THE PLACE OF DESIGNING IN PRODUCTION CHAINS: A BASIS FOR DESIGN EDUCATION

This paper suggests that in teaching design, or «how to design», it is important to make the context in which designing occurs as explicit as possible. Much of what we do as designers will, of necessity, remain understanding of the context of our designing. Such understanding may be an important way to increase our capacities as professionals in a complex and changing environment of design practice.

There are many kinds of context that can be discussed, but two are very important. The first is the context of other people who are engaged in making the built environment. The second is the context of physical elements which are subject to manipulation.

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A way of understanding these two kinds of contexts, and their relations, are the subject of what follows. A graphic notation tool is briefly demonstrated and insights from developing and using it discussed. The tool is in the family of graphic modeling tools used in organizational theory and production analysis, but differs from them by integrating in one tool both the parts manipulated and the agents controlling the parts.

DISTINGUISHING DESIGNING AND MAKING

It should go without saying that designing serves making or production. That is, we engage in the hard work of designing principally to steer the making of some artifact. Even when we enter a design competition, we work as though what is proposed will be realized.

It is usually understood that in most cases today, these two activities —designing and making— are accomplished by different kinds of agents. We have, in fact, at least two distinct species of professionals. In the design and production of buildings, for example, we have families of designers called architects and engineers on the one hand, and families of manufacturers and constructors on the other hand. This distinction in roles is familiar. But we also realize that with the distinction, we may find instances in which the roles are blurred or merged in one agent.

It is important to note that construction or production can occur without designing as we know it as professional architects or engineers. Someone may make a building or another complex artifact with few or no drawings or detailed specifications. In that case, much is assumed, or is implicit and unspoken, but is nevertheless important and also thoroughly understood by everyone involved.[1]

But while building may occur without the formal activity of designing in evidence, designing as a formal activity will never happen, by this definition, without building or production as the expected outcome. To do otherwise makes us approach artistic endeavors. There is of course nothing wrong with making renderings, drawings, and other representations whose intention is not to lead to action. But doing so for its own sake should not be mistaken for designing. Such expressions are merely different, but not more or less than designing.

This distinction between designing and production helps us to see a part of the context of people involved in making the built environment: there are those that propose what the environment could be, and those that make what is proposed. Of course there are many other vital roles, including the roles of client, regulator, and financer, but the roles of designer and producer are the subject here.

REPRESENTATIONS

Making representations of images held intuitively in mind, in the form of drawings, models, and other appearances, is an old practice, very much part of the cultures in which such appearances emerge and flourish as an aid to communication and understanding. Representations seem to appear in human discourse to serve such various purposes as sharing impressions, guiding action on the part of others, and describing artifacts, events, natural systems and processes in a world too difficult to understand in the fullness of reality.

Representations are also a kind of accounting. They are selective, including what is of interest and excluding the rest, and thus without fail manifest a point of view, despite technical rhetoric to the contrary.

Pictorial representations of various sorts have apparently been commonplace and, as with discursive or written languages,[2] are often shared by both experts and laymen.[3] When they are thus shared, they are a sort of vernacular way of understanding, not unlike vernacular ways of building such as the North American 2 x 4 system, a way of building wooden houses which has been shared by experts and laymen alike over an extended period of time.[4] These «ways» become powerful, and evolve slowly, knitting themselves into a culture in fascinating ways.

When, at a particular time, a branch of knowledge has been claimed as the province of a guild or profession, one way to identify that group has been by the representations it makes of its «part» of the world from its point of view. Sometimes these modes of viewing and representing the world become esoteric, cutting off those «in the know»,

1. Habraken, N. John, 1988, *The Appearance of the Form*, Cambridge, Awater Press.

2. Langer, Suzanne, 1942, *Philosophy in a New Key*, Cambridge, Harvard University Press.

3. Tufte, Edward, 1990, *Envisioning Information*, Cheshire, Conn., Graphics Press.

4. Habraken, N. John, 1988 (3rd edition) *Transformations of the Site*, Cambridge, Awater Press.

further reinforcing the boundaries between pröfessions, and between professionals and non-professionals. Examples such as complex diagrams of engineered structures come to mind, found in any textbook on structural design, or diagrams of genetic structures in the field of genetic engineering, or graphic modeling architecture used in international product standards development such as the International Standards Organization's work through the voluntary PDES (Product Data Exchange Specification) Organization.[5]

REPRESENTATIONS: MODELING COMPLEX PHENOMENA

For some time, those involved in efforts to model complex phenomena have distinguished two classes of representations, one generally called «process or activity» modeling, the other called «state» modeling. This has generally been adopted by the classical academic division including the social and the physical sciences. Science, in fact, has been largely interested in first of all giving a good description of some phenomenom (its state of «blueprint»), and secondly developing the equations of the processes that will produce the phenomenon (its recipe).[6]

Substantial modeling work has evolved also in engineering, computer sciences, and manufacturing studies.[7-8]

During the same time that «state» and «process» modeling has been part of an accepted paradigm in the academic and research communities, research traditions coincidental with it have matured, particularly in the social and physical sciences, but also in the many engineering subfields.

It is worth noting that during this same period of maturing disciplinary roots, the allied fields under the rubric of environmental design such as architecture and urban design have not developed similarly distinct and well recognized research traditions. Part of the explanation for this may be that these fields do not follow the classification of knowledge found in the division between the social and physical sciences and the arts. And yet, environmental design, like engineering, requires its scholars and practitioners to have skills not only in observation of the behavior of the built environment under various conditions, but in the formulation of proposals to change the built environment. If we include the fields of production and construction, the requeriments on knowledge often encompass an understanding of both designing and the production of what is proposed. The absence of a mature research tradition in environmental design is a subject an understanding of which is important for the future of a distinct architectural profession and a place for it as a respected field of study in the university community.

