Business Object Reference Ontology Program

simplifying semantics

Working Paper

OP2

Ontology:Paradigm-2

Substance Ontology Paradigm

Issue: Version - 4.01 - 01-July-2001

Contact

For queries regarding this document, or the BORO Program in general, please use the following email address:

contact@BOROProgram.org

OP2

ONTOLOGY: PARADIGM - 2

SUBSTANCE ONTOLOGY PARADIGM

CONTENTS

BORO

CONTENTS
OP2

OP2

ONTOLOGY: PARADIGM - 2

SUBSTANCE ONTOLOGY PARADIGM

1 Introduction

In *OP1—Entity Ontology Paradigm*, we saw how the entity paradigm's simplification confused its semantics. In this paper, we look at the substance paradigm's clearer semantics. We shall see that it is not only consistent but extremely powerful. In particular, we shall see how its secondary hierarchy significantly increases the potential for re-use.

Developing a firm grasp of substance semantics is important because, in our journey to the object paradigm, we will use it as a benchmark, checking whether we are making progress. This is not as easy as it sounds. Unlike technology, which clearly improves over time, conceptual systems (such as semantics) do not progress quite so clearly. Old semantics can (in parts) be just as good as, if not better than, new semantics. We will see, for example, in *OP3—Logical Ontology Paradigm* how logical semantics' attempts to improve on the semantics for change only work partially.

2 The semantics of the fundamental substance and attribute particles

In *OP1—Entity Ontology Paradigm*, we looked at the framework of the substance paradigm in terms of what was taken out during the construction of the entity paradigm. This is useful and important. But now we go to the heart of the matter; we look at the semantics of the fundamental substance and attribute particles. This explains why the substance paradigm has the framework it does, and so gives us an insight into why the simplified entity and attribute particles are the way they are.

2.1 Primary particles

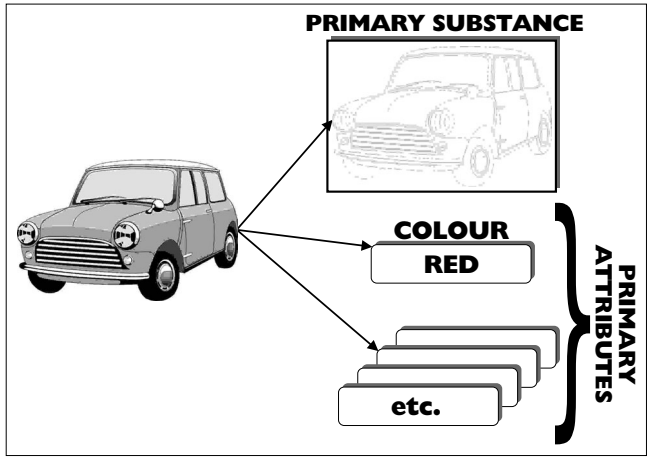
The primary level is where our ideas of substance and attribute particles make closest contact with actual particles in the real world. There is a simple, direct, one-to-one relationship between the two. Substance is, in some ways, more fundamental than attributes so we start with it.

2.1.1 Underlying primary substance

Some people find the semantics of Aristotle's primary substance difficult to grasp. They find it easy to manipulate the primary substance signs (such as the words 'my car') used for information, but find it difficult to see what these signs refer to. It is not so much that they find it difficult in itself. It is more that, when looked at directly, primary substances appear odd.

We can get an understanding of what primary substance is from this simple thought experiment. Imagine my car. Imagine each of its attributes in turn and then imagine the car without that attribute. Eventually we are left with a ghostly hulk that has no attributes as shown in *Figure OP2-1*. This is my car's substance.

Figure OP2-1 Underlying primary substance



For Aristotle, substance was a neutral foundation for things. Each thing was a single inert hunk of matter impregnated by a number of attributes, rather like water soaking into a sponge. This is why, when we take my car and strip away all it's attributes (mentally, we cannot do this physically), all that we are left with is its substance. This ghost of the original car is a single inert hunk of matter that is no impregnated by attributes.

Most people unconsciously use Aristotle's substance paradigm when seeing attributes. They are happy seeing attributes that belong to something. The problems arise when they start asking themselves what the attributes belong to. The logical (and historically correct) answer is a ghostly substance. But this seems, to modern eyes, unbelievable.

2.1.2 Modern science's view of matter

Part of the reason people now find the notion of substance unbelievable is that its view of things containing a neutral hunk of inert matter is completely foreign to modern science. Since the 17th century, scientists have regarded matter as the small particles of which things are composed. They believe that the way these small particles of matter behave determines the thing's attributes. So a piece of lead is heavy because its particles are heavy; a piece of cloth is red because its particles emit light rays of the right wavelength.

Modern scientists' particle matter is very different from Aristotelian substance. This raises a mental barrier to us accepting that, in most of our everyday life, we see things in terms of substances and their attributes. However, we tend to see a body's attributes as belonging to something, and that something is substance. There is no way for us to escape this fact because attributes are logically dependent for their existence upon substances.

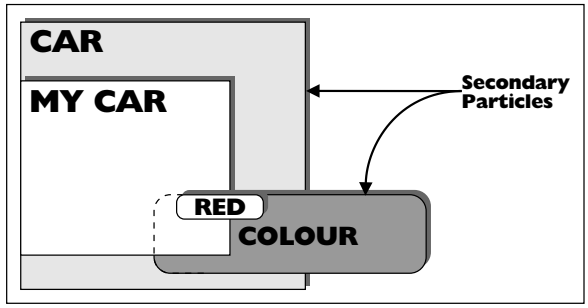
2.2 Secondary particles

The semantics of the secondary particles in the substance paradigm is not well defined. Aristotle expresses the difference between primary and secondary substance in his Categories as follows:

Substance in the most literal and primary and common sense of the term is that which is neither predicated of a subject nor exists in a subject, as for example, the individual man or horse. Those things are called secondary substances to which, as species, belong the things called substances in the primary sense and also the genera of these species. For example, the individual man belongs to the species man, and the genus of the species is animal. These, then, are called secondary substances, as for example, both man and animal.

