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THE BORO APPROACH: STRATEGY - 3

WHAT AND HOW WE RE-ENGINEER

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WHAT AND HOW WE RE-ENGINEER

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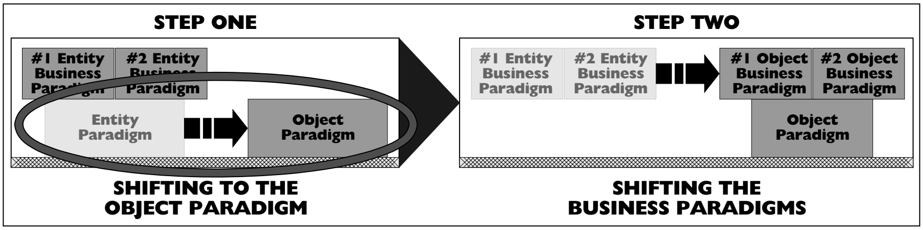
WHAT AND HOW WE RE-ENGINEER

1 Introduction

In *AS2—Using Objects to Reflect the Business Accurately*, we divided the re-engineering of our business paradigm's entities into two steps— as illustrated in *Figure AS3–1*. Step one is a re-engineering of the entity foundations (in other words, the entity paradigm).

Figure AS3–1
Re-engineering the entity paradigm



In this and the following paper *AS4—Focusing on the Things in the Business*, we look at our strategy for this re-engineering. In this paper we address three questions:

- What do we re-engineer?
- How do we re-engineer?
- What benefits does it bring?

In the next paper, *AS4—Focusing on the Things in the Business*, we focus in on exactly what we will re-engineer—the things in the business.

2 What do we re-engineer?

What do we re-engineer? We ask the question at two levels, so, we get two answers—paradigms, and fundamental particles.

At the top level, we re-engineer paradigms. Seeing what this involves helps us to understand what is going on. At a lower level, we re-engineer the fundamental particles from which the paradigm is built. We look at these two levels in the following sections.

2.1 Paradigms

Seeing what happens when we shift from one paradigm to another is the best way to understand what a paradigm is. In *AS2—Using Objects to Reflect the Business Accurately*, we made the point that this involves fundamental changes to the way we see things. But until you have actually been through the experience, it is difficult to appreciate that just seeing something differently can have a fundamental impact. However, we can use an analogy between ambiguous pictures and paradigm shifts to get a feel for what is going on.

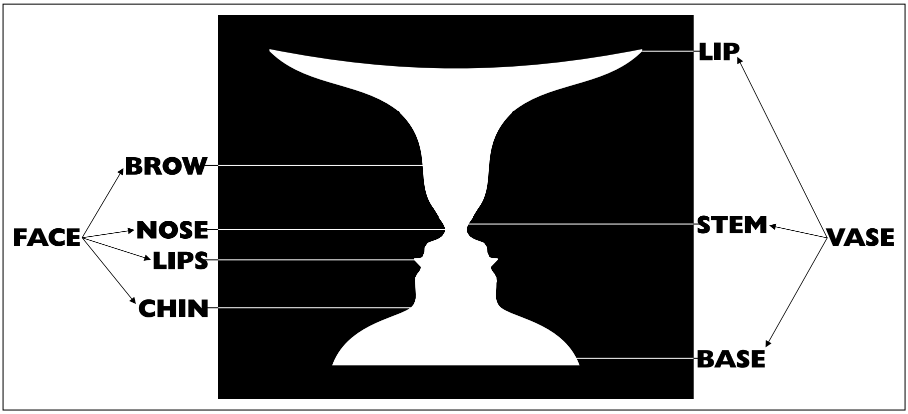
2.1.1 A re-engineering analogy

We use the well-known ambiguous picture in *Figure AS3-2*, not just to give us a feel for what is going on, but also to counter two common misconceptions. Most people tend to assume that:

1 Different views of the same thing must somehow be basically similar, and
2 Seeing something differently involves changing the thing.

Neither of these is true for the ambiguous picture. Its two views are not at all similar and, despite this, nothing in the underlying picture has changed. What changes when we shift from one view to another is how we see the underlying picture. The picture itself remains the same.

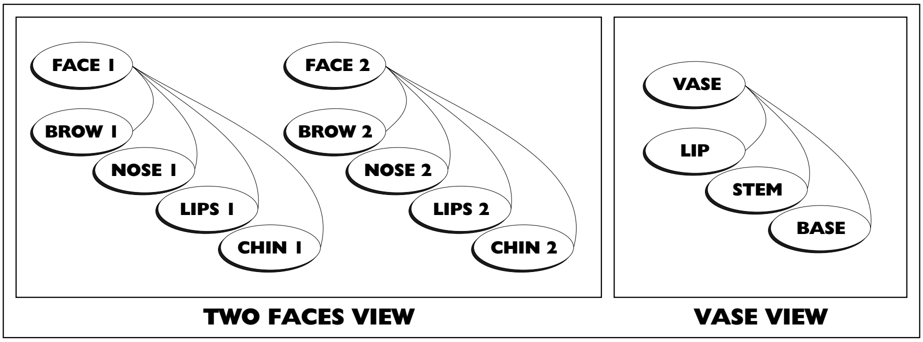
Figure AS3–2
Two views of the same underlying picture



Let us look at what is going on in more detail. Assume I start by seeing two faces and then I switch to seeing a vase. When I switch, I have to dismantle my image of two faces and then construct an image of the vase. When I do this, the picture does not change. Nevertheless, I start to see the same picture in a radically different way.

We can get some idea of how different each perception is by looking at the way the two views classify the parts of the picture —at their semantic structure. This is mapped in *Figure AS3–3*. The two structures are so different that the only elements with similar names ('lip' and 'lips') refer to different parts of the picture.

