Component-Based Business
Background Material

On Intelligence

Richard Veryard, October 2000

Intelligence is a recognizable property of various entities.

People, artefacts, organizations, and other systems may have intelligence.

The word 'intelligent' has been used to describe people since the late 14th century, animals since the 19th century, and devices and machines since the 1960s. In normal parlance, intelligence can be displayed by human adults and children, dogs, cats and dolphins, and computer programs.

Human intelligence

In everyday life, we recognize people as intelligent by the way they speak and the way they act. Certainly not just by their facility in solving the simple puzzles set in IQ and Mensa tests.

An intelligent person has three things: an exceptional ability to grasp complex information from the outside world, an exceptional ability to respond appropriately to this information, and an ability to learn quickly.

Psychologists started to develop a scientific notion of Intelligence around the middle of the nineteenth century, to explain and predict differences in intellectual ability. Many eminent Victorian scientists were sceptical about this project, including (apparently) Charles Darwin. Darwin seems to have had qualms about comparing the intelligence of members of the same species, although he seems to have had no qualms about comparing the intelligence of different species. Indeed, he is quoted in the OED discussing the intelligence of worms.

Modern psychologists view Darwin's scepticism with some puzzlement. They imagine that he ought to have been an enthusiastic supporter of any investigation of human difference. After all, his theory of evolution was all about the development and consequences of differences. Furthermore, he was surely one of the most intelligent men of his time, so he could only have benefited from such an investigation.

This last point rests on an important difference between the modern psychologist's mindset and value system, and a Victorian one. Darwin would probably have preferred to attribute his success to hard work, and might have resisted the idea that he had some kind of 'unfair' advantage based on innate ability.

Non-human intelligence

We usually have no difficulty talking about canine intelligence, or artificial intelligence, although we have no clear idea how to measure these qualities.

Animal intelligence consists largely in the skills of cognition, memory, learning and manipulation. Dolphins are more intelligent than dogs, because they learn tricks quicker; cats are more intelligent than dogs because they refuse to learn tricks. Dogs adapt to human needs, while cats get humans to adapt to their needs, or go off to find better humans. Thus dogs and cats display or deploy their intelligence differently: dogs adapting themselves to the environment and cats changing the environment to suit themselves.

Organizational intelligence

What about the intelligence of an organization? Just like people, an organization may behave in intelligent or unintelligent ways. And, as we shall see later on, the collective intelligence of the organization often bears little relationship to the individual intelligence of the people in the organization.

Most observers can probably think of organizations that have appeared oblivious to its environment, made the same errors over and over again, and displayed no ability to remember or learn. Many of these organizations have already collapsed; many yet survive through political intervention or clinging to some fortuitous monopoly.

When we find this kind of behaviour in people, we may take it as evidence of crass stupidity, and so it seems reasonable to describe organizations the same way. Unintelligent organizations fail to detect even the most obvious signals of change in their environment, and they fail to respond appropriately – if at all – to the most insistent demands from their stakeholders. They learn slowly, making the same mistakes repeatedly without any insight or understanding.

Q Think of some organizations that have collapsed. Could the symptoms of unintelligence have been detected in advance? Could a greater degree of organizational intelligence have saved them? If so, how?

Q Think of some organizations that currently survive, despite symptoms of extreme unintelligence. On what does their survival depend? How long do you imagine they might survive?

Other organizations are alert to changing circumstances, react creatively to new threats and opportunities, are constantly learning from their own experiences and from the mistakes of their competitors. These organizations display the same qualities that we can recognize in intelligent people: an eager and receptive curiosity, a consistent but flexible set of responses, and an ability to learn quickly.

It seems appropriate to refer to this difference as a difference in organizational intelligence.

Q Think of some organizations that have survived adversity, against the odds. Do you think this was sheer luck, or were there some elements of organizational intelligence that helped?

Measuring human intelligence

For human children, we have a measure of intelligence known as 'mental age'. Thus a clever seven-year-old may have a mental age of ten; while a handicapped teenager may have a mental age of five. Having a mental age of x is equivalent to having the mental abilities of the 'standard' x-year-old. (This assumes that such standards mean something – we won't discuss that here.)

Even if we suppose this measure to be valid for children, it's not much use for comparing adults. Is a mental age of forty more or less intelligent than a mental age of sixty? If we say of a thirty-five-year old woman that she has a mental age of twenty, this will probably be taken not as an insult to her intelligence but as a compliment to her youthful energy.