The notion of how a primary substance 'belongs' to a secondary substance is unclear. I find that the easiest way to think about it is to consider a secondary substance as an amalgamation of primary substances. Similarly, I think of a secondary attribute as an amalgamation of primary attributes. So, for example, my car's primary substance is part of car secondary substance and my car's red attribute is part of the secondary colour attribute. This is shown schematically in *Figure OP2-2*.

Figure OP2-2 Secondary particles



3 Changes—a key type of thing

As noted in *OP1—Entity Ontology Paradigm*, changes are one of the key types of things our re-engineering focuses on. Working out what changes are, eventually leads us to the object paradigm. The substance paradigm lays the groundwork with a basic set of patterns. When we see how Aristotle used these patterns to describe changes, we will better appreciate the sophistication of his paradigm.

We start by looking at what changes are in the substance paradigm. We then look at a problem with changes and at how Aristotle's substance particle neatly avoids it. We then look at how Aristotle used his solution as a general pattern for changes.

3.1 Changes in the substance paradigm

Once we recognise that primary substance is the hunk of neutral inert matter underlying things, it becomes clear that attributes play a vital role in explaining what changes are.

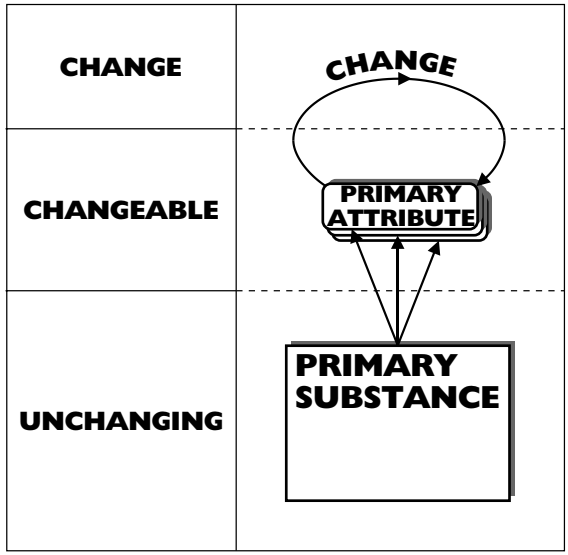
3.1.1 Defining change

If substance is inert and does not change, then when something changes it must be an attribute that changes. It is like a chameleon changing colour—the chameleon itself does not change, only its colour attribute. This division into unchanging

substance and changing attributes dictates the substance paradigm's definition of what change is; it is one attribute changing into another.

This leads to the three-tier structure for dealing with change shown in *Figure OP2-3*. At the bottom is unchanging substance, in the middle is potentially changing attributes and at the top is the actual change process, the changing of attributes. This makes change, one of our key types of things, an implicit third non-thing kind of particle.

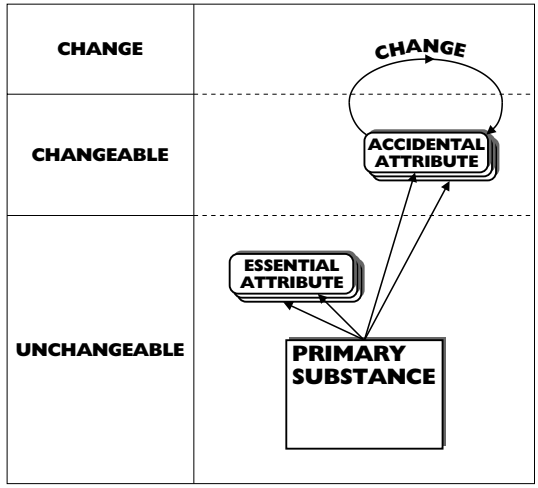
Figure OP2-3 Primary levels of change



3.1.2 Accidental (changing) and essential (unchanging) attributes

There is one small addition to the substance paradigm's framework for change. One of the first things Aristotle and his followers noticed is that not all attributes are capable of change—some are essential to the substance's existence. These were called essential attributes (from the Latin *esse*—to be). When we talk about the 'essential nature' of something, we are harking back to this Aristotelian distinction. Attributes that could potentially change were called accidental (from the Latin *accidere*—to happen). This distinction is shown schematically in *Figure OP2-4*.

Figure OP2-4 Essential and accidental attributes



This is an easy distinction for people used to working with computer systems to comprehend. They are familiar with files (secondary substances) in computer systems that have fields (secondary attributes). They are familiar with programs for amending the file's records (primary substances), which enable users to change some fields (primary attributes). These fields are the computing equivalent of accidental attributes. Fields that the users are not allowed to change are typically the computing equivalent of essential attributes.

3.2 A problem with changes

We can see the benefits of an unchanging substance if we look at how it handles a problem with changes well known to the Ancient Greeks. One of them, Heraclitus of Ephesus, was referring to this problem when he asked his famous question:

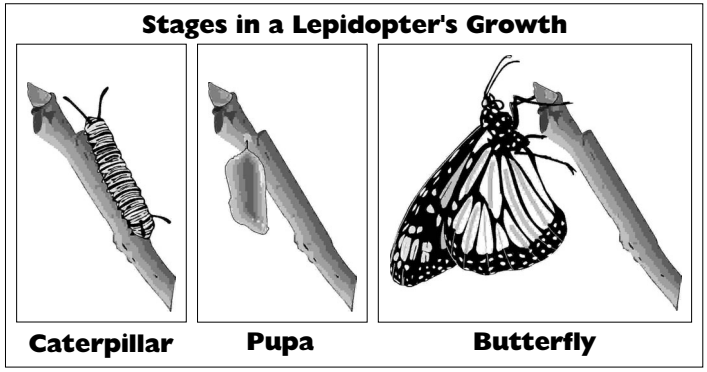
> Can we bathe in the same river twice?

