Concurrent Systems Modelling: Agentification, Artefacts, Animation

(formerly MSc Lecture T1 given by Meurig Beynon)

1. A Hierarchy of Agent Models

In developing our understanding of commonsense concurrent systems, it is helpful to think in terms of a hierarchy of agent models: 0-agent, 1-agent and multi-agent systems. The peculiar quality of the agency of external observer has already been remarked (see Empirical Modelling for the Single Agent): it encompasses power to experiment, to venture into the unknown. There is a familiar sense in which an agent is apprehended in just this fashion: as an entity with the capacity to transport us to an unfamiliar context for observation. It is this intuition that informs the classification of the computer models we consider in this course: the 0-agent, 1-agent or multi-agent.

To elaborate on this view of agency we should consider what *transport into a new context* means. The answer is firmly rooted in empirical knowledge about a system's behaviour. At one stage in our observation of a system, we respond to the unexpected by refining our explanatory model, on the basis that what we have observed is previously undiscovered subtlety within what is essentially the same observational regime ("That's the first time that anyone's played N-K4 in this variation"). At another stage of familiarity with a system, we interpret the unexpected in an entirely different way - as a patent change of observational regime ("I think my opponent must be dead", "The linkage must be broken"). In the latter context, experience suggests that there has been an irrevocable, and often chaotic, change in the mode of operation of the system, and the integrity of the observational framework cannot be maintained (any more than normal railway operation can be resumed in the aftermath of a serious accident). It is this radical departure from normal mode of behaviour that associates surprise with agency. Its most extreme but simple manifestation is the death of the external observer.

This analysis provides a suitable empirical basis for the classification of systems and models (I don't *know* that resurrection is impossible, but I don't really expect it to happen). My choice of classification may also have a pragmatic, empirical quality (it is convenient to assume that the computer will function reliably and execute this program to termination within my lifetime, and that the way in which I interpret its response is predetermined - cf. "that's a pretty looking number" or "Good grief! - Solaris is slow today").

A 0-agent system is one that has no capacity to surprise us. At some level of abstraction, nothing in the system exhibits change, nor can the external observer influence the system in any way ("there's nothing I can do about it"). In Empirical Modelling terms, a 0-agent system is associated with a context in which the correspondence between the model and its referent is immutable - as in a conventional formal model. Only View 3 agents inhabit 0-agent models.

In a n-agent system, where n is non-zero, there is a View 2 agent - an entity that demonstrably has the capacity to surprise (cf. the apple that fell on Newton's head). Once we acknowledge the presence of any agency of this kind in a commonsense concurrent system, it is natural to see many entities within the system in this light. For instance, most systems have integral components whose failure to function reliably leads to incoherent behaviour. In Empirical Modelling terms, at any rate where a conventional computer is involved, the most important 1-agent system is the generalised spreadsheet, where the external observer is the sole instigator of change and all responses to the external observer's interaction are construed as entirely predictable.

Multi-agent systems are at the centre of modern applications of computing. They are systems in which (even presuming the components themselves to be reliable) the reliability of corporate interaction between state-changing components has itself to be established before conventional programming principles can be brought to bear. This area of investigation - reactive systems, in the sense of [2] - has been a particular focus of interest in Empirical Modelling. A crucial observation in this connection is that where the external observer acts as the View 2 agent in a 1-agent model on a conventional computer, they are by default in a position to act as a superagent, and so can simulate surprising actions on behalf of other agents in the model. (This is the principle behind the Abstract Definitive Machine, and the user-driven agent-based models in eden.) In this sense, Empirical Modelling allows us to represent what can be regarded as multi-agent models.

2. Separating Agency from the External Observer

One interpretation of an agent's capacity to transport us to a new context is that it has power over us. An agent that can lock a door, and potentially never return to unlock it, effects a radical change to the mode of operation of our commonsense world. It also exercises power over the power we exercise over things. To model such agency faithfully, it is in general essential to distinguish between my agency and my perception of the concurrent system as the external observer ("I can't be the external observer at my own funeral"). This is a significant shift of perspective. So far, our emphasis has been on examining and representing the agency of the external observer of a commonsense concurrent system. Up to now, we have seen ourselves both as the mind in which the concurrent system is created, and the agent by whom it is being modelled. From now on, we shall also be concerned with the conceptual separation of agency from the external observer.

The term "conceptual separation" is unavoidable here. What to us appears a consistent personal world may be a mad world in relation to others. For all that, however nobly we try, we cannot *literally* see ourselves as others see us. The idiosyncrasy of our personal world manifests itself in difficulties of communication for which the primary remedy is experience of situated interaction with other human observers.

The same process of construction of artefacts that serves to represent our experience to ourselves is to some degree effective in communicating our experience with other observers. Even this is to pre-empt the issue of how it is that we acknowledge other observers as *like ourselves*. Our previous discussion has indicated how our observation and interaction with a system can distinguish others as View 1 agents: to go beyond this stage, we have to observe and interact with others in the context of a common environment, and recognise sufficient consistency and affinity in stimulus-response behaviour to acknowledge their perspective on agency and observation as in part congruent to our own.

There is an important distinction to be drawn here between private and shared conviction. The power of artefacts in communication derives from the fact that, for practical purposes, our minds meet in a world of objects which they share in common [3]. At the same time, in giving a proper account of concurrent systems, it is essential to remember that not all minds have the same access even to the world of objects. Your use of an artefact to represent an OXO position may serve a useful function for you in representing your knowledge of the game, but the same artefact won't necessarily serve for me. You may use red and green coloured tokens, and I might be colour-blind.