Figure AS3–3
Map of the semantic structure of the two views



Fundamental paradigm shifts work in a way analogous to this ambiguous picture. Our current paradigm imposes one view on the world. The shift to a new paradigm leads to a radically different way of seeing exactly the same world. Like the picture, we can only see the world through one paradigm at a time. But unlike the picture, where we can shift back and forth between the two views at will, a paradigm shift is normally one way—from the old to the new. This is because when we see the new paradigm's world view, we recognise the faults of the old one. The new paradigm then appears obviously better: we are not tempted to shift back.

The analogy holds in another important way. Like the picture, a paradigm shift involves a substantial discontinuity. Intuitively we tend to assume that two views of the same underlying thing must be similar, but the opposite is true of both the picture and paradigm shifts—they are completely different. This explains why they have the potential for delivering enormous leaps in performance.

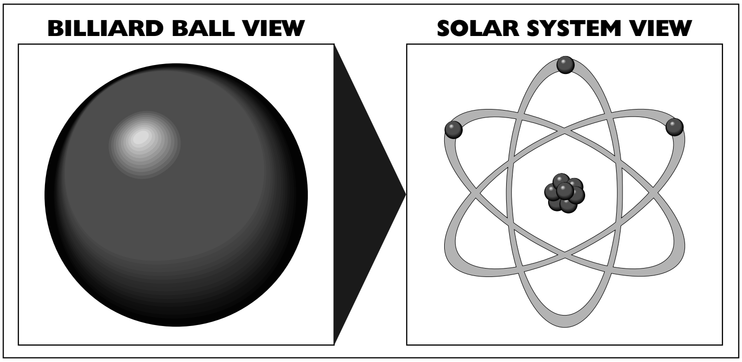
2.1.2 Radical changes lead to radically different questions—an example

When we start seeing something in a different way, we ask different questions about it. For example, we would naturally ask different questions about the vase and two faces in the ambiguous picture. Many historical examples of paradigm shifts significantly change the questions people ask and so the way they think and behave. The following example from chemistry illustrates how this happens.

In the 19th century, chemists assumed that things were made out of indivisible billiard ball-like atoms. They assumed that the atoms of each particular element were indistinguishable and that the atoms of different elements had different weights. In this scheme, it made sense for chemists to devote a lot of effort into trying to calculate precisely how much the standard billiard ball atom of a particular element weighed. For example, they calculated chlorine had an atomic weight of 35.453.

When the paradigm for atoms shifted in the 1920s, under the new scheme of things, atoms were seen as miniature solar systems—so they had divisible parts (see the two views illustrated in *Figure AS3–4*). Chemists then began to look at elements in a new light. Instead of indistinguishable atoms, they began to see that some elements had a number of different types of atoms; each with different weights that they called isotopes.

Figure AS3-4
Two views of an atom



This, they realised, meant that their cherished atomic weights were not a fundamental property of the element's atoms but a fortuitous mixing of different isotopes. Chlorine's, for instance, was the result of a natural mixture of two isotopes, 35 and 37, in the ratios 75.33 percent and 24.47 percent. It was not a real property of the chlorine atom at all. Chemists then lost all interest in atomic weights and stopped trying to calculate them. They regarded all their previous efforts as irrelevant. The new way of seeing atoms had changed the questions they asked and so the way they thought and behaved.

2.1.3 Paradigms as holistic frameworks

One of the reasons that paradigms have such an influence on our thinking and behaviour is because they provide holistic frameworks for our knowledge. In other words, they offer consistent and coherent systems for seeing the world.

Unambiguous views of the world

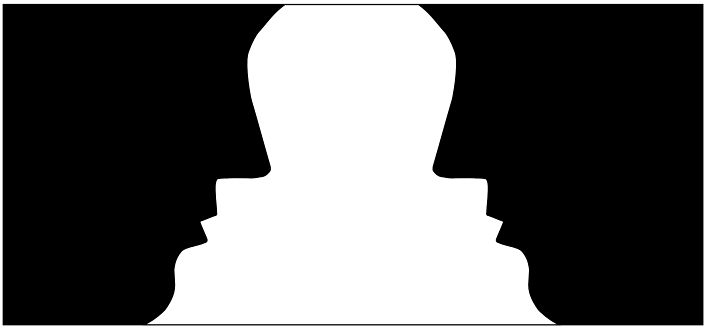
A key function of these holistic frameworks is to give us an unambiguous view of the world. The fact that we can view a picture in a number of ways (at different times) implies that the picture in itself cannot determine what we see. However, we can deal with a picture much more efficiently if we have an unambiguous view of what it is. That is why our brain naturally imposes such a view and why we only see one view at a time.

The same principle operates with paradigms. Our knowledge of the world is ambiguous. So our brain uses a paradigm to give us a particular unambiguous view. The paradigm makes us feel that this is the only natural view of a situation. Most of the time, it is so successful that we find it difficult to accept that our view is only one of many possible interpretations.

Needing the whole holistic picture—an analogy

In a holistic framework, the whole is more than the sum of its parts. For a paradigm, this means that we do not see its parts until we have seen the whole. In other words, we can only see the elements that make up a paradigm as its parts in the context of the whole paradigm. This sounds odd, but we can illustrate what it means with another picture analogy. Consider the picture of two faces in Figure AS3–5. This is unambiguous. It does not look like two vases, or indeed anything other than two faces.