The answer is obviously both yes and no. Yes, it is the same river—no, it is not the same water.

3.2.1 The problem—what makes something the same?

But why is this the answer? Why do we call the river the same at different times? It stays roughly the same size and shape and stays in roughly the same position. But this cannot be what makes it the same river. To see this, consider a lepidopter. It starts out as a caterpillar then metamorphoses into a pupa then metamorphoses again into a butterfly (shown in *Figure OP2-5*). It does not stay even roughly the same size and shape, it certainly does not stay in roughly the same position. Yet we have no problems with saying it is the same thing through all its changes. There must be something other than similar size and shape making it the same.

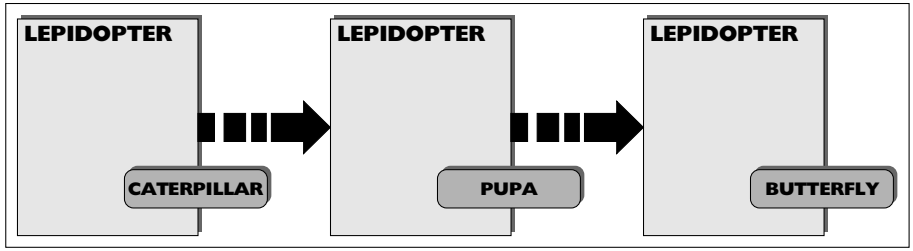
Figure OP2-5
A changing lepidopter



3.2.2 The answer—unchanging substance

The substance paradigm has a simple solution to the problem. It suggests that it is the lepidopter and river's unchanging substance that makes them the same. This is illustrated schematically for lepidopters in *Figure OP2-6*.

Figure OP2-6 Unchanging substance



3.3 Aristotle's general pattern for change

Once Aristotle established that change was the process of one attribute changing into another, he used this as the general pattern for change.

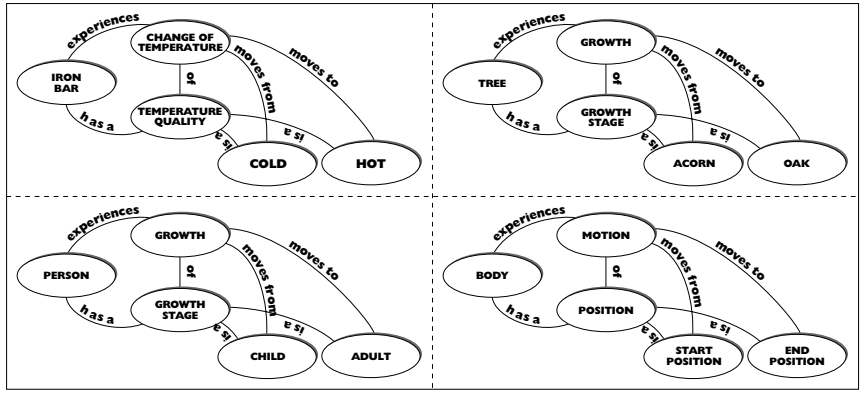
3.3.1 Change as change of attributes

He claimed that this general pattern covered a wide variety of, to us now, unrelated changes. Examples include:

- Growth (the transformation of an acorn to an oak or the growth of a child into adulthood),
- Alterations of intensity (the heating up of a cold iron bar), as well as
- Change of position (the falling of a stone).

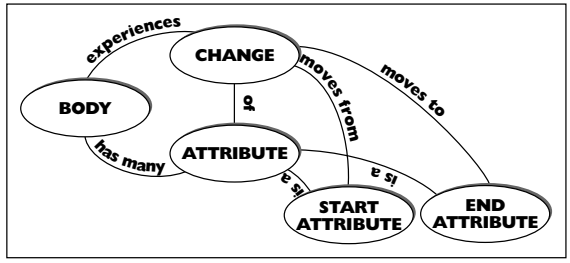
These patterns are illustrated in *Figure OP2-7*.

Figure OP2-7 Examples of patterns of change



For Aristotle, all these various types of change were similar; he saw them as members of a single natural family, each exhibiting the same general pattern. Because they all shared the same pattern, he could, and did, generalise them into the single comprehensive pattern illustrated in *Figure OP2–8*.

Figure OP2–8 General pattern of Aristotelian change



This general pattern bound the particular patterns of change closer together. It also had a big effect on how Aristotle and his followers thought about change. For them, analysing change primarily involved identifying the basic characteristics that apply to all the members of the family of change patterns. Analysing the individual characteristics of the various sub-types of change was much less important. In this way, the general pattern influenced the way in which people thought of the lower level patterns.

3.4 Aristotle's pattern for motion

One good example of how the general pattern shaped the lower level patterns is motion—change of position. Within the Aristotelian paradigm, the shape of motion's pattern was largely dictated by the shape of the general change pattern. (Compare the pattern for motion in the bottom right corner of *Figure OP2–7* with the general pattern in *Figure OP2–8*.)

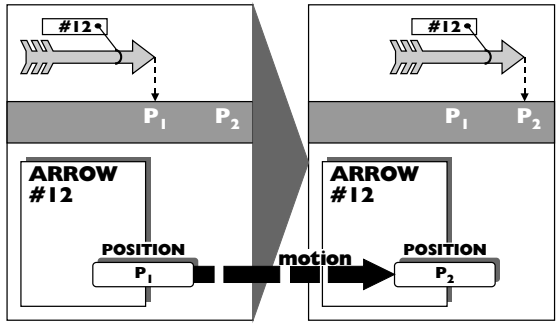
We can see this in the substance paradigm's resolution of an ancient paradox. The Ancient Greek thinker, Zeno of Elea (who lived around the early 5th century BC), raised a number of paradoxes. The one we are interested in is based on a problem with change and relates to the problem of motion. It appears to prove that moving arrows could not be moving.