IQ is a flawed attempt to measure the intelligence of people.

Psychologists have invented another measure of intelligence, known as the Intelligence Quotient (IQ). This has been widely criticized for its cultural bias, since it ignores many of the mental abilities that normal parlance regards as intelligent, and concentrates on a few unevenly distributed cognitive skills.

In particular, IQ has been criticised for decades for being culturally biased. The tests are so designed that people from different ethnic backgrounds get different scores, although the psychologists designing the tests try hard to separate what they imagine to be innate mental ability from learned knowledge and social conditioning. The cultural bias remains, although it is a little more subtle now than it was in the early days, when East European immigrants arriving in New York were deemed unintelligent if they were unfamiliar with the works of Shakespeare.

Of course, the fact that some of the East European communities discovered this criterion, and forewarned their brethren, may be regarded by some people as a sign of collective intelligence on their part – and by other people as cheating.

Q Do you think it was intelligent of the US immigration authorities to use this test?

In any case, traditional IQ scores fail to reflect accurately our intuitive notions of intelligent behaviour. They are not an accurate predictor of what they're supposed to describe or predict, although there may well be some loose correlation.

In principle, intelligence is measurable.

Just because current measures of IQ are flawed doesn't mean that intelligence is inherently unmeasurable.

In normal parlance, we are perfectly happy saying that A is more intelligent than B, or even that A's superiority over B is greater than B's superiority over C. Future psychologists may well develop scientifically valid measures of human intelligence that are acceptably close to our intuitive notions of intelligence.

This suggests although it seems that we do not yet have a scientifically valid measure of intelligence that conforms with normal parlance, this does not mean we could never have one.

At the very least, we can compare intelligence (between entities, or for the same entity over time), and estimate relative intelligence in a given context, subject to a number of assumptions.

The measurement of intelligence may require several dimensions.

There are many different ways in which people may use their intelligence. One person may become an orchestral conductor, while another becomes a rocket scientist. These occupations both require considerable intelligence to start with; and the people who are successful in these occupations must practise and strengthen particular cognitive skills.

If we then try to compare the intelligence of an orchestral conductor with that of a rocket scientist, we may say that the first is more intelligent in such-and-such respects, while the second is more intelligent in other respects.

When a person specializes in one area, her intelligence is focused on that area, to the exclusion of other areas. The intelligence becomes deeper, but perhaps narrower.

Thus we are not committed to the idea that intelligence is adequately represented by a simple scalar measure. Balanced assessment of intelligence may require several separate measurements, along different dimensions.

But these measurements may turn out in practice to be roughly in proportion, much as the measurements of the human body. People can vary in height, weight, waist measurement or some other dimension; and for some purposes, we need to be clear which of these dimensions we are interested in. But for other purposes, we can simply say that someone is large or small. And when we talk about the physical growth of a child, we expect this growth to keep all dimensions more-or-less in proportion.

So in this book, in order to keep things simple, I shall talk about intelligence as if it were a simple quality. When I talk about increases in intelligence, you should understand that this normally means well-balanced increases in all aspects of intelligence.

Measurement of non-human intelligence is also possible in principle.

For domestic animals and computer programs, we have no general measures at all. But as we saw earlier, we can make statements about the relative intelligence of dogs and cats, or dogs and dolphins.

With artificial intelligence, some local measures are possible. For example, we can measure the FIDE rating of a chess program, but the statistical relationship between FIDE ratings and IQ is very weak. We cannot compare the intelligence of two medical diagnostic programs, let alone compare the intelligence of a chess program with that of a medical diagnostic program.

> **Q** Are there any grounds for believing that quantification of the intelligence of non-human artefacts or other entities is impossible in principle? Do you think it likely that a reasonably useful measure might be developed?

Intelligence is worth something.

Intelligence is assigned a positive value, according to many popular value systems.

Calling someone intelligent is regarded as praise. Calling someone stupid is an insult. People pride themselves in their intelligence, and in the intelligence of their children and pets.

The education system values intelligence, although it places a particular slant on what shall counts as intelligence. Much of the education system concentrates on enhancing some aspects of intelligence. The employment system also values intelligence, subject to certain counter-balancing properties (notably Character).

