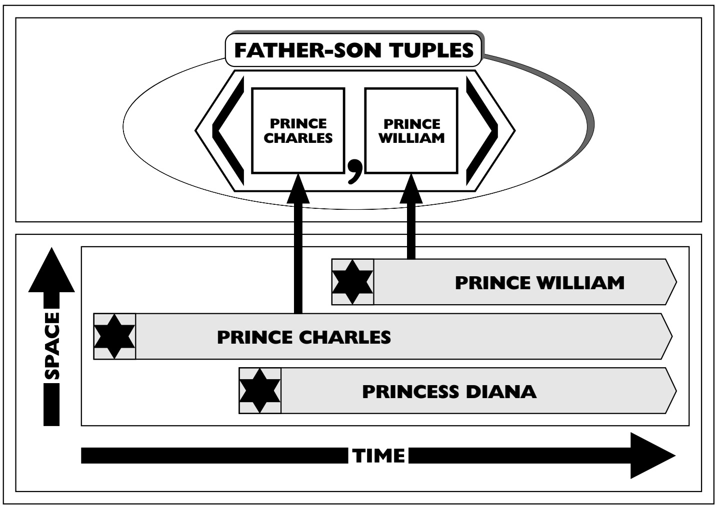
6 Tuples of four-dimensional objects

Tuples like classes are often constructed out of physical bodies. These tuples, like classes, have an extension that depends on the extensions of the physical bodies from which they are constructed. This means that within the logical paradigm, they also suffer from the problem of identity over time.

We can see this by looking again at the example we originally used to explain tuples in logical semantics. Consider the couple <Prince Charles, Prince William> which belongs to the father–son tuples class. It is constructed out of the physical objects Prince Charles and Prince William. If, at different times, these have different three-dimensional extensions (as they do in logical semantics), then the couple must also have different extensions at different times.

As with classes, this problem disappears after the shift to four-dimensional extensions. Then the tuple's places are filled with timeless four-dimensional extensions, as illustrated in *Figure OP4–11*. When the physical bodies are given a more solid foundation, then the objects constructed out of them (such as tuples and classes) also share in it.

Figure OP4–11 Tuples with four-dimensional places



7 A new way of seeing bodies—a key type of thing

The shift to four-dimensional extension gives us a radically different and better foundation for the area of semantics we are looking at now—bodies. It also—as the previous section explained—gives us a more solid foundation for both classes and tuples of physical bodies. However, it involves a radically new and different way of seeing things, one that is much newer than the logical paradigm and so has had much less time to make its way into the general consciousness.

At least with the logical paradigm, the new way of seeing things has worked its way into our language. For example, we have words for 'part of' and 'member of', even if we do not use them as accurately as the logical paradigm demands. Whereas, we have no obvious words to describe overlapping four-dimensional objects such as Mr. Smith and the chairman. We have to describe them in a round-about way—saying 'Mr. Smith is *currently* chairman'. Not many people would understand what we meant if we said 'the Mr. Smith and chairman objects currently overlap'.

Intriguingly, the shift to object semantics gives us a more accurate way of seeing sameness. Modern western civilisation has a more accurate way of seeing sameness than oral cultures such as the Huichol Indians (I described this in *OP2—Substance Ontology Paradigm*). We find it difficult to understand why the Huichol Indians say that corn and deer are the 'same'. Now the boot is on the other foot. Someone steeped in the object paradigm finds it difficult to understand why modern westerners say that Mr. Smith and the Chairman of NatLand Bank are the 'same'. The object paradigm has developed a more accurate notion of sameness that renders this way of speaking obsolete.

From language's point of view the shift to the object paradigm involves immense changes. In language, time is currently described using tense. If language is to reflect the object paradigm's amalgamation of time and space, we need to develop a tense-less language that describes space-time. This would be a substantial change.

8 Changes as Three-Dimensional Objects

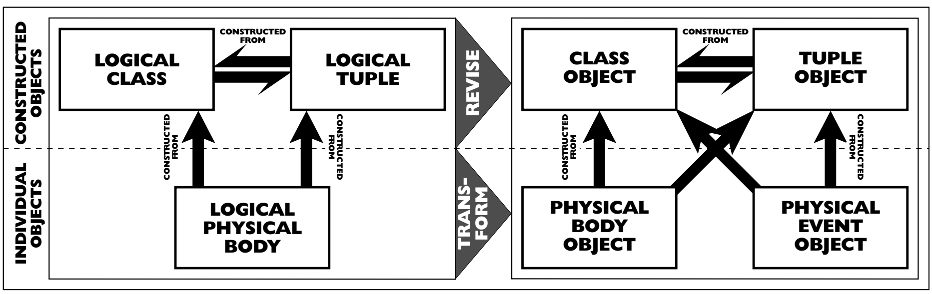
The first half of this paper should have given you an insight into how object semantics works for physical bodies. It has how logical semantics' time-bound notion of physical bodies as three-dimensional extension can be re-engineered into a notion of timeless four-dimensional extension. And how this new notion resolves logical semantics' problem with explaining the nature of identity 'over time' for physical bodies, classes and tuples.

However, at the beginning of this paper, we identified another semantic area unresolved by the logical semantics; changes. The second half of this paper deals with a radically different, much improved and consistent explanation of changes as objects. They use two very different types of change objects to do this:

- States, and
- Events.

States are types of physical bodies, much like the physical bodies of which they are states. Events, on the other hand, are a new type of individual physical object. The patterns of connections between these two types of objects both explain and transform our current notions of change. The introduction of the new physical event objects extends the structure of the paradigm (illustrated in *Figure OP4–12*). This only affects the individual objects level. The structure at the constructed objects level, which contains classes and tuples, is unaffected.

Figure OP4–12 Structural extension in the shift to objects



9 States as physical body objects

We start by looking at object semantics' explanation of states. The substance paradigm had a clear vision of what a state is; so, we use it as our starting point. We look at what it describes as states and then use object semantics to transform these into objects.

We then look at some of states' common patterns. We start with the common and intuitive state–sub-state and state–sub-class patterns. We then get a feel for state's counterintuitive nature by looking at two odd patterns; components as fusions of states and objects that are states of themselves.

Changes are patterns in time, and states form patterns in time that reflect the changes. We look at a key element of these patterns, the time ordering of the states.

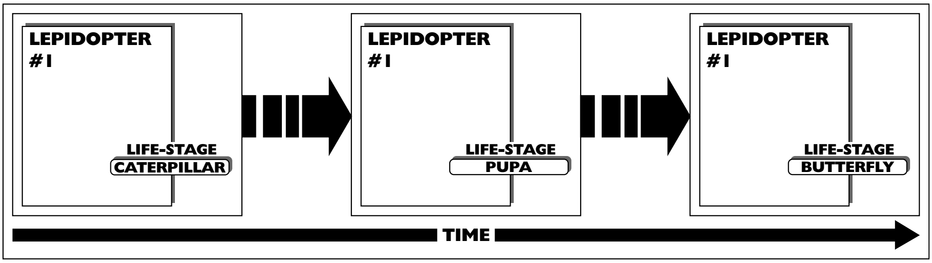
Finally, we look at state tuples. These are re-engineered from changes of a substance paradigm's relational attribute. In object semantics, these attributes have to be re-engineered into tuples of states. They cannot be re-engineered directly into couples, as they were in the logical paradigm.

9.1 Substance paradigm's view of changing states

In *OP2—Substance Ontology Paradigm*, we looked at the substance paradigm's consistent and coherent view of changes (based on the now discredited notion of substance). In it, states were not explicitly particles; but the substance framework gave a clear and accurate explanation of what they are. If you remember, the attributes of a primary substance can be divided into two main types: essential and accidental. Essential attributes cannot change, but accidental attributes can and do change. A state (which comes from the Latin *status*, to stand) is what a substance is in when it possesses a particular accidental attribute. We can see it as the substance for the period of time that the particular accidental attribute belongs to it. Where an attribute can have a range of values and each value corresponds to a state, we sometimes talk of the state of an attribute.

We can use the lepidopter in Figure OP4–13 to explain what a state is, and how it relates to an attribute value. In the figure, lepidopter substance #1 starts life with an accidental attribute of caterpillar-ness, which changes to pupa-ness and then butterfly-ness. We see this as a single attribute that changes value; we have called it the life-stage attribute. This has as values; caterpillar, pupa and butterfly. Lepidopter substance #1's changes are then changes in the value of the life-stage attribute. When the life-stage attribute has a particular value, we talk of the substance being in a particular state. When it has the value caterpillar, the substance is in a caterpillar state. It remains in this state as long as the life-stage attribute continues to have a caterpillar value. When the life-stage attribute changes to a pupa value, it moves into a pupa state, and so on.

Figure OP4–13
The lepidopter #1's states



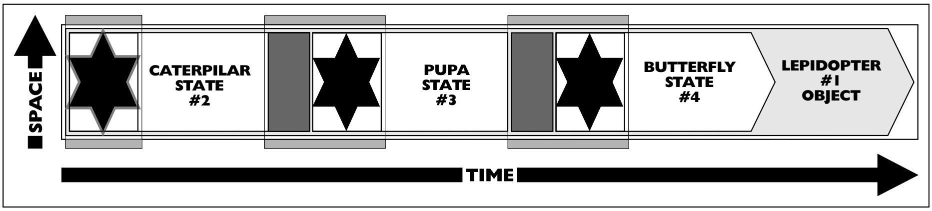
9.2 Applying object semantics to changing states

Object semantics provides a radical re-interpretation of this view of states. We have some pretty strong pointers to what this re-interpretation will be. States, in object semantics, have to be objects. As objects they can either be physical bodies, classes or tuples (or some new type of object). Whatever they are, they have to have four-dimensional extension (either directly or as a collection of extensions) and so be time-less; change cannot enter the picture.