We are happy to accept that the phrase 'is red' refers to a red attribute. So it is easy to assume that because the phrase 'is moving' in the sentence 'the arrow is moving' looks similar, it must also refer to something. Within the substance paradigm, we would assume it referred to a moving attribute. The similar linguistic shape turns out to be misleading. Zeno proposed a simple thought experiment that showed the arrow cannot be moving.

Consider a situation where an arrow has been shot. Think of it the instant after it leaves the bow. It would have a particular position, say two inches in front of the bowstring. Is it moving; does it have a moving attribute? One's initial reaction is to say yes. However, on reflection, if the arrow is at a particular point at a particular instant in time, it cannot be moving—it must be at rest.

Consider the arrow a second later. It is again at rest in a particular position and again, not moving. In fact, if we consider the arrow at any point in its trajectory, it will be at rest, not moving. If it is not moving, how can it have a moving attribute. This led Zeno and others to say motion is, in one sense, an illusion. We can still explain motion within the substance paradigm. It is changing one position attribute for another—as shown in *Figure OP2-9*. This falls neatly under the general change pattern.

Figure OP2-9 Aristotelian motion of an arrow



The general pattern for change inherent in the substance paradigm elegantly explains what motion is in a way that avoids Zeno's paradox. It is a change in the position attribute. The 20th century thinker, Bertrand Russell, called this an

'at-at' approach —the arrow is 'at' one position 'at' one time and 'at' another position 'at' another time.

Essentially what the thought experiment brings to our attention is that even though 'is moving' looks like an attribute it cannot be one. Within the substance paradigm, 'is moving' refers to a process of changing position attributes. In terms of the three levels of change (shown in *Figure OP2-3*), it belongs to the top level and so is neither a substance nor an attribute.

Zeno's paradox is a useful way of assessing how well a paradigm deals with change. In *OP3—Logical Ontology Paradigm*, the paradox will reveal the logical paradigm's similar implicit change particle—dynamic classifications. It is only in the object paradigm that the paradox is resolved with a type of object particle that explicitly captures the pattern for change. We shall see how this new type of object is re-engineered in *OP4—Business Object Ontology Paradigm*.

4 Generalising re-usable substance and attribute patterns

The substance paradigm has significantly more potential for generalisation, and so re-use, than the entity paradigm. Because it is a more sophisticated version of the entity paradigm, it retains all the entity paradigm's potential for re-use, and supplements it with its own. This increased potential comes from the generalisation inherent in the secondary level hierarchies. We now look at this and also at how Aristotle tried to harness its power into a general hierarchy of types of things—the categories.

4.1 Inheritance down the secondary level hierarchy

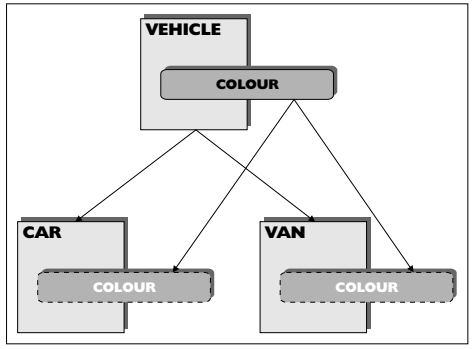
We saw in *OP1—Entity Ontology Paradigm*, how the entity paradigm re-use operates at the individual level. How it can fix a pattern of attribute types for an entity type, which is then (re-)used for its individual entities (shown in *OP1's Figure OP1-7*). In the substance paradigm, generalisation and re-use operate in the sec-

ondary level hierarchies. This involves a higher level secondary substance fixing patterns of secondary attributes for lower level secondary substances.

4.2 Inheriting secondary attributes

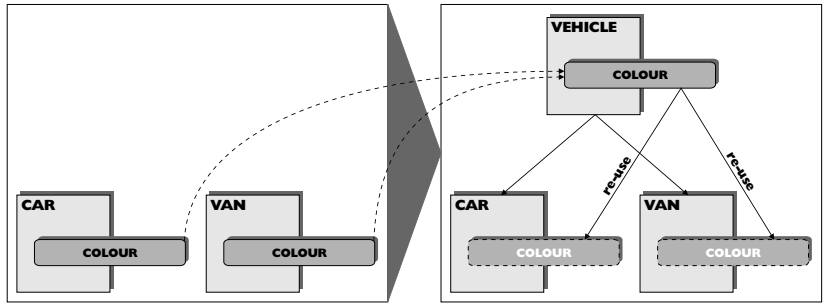
For example, if the secondary substance vehicle has a colour attribute then this attribute is inherited by all the secondary substances below it in the hierarchy. As shown in *Figure OP2-10*, this includes the car and van secondary substances. The figure shows three colour attributes. However only one of these, the vehicle's colour attribute, actually exists. The other two, the car and van substances' inherited colour attributes are there to illustrate where vehicle's colour attribute is being inherited.

Figure OP2-10 Inheriting secondary attributes down the secondary substance hierarchy



This secondary substance hierarchy can be used to compact more information in less space. *Figure OP2-11* illustrates how this works. On its left-hand side is a model with no secondary substance hierarchy, where the car and van substances both have a colour attribute. On its right hand side is the same model with a secondary hierarchy. In this model, there is only one colour attribute. This belongs to the vehicle substance and is, as shown, inherited by the car and van substances. In this very simple example, two attributes are compacted into one.