> Q What forms of intelligence and character are perceived and valued by the education system? What forms of intelligence and character are perceived and valued by the employment system? Do you think it's a good thing to align the perceptions and values of the two systems?

Intelligence is usually assumed to confer an evolutionary advantage, subject to a number of constraints and assumptions. However, some writers have argued the converse: intelligence (along with self-consciousness) is merely a side-effect of other evolutionary forces and phenomena, and an unfortunate one at that.

But it surely seems reasonable to work on the basis that organizational intelligence has a positive value. An intelligent organization is likely to be more successful in the short term, and have greater prospects for survival and growth in the longer term. Staff morale is likely to be better, and the individual employees will themselves have greater opportunities for personal growth and fulfilment. In the broader socio-economic system, intelligent organizations will create more wealth – not merely economic wealth but in human potential.

Do organizations pay for maintaining intelligence or is it free?

Intelligence has a cost. There may be situations where the cost of intelligence is greater than the benefits.

Obviously the human brain has high nutrition and oxygen needs, and this represents a metabolic cost for the human organism as a whole.

The popular belief that the intelligence of a business organization is contained in the top management layer, may be used by brilliant entrepreneurs and fat cats alike to justify their compensation schemes.

In software architectures, an increasing amount of intelligence is buried in the middleware, which is getting fatter and fatter, and using more and more hardware. The hardware is just about keeping pace.

Traditional economies were based on the assumption that much of the work – perhaps most of it – was tedious and/or odious. It was believed that these jobs were suited for less intelligent, less educated people. Not just because education was expensive, but because an intelligent person would be more unhappy in such a job than an unintelligent person would be.

It seemed appropriate that there should be a spread of abilities, with a small number of highly intelligent, highly educated people taking the grade-A jobs, a larger

number of second-rate people taking the grade-B jobs, and so on. A parody of this view is found in Aldous Huxley's novel: ***Brave New World***.

> Q Do you think that there will always be jobs for which too much intelligence or education may be a disadvantage?

A similar theory is widespread with organizations.

Organizations facing a flat and unchanging environment may not need much intelligence, but organizations facing diverse and turbulent environments may need much higher degrees of intelligence. To the extent that organizational intelligence costs something to develop and maintain, this investment may be justified in the latter case, but not in the former case.

But there is a widespread belief that there is a universal trend away from flat and unchanging environments towards diverse and turbulent ones, and this seems to entail a greater overall need for organizational intelligence.

> Q Do you think that there will always be situations where organizational intelligence is not required? Do you think that there are situations where organizational intelligence may be a disadvantage?

Is there really a universal trend away from flat and unchanging environments towards diverse and turbulent ones? The belief in accelerating technological and social change is taken as an unquestioned assumption for many writings on business and technology. Where evidence for this trend is offered, it is usually based on fairly superficial or narrow metrics, such as the growing number of patents, or on selected anecdotes; and the argument has little or no historical perspective. After all, there have been many other epochs in history when people thought the established order was breaking down, and exaggerated the turbulence to come.

> Q Do you think that there are some aspects of modern business life that are becoming more predictable and controlled?

We seem to get chips with everything.

Each generation of computer chip costs more than the previous one, thanks to growing R&D and production set-up costs.

Something wrong there, surely? Everybody knows that chips are getting cheaper and cheaper.

This paradox can only be sustained by ever growing production volumes. Put simply, if the next generation of chip costs billions of dollars or more, and each chip only sells for a few dollars or less, the chip manufacturers have to produce billions and billions of chips to recoup their investment.

So there is a supply-driven pressure to find more and more ways of using these chips. Not just in computers, but embedded in a wide range of machines and other devices. It seems that all components, however small, need to be "intelligent"; and all components, however small, need to be "wired".

Is there any real value in this intelligence, or are we all hypnotized by the hype of the chip manufacturers? For the moment, let's just note that the exploitation of these chips is growing fast enough to keep the chip manufactures in business. This means that there is sufficient demand to match the supply of chips, albeit at falling prices. Nobody would buy or use the chips at all, however cheap they were, unless they were persuaded that it added value to the products or components into which they were embedding the chips.

See Component-Based Business, Chapter Three for a discussion of the extent to which "intelligence" and "wiring" might really add value to components.

Intelligence has five key elements

Intelligence can be divided into five characteristic abilities.