9.2.1 Re-interpreting the lepidopter example

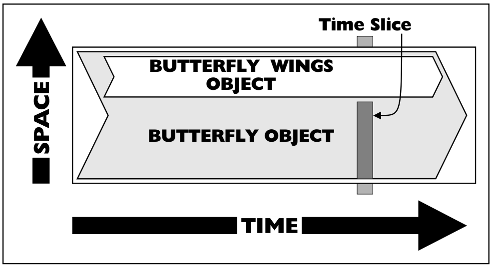
With these pointers, physical state objects are not difficult to find. If we look at the space-time map of the lepidopter example (shown in Figure OP4–14), the states stick out like sore thumbs. They are temporal parts of lepidopter #1. The caterpillar state #2, pupa state #3 and butterfly state #4 objects divide lepidopter #1 along the time dimension into three. The three state objects are not a new type of object, but physical bodies, just like lepidopter #1. What makes them a state is that they are part of another physical body—in other words, the whole–part pattern connection with lepidopter #1.

Figure OP4–14
Lepidopter #1's state objects



Not every part of a physical body is a state. A state object has to be *all* the spatial extension of an object over a period of time. For example, a butterfly's wings are part of the butterfly, but we do not see them as state objects. Furthermore, if we take a time-slice of a butterfly, but leave out the wings (illustrated in *Figure OP4–15*), then this is also not a state.

Figure OP4–15
A non-state part



Once we realise what a state object is, we begin to see them everywhere. This should not be a surprise. If we look at the population of things in the substance paradigm, states have a big representation. A substance almost always has more than a few attributes. Most of these are accidental, with at least a few states. So, inevitably, states are more numerous than substances or attributes.

9.2.2 State identity

This object-oriented way of looking at states as physical objects gives a more accurate meaning to a state's identity. It provides a clear and simple way of deciding whether two states are the same. We can see this from the following thought experiment. Imagine a young boy with tonsillitis. Assume I meet him twice and on both occasions he is ill with tonsillitis. On the second meeting, I ask his parents:

Is he in the same state as he was when we first met?

His parents need to interpret the question. It might mean:

1 Is the disease as bad as it was last time I saw him?

Or perhaps:

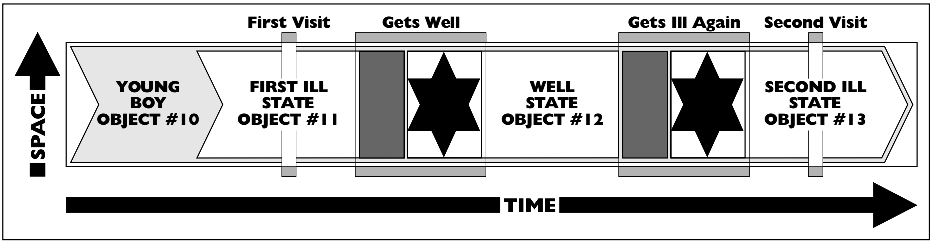
2 Is this the same disease as he had last time?

It is unlikely that I am asking whether the diseased state the boy is in now, is the same thing as the diseased state he was in the last time we saw him. Our every-day notion of state is not strong enough to give it an identity.

To see this, imagine that in the period between the two meetings, the boy had recovered from the first bout of tonsillitis and succumbed to a second, and was now as ill as before. Then, if the parents interpreted the question as (1) above, they would answer 'yes'. However, if the parents interpreted the question as (2) above, there are two possible answers. If the same underlying strain of tonsillitis caused the first and second bouts of illness, then they would answer 'yes'. If, on the other hand, there were two different strains, they would answer 'no'. In every-day language, even though my original question appears to be about a physical state object, it is really just a way of speaking.

In the object paradigm, states are objects with an identity. Let's assume that disease state objects are relatively continuous over time. Then, in our example, there are exactly two ill state objects, each with a clearly defined extension. These are objects #11 & #13 in the space-time map of *Figure OP4–16*. With these state objects, we do not need to work out what my original question might 'mean' to decide on an answer. The states are well-defined objects and the answer is unambiguously 'no'. The object paradigm has given us a more accurate notion of sameness for states.

Figure OP4–16
Ill state objects



9.2.3 State hierarchies

In business object models, I have found that state objects often fall into one, other or both of two closely linked hierarchy patterns; the state–sub-state and state–sub-class patterns. We now look at these and see how they are based on two of object semantics' fundamental patterns: the mereological whole–part and logical super–sub-class patterns.

State-sub-state pattern

States can themselves have states and this leads to a state–sub-state hierarchy. For example, assume that biologists divide the caterpillar state of the lepidoptera's life-cycle into an early and a late stage. The space-time map in *Figure OP4–17* shows this division for caterpillar state #2. Notice that the early and late stages are state objects (#'s 5 and 6)—they are temporal slices of caterpillar state #2. This is a state–sub-state hierarchy pattern. It is perhaps easier to see in the hierarchy diagram. of *Figure OP4–18*. You probably recognised that the state–sub-state hierarchy pattern is based on object semantics' strengthened spatio-temporal whole–part pattern.

Figure OP4–17
The caterpillar state's state objects

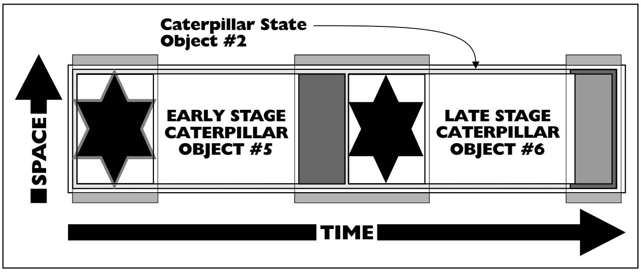
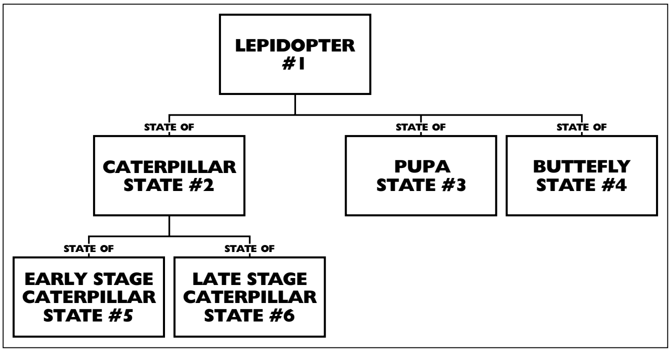


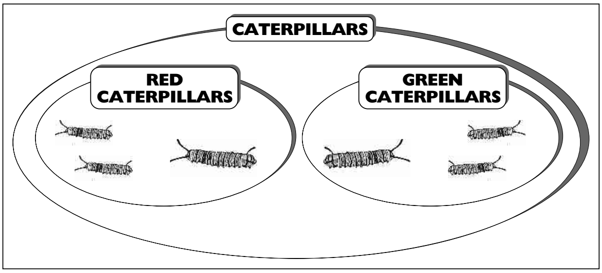
Figure OP4–18
State–sub-state hierarchy diagram



State-sub-class pattern

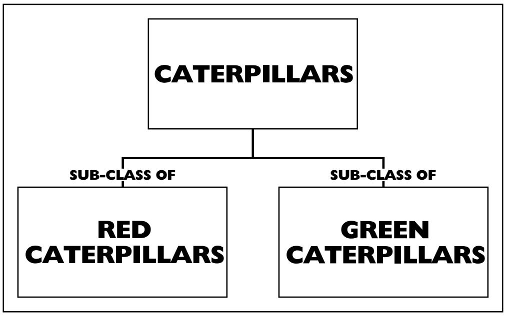
The state–sub-state pattern should be distinguished from the closely linked, but different, state–sub-class-pattern. We can use caterpillar states to illustrate this. Assume that biologists classify caterpillar's states by colour. Assume also that there are red and green caterpillars and that they do not change colour. This means that red and green are not states of the caterpillar. So, for example, a red caterpillar state will be the same object as the caterpillar state, and so have the same extension. However, it does lead to a distinction at class level—the class of caterpillars has a red caterpillar and a green caterpillar sub-class. This pattern is shown in the Venn diagram in *Figure OP4–19*.

Figure OP4–19
The caterpillar (state) class's sub-classes



Notice that these are not, like the early and late stages, sub-states of the caterpillar state, but sub-classes of the caterpillar (state) class. These sub-classes have a state–sub-class hierarchy pattern. This can be seen more clearly in the hierarchy diagram in *Figure OP4–20*. This time the pattern is based upon the super–sub-class pattern, not the whole–part pattern (as with the state–sub-state hierarchy).