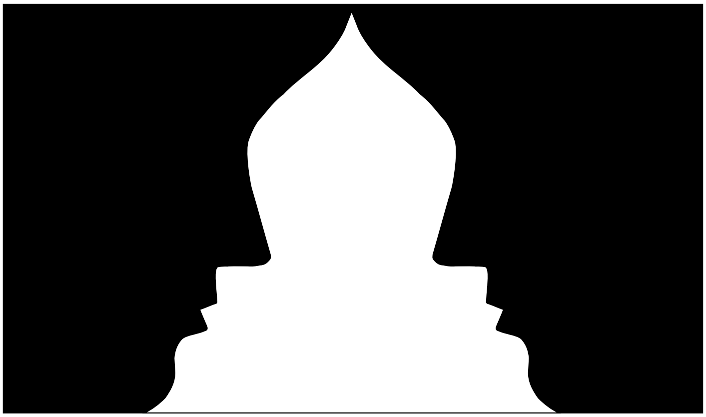
Figure AS3–5 Another two faces



Now look at the picture in Figure AS3–6. It is ambiguous; we can see it as either a mosque's minaret or two faces. You may have noticed that Figure AS3–5 is the same picture as Figure AS3–6, with the top section removed. This means Figure AS3–5 must contain most of the elements that make up Figure AS3–6's minaret view. When we first saw it, however, we did not see two-thirds of a minaret. This is because we need to see the whole minaret pattern before we can recognise a part of it. Figure AS3–5 does not have enough of the pattern to make up a whole minaret, so we do not see one. This means we also did not see the elements of Figure AS3–5 as parts of the minaret.

We need to see the whole pattern before we can see the parts. Now that we have seen the whole minaret pattern, we can look at *Figure AS3–5* and see its elements as parts of the minaret.

Figure AS3–6
Two faces or a mosque's minaret



2.1.4 Difficulties in seeing a new paradigm

The ease with which we can shift from one view of an ambiguous picture to another may seem to imply that shifting paradigms is just as easy. Unfortunately, this is not so. When we start re-engineering, we shall find all sorts of difficulties.

Paradigms, by their nature, do not encourage re-seeing, re-thinking and re-inventing. Their task is, as we said earlier, to make us see one unambiguous view of things. This makes them difficult to re-engineer. The features of a paradigm that are strengths when dealing with everyday tasks tend to become barriers to a successful re-engineering.

In everyday use, a paradigm's strength comes from enabling us to accommodate the new patterns we meet into its framework. This becomes a problem when we start re-engineering. Then we often need to recognise when a new pattern does not properly fit in with our current paradigm. This is what starts the re-engineering process rolling.

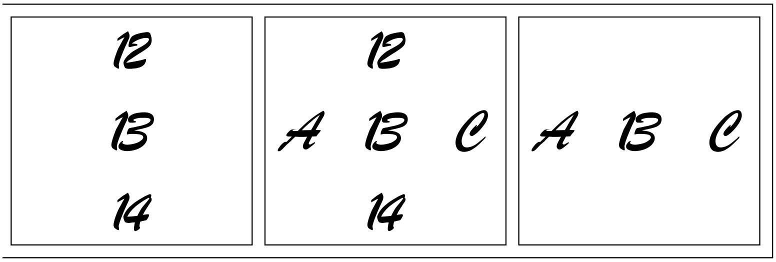
However, our current paradigm tends to make it difficult for us to recognise this. It trains us to see the world in a particular way. It also, by default, trains us not to see the world in the way we need to for the new paradigm. Instead, we see the new patterns that should provoke a re-engineering in the existing paradigm's terms.

Difficult to see new patterns—another pictureanalogy

We use another picture analogy to illustrate how this works. *Figure AS3-7* has three boxes based upon those used in a common psychology experiment. These are shown to people one box at a time, and they are asked to say what they see.

The experiment reveals that what people see in the first box affects what they do and do not see in the later boxes. When people are shown the box on the left first, they see the sequence of numbers 12–13–14. If they then look at the middle box, they still see the middle character as '13'. Surprisingly, a number of people, when looking at the box on the right, still see the middle character as '13'. Recognising the 12–13–14 pattern in the first box has stopped them seeing the A–B–C pattern in the second and, in some cases, the third box.

Figure AS3-7 How what we see first affects what we see later



This is not because people find it easier to see numbers than characters. This was proved by repeating the experiment in the reverse order, showing the box on the right first. People then start off seeing the sequence of letters A–B–C. This sets the pattern. So when they then look at the box in the middle, they see the middle character as 'B'. And again when they look at the box on the left, some people still see the middle character as 'B', in other words, a sequence 12–B–14.

In both cases once people grasp the first pattern, they have some initial difficulty in seeing an alternative pattern even when the original one is incomplete (as in the last box). This gives us some idea of how difficult it is to see a new pattern that is ruled out by the current pattern. It also gives us an idea of how difficult it can be to re-engineer when the old paradigm trains us not to see the pattern we need to recognise for the new paradigm.

Germ paradigm — Pasteur example

This picture example is not just an academic psychological trick. In such practical disciplines as medicine, paradigms have trained doctors to see new patterns of disease as part of an old pattern, sometimes with deadly results. Consider, for example, what we shall call the germ paradigm.

In the 19th century, the French scientist Louis Pasteur (1822–1895) developed an understanding of germs (micro-organisms) and a recognition that these played an important role in disease. He used this knowledge to help the French beer, wine, and silk industries. He also used it to improve people's health, developing vaccinations against anthrax and rabies. His and other scientists' successes with the 'germ paradigm' led to a belief in the medical profession that, if a disease was not caused by a parasite, it must be caused by a germ. They assumed that the answer to the question—'What is causing this disease?'—involved either parasites or germs.

This acceptance of the germ paradigm eventually led to problems. We now know that some diseases are caused by a deficiency in diet (and not germs or parasites). One of these diseases is beriberi. In the early years of this century, there was an epidemic of beriberi in Asia that killed millions of Chinese and Indonesians. The germ paradigm was so deeply embedded in the medical establishment's thinking that they unconsciously and unthinkingly assumed that the beriberi epidemic was caused by germs and carried out their research accordingly.

Eventually, dietary experiments by the Japanese navy challenged this assumption. These helped to prove that it was not the presence of germs that caused the disease, but the absence of something in the rice people were eating. It was then discovered that the new processes of steam-polishing rice, imported from Europe to Asia, destroyed the vitamin B_1 in the hull of the rice. It was the lack of this vitamin B_1 that was causing the beriberi epidemic.