Further discussion of such issues can be found in [1]. A fundamental theme, common to [4] and to James [3], is that interaction with objects is prior to formal language as a means to knowledge and communication. This is not to deny that natural languages use words in very much the same way as Empirical Modelling uses variables and artefacts. A sign on paper or a noise uttered is directly correlated to the state of the world as directly experienced. This has been described as a *phenomenological* use of language. Formal language, on the other hand, refers to the domain of View 3 agents.

3. Projection of Agency

When we distinguish our agency from our role as external observer, we are led to two different perspectives on systems:

a. identify with the agents, and consider what the external observer sees

This is the problem of concurrent engineering. We conceive concurrent systems composed of agents like ourselves, and consider how to accommodate their capacity for mutual surprise, and accordingly mutual conflict, from the perspective of an external observer. In this context, our problem is to find an appropriate viewpoint from which to make objective sense of many inconsistent, incoherent and asynchronous views;

b. identify with the external observer, and consider what an agent sees

This is the perspective of the experimental scientist. We can focus on representing agency within a system as if it were our own. This is what is involved in the explanation of a phenomenon: accounting for the observed behaviour of agents in terms of metaphors that our intelligible in human terms.

These two patterns of identification are also familiar in another guise:

a. if I know what the components do, how can I determine what the system does, or realise a particular system behaviour;

b. if I know the system behaviour, how can I account for it in terms of the behaviour of the components, or design components and protocols to realise it.

Empirical Modelling has a role in both contexts: in the former, exploiting artefacts as a means of rationalising the communication between component agents [5]; in the latter, as a means of representing what an agent can be presumed to "experience".

The explanatory frameworks we apply in commonsense concurrency are essentially based upon the concept of putting ourselves in the position of another agent in this fashion. We extrapolate from our own experience, projecting on to other agents the kind of stimulus-response context that guides our own activity. In some sense, the most significant element in this projection is embodied in the leap of imagination that carries each of us from our own to another person's perspective; it involves the essential discontinuity of passing from one consciousness to another to which James draws attention (Quote B1). It is well-recognised that personification - the projection of human agency on to an *inanimate* object - is deeply embedded in our mental processes.

Empirical Modelling involves principles for the construction of artefacts that represent the primary access we have to insight and knowledge about external agency in all its diverse forms. The development of such artefacts has been liberated through the development of the computer to the point where they can arguably be interpreted as an extension of language.

4. Elements in the Representation of Multi-Agent Systems

There are three aspects to examine in Empirical Modelling for concurrent systems: the process of agentification, the construction of artefacts, and the animation of system behaviour. These will be the central concerns of subsequent lectures. The following brief synopses set out the agenda to be considered in each case.

4.1. Agentification

Agentification involves identifying the agents in a system and finding and classifying the observables to which they may be construed to respond. This is a creative and experimental process for which no guarantee of success can be given in advance. Success depends upon being able to identify reliable patterns of stimulus-response behaviour that are sufficiently similar to patterns that we ourselves can conceive that we can represent them metaphorically using artefacts. The identification of View 1, View 2 and View 3 agency are all significant steps towards successful representation, but it is not usually realistic to expect theoretical prediction of the behaviour of a system of the kind that mature science achieves.

4..2. Artefacts

We use the term "artefact" to refer to physical / computer-based models with which we can interact. Artefacts can be used to imitate experiences we have, the experience we believe other human agents have, and the kind of person-like interaction we can usefully project onto inanimate agents as representative of their stimulus-response patterns. Artefacts play several crucial roles:

* in the process of representing and acquiring conviction about personal experience

* in communication between human agents

* in the representation of agency of all types (cf. Gooding's construals [6]).

The development of artefacts is associated with experiment and observation, and with skill acquisition. Empirical Modelling is particularly concerned with exploiting the computer as an instrument mediating between an observable (conceptual entity) and a perceptual (perceivable entity).

4.3. Animation

The concept of a system behaviour is connected with the development of consistent expectations about patterns of interaction - an empirical process. It is such expectations that are violated when the system takes us by surprise. Knowledge about the behaviour of a system can be classified in terms of 3 views closely associated with the 3 views of agency introduced above. A duality between agency and system behaviour is evident in as much as where we perceive only View 1 agents, the system behaviour is exceedingly ill-constrained, whilst where we perceive only View 3 agents, the system behaviour is tightly circumscribed.

View 1 behaviour: Agent identification

Observables for the agents have been partially identified and classified according to the role they play in interaction within the system. The behaviour of the system in this case is such that we can account for what happens with reference to the agents we have identified, but only by referring to interactions that are not preconceived. For instance, in the early days of railways, it was common for a successful enquiry into a railway accident to reveal nothing new about how the components in a system were capable of interacting, but to disclose interactions that were quite outside the realm of the railway designer's and management's imagination.

View 2 behaviour: Animation via superagent

The observables and agents have been so comprehensively identified and classified that it appears that all possible behaviours of the system can be explained in terms of them. The interactions between agents, expressed as privileges for action in certain contexts, have also been identified and any system behaviour can be simulated by intelligent execution of these privileges.

View 3 behaviour: Automation of behaviour

The behaviour of the system is circumscribed and can be realised through the automatic execution of agent protocols.

This classification of system behaviour is of course empirical in nature. Empirical Modelling addresses the construction of artefacts to represent behaviours in these three categories by identifying agents, analysing and classifying the observables and privileges upon which their pattern of interaction depends ("LSD specification"), and using the computational framework of the Abstract Definitive Machine for animation. The degree to which automatic animation is possible depends upon the extent to which behaviour has been circumscribed: where there are View 1 and View 2 agents, animation has to rely upon intelligent interaction on the part of the modeller.

References

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