Figure OP4–20
State–sub-class hierarchy diagram



Distinct states

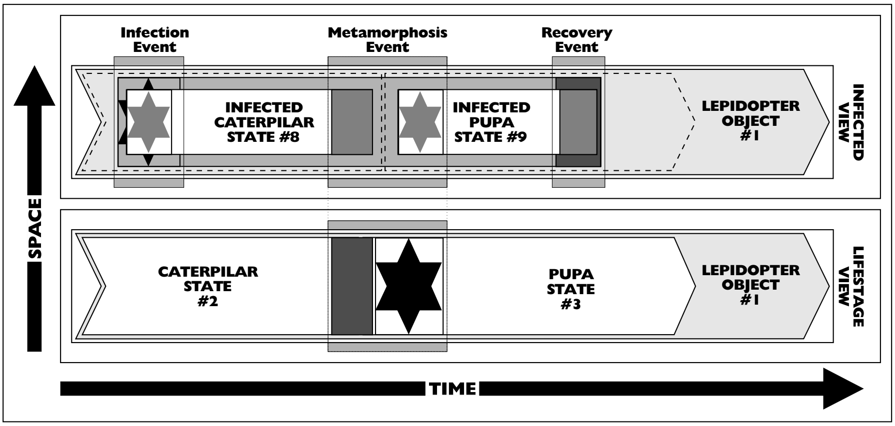
In the last two examples, the states we looked at were all distinct; they did not overlap. They were distinct on two levels—the whole–part and the super–sub-class levels. From a whole–part perspective, the four-dimensional extensions of the individual early and late stage caterpillars do not overlap. There is no part of one extension that is also a part of the other's extension. This is plain to see from *Figure OP4–17's* space-time map.

The red and green caterpillar state classes are also distinct, but from a super–sub-class perspective. No member of the red caterpillar class is also a member of the green caterpillar class, and vice versa. This is plain to see from *Figure OP4–19's* Venn diagram.

Overlapping states

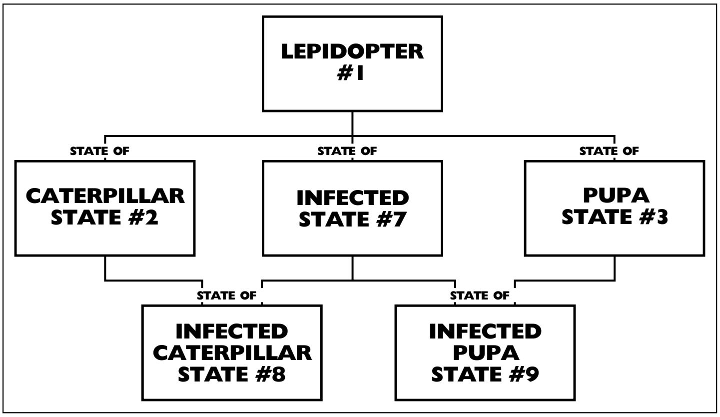
States, however, do not have to be distinct at either the whole–part or the super–sub-class levels. For example, individual sub-states can overlap; in other words, they can have parts in common. Take the lepidoptera example again. Consider a lepidopter (#1) that becomes infected while it is a caterpillar (in caterpillar state #2). It is still infected when it metamorphoses into a pupa state (#3). However, it recovers before it turns into a butterfly state. This introduces a new 'infected' state (#7) that overlaps both the caterpillar and pupa states. This means there is an infected caterpillar sub-state #8 and an infected pupa sub-state #9, as illustrated in space-time map in *Figure OP4–21*.

Figure OP4–21 Overlapping sub-states space-time map



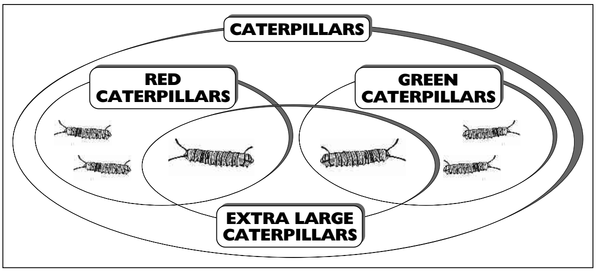
As before, these states form a state–sub-state hierarchy pattern—shown in the hierarchy diagram in *Figure OP4–22*). However, unlike the distinct sub-states that formed a tree hierarchy, these overlapping sub-states form a lattice hierarchy.

Figure OP4–22 Overlapping sub-states hierarchy diagram



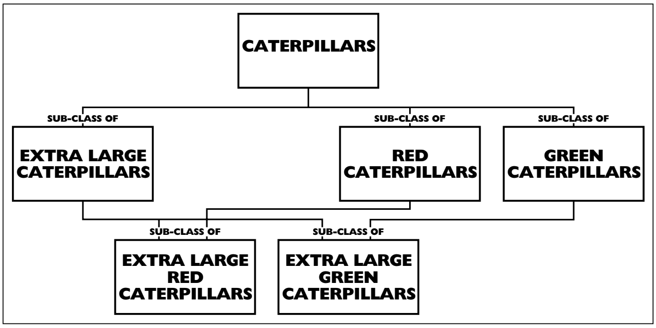
State-sub-classes can overlap as well. Assume, in the caterpillar example, that biologists also classify some caterpillars as extra-large and that both red and green caterpillars can be so classified. As Figure OP4–23 shows, the caterpillar state's sub-classes overlap.

Figure OP4–23 Overlapping sub-classes Venn diagram



These overlapping state classes form a super-sub-class hierarchy pattern with the extra large red and extra large green caterpillar sub-classes at the bottom. This has a lattice structure (shown in the hierarchy diagram in Figure OP4–24).

Figure OP4-24
Overlapping sub-classes hierarchy diagram



9.3 Consequences of timeless state objects

The notion of states as objects that are temporal parts of physical bodies leads to a new way of seeing them as physical bodies that do not change. This has some counterintuitive consequences. To get a better understanding of states, we look at two of them:

- Components as fusions of states, and
- Objects that are states of themselves.

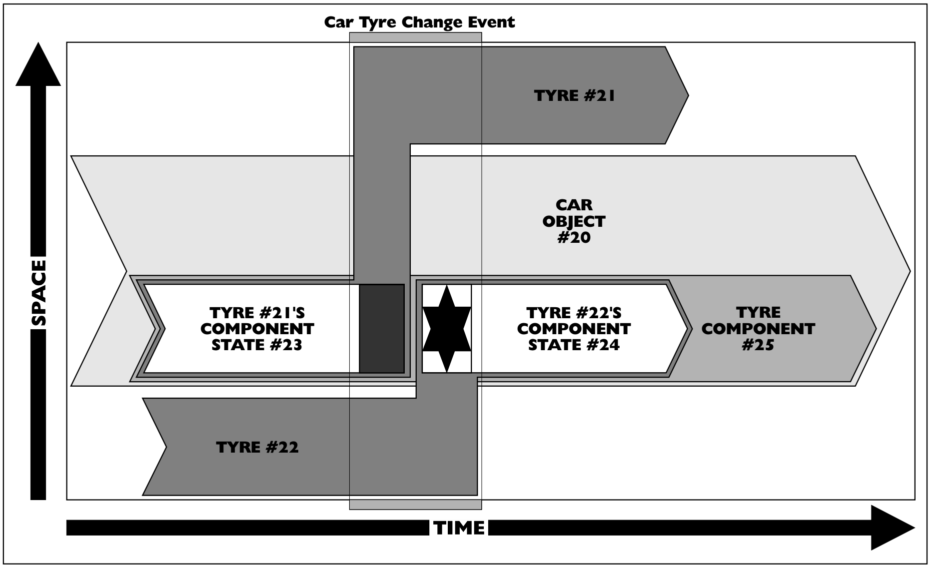
9.3.1 Components as fusions of states

It is a truism that a whole is the sum of its parts. So it would seem reasonable to expect a thing to be the sum (the fusion) of all its components. However, object semantics reveals an inherent ambiguity in such everyday talk of components. At any point in time, it seems quite clear what a thing's components are. But it becomes much less clear when we consider different points in time.

Here is an example that illustrates the problem. We expect some of a car's components to change. For instance, it is customary to change a car's tyres when they are worn; it is illegal not to. When we change a car's tyre, it stays the same car. It still has its full complement of components. It is just that one of its components has been changed. But what is this component we are talking about? It is one tyre before the change and another tyre after the change.

Object semantics gives a clearer and more accurate answer. Look at the space-time map of the car object #20 in *Figure OP4–25*. This shows that the four-dimensional extension of the car contains a temporal part of one tyre (#21) followed by the temporal part of another tyre (#22). At any one time, the car overlaps with only one tyre;. but, over time, it overlaps with two tyres. (You may recognise this as a similar pattern to the chairman thought experiment.) The two tyres have state objects that are 'components' of the car.