Figure OP2-11 Re-use compacting information

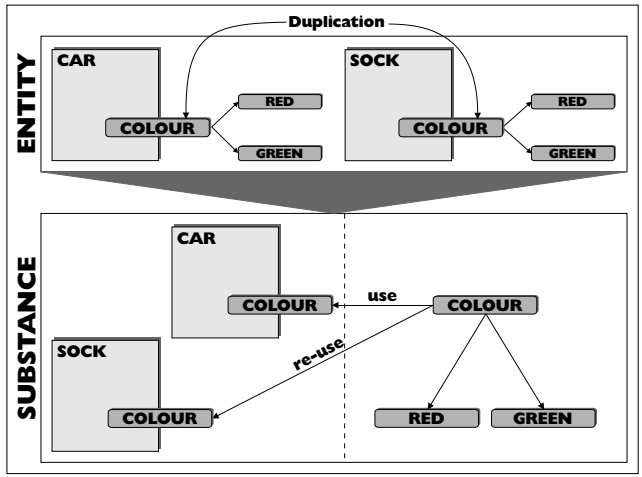


4.2.1 Re-use across secondary substances

There is another form of re-use that occurs in the substance paradigm. Because the secondary attribute hierarchies are independent of substance, it is possible for them to be re-used across secondary substances. Like attribute inheritance, this operates at the secondary level and through re-use leads to compacting.

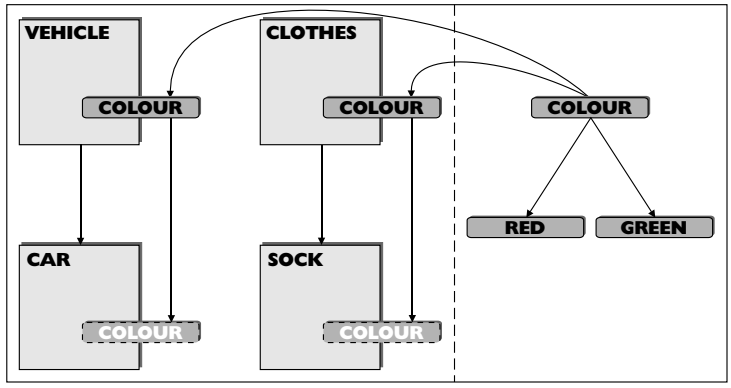
It is easiest to see how this works with an example. We use cars and colours again. There is a colour attribute hierarchy that is linked to the car substance hierarchy. It is, however, independent of the hierarchy, which means it can be linked to other substances. It could, for example, be linked to socks. These are coloured; some socks are red, some green. When we start analysing the sock secondary substance, we need to recognise that it is linked to the colour attribute hierarchy—as shown in the substance section of *Figure OP2-12*. If we did not have a secondary hierarchy we would have to construct the colour attribute anew—as shown in the entity section of *Figure OP2-12*.

Figure OP2-12
Re-using the colour attribute hierarchy



The higher up the secondary substance hierarchy an independent attribute hierarchy is connected, the more fruitful re-use and thus compacting we get. Consider what happens when we generalise the independent colour attribute connections in the substance section of *Figure OP2-12* up a level. We take the connections from car up to vehicle and from sock up to clothes—as shown in *Figure OP2-13*. Even in this simple example the scale of compacting is significant. The colour attribute hierarchy does not have to be re-built for each type of vehicle or clothes. This kind of compacting cannot be done in the entity paradigm—without a secondary level hierarchy in its framework, it just is not powerful enough.

Figure OP2-13
Generalising the re-use of the colour attribute hierarchy



4.3 Extending the framework for re-use—the Aristotelian categories

Aristotle also made another very important step for generalisation and so for re-use. He suggested that there was a general framework below the level of fundamental particles. This would mean that all information systems, computer or otherwise, could share a common, high level, framework.

Today it is normal for people in different corporations to use computer systems with different frameworks. It is even common for people within a large organisation to use systems with different frameworks. If there was one common, high level, framework across all these systems, this would greatly simplify integrating information.

All those centuries ago, Aristotle saw the need for a wider general framework. He outlined his proposal for a system of ten categories that identified specific types of secondary attributes. This was then developed and enhanced by his followers. In *MW1—Re-Engineering Country*, we will see how the system of categories develops into the object-oriented notion of a general lexicon or reference ontology.

4.3.1 Types of categories

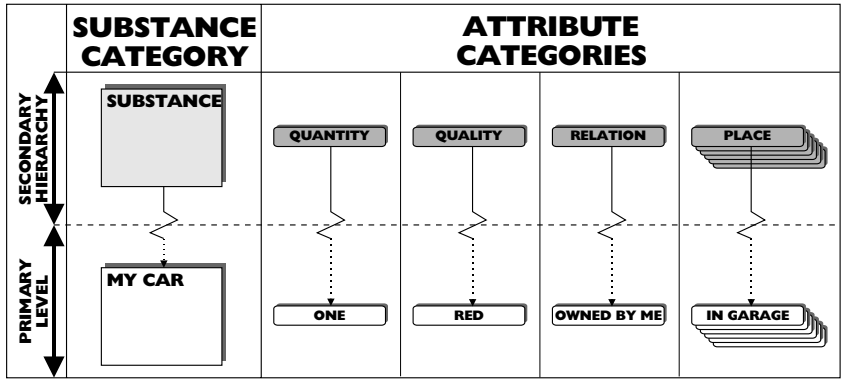
Aristotle worked from an analysis of language. He found, or thought he found, that words or phrases, and so the things they referred to, fell into one or more of ten categories. These were:

- Substance,
- Quantity,
- Quality,
- Relation,
- Place,
- Time,
- Posture,

- State,
- Action, and
- Passion.

In this framework, the nouns 'plant' and 'animal' signify kinds of (secondary) substance and so are in the category substance. The noun 'colour' signifies a quality and so is in the category quality. The first category is substance, the other nine categories are kinds of attributes. So the category structure ends up looking like *Figure OP2–14*.