Perception	The ability to make complex observations of the environment.
Information Processing	The ability to manipulate and transform information. Reasoning.
Memory	The ability to store and recall information.
Learning	The ability to develop new knowledge and skills, and to learn from experience.
Behaviour	The ability to adjust behaviour to suit the situation. The ability to behave flexibly in different situations – sometimes called **requisite variety**.

Table 1: Elements of Intelligence.

Intelligence is related to creativity. Intelligence may require the ability to innovate – not innovation for its own sake, but appropriate innovation, connected with the demands of the environment.

Intelligence is commonly contrasted with words connoting lack of perception (blind, stupid) or expression (dumb).

- The Blind Watchmaker – a book by the Neo-Darwinian Richard Dawkins.
- Dumb terminal, dumb waiter – devices lacking "intelligence".

This suggests that these are the most obvious elements of intelligence, or the ones that can be recognized most quickly. It does not mean that they are the most important.

Q Which of these five elements can be observed or tested on a single occasion? Which of them requires observation over time, or an extended series of tests?

Intelligence can be altered.

Intelligence can be developed.

Although many people think that intelligence is an innate and unalterable ability, there is lots of evidence that it can be improved by exercise, and reduced by suppression.

The education system has formal objectives that relate to the improvement of intelligence.

- Traditional education focused on the development of memory – the accumulation of "facts".
- Modern education focuses on the development of the ability to process information – the churning of "facts" rather than their simple accumulation.

In the past, the education system was focused on developing memory. The point was to transfer ready-processed information from adults into children, either via lectures or via books, and then test how much they remembered.

Today's education system has a great emphasis on developing information processing skills. Children are given projects, which require them to collect and collate information from a variety of sources, including local libraries and the internet. (As a result of this, the children often end up better informed about some topics than the adults around them, which would never have been possible in the old system. There is no need for adults to feel threatened by this, but it seems that many do.)

Information processing is clearly an important skill in today's world. Personal memory is perhaps less valuable than it once was. But a balanced education must pay attention to all five aspects of intelligence.

If schools have a mission to make people more intelligent, we can also identify a mission for engineers to make technological devices more intelligent, and for managers and consultants to make organizations more intelligent.

Q What does it take to make a device "intelligent"? Is it enough merely to embed a chip, and/or connect it to the Internet?

The quest for organizational intelligence includes several parallel themes. What is often called **business intelligence** focuses primarily on an ability to perceive and process complex data from external sources, including analysis of competitor behaviour. This is an important aspect of what we're calling organizational intelligence, but not the whole story. Another important theme is covered by the term **organizational learning**.

Q What does it take to make an organization "intelligent", besides business intelligence and organizational learning?

Intelligence can be impaired.

Despite its good intentions, the education system actually succeeds in reducing the intelligence of children.

- Most children start school brimming with intelligence and creativity. They are bright and eager to learn.
- Most children leave school programmed for a pre-appointed position in society. Their intellectual senses are dulled, and their creativity all but destroyed.
- Even the ones that are regarded as "successful" are often stressed out and psychologically damaged. They have become exam-passing machines, but at enormous cost to themselves.

Intelligence can be repaired.

Sometimes the most effective way of improving intelligence is to remove the blocks that inhibit the "natural" intelligence. (The same is true of creativity.)

Most people are born intelligent and creative. As we have seen, a lot of this intelligence and creativity gets lost by the time we leave school – but sometimes it can be rediscovered in later life.

Often the focus for personal development is not "How can I become more intelligent and creative?" but "How can I remove the blocks that get in the way of the intelligence and creativity that is buried within me?"

And this can also be an invaluable starting point for management consultancy: searching for the barriers to collective intelligence and creativity within a single organization, or across a complex consortium or supply chain.

Does the consultant want the client system to have intelligence or character? Let's answer this question by considering a client system that includes the consultant as a key component. Most consultants would want the client-with-consultant system to be successful and to have a range of positive qualities, including intelligence and character. Some consultants may want to be tightly bound in this system, so that they cannot be unplugged and thrown away. Others may prefer to be loosely bound, with a clear exit strategy. This preference may be for all sorts of reasons – perhaps rational, ethical ones, or perhaps because of an unconscious fear of long-term commitment.

Must we always attribute stupidity to the whole system?

Although stupidity, like many other system problems – if it is a problem – may often need systemic intervention, we shouldn't presume it always does.