Figure OP4–25
Car tyre change space-time map



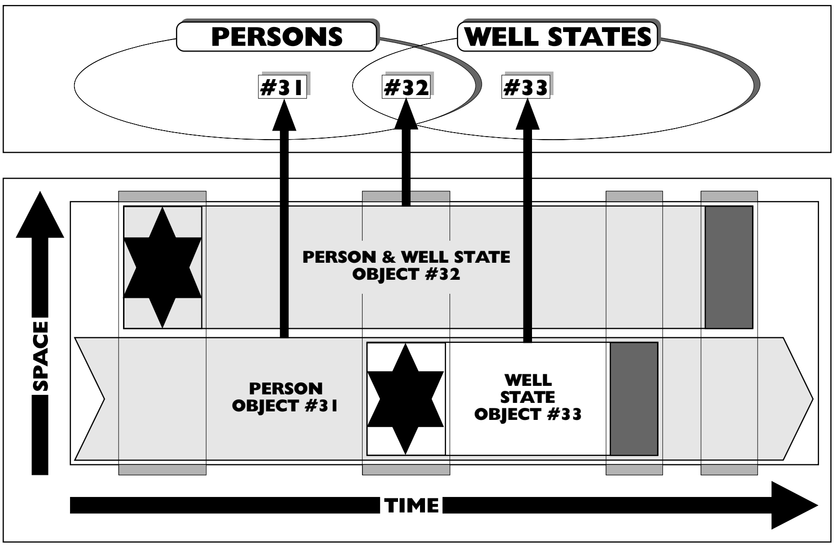
If this is as far as we go, then the car could be said to have a different component before and after the change. But this is not at all satisfactory, because it would mean that the 'components' change over time—an anathema in our timeless object paradigm. We need a timeless explanation. We get it by constructing a tyre component from the fusion of all the 'component' tyre states. This is shown in the space-time map as the car's tyre component—object #25. It is a component of the car; it is a part of the car; it is a fusion of the tyre state objects (#'s 23 & 24); and most important of all, it is timeless. This more sophisticated object-oriented component has none of the inherent ambiguity of our everyday notion.

9.3.2 Objects that are states of themselves

A different and more counterintuitive situation arises for states that do not change—the object appears to be a state of itself. In the substance paradigm, a state existed where there was an attribute that had the potential for change; it need not actually change. If we translate this into object semantics, it means that a physical body can be a state object of itself. We can illustrate how this 'happens', using the notion of the well state of a person.

Consider someone who has been ill and is now well—such as the boy with tonsillitis in the example illustrated in *Figure OP4–16*. He is in a well state that is one of a number of well state objects whose extensions are time-slices of his overall timeline. Now consider a super-fit girl with a superb constitution. Her four-dimensional extension, stretching from birth to death, is a member of the persons class. Assume also that she was permanently in *good* health (in other words, in a well state) from the day she was born until the day she died. As her well state's time-slice stretches from birth to death, it fills her four-dimensional extension exactly. Extension is the basis of object identity; so it follows that she is her own well state object (see object #32 in *Figure OP4–26*).

Figure OP4–26
Person as a well state



To see what this means, we need to recognise that what makes a physical body a well state object is that it is a member of the class of well state objects. And that what makes it a person object is that it is a member of the class of person objects. So all we are really saying is that the super-fit person is a physical body (in the object paradigm sense) that is a member of both the class of well state objects and the class of person objects. This may feel a bit counterintuitive at first, but it does not lead to any contradictions and it is a necessary result of treating states as four-dimensional objects.

This is a contrived example—used to make a point clearly. A more common example, at least nowadays, is gender. Most people stay the same gender throughout their life. In other words, most women belong to the class female and most men the class male. However, those people who have gender–changes will have a male state belonging to the class male and a female state belonging to the class female. This means the gender classes (male and female) contain both whole person objects and person state objects.

Gender provides a good example of the usefulness of taking a flexible view on whether a class contains individuals or states. There are some species that, unlike us, naturally change gender and some, like the earthworm, that can be both genders at once. For these, gender is naturally a state. If we generalise the gender pattern from humans to animals, it needs to be able to handle these species. If we were flexible about allowing the male and female humans classes to have states as members, then the generalisation is trivial.

9.4 State object's time-ordered connections

Even though time and space share many similar patterns that can be generalised, time has one useful pattern that space does not. It has a well-defined absolute direction—from the past to the future. Space's directions are not so well-defined. The direction that I, in England, call 'up', people on the other side of the world; in Australia, call down; and people in North Africa, halfway around the globe, call along. There is no absolute direction in any of space's three dimensions. Time's arrow, however, points in only one direction (leaving aside the extreme conditions considered by modern physicists).

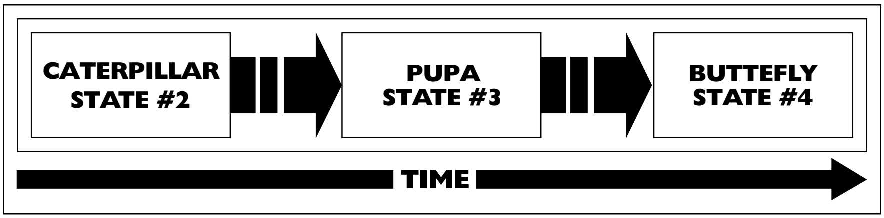
In object semantics, time's absolute direction is used to enhance patterns, originally developed for space, to describe the time dimension in space-time. We now look at how we use these patterns to describe time-ordered connections for state objects.

9.4.1 Sequences of states

A common time-ordered pattern for states is a sequence, where one state naturally follows another. We tend to talk of one state being before another. We have a natural image of something being in a particular state, then something happens and it moves into another state.

However, in object semantics, things do not 'happen'; the world is timeless. So we borrow a pattern from space, generalise it to timeless space-time, and use it to describe these time-ordered happenings. In space, we can put a number of things in a line, and then talk about one object being after another. This same pattern, generalised to space-time, applies to sequences in time of state objects. In the lepidopter example, its three states can be considered as objects following one after the other, in sequence, along the time dimension (illustrated in *Figure OP4–27*).

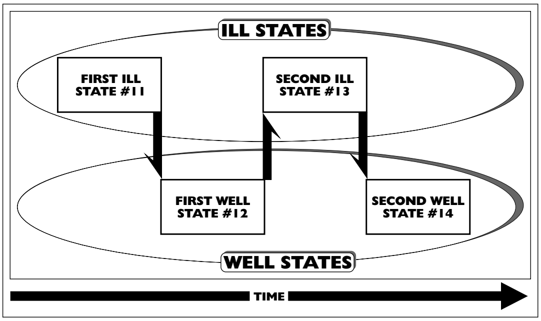
Figure OP4–27
State objects laid out in space-time



9.4.2 Alternating states

Another common pattern is alternating states. We can use the young boy modelled in *Figure OP4–16* to illustrate it. He alternates from an ill (tonsillitis) state to a well state. To model this using object semantics, we again have to revise our time-oriented everyday way of speaking. As in the last example, we use the 'things in a line' space pattern generalised to space-time. We see these alternating state objects following, one after the other along the line of the time dimension (illustrated in *Figure OP4–28*). This shows quite clearly the state objects alternating between the ill and well state classes

Figure OP4–28
State objects alternating between state classes



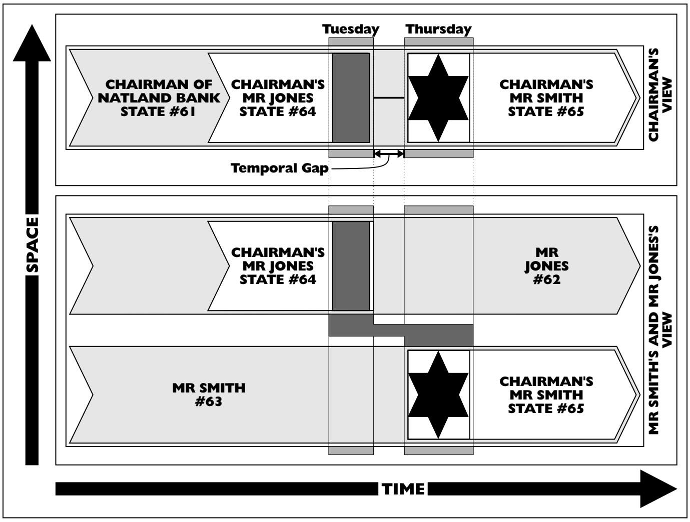
This kind of pattern is common where an object can switch between two states; for example, when a bank balance alternates between being in credit and overdrawn. Or the shelf on a warehouse alternates between holding stock and being empty.

9.4.3 Contiguous states

We can borrow another distinction from space to describe time patterns such as these—contiguity or, in less technical terms, touching. When a series of objects follow each other in space, each pair of objects can either be touching or have a gap between them. This same spatial pattern occurs along the time dimension in space-time. In everyday language, we say that sequential states either follow each other immediately or after a time. In object semantics' timeless view of things, these state objects are either contiguous (touching) or not.

For example, the lepidopter's state objects in *Figure OP4–27* are contiguous. There is no time gap between the caterpillar state and the pupa state. Contiguity is common in time-ordered patterns, but by no means universal. The chairman thought experiment, from *OP3—Logical Ontology Paradigm*, provides us with a counter-example. Mr. Jones as chairman and Mr. Smith as chairman are two states of the chairman object (shown in the space-time map in *Figure OP4–29*). However, Mr. Jones resigned as chairman on Tuesday and Mr. Smith was appointed the new chairman on Thursday. So there is a temporal gap between the two states. Because of no intervening chairman state, the same temporal gap exists for the chairman object. It is disconnected with no four-dimension extension between the resignation event on Tuesday and the appointment event on Thursday.