Figure OP2–14 Category structure



Tree structure of categories

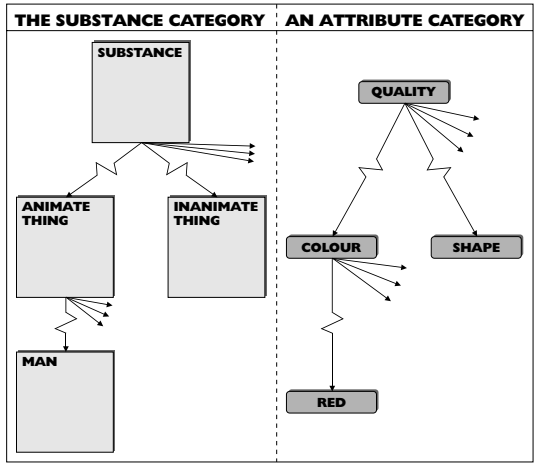
The ten categories were only the top level of the structure. Below each of them there were divisions and sub-divisions. Aristotle took a relaxed view on whether the list of categories was exhaustive and whether categories could overlap (in other words, have a lattice structure).

However, his followers, like all followers, moulded Aristotle's relaxed view into a stricter orthodoxy. For them, there were ten mutually exclusive categories whose divisions and sub-divisions had also to be mutually exclusive. They developed the traditional system of definition by genus and differentia—the 'method of division'. This starts with a very general classification (the genus) and divides it into smaller mutually exclusive types (species). This is done by means of some property (the differentia), which every member of the genus either does or does not have. The result is a tree structure.

The simplest and best known system of categories was developed by Porphyry, a 3rd century AD commentator on Aristotle's categories. His 'Tree of Porphyry' started by dividing things into material (bodies) and the immaterial; bodies into the animate (living things) and the inanimate; living things into those that had sensation (animals) and those that did not (vegetables); and the animals into rational (man) and non-rational (brutes). This served as a model for most subsequent systems of taxonomy. For example, the modern classification of the animal kingdom based on work done by the English naturalist John Ray (1627–1705), and the botanical classification devised by the Swedish taxonomist, Linnaeus (Carl von Linné, 1707–78).

Similar divisions are made in the attribute categories. For example, colour in the attribute category quality is divided into red, blue, green, etc. and then further divided and sub-divided. The shape of the resulting structure is shown in *Figure OP2–15*.

Figure OP2–15 Category tree structure

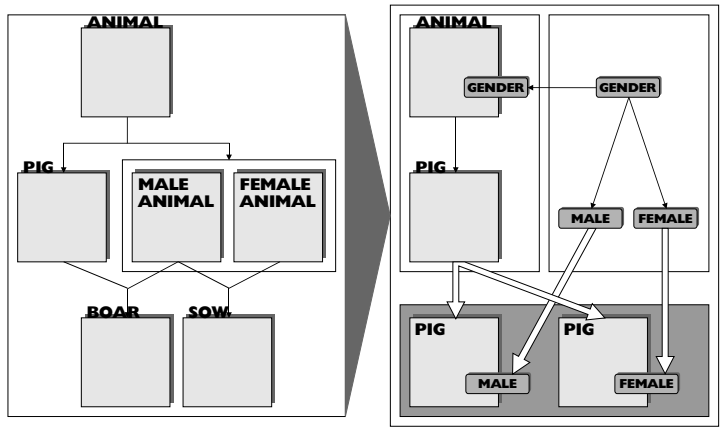


Categories as a rudimentary lattice

A tree structure is too constraining to reflect the world adequately. However, it would be incorrect to describe Aristotle's system of categories as a pure tree structure. It is really a type of rudimentary lattice structure built using parallel tree structures, one that is less constraining than a simple tree structure. For example, the lattice shown on the left-hand side of *Figure OP2–16* would be translated into a tree substance hierarchy and a parallel gender attribute hierarchy.

However, these parallel tree structures are not as powerful as a full lattice structure. In other words, they are not really powerful enough to describe the type of structures that exist in the real world.

Figure OP2-16 Parallel tree structures – rudimentary lattice structure



What is interesting is that this tree constraint is not necessary to the substance paradigm. Aristotle's followers imposed it in the (mistaken) belief that they were making the structure more organised. To them it somehow seemed better if each category was divided into *mutually exclusive* sub-categories. This shows how deeply the tree way of seeing was embedded in people's minds then—as it still is now.

Single inheritance and OOPs

Aristotelian categories have been enormously influential. They are still a powerful influence on the way we see and 'categorise' the world. We can see this influence in O-O programming languages. Early versions had what was called a single inheritance structure—what we have been calling here a tree structure.

Now these languages have developed multiple inheritance structures, but programmers still have difficulty in breaking away from the tree category way of seeing things. For example, at a recent O-O conference, most speakers who talked about multiple inheritance said they had found it was of limited use. Which it is, if you are still working within a tree category pattern.

4.4 Relation between primary and secondary levels

In the substance and entity paradigm, the relationship between the primary and secondary levels is refreshingly simple. Primary level particles belong to one and only one secondary level particle. This is known as single classification. A more flexible relationship is possible—at least from a structural point of view—where primary level particles can belong to more than one secondary level particle. This is known as multiple classification.

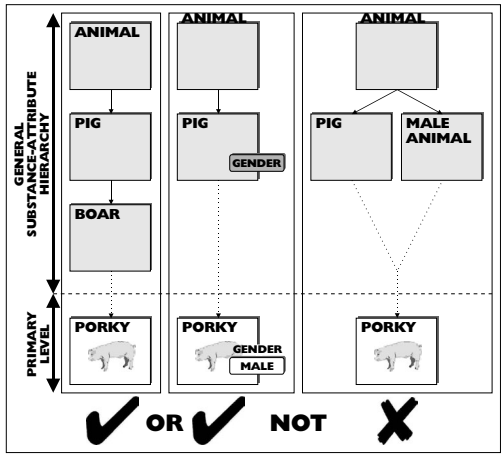
4.4.1 Single and multiple classification

Part of the reason that both paradigms have a single classification framework is in the nature of substance. This fosters a feeling that primary substances are of particular type and only of that type (in other words, belong to one particular secondary substance). This means that the possibility of multiple classification is not naturally considered by people working within the paradigm.