Intriguingly, a leading professor of tropical disease at that time, Patrick Manson, did not accept the new paradigm, despite all the evidence. He insisted on interpreting the Japanese navy findings in a way consistent with the old germ paradigm. He claimed that the germs that caused the disease can and do live in the polished rice but cannot live in the unpolished rice. His training in the old paradigm was so strong that he was seeing the new patterns in its terms. At that stage the 'new pattern' (in other words, the results of the Japanese navy's experiments) could be interpreted to support either theory. Only later on did it become clear that the germ paradigm was not a helpful way of looking at beriberi.

In a more modern medical context, some 'rogue' scientists are suggesting that AIDS researchers might be thinking and behaving in a similar way. They think that AIDS researchers might be stuck with a 'virus paradigm' that directs them to only look for a virus as the cause for AIDS. Their concern is that this may be making them ignore alternative patterns that might turn out to be more fruitful.

In a computing context, we can see something similar happening in O-O programming. When an O-O programming language (OOPL) is introduced into a traditional programming environment, programmers trained in traditional programming often still use the traditional patterns to program in the new language. They have been taught to see and ignore other patterns. These other patterns include those they need to see to make effective use of the new OOPL. As a result, they have some difficulty learning how to work with it.

2.2 What do we re-engineer?-—The fundamentalparticles of paradigms

We have seen that the answer to the question—'What do we re-engineer?'—at the top level is paradigms. We now ask this question at a lower level. The answer this time is fundamental particles. Paradigms are often built around one or more central patterns or particles. When this happens, a fundamental re-engineering usually involves changing those particles.

2.2.1 Re-engineering information's fundamentalparticles

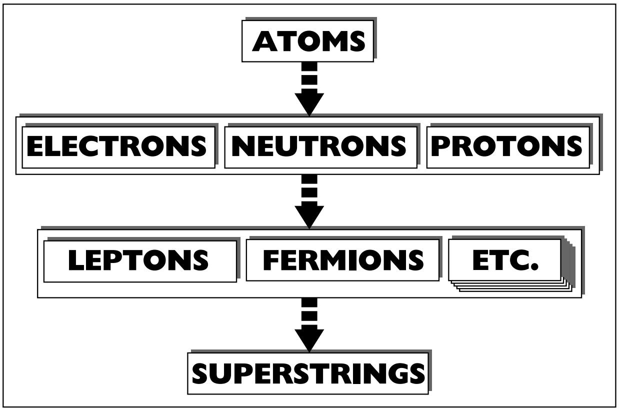
There is a close analogy between the way physical matter paradigms, such as the atom paradigm in the earlier chlorine example, work and the way information paradigms work. We now pursue that analogy.

The physical matter paradigm analogy

Physics explains the world in terms of its physical matter paradigm. The most fundamental patterns in this paradigm are physical particles. These are the building blocks from which physicists construct their world. They started the 20th century with a paradigm in which the atom was the fundamental physical particle. While they subscribed to this paradigm, they believed everything—from aardvarks to zebras—was made of indivisible atoms.

Since then, physicists have re-engineered the physical matter paradigm a number of times—each re-engineering is characterised by a complete change of fundamental particles (shown in *Figure AS3-8*). When physicists divided the atom, they introduced a whole new family of fundamental particles: electrons, neutrons, and protons. When they put these into their enormous particle accelerators, they found (and so shifted to) a profusion of new types of particle—things such as leptons and fermions. Their latest paradigm is less prolific; it has a single type of fundamental particle—superstrings.

Figure AS3-8 Shifts of fundamental physical matter particles

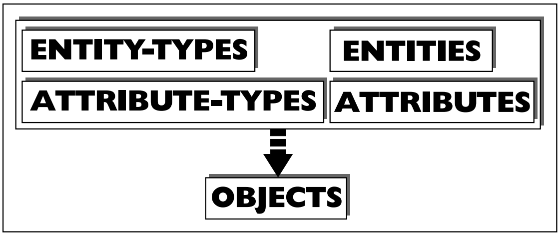


The information paradigm's particles

Information paradigms work in a similar way. Just as physical matter paradigms have fundamental physical particles, so they have fundamental information particles. When we use the paradigm, we use these particles to build up our picture of the world. For instance, the entity paradigm has four explicit fundamental particles: entity types, entities, attribute types, and attributes. When we use the entity paradigm, we build up our picture of the world using these four particles.

Re-engineering our entity paradigms, like re-engineering physical matter paradigms, involves a radical shift of fundamental particles. When, in Parts Three and Four, we re-engineer to the object paradigm, we shall see these fundamental particles change. We will start with the entity paradigm's four particles and end up with the object paradigm's single particle (shown in *Figure AS3–9)*. This is a similar pattern of changing particles to the re-engineering of the physical matter paradigm illustrated in *Figure AS3–8*

Figure AS3–9 Shifting fundamental information particles



2.2.2 Recognising that business models have fundamental particles

Some people initially find it difficult to think about fundamental particles and how we use them to see the world (or business). It gets too close to the foundations of how we see the world. Sometimes, people in the computer industry also succumb to the feeling that somehow the notion of fundamental particles does not apply to business models.

For example, most people working with computers would accept that one must be conceptually accurate when talking about computer code (computer software system's fundamental particles). However, some of them are less happy about being accurate when talking about the business's particles. They are not sure whether the things in the business are objects or entities; for example, is a car a car object or a car entity. They probably feel that this is not particularly relevant to them. They certainly do not think that their talk about business things commits them to any particular type of thing and certainly not any type of fundamental particle. For example, if they were to put a sign for a car entity in their business model, they would not feel that this commits them to classifying the car as an entity. Or, that it commits them to having entities as their fundamental particles.

This attitude may be appropriate for casual conversation, but is quite harmful when doing something formal, such as business modelling. If we unconsciously use an entity approach to business modelling then, whether we like it or not, we are seeing the business in terms of entities and attributes. Ontology, the branch of knowledge that studies fundamental information particles, calls this 'ontic commitment'. Until we realise how crucial this 'ontic commitment' is, we will not be able to start the re-engineering process.