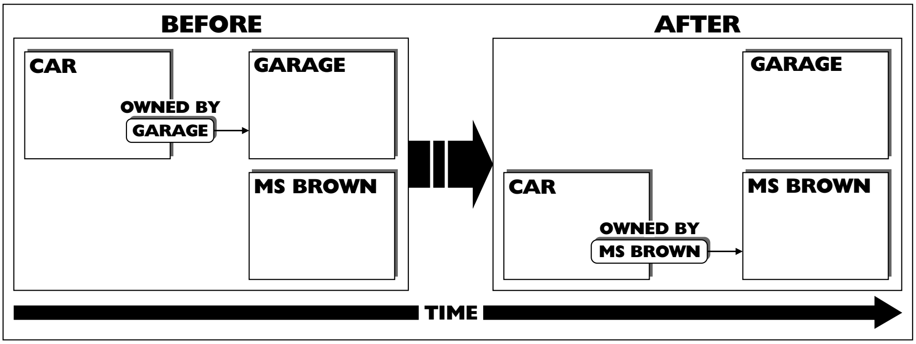
Figure OP4–29 Chairman state objects



9.5 State tuples—tuples with state object places

So far we have not considered the impact of states on tuples; we do so now. In the substance paradigm, relational attributes were attributes and so could, in principle, change. For example, consider a car owned by a garage. In substance-speak, this is a car substance with an owned by relational attribute. This attribute can change. In fact, as the garage is trying to sell the car, it is likely to change. Assume the garage does sell the car to Ms Brown. The owned by attribute changes; it no longer points to the garage, it points to Ms Brown (illustrated in *Figure OP4–30*).

Figure OP4–30 Changing car ownership attribute



How do we interpret the 'owned by' attribute in object semantics? We cannot simply follow the logical paradigm's treatment of relational attributes. Then we would re-engineer the attribute into a tuple object belonging to an 'owned by' tuples class. The tuple would start with the three-dimensional extension <car, garage> and then switch to the three-dimensional extension <car, Ms Brown>.

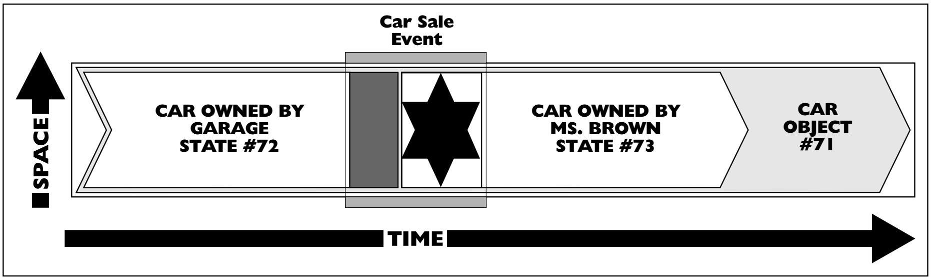
The problem is that this logical tuple changes, which tuples should not do in the object paradigm. If we are a little more sophisticated, we can resolve this problem. We need to construct the tuple from states of the car object, rather than the car object itself. Then, we have an object that captures the change pattern.

We divide the car object into states either side of the sale event. It has a car 'owned by garage' state (object) before the sale and an 'owned by Ms Brown' state (object) after the sale (illustrated in *Figure OP4–31*). We then use these state objects to construct two couples:

- <car owned by garage state, garage>, and
- <car owned by Ms Brown state, Ms Brown>.

These are the couples that belong to the 'owned by' tuples class. This neatly captures the change in a time-less way. You will have noticed that the car owned by state objects (like the lepidopter state objects in *Figure OP4–27*) fall into a natural time-ordered sequence.

Figure OP4–31
Car ownership
state objects



10 Events – a new kind of physical object

So far in this second part of the paper, we have looked at states. We saw how, under object semantics, these state objects are four-dimensional physical bodies—just like the physical bodies of which they are states. For example, the caterpillar state is as much of a physical body as the lepidopter object it is a state of.

We now look at the second type of object that the object paradigm uses to model changes, events. Unlike state objects, these are a new type of fundamental particle. What pattern underlies this particle? We touched upon it at the end of *OP3—Logical Ontology Paradigm*. There we talked about how, within the logical paradigm, dynamic classification was not an object and so could not make use of the class and tuple patterns.

We now look at how object semantics transforms dynamic classifications into a new kind of object—event objects. We first look at what event objects are and the patterns they generate. Then we see how they capture and transform our ordinary notions of cause and effect—and much more—giving us an insight into understanding.

10.1 The object paradigm's shift to event physical objects

We now look at the shift to event objects from the logical paradigm's dynamic classifications. We identify the extension of these events, establishing them as objects. Then we look at the following patterns:

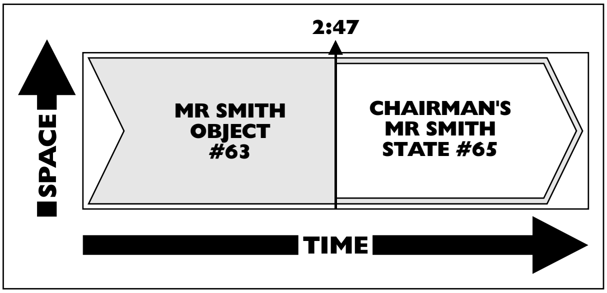
- The object versions of the happens–to and happens–at patterns,
- The encapsulation of complex events, and
- The object version of state change events.

10.1.1 Physical events as three-dimensional objects in a four-dimensional world

In some ways, our everyday intuitions about events anticipates object semantics. We say that the car accident happened at 10:00 am or that Mr. Smith was appointed Chairman of NatLand Bank at 2:47 pm. We see these events as happening at a point in time. This contrasts with the physical bodies that the changes happen to, objects such as the car in the accident and Mr. Smith. These we instinctively see as persisting through time.

Object semantics respects this distinction. In it, events (unlike physical bodies) do not persist through time. To see what they are (what extension they occupy), consider the Chairman of NatLand Bank example again. Assume that the Mr. Smith's appointment to chairman event occurred at exactly 2:47 pm. Look carefully at the space-time map of this event in *Figure OP4–32*. The only candidate for the event is the moment in Mr. Smith's time line that he is appointed chairman. This is a slice of his four-dimensional extension at precisely 2:47 pm.

Figure OP4–32 Mr. Smith's appointment event space-time map

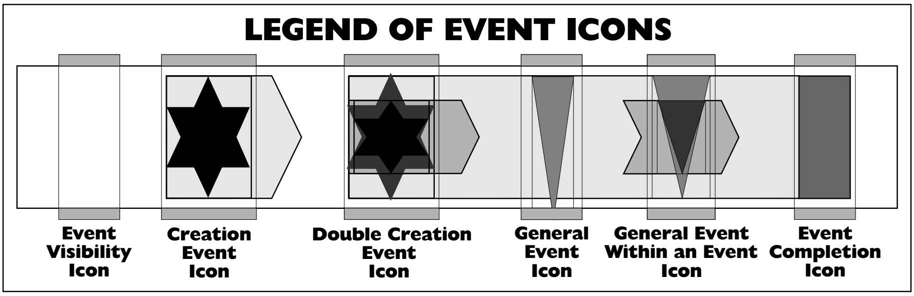


While event and states are both time-slices, unlike states, events do not persist through time. They have zero thickness along the time dimension, because they only occupy an instant in time. This gives us a very neat distinction between physical bodies and physical events. Physical bodies persist through time; whereas, physical events do not. This makes bodies four-dimensional and events three-dimensional, but three-dimensional in a four-dimensional world. This gives a clear and simple way of distinguishing events (changes) from bodies; the first and fourth of our key types of things.

Drawing events on space-time maps

It is not easy to see the event in *Figure OP4–32*; it is a line at the very edge of a box. To get around this problem, I adopt a policy of turning the events in space-time maps into icons. This has the disadvantage of appearing to give them extension along the time dimension, but I find that this is more than outweighed by the advantage of being able to see them clearly. To signal that the time dimension is suspended for the icons, I put them in event visibility boxes. The most common events are the 'creation' or start and 'completion' or end events for physical bodies, and these have their own icons; a star for creation and a rectangle for completion. These icons have been used in most of the space-time maps in this paper, for instance in *Figures OP4–29* and *OP4–31*. There is also a general event icon, which we have not used yet. To help you identify the icons, *Figure OP4–33* gives a legend.

Figure OP4–33 Legend of event icons for space-time maps



Most people will initially find it odd seeing an event as a three-dimensional slice of a physical body. Part of the problem is that the extension by itself does not seem like an event. However, we need to remember Frege's definition of meaning as composed of sense and reference (discussed in *OP3—Logical Ontology Paradigm*). The three-dimensional extension is only the reference; the sense is the event's relevant connections to other objects. In other words, the pattern of connections between it and other extensions some of which are modelled in the space-time maps. The extension and the sense combine to make up the meaning.

For example, the appointment event time-slice of Mr. Smith does not stand by itself. It acquires meaning by being put into context with the other objects; some of which we have not shown. For example, the Board appointed Mr. Smith chairman, so there is a connection between the Board and the appointment event. We look in more detail at these types of 'causal' connections in a later section.