However, if they were to consider it then there would be semantic problems. If the hunk of inert matter was composed of two substances, would the two substances be thoroughly mixed? How would it inherit the patterns of attributes from both substances? If the substances were mixed, would the attributes belong to the whole mixture or only those bits of substance that inherited them?

In *Figure OP2-17* we can see the structural differences between these two types of classification illustrated. If multiple classification were allowed, we could classify Porky as a pig and male animal. Because we are restricted to single classification, we have two options. We can identify a new substance, boar (male pig), instead of male animal. Because this new substance only belongs to the pig substance, no multiple classification is involved. Or we can treat male as an attribute—again this does not involve multiple classification. These three options are shown in *Figure OP2-17*.

Figure OP2-17 Tendency towards single classification



Interestingly this tendency towards single classification means that the parallel tree structure format of the categories (shown in *Figure OP2-16*) is preserved across the primary-secondary level divide. As *Figure OP2-17* shows, multiple classification allows a lattice across the divide; whereas, single classification restricts the link to a tree structure.

4.4.2 Static and dynamic classification

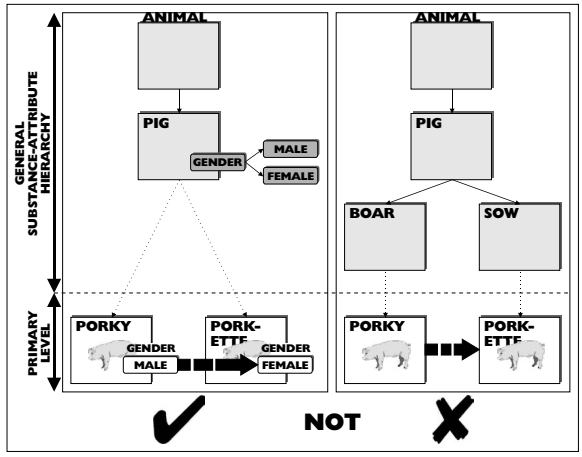
Seeing primary substance as a homogenous hunk of matter underlying things has another effect on the relationship between the primary and secondary levels. We tend to assume that a primary substance always belongs to the same secondary substance and that the relationship between the two never changes. This is called static classification. If a primary substance could change its secondary substance, then the link between the two would be called a dynamic classification.

The reason for the substance paradigm restricting itself to static classification is, like single classification, rooted in the nature of substance. Substance gives a body its identity over time. So the idea of a substance changing its type appears contradictory. If something's substance changed its type, how could it remain the same thing? If something changes, then—within the substance paradigm — it must be an attribute.

We can see how this works in an example. Assume that Porky the pig has a sex change—he/she starts off as a boar and ends up a sow. If dynamic classification were allowed, we would classify Porky initially as boar secondary substance. Then, during the sex change operation, dynamically change the classification to sow substance.

However, the substance paradigm does not allow dynamic classification. As Porky's sex changes, this means that, by definition, it is an attribute. So what is happening is a gender attribute changing, not a boar substance being re-classified. The two alternatives are shown in *Figure OP2-18*.

Figure OP2-18 Tendency towards static classification



4.4.3 O-O programming languages

This static classification aspect of the substance paradigm has, like single classification, influenced the development of O-O programming languages. These typically follow the substance paradigm in having a static classification framework, where objects cannot dynamically change type. This means that, as in the substance paradigm, attributes have to handle change.

5 Our current way of seeing

Static classification in O-O programming languages is just one of a myriad of ways in which the substance paradigm has influenced the way we now see things. Over the centuries, Aristotle's paradigm has embedded itself deeper and deeper in our consciousness, until it now seems a natural and normal way to see. As with most paradigms, this works at an unconscious level.

What this paper has done is make it conscious—revealing the semantics at the heart of the substance paradigm and so also the entity paradigm. We now have a clear and consistent idea of our current way of seeing's semantics. We consciously appreciate what a substance and an attribute are; and also, what the corresponding entity and attribute signs in entity-oriented models refer to. This conscious appreciation of our current way of seeing is an essential precursor to consciously working our way forward to the object paradigm.

5.1 The development of finer, more accurate, distinctions

The development of the substance paradigm in 4th century BC Greece was part of a general improvement in semantics enabled by the development of writing technology and the invention of the alphabet. One aspect of this that is relevant to our re-engineering is an overall development of finer, more accurate, distinctions. (We shall see, in later papers, how the re-engineering from entities to objects continues this development.)

5.1.1 Distinguishing between the literal and the metaphorical

One good example of the development of more accurate distinctions is recognising the difference between literal and metaphorical descriptions. Before Aristotle's time, people did not make this distinction. Aristotle's teacher Plato had not quite arrived at it. In the *Sophist* he condemns 'likenesses' (in other words, metaphors) as 'a most slippery tribe' even though he is himself using one.

Aristotle, however, made the distinction both forcefully and explicitly. He condemned metaphors outright, insisting that they should not be used in definitions and criticising them in his predecessors work. For example, Aristotle criticises Empedocles for describing salt water as the sweat of the Earth (and so, by implication, that sweat and sea-water are the same).

Aristotle comments:

> *Perhaps to say that is to speak adequately for poetic purposes—for metaphor is poetic—but it is not adequate for understanding the nature [of a thing].*

With hindsight we can see that it was not so much that Empedocles was mistaken, but that he had not developed a sufficiently accurate framework to distinguish between the literal and metaphoric.

5.1.2 Comparing oral and literate cultures

If we compare the way oral and literate cultures see signs and sameness, we can clearly see the development of the finer and more accurate distinctions that came with writing. The notion of a sign is quite broad. We say things like:

A rapid pulse is a sign of a fever.
This footprint is a sign someone passed here recently.
Pottery fragments are a sign of human civilisation.

We also talk of things as signs representing other things:

The elephant represents the (US) Republican party.
The (UK) Member of Parliament represents his constituents.