We might not be conscious of making this ontic commitment when we build systems because we are focusing on technical problems. But it is still there, happening at a subconscious level. The problem with leaving these kinds of decisions to the whims of our subconscious mind is that our ontology (in other words, our scheme of fundamental particles) tends to end up as a confused hotchpotch. People may be able to muddle through system building with a confused ontology, but they are missing out on an enormous opportunity. To take advantage of it, they need to make accurate 'ontological' decisions about types of business things during business modelling.

Some people might think we can avoid this 'ontic commitment' by leaving out the business modelling stage altogether. But they are fooling themselves. As soon as we start talking about business things—which we have to do at some stage—we have committed ourselves. So even if we start our system building by coding, we still make an ontic commitment. A system whose computer code refers to things in the business—even apparently innocuous things like 'company', 'date', or 'amount'—is clearly committed to those things' existence. And they are of a certain type: entities, objects, or something else. There is no way of avoiding this.

2.2.3 Fundamental particles versus complex business objects

We may now accept that, when we model, we commit ourselves to some kind of fundamental particle of business information. But people often succumb to another feeling—one that says thinking about these fundamental particles is a waste of time. They feel more benefit is to be gained from coming to grips with complex business objects. (In the financial sector a complex object would be something specialised, such as a 'reverse repo'—a complex deal with a number of elements.)

What they (and we) need to recognise is that the only way to transform apparently complex business objects, such as reverse repos, into simple ones is to start with their fundamental particles. For most people, the problem is getting our ideas about complex objects into shape seems to have an obvious benefit. Whereas, the benefit of getting their fundamental particles right is not so obvious.

Building constructio n analogy

Another analogy, this time an engineering one, should help us see more clearly why starting with fundamental particles rather than complex business objects brings much bigger benefits. If we look at the history of building construction, we can see that, at each stage of its development, the nature of its fundamental particles placed a limit on what could be built. (These particles are relatively easy to spot because they are literally physical building blocks.) History shows that shifting to new and better particles has led to big improvements.

A long time ago when most buildings were made out of mud and straw, we could say the builders had a mud paradigm. While the buildings were attractive, and in hot dry countries practical, it was technically difficult, often impossible, to construct a building much higher than two stories. Mud (the fundamental particle) just did not have the strength for it.

Then builders discovered that once mud is baked in a kiln to produce a brick its strength increases substantially. Buildings with ten stories became feasible using this new, stronger, brick particle. But bricks have their limit. They cannot support the skyscrapers we see in most major city centres. These use a different, stronger, building block—re-enforced steel and concrete. With this new 'particle', buildings reaching up to the clouds can and have been built.

It is plain that the stronger the particle, the taller the building can be constructed. If someone had not worked at improving the fundamental particle, we would not be able to construct the tall structures we have today.

A similar analogy can be made with the way in which we talk of early human civilisations. We talk of a Stone Age followed by the Bronze and then the Iron Age. These names refer to the material (the fundamental particles) used to make tools. The nature of the 'particles' clearly had an enormous influence on the overall nature of the civilisation. Advances in material (particles) led to substantial advances in technology.

The fundamental particles used in the information paradigm work in the same way. We can only build strong powerful computer systems if we use strong powerful particles. These are not physical, like building materials. The physical problems of building computer hardware are reasonably well understood. Engineers are having enormous success developing better hardware without a fundamentally new physical particle.

The fundamental particles of an information paradigm are more like ideas than physical building materials. Most system builders are now using entity and attribute particles (ideas). However, they are finding that these particles do not match up to the task of building very complex business systems—just as house builders found their mud 'particles' were not strong enough for tall houses. When they try to build complex business systems, they have to put in a substantial effort and, even then, often fail.

They need stronger and more powerful particles than entities and attributes. With a better information particle, such as business objects, they will have more success building these very complex systems. When we look at the problem in this way, spending time improving the fundamental particle, by re-engineering entities to objects, is not a waste of time. In fact, it is probably the only practical and sensible way to deal with the situation.

3 How do we re-engineer? —With thought experiments

How do we re-see and re-think the entity paradigm's fundamental particles? What tools do we have to help us? If we were scientists trying to find new facts about the world, we could conduct physical experiments with test tubes or pulleys or whatever in our laboratory. But here we do not want to find new facts; we want to re-see and re-think existing ones. We do this using thought experiments—a kind of mental analogue of the physical experiments—scientists do.

3.1 How to do a thought experiment

Physical experiments involve carefully observing something happening, often in a laboratory. Typically, the experimenter predicts what he expects to happen and sees whether it actually does. Thought experiments are similar but they involve no physical observation whatsoever, merely thinking or mental observation. This means that they do not need a laboratory. These are the kind of experiments that can be performed in an easy chair.

3.2 Principles of a thought experiment

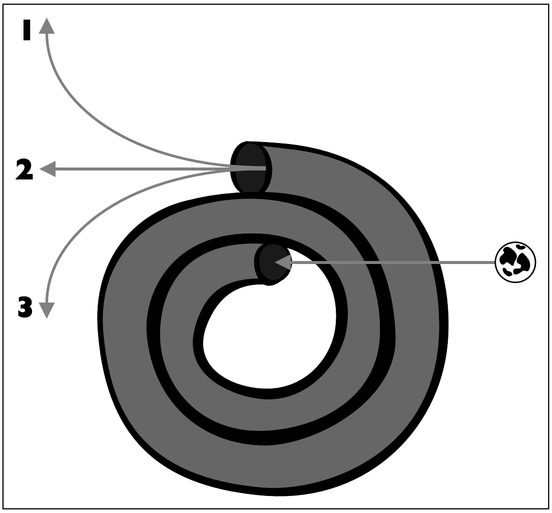
A thought experiment works by first making an inconsistency in a paradigm explicit. Highlighting the inconsistency engenders a distrust of the paradigm. Then, the thought experiment demonstrates how the new paradigm neatly gets around the inconsistency—clearly showing its superiority.