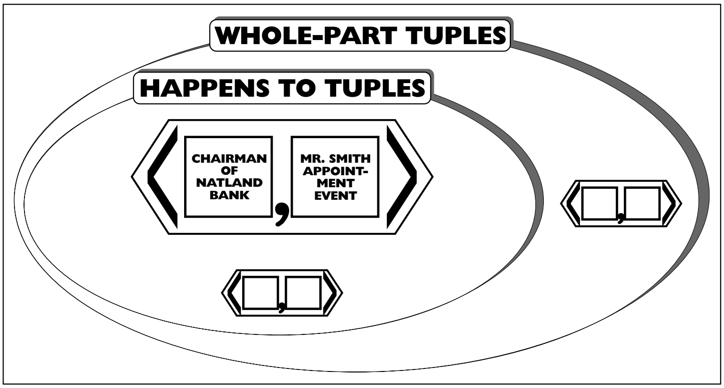
10.1.2 The happens–to (whole–part) tuple

Seeing an event object as a three-dimensional extension in a four-dimensional world enables us to see a number of new patterns. One such pattern is the 'happens–to' tuple. This neatly illustrates how, in object semantics, analysis often becomes a matter of mapping patterns of connections between extensions, typically involving the whole–part pattern.

We loosely say that the appointment event 'happens to' the chairman. In the substance paradigm, this would be explained as Mr. Smith's substance acquiring a chairman attribute. In the logical paradigm, as Mr. Smith being dynamically classified as a chairman. In both paradigms, the 'happens-to' connection is not captured by its fundamental particles and so, in a sense, is outside their scopes. It is neither a substance, an attribute, a tuple or a class—it is certainly not a physical body.

In object semantics, the 'happens-to' tuple is an extension and so an object within the scope of the paradigm. To understand it, we need to, at least, map its pattern of connections with other extensions. In the case of the chairman's appointment, the most important connection is that the extension of the event is a part of the extension of the chairman. This is visible in the space-time map in *Figure OP4-32* This means that the <chairman, Mr. Smith's appointment event> couple not only belongs to the 'happens-to' tuples class, but also the whole-part tuples class. This is generally true of all 'happens-to' couples, which means the 'happens-to' tuples class is a sub-class of the whole-part tuples class (illustrated by *Figure OP4-34*.

Figure OP4-34
Happens-to
tuples class



10.1.3 The happens-at (whole-part) tuples

There is another useful connection in our example, the happens-at pattern. When we described the earlier example we said:

> Mr. Smith was appointed Chairman of NatLand Bank at 2:47 pm.

In other words the appointment event happened at 2:47 pm. This raises the interesting question of:

What is the 2:47 pm object?

We need to know because it occupies one of the places in the happens–at couple (which is <2:47 pm, Mr. Smith's appointment event>).

Object semantics approach to this is, as usual, simple but radical. It proposes an extension for the instant 2:47pm. But what extension? We know its temporal dimensions. Because it is instantaneous, it has zero time dimension. What are its spatial dimensions? The object paradigm proposes that it is the whole of space (at that instant 2:47 pm). So it is the instantaneous time-slice through the whole of space-time at 2:47 pm. Because it is an instantaneous time-slice, it is three-dimensional with zero time dimension. Under object semantics' distinction between bodies and events, this makes it an event. This interpretation of 2:47 pm means that Mr. Smith's appointment event is part of the 2:47 pm instant event. So the happens–at tuples class, like the happens–to tuples class, is a sub-class of the whole–part tuples class (in pattern-speak, the happens–at pattern is part of the whole–part pattern).

Time objects

We now have the key to explaining what a day, a month and a year are in object semantics. Let's take 25th May 1999 as our example. We want to find out what its extension is. We intuitively think of this day lasting for twenty-four hours. In object semantics, this means that the time dimension of the day object is twenty-four hours long; starting at just after midnight on the 24th and finishing at midnight on the 25th. We now know its time dimensions, but what about its spatial dimensions? It follows the same pattern as the 2:47pm instant object; it is all of space between those two times. Similar transformations into physical bodies are made to months and years. Object semantics physicalises time. We shall look at these time patterns in more detail in the worked example in *MW4—Re-Engineering Time*.

We have some intuition that spatial whole–part and temporal whole–part patterns are similar. We routinely use the same prepositions for both patterns—saying:

I went to Brighton *in* 1999. and

The hat is *in* the box.

However, our use of prepositions does not always tie in with the object paradigm's understanding. We don't say;

I went to Brighton *in* the 25th May.

but

I went to Brighton *on* the 25th May.

How this temporal 'on' is related to the spatial 'on' is unclear.

Furthermore we do not normally see days as spatio-temporal objects. If we did, we might say:

My trip to the Brighton object is *in* the 25th May object.

As we can see our use of language has not caught up with the object paradigm's more general and conceptually coherent notion of whole–part.

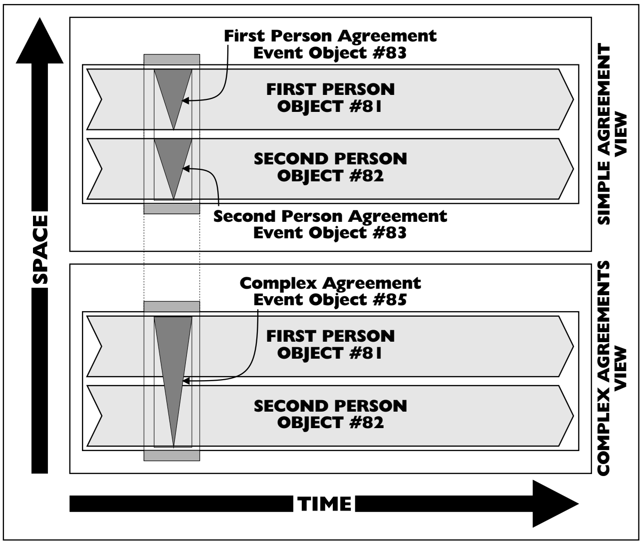
It should come as no surprise that the notion of event we have just examined bears a strong similarity to Einsteinian physics' definition of an event as a point in space-time—something with zero spatial and temporal dimensions. After all, the notion of space-time was borrowed from Einstein's theory to begin with. To explain the types of events that happen to the people-sized objects that business modelling deals with, we extended the physicists' definition of an event to encompass spatial dimensions.

10.1.4 Encapsulating complex events

So far we have been looking at examples of simple events occurring to one particular physical body. We now look at the encapsulation of more complex series of events. We see how object semantics explains complex events as encapsulations of simple events.

When two or more events are encapsulated into a single more complex event object, this new object is the fusion of the extensions of the encapsulated events. In a similar fashion to overall stuff (discussed earlier in this paper), the complex event has a disconnected extension. For example, assume two people reach an agreement (also assume that this is done over the phone to make sure their extensions are disconnected). In object terms, there is an overall agreement event for both people. This is the fusion (or encapsulation) of the two agreement events for the individual people. *Figure OP4–35* illustrates this. The encapsulated event has a single disconnected extension composed of the fusion of the extensions of the two component events.

Figure OP4–35 Encapsulated events



This same principle of encapsulation (fusing the component extensions) applies to much more complex events. Consider the Second World War. This is a single complex event object, but it is also a very complex network of events. It is the fusion of the extensions of a large number of simple events that happened to physical bodies. These form the base of an encapsulation (whole–part) hierarchy of more and more complex events, with the Second World War at its apex. Each of the smaller events is encapsulated into (a part of) one or more of the larger events. So, for example, the evacuation from Dunkirk and the D-Day landings are both encapsulated into (parts of) the overall complex Second World War event.

At first sight, it may seem that a complex event such as the Second World War persists through time. We (in Britain) talk about it starting in 1939 and ending in 1945. But there is a distinction to be drawn here. While the complex event may have parts in both 1939 and 1945, this does not mean it persists between 1939 and 1945. Because each of the simple parts has zero thickness along the time dimension, the total thickness of the fusion of these parts is the sum of the thickness of its parts. Now 0+0=0, even (mathematicians tell us) if we do it an infinite number of times. In the Second World War's case, we are adding a large, but finite, number of zeros. So no matter how many events make up the complex Second World War event, it still has zero time dimension and so stubbornly remains a three-dimensional event.

Complex events without a body

The new way of looking at complex events leads to a conclusion that is obvious but incapable of being captured properly in previous paradigms. Complex events do not always happen to a physical body. Indeed most of them, like the complex agreement event in *Figure OP4–35* and the Second World War, do not. In the substance paradigm, a change always happened to an attribute belonging to a substance. In the logical paradigm, a change happened to an object that was dynamically classified. In object semantics, simple events happen to a physical body, such as Mr. Smith's appointment happens to Mr. Smith. But a more complex event does not have to. As in the complex agreement event in Figure 8.24, its constituent simple event parts each happen to a physical body, but not usually the same one. As more events are encapsulated into a complex event, it gets more and more unlikely that they will have a physical body in common. In other words, it is unlikely that the extensions of all the individual events would be temporal parts of a single physical body. Typically, they are spread over a number.

These complex events without bodies have interesting repercussions for current O-O programming languages (OOPLs). Methods are, in some ways, OOPLs equivalent of events and 'objects' its equivalent of bodies. In most OOPLs, methods are firmly tied to 'objects' (in the object semantics' way of speaking, events are tied to bodies). In this environment, complex events, such as the Second World War, have to be squeezed into the framework. A technique often used is to create a pseudo-object (in our terms, a body) for the event to happen to. So there would be a Second World War 'object' for the complex Second World War event to happen to. As is noted in *AS2—Using Objects to Reflect the Business Accurately*, O-O programming is, in some ways, a halfway house with elements of both the substance and object paradigms; insisting events have to happen to 'objects' is one example.