We use both of these ways of talking to explain the meaning of words and symbols:

The word 'dog' is a sign for a dog.
The symbol '$' represents dollars.

At a general level, all these types of signs have something in common. But modern western culture, with the resources of writing, has developed a sophisticated understanding of their differences. It recognises that the link between the word 'dog' and a dog is not the same as the link between a rapid pulse and fever.

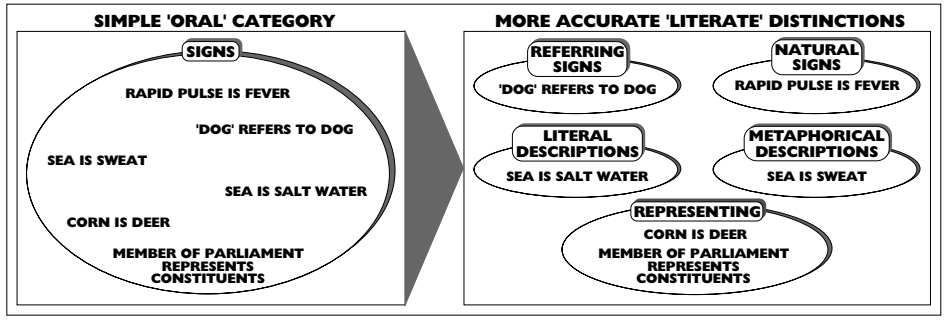
However, these distinctions took a long time to develop. Often oral cultures not only do not make these distinctions but also do not make a sharp distinction between the thing itself and something that represents it. A well-researched example is the Huichol Indians of Mexico, who sacrifice deer to their gods. When no deer is available, they offer corn in its place. They explain this by saying that the corn is the same as deer.

This sounds amazing to our literate ears. We can see it is in their interest to say that corn is deer; it means they have something to sacrifice to the gods. The connections go deeper than that. For example, their mythology claims that corn was once a deer. However this does not explain why, in discussions, they adamantly claim that corn and deer are the same. A claim that, to our literate minds, is unintelligible.

The Huichol are not unique: other oral cultures make similar claims. The Nuer of Sudan claim that twins are birds. The Zafimaniry claim that the centre post of the clan's chief hut is an ancestor. The Puluwat Islander navigators claim that east is a big bird. We have similar claims in our history. Statements such as 'this is my body' in the Christian bible, puzzled the scholars developing a literate (and literal) understanding of text in the Middle Ages and still puzzles some people today.

We can understand what is going on once we realise that the problem is not with the oral cultures' ideas of corn and deer, but with their ideas of signs and sameness. Without the resources of writing, they have not yet developed our modern, more accurate, distinctions between different types of signs and sameness. *Figure OP2-19* illustrates this development schematically. The Huichol Indians claim that corn is deer because, for them, saying that 'corn is deer' is the same type of thing as saying that 'corn represents deer'. 'Is the same as' and represents' belong to the same conceptual category.

Figure OP2-19 Shift to finer, more accurate, distinctions



This is why the Huichol form of identity claim is common in oral cultures, but unintelligible to literate ones. Oral cultures do not need as sharp a distinction as literate ones; for them the potential ambiguity it is not a problem. We shall re-visit the Huichol Indians when we look at how the shift to the logical and object paradigms leads to similar developments of finer distinctions. There the boot will be on the other foot. Most of us will be in the position of the Huichol Indians. We will (initially, at least) find it difficult to see what these new distinctions are and why they need to be made.

6 The four key types of things

We have seen that the substance paradigm, despite its extreme age, was and is sophisticated. We have seen how it addresses all four of the key types of things we identified in *OP1—Entity Ontology Paradigm*:

- How it uses the notion of primary substance and attributes to handle things' particularity.
- How it uses the notion of secondary substance and attributes to handle types. How it uses the secondary hierarchies to handle levels of generality.
- How it uses relational attributes to handle relationships—although, as we have seen, this is not really a satisfactory solution.
- How it uses shifts to new accidental attributes to handle changes—although these shifts are, in a sense, a new implicit type of particle.

For our purposes, it offers a comprehensive semantics for the four key types of things. This is why it makes such a good benchmark and starting point for our re-engineering to object semantics.

7 Summary

In *OP1—Entity Ontology Paradigm*, we saw why the substance paradigm was simplified into the entity paradigm and the semantic confusion this caused. We also recognised that this simplification taught us to down play, even ignore, the semantic aspects of business entity modelling. We discussed the root cause of this, the two-dimensionality of paper and ink technology. With the invention of computing technology, this constraint disappears and we have an opportunity to re-introduce semantics into business modelling.

Some people may be tempted to do this within the substance paradigm's semantics described in this paper. It is, in many ways, an improvement on the entity paradigm. It has the benefits of both secondary substance and attribute hierarchies and, through the use of independent attribute hierarchies, the potential for re-use across secondary substances. But the substance paradigm is not just old; it is ancient—over two thousand years old. There have been several generations of developments in semantics since then. It only makes sense to take advantage of the improvements they offer.

Furthermore, the substance paradigm seems to have a couple of potential problems in reflecting the real world accurately. We have seen how its treatment of relationships is unsatisfactory. We have also seen that its secondary hierarchies cannot handle multiple inheritance and classification. If we want to take full advantage of computing technology's flexibility, we need to rise above these constraints.

Nevertheless, the substance paradigm plays an important part in our re-engineering of the information paradigm. It acts as a benchmark against which we can measure the progress of the re-engineering. Each step forward should offer bet-

ter solutions to the issues, and, in the end, more potential for re-use. In *OP3—Logical Ontology Paradigm*, we re-engineer into the next paradigm on our route to objects.

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 - MO
MO—The BORO Re-Engineering Methodology: Overview

MO1—*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?*

SUBSTANCE ONTOLOGY PARADIGM

A–G

A

C

D

E

F

G

H

I

L

M

O

P

R

S

T

Z