A typical experiment works like this. We are asked to think about what we would normally expect to happen in a situation. This is chosen to highlight the superior coherence of the new paradigm. We are often also shown how our current paradigm leads us to expect two contradictory things to happen—as in the example below. At no stage do we actually have to do anything.

3.3 An example of a thought experiment

Here is a simple thought experiment. It has been used by psychologists to show how misleading our intuitions can be. Consider *Figure AS3–10*, which shows the apparatus for the experiment—an imagined piece of coiled-up tube and a marble.

Figure AS3–10
Shooting a marble into a coiled tube



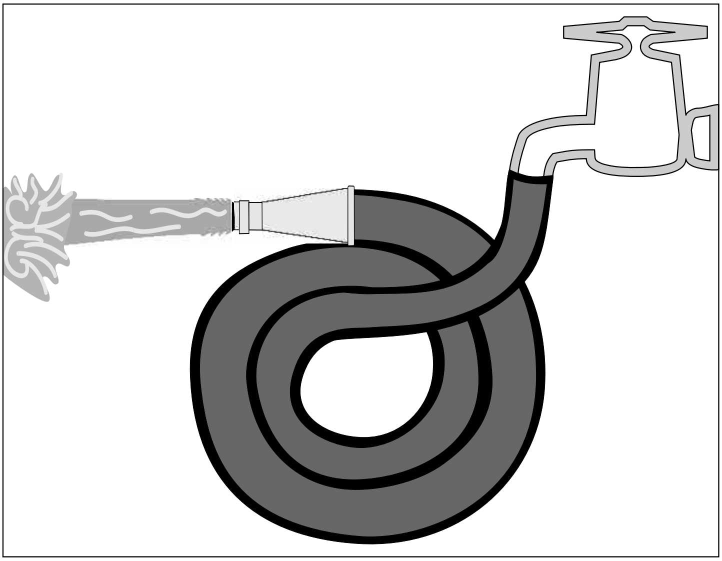
Now imagine what would happen if the coiled tube was laid flat on a table and a marble was shot at great speed into the inner end of the tube. We all agree that it would speed around the coils of the tube and come out fast at the outer end of the tube. The question is:

> What direction does it go in once it has left the tube?

Is it one of the directions marked in the figure or a different direction? Psychologists, who have done this test under controlled conditions, find most people (around 70 percent) chose direction 1. This includes physics graduates who have been taught the laws of motion and have a good understanding of what would happen.

To get our inconsistency, we do another similar thought experiment. This time, the experiment is conducted with a garden hose and water. We imagine water being pushed down a similarly coiled garden hose laid flat on the lawn. What direction do we see it emerging from the end? Everyone knows it gushes straight out—as shown in *Figure AS3–11*.

Figure AS3–11
Water spurting out of a garden hose



The two experiments have a similar pattern. They both involve something going through a coil and coming out the end at speed. Most people, when they recognise this, realise that there is a common general pattern and that direction 2 is the correct answer to the first thought experiment. When the thought experiment involves something as familiar as a garden hose then we can predict the results properly; the water goes straight out of the hose—not up or down. We then use the familiar pattern from the garden hose experiment to clear up our pattern for what happens in the marble experiment.

Interestingly, this example clearly shows how we still have some false ancient intuitions deeply rooted in our minds. Ancient and medieval physics predicted the marble in the first experiment would travel in direction 1, the common choice for 70 percent of people today. By coincidence, this physics is based on the work of the Ancient Greek Aristotle. (The substance paradigm, as we will see in *OP1—Entity Ontology Paradigm*, is also based on his work.)

Yet, Aristotle's way of thinking has been scientifically out of date since the 17th century when Newton discovered his laws of motion. The hose and the marble experiments are actually both direct applications of his first law of motion:

A body continues in its state of rest, or uniform motion, unless acted upon by some external force.

When the water (or the marble) leaves the nozzle, it is moving straight forward. The other external forces acting upon it (gravity and friction) are too small to be relevant for the first few inches of movement and so can be ignored. Because there is effectively no external force, the water (and marble) should move with a uniform motion—in other words, in a straight line.

Since the 17th century, physics has predicted correctly that the marble would go in direction 2. It is just that these laws have not fully worked their way into everyone's minds. We shall see a similar situation in Part Two with Aristotle's ancient substance paradigm. Most people still use it because later developments have not worked themselves into their minds.

3.4 Einstein's thought experiment

The thought experiment is a powerful tool for re-engineering paradigms. That's why scientists often use it to explain their major shifts. Even sophisticated modern paradigm shifts are often explained using simple thought experiments. Albert Einstein's theory of relativity is a good example. This is an extremely sophisticated theory (paradigm). It is so sophisticated that when Einstein published his results, most of his contemporaries had great difficulty in understanding them. Yet, he explained his theory of relativity using a simple thought experiment with such everyday objects as a moving train, bolts of lightning, and a couple of people to observe what was going on.

Thought experiments like these have been, and will continue to be, a natural and useful tool when re-engineering. They help us re-see, re-think and re-invent. You will come across a number of them in our re-engineering.

4 The benefits re-engineering brings

Re-engineering to objects creates a foundation for the re-engineering of business paradigms. I have found that together these bring two main benefits. They enable:

1 More accurate patterns, and so functionally richer systems, and
2 More compact patterns, and so simpler systems.

4.1 More accurate patterns, functionally richer systems

Re-engineering business paradigms enables us to construct more accurate, functionally richer business models. Working with business objects is like working with a powerful microscope. It enables us to see the real world more accurately. This, in turn, enables us to spot functionally richer, re-usable business objects.