10.1.5 Object-version of state change events and Zeno's paradox

It would seem that we now have a consistent and coherent picture of what event objects are and how they have extension. We have seen how events differ fundamentally from bodies. They only have three-dimensional spatial extension, with zero temporal extension—unlike bodies, which have a temporal dimension, and so persist through time.

However, there is a small area left, state change events, with an outstanding problem—Zeno of Elea's paradox. We first met this paradox in *OP2—Substance Ontology Paradigm* where we saw how the substance paradigm resolved the paradox using the now discredited notion of substance. We looked at it again in *OP3—Logical Ontology Paradigm*, where we saw the problems it caused in the logical paradigm if change was treated as an object with extension. If we do not see certain types of events in the right way, the paradox appears to cause problems for object semantics as well.

We can see why by looking again at the change example in *OP3—Logical Ontology Paradigm* (see OP3's *Figure OP3-40*). This assumes that there is a tomato changing colour—from green to red. The problem is that the instantaneous colour change has extension, albeit three-dimensional, and so has a colour. And the colour cannot be either green or red; otherwise, it would not be a change.

The object paradigm does not seem to have resolved this problem. The simple event we re-engineer from the instantaneous colour change has the same problems as its logical predecessor. We need to be more sophisticated in our re-engineering. We need to re-interpret the instantaneous colour change as a complex encapsulation of two events. This is the encapsulation of the completion event of the before state and the creation event of the after state (illustrated in *Figure OP4–36*). Zeno's paradox is no longer paradoxical because the encapsulated event does not have to have a single colour.

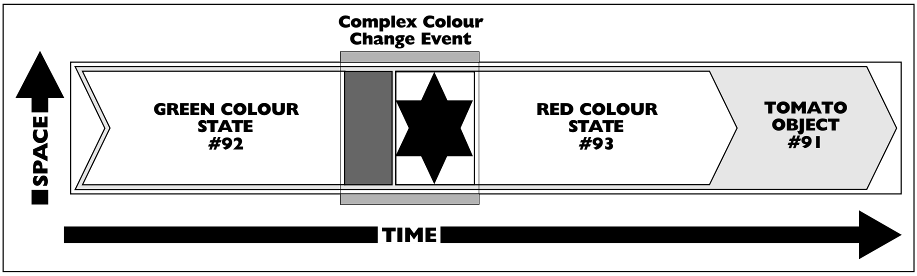


Figure OP4–36
Complex event of the tomato changing colour space-time map

10.2 Events, causes and effects

We now have a consistent semantics for events as a new type of physical object. Unlike the dynamic classifications of the logical paradigm, they are objects, and so they can make use of the class and tuple patterns. They can be collected into classes or arranged into ordered tuples, just like any other object. They can have whole–part and super–sub-class patterns. They have, however, another equally important aspect. They are the basis for time-ordered patterns that capture and transform our ordinary notions of cause and effect. In the patterns, events explain the link between causes and effects.

In object semantics, the cause and effect connections are used to describe and explain a far wider range of patterns than is traditional in modern times. The semantics' notion of cause has more to do with understanding (and explaining)—the objective of business modelling, as we recognised in *AS2—Using Objects to Reflect the Business Accurately*—than operation. It turns out that this approach has many similarities with the wide ranging ancient framework for cause originally brought together by Aristotle. We now look at this framework and see how it develops into the object paradigm's.

10.2.1 Aristotle's approach

Aristotle saw causes as explaining an event, helping us to understand it. So, to us, his classifications of cause seem to be explanatory principles; for example, he includes what we see as effects (the results or consequences of the event) as causes. He synthesised his framework from a number of traditions and the result was four types of cause or explanation:

- The efficient - that which makes a change happen,
- The material - what the change happens to,
- The formal - what the change results in, and
- The final - the end or purpose of the change.

Aristotle believed all of these were needed to give a proper explanation and criticised his predecessors for emphasising some to the neglect of others. A similar criticism could be made of our modern attitude, which often restricts us to the efficient cause—that which makes a change happen.

To see how Aristotle's approach works, consider a sculptor who has carved a statue from a block of marble. In this case, the types of cause are:

- The sculptor is the efficient cause, because he carves the block of marble into the statue.
- The marble is the material cause, because it is what the change happens to.
- The statue is the formal cause, because this is what the sculptor wanted to carve.
- The sale is the goal or final cause, because sculptor made the statue to sell.

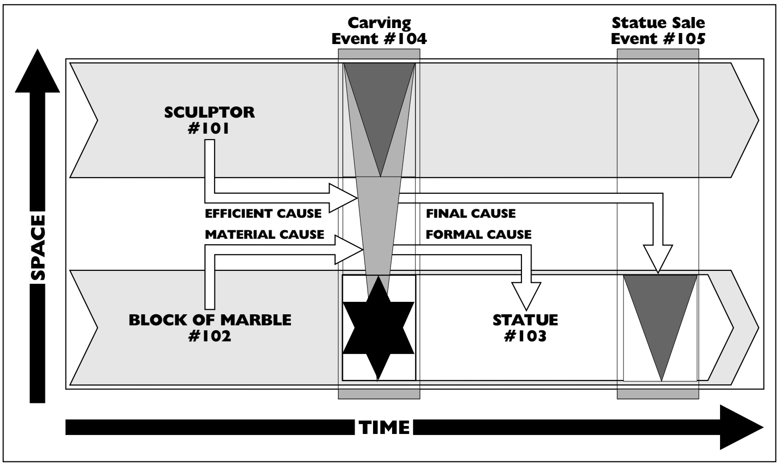
Aristotle was suggesting that when we describe all four types of cause (as we have just done here), we are giving a description of everything we need to know to understand the event.

10.2.2 Object semantics' approach

In object semantics, Aristotle's types of cause translate neatly into time-ordered patterns involving events. These are the event object's equivalent of the state object's time-ordered patterns we looked at earlier. As with the state object's patterns, we can illustrate the patterns with space-time maps.

Look at Figure *Figure OP4–37*. It is a space-time map for the sculptor carving a statue—with an additional event, the sale of the statue by the sculptor. To make the patterns more visible, we assume that the complex encapsulated process of carving the statue and the sale are both simple instantaneous events. (People versed in current O-O thinking can see this as the business modelling's equivalent of OOPL's 'information hiding'. The cause is a connection with the complex encapsulated event not its simple parts.)

Figure OP4–37 Sculptor carving a statue space-time map



Each of Aristotle's four types of change appear in the space-time map. Their links to the carving event are illustrated with arrows. Underlying each arrow is a pattern of connections between the extensions of the objects involved in the statue carving event

The efficient cause is the sculptor who carved the statue. In more modern terminology, the sculptor is a pre-condition for the carving event. This is analysed as a tuple between the sculptor physical body and the carving event (the couple belonging to the cause tuples class). In time ordering terms, the sculptor physical body extension must 'exist before, during and after' the carving event extension.

The formal cause is the statue that is a result of the carving event. In modern terminology, the post-condition of the carving event. This is analysed as a connection between the carving event and the statue physical body. The carving event is a complex (encapsulated) event. The statue is a state object of the marble object, whose creation event is part of the carving event. This means the connection between the statue and the carving event is one of overlapping parts.

The material cause is the block of marble that is carved. This is also a pre-condition for the carving event, though one with a different time pattern to the efficient cause. This is analysed as a connection between the block of marble and the carving event. The connection has an overlapping pattern because the block of marble contains the statue object's creation event, which is part of the carving event. Like the efficient cause pre-condition, the block of marble extension must 'exist before, during and after' the carving event extension.

Object semantics leads to a counterintuitive situation for the material cause, where the cause connection pattern is also a whole–part pattern. The cause is a couple, <block of marble, statue>, which belongs to the cause tuples class. This couple also belongs to the whole–part tuples class, because, as we can see from the space-time map, the statue is part of the block of marble. In other words, the connection is both cause and whole–part. We instinctively differentiate between cause with its roots in time and whole–part with its root in space. However, as this example shows, in space-time our instinctive reactions are misleading.

Last, the final cause is the eventual sale of the statue. This is analysed as a connection between the carving event and the sale event. In time ordering terms, the carving event 'precedes' the sale event. There are also other less important patterns; for instance, elements of the sale event are part of the efficient cause and the material cause.

This shows how working out the Aristotelian causes is part of the overall task of mapping the sense of an event. When we analyse the pattern of connections between the extensions of the objects involved in the statue carving event, we naturally unearth them. This also shows that Aristotle and his predecessors intuitively understood the physical time patterns that object semantics make explicit. Their categorisation reflects the various aspects of the different underlying time patterns that explain the event. It by no means exhausts the time patterns that occur, but it does give us some idea of the most common patterns. It also gives us a feel for how analysing the patterns of connections between extensions can explain an event.

11 The time-based 'consciousness' of information systems

One of the prime characteristics of the object paradigm is the time-less nature of its objects. They give us an 'objective' view, independent of any particular information system at any particular time. This is an extremely powerful way of seeing the world. However, there is one aspect of an information system that cannot, whatever we do, be captured in a totally timeless way. This is its shifting position in time. From the information system's perspective, its 'consciousness' exists at a point in time that is moving inexorably along the time dimension.