People sometimes go too far in ascribing a negative property to an internal complication. For example, why does this person fail to act appropriately in a given social situation? It may be because there is some psychological history that blocks the appropriate action (whatever that is). But it may also be that the person has never had the opportunity to learn any appropriate action, or any suitable role models.

A therapist may sometimes need to explore the family history of a client, to analyse system blocks. But sometimes, the client just needs to learn a new behaviour – plug in a social skill as a new component of the client's personality.

There may well be a second-order problem, to do with the failure of the client to acquire a 'complete' set of social skills, or to solve this problem himself. There may have been blocks in the past, which prevented the client learning something. But there may be no such problem.

Intelligence is an emergent property of a system

Intelligence must be taken in the context of a system.

An organization is a socio-technical system, and may be composed of many interoperating systems, each containing some intelligence. Thus the human intelligence of many employees is combined with the artificial intelligence of machines, contained in intelligent buildings, and distributed through intelligent cyberspace.

People and computers alike display intelligent behaviour in some contexts, and not in others. People and computers alike depend on a complex support network. A person's ability to solve certain puzzles depends on various cultural factors. A

computer's ability to beat a Grandmaster at chess depends on a team of chess experts and skilled programmers.

In a recent article in the New York Review, John Searle makes the point that when computers can beat grandmasters at chess, this does not prove that computers are now more intelligent than humans. "The real competition was not between Kasparov and the machine, but between Kasparov and a team of engineers and programmers." [New York Review of Books, vol xlvi number 6, April 8th 1999]

As in Formula One racing, where the driver takes the credit for the work of a team, so the chess computer Deep Blue took the credit for the work of a well-coordinated team of people and other machines. A Formula One driver does not need to be a creative thinker – that falls to other members of the team – but must have incredibly fast reactions. The same is true of a computer.

Children of competitive middle-class parents are increasingly being subjected to additional training, including IQ coaching, in order to get high scores on various tests – perhaps to win places and scholarships to elite schools, or perhaps simply because it is thought to be a worthy activity in its own right. But what is being tested here, what do the tests really reveal? – the brain-power of the child, the skill of the coach, or the enthusiasm and resources of the parents?

What appears to be a self-contained child may be merely a test-scoring system. But if we reduce our children to test-scoring systems, if we reduce our schools to test-scoring-system improvement systems, where's the intelligence in that?

The parents may perceive the stupidity of the system, but regard themselves as adopting the only intelligent response to a stupid situation. This is another example of going along with coercion.

Some parents try to do the best for their children within a stupid system, and at the same time they work to change the system (e.g. through political action). This seems reasonable in principle, but there is a character issue here. If a politician does this, it is often taken as a sign of his lack of commitment to change. If you really believe in comprehensive education for everyone, what are you doing sending your children to selective schools?

The intelligence of a system is not a simple arithmetic function of the intelligence of the subsystems. Lots of intelligent pieces doesn't add up to an intelligent organization

To make an intelligent organization, it isn't enough to recruit the brightest people, locate them in state-of-the-art office buildings, and provide them with the smartest computer tools and networks. Super-intelligent individuals are often poor at talking to one another and sharing knowledge, let alone coordinating their work effectively. Each individual may only make a given mistake once, but if the people don't talk to each other, the same mistake can be repeated hundreds of times without any organizational learning.

And even if an organization is collectively oblivious to major threats and opportunities in its environment, that doesn't mean that the individual employees are unaware of these threats and opportunities. Intelligent people get very frustrated and demotivated in stupid organizations; they can see what is happening, and they can often see what needs to be done, but they don't have adequate channels of communication or action.

Organizational intelligence is what systems thinkers call an emergent property – it is an attribute of the whole system, not of the individual parts. What matters most is how the parts of the organization are put together.

A stupid organization can be composed of apparently intelligent people.

Most universities conform to this pattern. The cleverer the professors, the worse it gets.

> Q If you have any recent experience of university organizations, does your experience confirm this hypothesis? What do you think happens?

An intelligent system can be composed of unintelligent components.

Colonies of insects (ants or bees) display intelligence at the level of the colony. An individual insect has a tiny brain, but the collective behaviour of the whole colony is something else.

There are many delightful tales of insect colonies outwitting human beings. My favourite one concerns some researchers who wanted to find out the distance that bees could travel, so they experimented with placing artificial sources of sugar further and further from the hive. Each time they moved the sugar, a few bees watched and then flew back to the hive to report the new location. But one day, they arrived at the site to move the sugar, and there were no bees around at all. Well, they decided to move the sugar anyway, according to their predetermined research plan – and there were the bees at the new location, waiting for them!