In general, the more accurately a model reflects the world, the more powerful it is. This is true of most models, not just business models. Engineers testing a new car or aircraft design in a wind tunnel make the model accurate enough to reflect how the real car or aircraft would behave.

The less accurate a model, the less powerful it is. Imagine the model of a battle drawn up on a dinner table by a Colonel Blimp. The salt cellar is the advancing enemy army and the butter dish is a hill. This model has its uses, but these are limited by its inaccuracy. For example, we would not even think of saying that because the salt cellar cannot stand on top of the sloped butter dish, the enemy army would not be able to take the hill it represents. We know the model is not an accurate enough representation of the situation.

If we wanted to know what the enemy army could or could not do, we would need a more accurate model. The models built using our current entity paradigm are like Colonel Blimp's model in that they are not accurate enough for any heavy duty work. Whereas, business object models with their increased accuracy are.

4.1.1 The cost and benefits of accuracy

The traditional attitude in system building, based on the current entity paradigm, is that increasing accuracy leads to spiralling increases in costs. This is not the case with objects. I have found (and we shall see in the worked examples of Part Six) that the more accurately we model the business, the simpler, more general and so re-usable the objects are. As the accuracy of the model increases so does the potential for generalisation and re-use of its objects. These more accurate objects can then be compacted into less space than their less accurate predecessors.

This means that, within the object paradigm, the traditional rule that increased accuracy leads to increased cost is turned on its head. The new rule is increased accuracy leads to increases in re-use and so reductions in cost.

There are parallel situations of accuracy assisting re-use in a number of engineering disciplines. It may help us to appreciate the part accuracy plays in information engineering if we look outside computing at the broader picture. Information engineering for computers is a new discipline. It does not have enough of a history to give a feel for how accuracy works. If we look at accuracy in an older, more mature, engineering discipline, we can get a better idea. Manufacturing is a good example because it has a kind of physical analogue to information re-use—interchangeable parts.

4.1.2 Manufacturing accuracy and re-use

Physical accuracy played an important part in the industrial revolution of the 18th century. This is particularly clear in the introduction of interchangeable parts, a kind of re-use that revolutionised manufacturing. We are nowadays so used to interchangeable parts that we find it difficult to imagine what a world without them would be like. We expect a new wheel to fit onto a car; we expect a new plug to fit into a socket. This seems to us the natural order of things. Before the industrial revolution, things were very different. Parts were not interchangeable; they were individually hand crafted. An axle was made to size for the specific pair of wheels on a specific cart. It could not be re-used, without further work, in another cart.

With physical things, such as axles and wheels, it is clear that they are only interchangeable if they are made to a certain level of accuracy. This level just could not be systematically achieved in manufacturing until the 19th century. Before then, the levels of inaccuracy that were tolerated seem astonishing to us. For example, in James Watt's steam engine (built in the 18th century) a sixpenny coin could easily fit between the piston and the cylinder.

The American inventor Eli Whitney (1765–1825) developed the first working system for manufacturing interchangeable parts. He was motivated by the potential benefits of mass production. If he could make interchangeable parts then he could make the parts *en masse* separately and assemble the whole product quickly and easily later on. He sold the American Congress on his idea that guns could be mass produced this way. He explained to them that he was going to machine his gun parts so accurately that his workers could assemble a gun from the first parts that came to hand. They would no longer have to tailor them to the individual gun. Congress gave him a government contract in 1798 to produce 10,000 army muskets, all with interchangeable parts. (This can be seen as an early example of military spending encouraging research and development.)

Whitney found the task more difficult than he had anticipated and took longer than planned; but, in the end, he was successful. He is said to have demonstrated his success dramatically. The story goes that he threw a box of the interchangeable parts at the feet of a government inspector and told him to make a musket from parts picked at random.

A colleague told me of a similar public demonstration arranged by his grandfather Frederick S. Bennett. Bennett was the British agent for the American car manufacturer Cadillac. In 1908, he arranged for Royal Automobile Club engineers to demonstrate that all the parts of a Cadillac car were interchangeable. They selected three new cars from their crates and took them completely apart—nut from bolt, piston from rings. The pieces were then put in a heap and thoroughly jumbled up. When the cars were reassembled, they started up the first time. Then, this was seen as a great feat.

This was an American achievement. Even as late as the Second World War, the parts for British Army vehicles and equipment, unlike their American counterparts, were not properly interchangeable. Soldiers had to adjust them with hacksaw and file to make them fit. Nowadays, when cars are routinely assembled from parts bought in from different factories all over the world, this seems remarkably primitive.

One interesting feature of Whitney's achievement is that it was accomplished without plans or sizes for the component parts. When he first introduced mass production, he relied on manual labourers using what were called filing jigs. These were used as templates to hand-file parts for his muskets to approximately matching dimensions. Both the filing jigs and the manufactured parts were the product of manual labour and depended for their accuracy upon the skill of the workers. Furthermore, not one person could measure the accuracy of a part using a standard unit of measurement. All they could do was look and feel whether the part matched the particular jig being used; measuring accuracy was limited to unaided human perception. As a result, manufacturing interchangeable parts was not easy.

Joseph Whitworth (1803–1887) helped to resolve this problem by establishing common standards for accuracy that enabled plans and sizes to be specified for components. He did this by developing precision instruments that measured accuracy far beyond the limits of the unaided human eye. He gave engineers not only a common standard for 'seeing' how accurate a part was, but a standard way of describing, in advance, its accuracy. This gave manufacturing the framework it needed to effectively and efficiently make interchangeable parts.

Whitworth developed measuring instruments that were far more accurate than any earlier instrument. Some were even accurate to a millionth of an inch. To some of his contemporaries, this level of accuracy seemed academic—only suitable for use in the laboratory. Yet, nowadays it is commonplace. Indeed, in some industries, such as silicon chip manufacturing, it is insufficient.