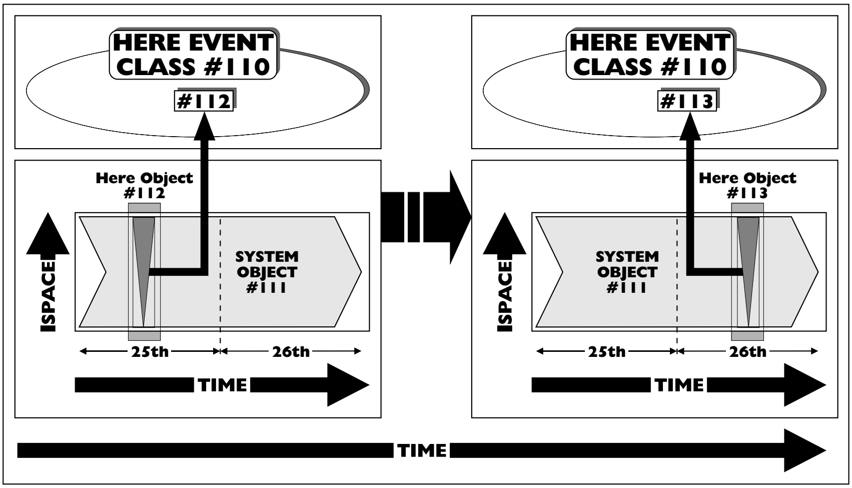
Computer systems are information systems and so they have a time-based 'consciousness'. They reflect this in their information; when the computer system's 'consciousness' is in the 24th May 1999, the leg of a deal that settles on the 25th May 1999 is classified as awaiting settlement. When its consciousness moves onto the 25th May 1999, it is re-classified as due today. This is a change in the computer’s ‘consciousness’; nothing has happened to the settlement. We need to be able to capture this in our business models.

11.1 The dynamic ‘here’ event

We do this by introducing a new kind of class object—the dynamic class or dyna-class. To reflect the information system’s consciousness moving down the time dimension, we use the dynamic ‘here’ event class. To explain what this object is, we first need to identify the system itself. It is a simple physical body, the four-dimensional extension of the system. We can then construct the new type of object that represents the moving consciousness—the dynamic ‘here’ event class. It is a class with a single member, the three-dimensional time-slice of the system at the instant of time that the consciousness is aware of. The time-slice’s zero length time dimension makes it an event.

This event behaves in a similar way to the three-dimensional extensions of physical bodies in the logical paradigm. As the system’s consciousness moves down the time dimension, the ‘here’ event class dynamically changes its member to the system’s current three-dimensional time-slice. It is called dynamic because, unlike other objects, it changes. Two ‘versions’ of the dynamic ‘here’ event class are illustrated in the system’s space-time map in *Figure OP4–38*.

Figure OP4–38 The dynamic 'here' event class space-time map

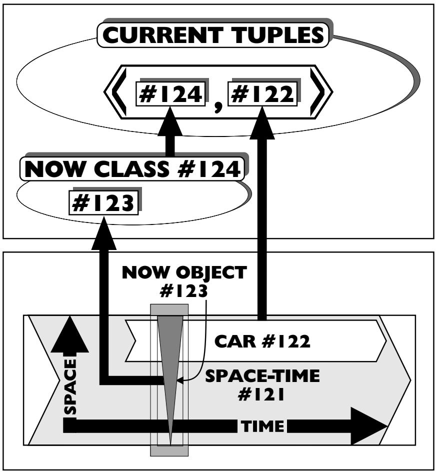


11.2 The dynamic 'now' event and the dynamic 'current' tuples class

We need to find a way to link the dynamic 'here' event class to non-dynamic objects. We do this through another dynamic class,—the 'now' event class. This is also a class with a single member, the instant that the 'here' member event occupies—in other words, the whole of space for that instant. Like the 'here' event class, it is dynamic, with its member tracking the system's consciousness.

Once we have the 'now' event class, we can use it to construct a dynamic current tuples class for any class of physical objects. Consider, for example, the class cars. Some of the members of this class will exist now. Speaking timelessly, they have a temporal part that is part of the now object. For each of these cars we can construct a couple, <now, car> (illustrated in the space-time map in *Figure OP4–39*). All these couples belong to the current tuples class. Those cars that do not overlap with the now object, do not have a couple in the current tuples class.

Figure OP4–39
The dynamic current tuples class space-time map



The current tuples class is dynamic, because one of the places of its couple is dynamic, making the couple dynamic and so the class it belongs to. These dynamic couples provide us with the link between the time-bound 'consciousness' of the system and the timeless world of object semantics.

11.3 Implementing dynamic (state) classes

The objective of business modelling is understanding and so I try to keep the dynamic classes to a minimum. However, when building the system, there may be good operational (as opposed to understanding) reasons for designing dynamic classes for implementation. For example, a system may only need to keep a record of all the current state objects and have no interest at all in historical state objects. In this case, implementing a dynamic class that only reflects the current state makes sense. It would be a waste of information storage space to hold details of the previous states. However, we do not have to consider these issues when constructing the business model.

12 A new way of seeing changes—a key type of thing

This paper provides us with a revised semantics for the fourth and final key type of thing—changes. Unlike previous paradigms, the object paradigm brings changes explicitly within its remit. Changes are event objects and share the patterns common to objects.

This is a radical change, one that, as we expect by now, requires a completely new way of seeing, thinking and talking about things. This enables us to see the world more accurately. The tyre component example illustrates this (see *Figure OP4–25*). Where, under the logical paradigm, we would see a tyre as simply a part of a car, object semantics reveals a more accurate and sophisticated pattern of overlapping parts.

Furthermore, the new way of seeing is really new. Unlike the logical paradigm's 'member of' and 'part of' patterns that have begun to work their way into ordinary everyday language, object semantics has made next to no inroads.

Object semantics' timeless view of the world has had some impact. Expressions like 'time-line' for four-dimensional objects have been imported from Einsteinian physics. But we still see and talk of them in a time-oriented way. We talk of things moving down their time-line, bringing time into the four-dimensional world. Furthermore, most people still think of a period of time starting and ending. They do not see it as a physical body containing all of space for period of time. They certainly do not see an hour as a physical object that is a spatio-temporal part of a day object, though they may talk of hours being 'in' a day.

Otherwise, there is very little evidence of object semantics impact on everyday language. There are no words for:

- An event as an instantaneous time-slice of a four-dimensional object,
- A complex event as a fusion of extensions of simpler events, and
- An instant as a time-slice through space-time.

This is hardly surprising. Object semantics is under a hundred years old and things as fundamental as semantics can take much longer to work themselves into the popular consciousness.

We can talk about objects in a timeless way by twisting our language. The traditional way of dealing with time in language is through tenses. We can describe the timeless four-dimensional world in a tenseless way by only using one tense, the present tense. We can start saying sentences such as 'the well state extended along the time dimension as far as 25th May'. We have done this, to some extent, in this paper.

13 A Language for Business Object Ontology

This discussion of language leads neatly onto the subject of another group of working papers. Natural language is not a suitable format for describing a formal and sophisticated semantics, such as the object paradigm, with any accuracy. Once people start seeing and thinking in the new object-oriented way, they need an accurate means of modelling their four-dimensional world. That is the topic of the *BG—Business Ontology: Graphical Notation* working papers. These look at the object syntax, and its notation, that together with object semantics form the object paradigm. People generally find that working through this - as well as the papers on the object ontology - gives them a more 'substantial' feel for object semantics.

BORO Working Papers - Bibliography

The BORO Working Papers

Volume A
A—The BORO Approach

Book AS
AS—The BORO Approach: Strategy

AS1—*An Overview of the Strategy*
AS2—*Using Objects to Reflect the Business Accurately*
AS3—*What and How we Re-engineer*
AS4—*Focusing on the Things in the Business*

Volume - O
O—ONTOLOGY Papers

Book - OP
OP—Ontology: Paradigms

OP1—*Entity Ontology Paradigm*
OP2—*Substance Ontology Paradigm*
OP3—*Logical Ontology Paradigm*
OP4—*Business Object Ontology Paradigm*

Volume - B
B—Business Ontology

Book - BO
BO—Business Ontology: Overview

BO1—*Business Ontology - Some Core Concepts*

Book - BG
BG—Business Ontology: Graphical Notation
Constructing Signs for Business Objects

Graphical Notation I
BG1— *Constructing Signs for Business Objects*
Graphical Notation II
BG2— *Constructing Signs for Business Objects' Patterns*

Volume - M
M—The BORO Re-Engineering Methodology

Book - M0
M0—The BORO Re-Engineering Methodology: Overview

M01—*The BORO Approach to Re-Engineering Ontologies*

Book - MW
MW—The BORO Methodology: Worked Examples

Worked Example 1
MW1—*Re-Engineering Country*
Worked Example 2
MW2—*Re-Engineering Region*
Worked Example 3
MW3— *Re-Engineering Bank Address*
Worked Example 4
MW4—*Re-Engineering Time*

Book - MA
MA—The BORO Re-Engineering Methodology: Applications

MA1—*Starting a Re-Engineering Project*
MA2—*Using Business Objects to Re-engineer the Business*

Book - MC
MC—The BORO Re-Engineering Methodology: Case Histories

Case History 1
MC1—*What is Pump Facility PF101?*

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