There's another version of this story, where some picnickers disturb some ants or wasps or something, trek across country to escape them, take a long route back to the car, and find the insects waiting for them there.

Many of these stories may be apocryphal, but the fact is that we do find them plausible.

Out of control – embrace the swarm.

The emergence of intelligence from large numbers of unintelligent or uncontrolled interactions can be found in a wide variety of domains.

Some writers are now proposing this as a management principle or heuristic. Tom Peters is well-known for making provocative and paradoxical statements about control; and Kevin Kelly, who has previously documented complex systems including biological, social and technological ones, has applied this thinking to the business domain.

Kelly makes the biological analogy explicit when he names one of his proposed strategies 'Embrace the Swarm'. He illustrates this with an example of a cement delivery company, summarized in Table 2, which shows how the uncontrolled interactions of a fleet of intelligent and autonomous drivers produced a much better outcome than had previously been achieved by central control.

Before	After
Cement delivery controlled centrally	Cement delivery left to drivers
Rigid delivery schedules fixed in advance	Drivers given full information and authority
Traffic delays, poor roads, unreliable third parties	On-time delivery rate =98%
On-time delivery rate <35%	

Table 2: "Embrace the Swarm"

Q Do you have any experience of distribution and decentralization resulting in such dramatic improvements? Do you have any experience of distribution and decentralization making things worse?

When intelligent components are successfully combined, they can achieve wonders.

Earlier in this chapter, we looked at Deep Blue, the IBM supercomputer that beat Gary Kasparov at chess. As I'm writing this (December 1999), IBM has started work on a sequel to Deep Blue, called Blue Gene. The plan is for a computer system composed of around a thousand circuit boards, each containing 64 of the most powerful chips available, all working in parallel. The system as a whole will be around a million times as fast as a normal desktop computer, vintage 1999. The project is estimated to take 4-5 years, and to cost $100 million.

Blue Gene's task is to simulate the building of proteins in the body, and to calculate how proteins fold themselves. They reckon the calculations will take this computer a year for a typical protein. (The body itself does the calculations in a fraction of a second, but that's another story.)

Intelligence is one of a class of emergent properties.

As we saw in a previous section, John Searle drew some interesting – and perhaps surprising – conclusions from the victory of Deep Blue over Gary Kasparov.

Searle's article was a contribution to an old philosophical debate, addressing such questions as: "Are machines more intelligent than people? Can computers have self-consciousness and freewill?"

Some people might ask: How intelligent are humans anyway? Can humans have self-consciousness and freewill?

Our discussion has led us to a rather different set of questions. What kinds of system can have such (emergent) properties as intelligence, self-consciousness and freewill?

Intelligence depends on the context – the larger system.

People and computers alike display intelligent behaviour in some contexts, and not in others. People and computers alike depend on a complex support network. A person's ability to solve certain puzzles depends on various cultural factors. A computer's ability to beat a Grandmaster at chess depends on a team of chess experts and skilled programmers.

Identity may be distributed over many components.

In any case, there are some problems with identity, both of people and of computers. Common sense notions of consciousness and freewill are undermined by both psychoanalysis and hypnotism. Thanks to componentry (see Component-Based Business, Chapter One), things seem increasingly disembodied and fragmented – we are increasingly led to see our artefacts and ourselves as loosely coupled components. And it's often easier to see the parts (or part-objects) than to see the wholes.

A person is not just a mass of organic material, but also a mass of characteristic ideas, thoughts and feelings, expressed in words or acted out, distributed across diaries and letters, or captured in the memories and interpretations of other people. My name is held on countless databases, with various fragments of information about me, and embossed on several pieces of plastic card. No doubt much of this information is incorrect, incomplete or out-of-date.

What appears to be a self-contained computer may be merely a facade, providing access to a distributed network of other machines and systems.

Further Reading

Richard Veryard, ***Plug and Play: Towards the Component-Based Business.*** Springer-Verlag, 2000 (forthcoming).

Richard Veryard, "Reasoning about Systems and their Properties". To be published in Peter Henderson (ed), ***Systems Engineering for Business Process Change Volume 2***, Springer-Verlag, 2001.