With these standards of accuracy in place, the practical benefits of Whitney's system of interchangeable parts became apparent. And his idea soon spread from the arms business to farm machinery and then to almost all mechanical production. It became known as the 'American system' of manufacturing. As time went by, the system was improved. More and more accurate machine tools and measuring devices were developed. This eventually led to the staggering success of 20th century mass production. A system that Ford used, during the Second World War, to deliver a B–17 bomber (the Flying Fortress) off their American production line every sixty-three minutes.

4.1.3 Accuracy's role in the shift to business objects

Business objects are leading to an industrialisation of information in which accuracy plays an important part. Just as physical accuracy was needed to make interchangeable parts, so referential accuracy is needed to construct general and so really re-usable objects. For example, general objects are constructed from the patterns of lower level objects. We need to be sure that we have captured the patterns for these lower level objects accurately. If we have not, then the generalisation magnifies the lower level inaccuracies and does not work.

Our current entity computing paradigm, like the old individually tailored methods of manufacturing, cannot deliver the required levels of accuracy. Business objects (like Whitney and Whitworth's approaches) can. As it brings greater and greater accuracy, it delivers an increasing potential for generalisation and re-use. This helps to drive the industrialisation of information.

4.2 More compact patterns, simpler systems

Most people find it counterintuitive that a system can be made both simpler and functionally richer—especially just by using more accurate patterns. When working within a paradigm (such as the entity paradigm), it is reasonable to assume that a piece of information has a natural complexity. If it is made simpler, it contains less information. When re-engineering to business objects, we cannot make this assumption. The purpose of the re-engineering is to transform complex patterns into simpler more compact ones.

4.2.1 A simple example of compacting

We can clarify how this counterintuitive purpose works with a simple example of how a complex pattern can be re-engineered into a simpler, functionally richer pattern. Consider the nodes and arcs in *Figure AS3–12*. We can describe the figure as follows:

A is a node.
B is a node.
C is a node.
D is a node.
Node A is connected by an arc to node B.
Node A is connected by an arc to node C.
Node A is connected by an arc to node D.
Node B is connected by an arc to node C.
Node B is connected by an arc to node D.
Node C is connected by an arc to node D.

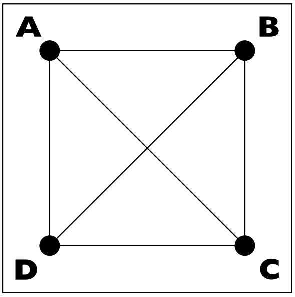
This description has two basic patterns:

1 X is a node.

2 Node X is connected by an arc to node Y.

Pattern (1) occurs four times and pattern (2) occurs six times.

Figure AS3–12
Nodes and arcs



Most of you, when you look at *Figure AS3–12,* will 'discover' a regularity not highlighted by the description above. You will notice that arcs connect every node to every other node. We can capture this regularity in a pattern. We will call this the fully connected node pattern. A node is fully connected if it has arcs connecting it to all the other nodes in the figure.

If we shift to this new pattern, we can construct a more compact (more compressed) and structurally simpler description of the figure:

A is a fully connected node.
B is a fully connected node.
C is a fully connected node.
D is a fully connected node.

This description is much more compact; it has four lines instead of ten. It is also much simpler in that it only involves one basic pattern:

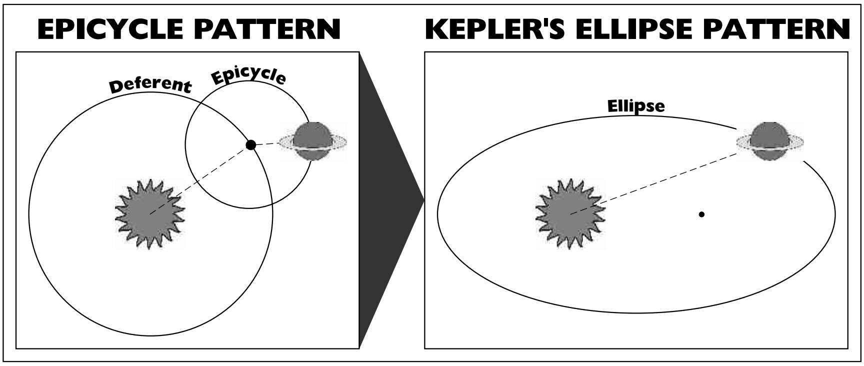
1 X is a fully connected node.

It is also richer than the first description. It explicitly recognises the fully connected nodes regularity.

4.2.2 A classic example of compacting

Because the previous example has been kept simple, it may seem contrived. But most paradigm shifts exhibit the same kind of compacting. Take, for instance, this classic example from the history of science. In the early 17th century, Johannes Kepler discovered that the planets moved in an elliptical pattern. Before Kepler, astronomers assumed that they followed an epicyclical motion where one or more circles move on another. The elliptical pattern is structurally simpler than the epicyclic (shown in *Figure AS3–13*). It also gives a much simpler and more accurate overall theory of planetary movement. It has the same compacting characteristics as our simple example.

Figure AS3–13 Epicyclical and elliptical patterns of planetary motion



5 Re-engineering entities into objects

The benefits of compacting and accuracy brought by the object paradigm make it a substantial improvement on its predecessor—the entity paradigm. The object paradigm is just beginning to change business modelling. As the change follows its course, business models will become substantially simpler, more compact, and more accurate.

In our journey from the entity to the object paradigm, we are going to follow the approach described here. We will use thought experiments to help us find the new patterns that undermine the old paradigm and start the re-engineering rolling. We will see how each re-engineering changes the paradigm's fundamental particles. We, no doubt, will find the entity paradigm hindering us from appreciating new patterns. We will also see how this new paradigm enables us to build simpler, more compact and more accurate models—and so, computer systems. In the next paper, *AS4—Focusing on the Things in the Business*, we sharpen the focus of our re-engineering.

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MW4—*Re-Engineering Time*

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MC—The BORO Re-Engineering Methodology: Case Histories

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WHAT AND HOW WE RE-ENGINEER

A–I