One of the reasons the subject of a research tradition is interesting to the field of environmental design is that the efforts to understand and model complex processes must address the conceptual problem of the fragmentation of knowledge from action, of process from product, of understanding and action, of observation from designing. Any view of the fragmentary nature of reality has its consequences in our efforts to model complex phenomena, and to practice out of that knowlegde. Our language corresponds with our implicit view of reality. Therefore, if we think of reality as essentially a collection of separate elements, we will model accordingly, and speak accordingly.

Environmental design is interesting and important in that it has generally eschewed a fragmentary view of reality and the physical environment in particular. The characteristic point of view from which environmental design studies are mounted is of an essential wholeness and interdependency of the physical world. This clashes with the classical view, and remains apart from accepted «disciplines» in classical universities in large measure because of an apparent disinterest in or inability to articulate a sound basis for taking measure of this perceived wholeness.

Environmental design scholars should note that in the field of physics, there is discussion that the division of process (forces of transformation) from product (object) may be a less than adequate classification of «ways of knowing». The argument is that even «states» are in process, and that there is a kind of false paradigm at work in conceiving of «autonomous and fixed» states at all, regardless of the «neat chunking» of transformative events that «fixed» models offer.[9] This work concerns the natural sciences, but the questions examined are instructive to the field of environmental design as well. The large question is how to understand wholeness, and how, further, to model wholeness without dividing that which is indivisible.

INTEGRATING PROCESS AND PRODUCT MODELING

The inevitable inadequacy of the separation of process and product modeling became central to the invention of a new modeling tool by this author. The aim of this new tool is the description of «parts making», and secondarily the place of designing in such processes. The tool has the acronym PAct (Parts and Action).

The point of view instantiated in the tool is that artifacts (raw materials, manufactured parts, buildings), as they are modified along a value chain from simple toward more complex artifacts, are in fact manipulated by human agents (individuals or companies). Parts do not become different or more complex by some «natural force». That is, agents change or control parts. The concept of «agents» is therefore a key to linking questions of «states» (a blueprint of a physical object or part) with issues of process (what is done to change a part). People change parts.

The two concepts introduced to bring together the insights available from traditional process and state modeling are *agent* and *control*. An agent is any person, or group, which controls a part. Control is the actual physical change to an

5. PDES/STEP, Document 4.1.3.2.1 Version 3.1, January 2, 1991; Working Paper; Greg A. Paul, Chrmn, % General Dynamics, Fort Worth, Texas.

6. Simon, Herbert A., 1980, *The Sciences of the Artificial*, Cambridge, MIT press.

7. Nevins, James L. and Whitney, Daniel E., 1989, *Concurrent Design of Products and Processes*, New York, McGraw Hill.

8. Carnegie Mellon University Robotics Institute, Pittsburgh.

9. Bohm, David, 1980, *Wholeness and the Implicate Order*, London, Ark Paperbacks.

artifact by a human agent. Using these concepts, the confusion of trying to separate process and product is avoided.

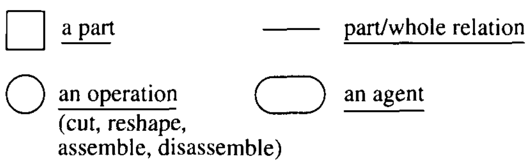
The central objective of introducing this notation tool is to bring control into the discussion of technology, among the various hardware related issues and questions of information and resource flows currently found in most process modeling. Up to now, we have not been able to map control in production chains.

In this modeling concept, an artifact (specified in as much detail as needed) cannot be represented outside the context of human action. Secondly, human action —control— always appears in the context of the artifact which is subject to manipulation. This is the case whether we are interested in «designer genes» in the field of genetic engineering, a new kind of flexible gas piping, or a house remodeling. Human action, operationalized as control, is always in view in the study of physical parts and the production chains in which they find themselves.

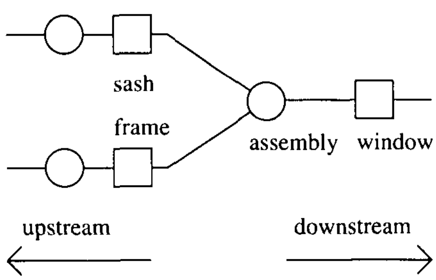
A NEW NOTATION TOOL TO MAP CONTROL IN PRODUCTION CHAINS

The following series of diagrams is given to show the basic elements of the PAct tool and to put into diagrams some of the questions raised by associating control with parts:

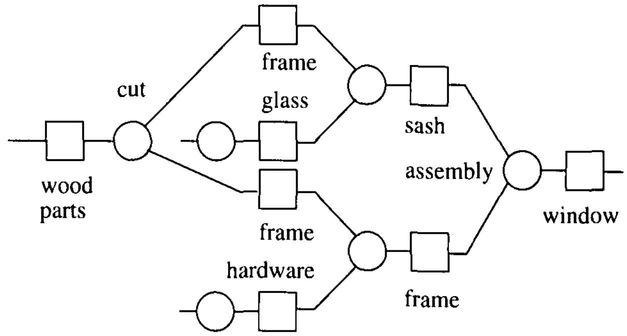
1. The basic elements of the diagrams are these:



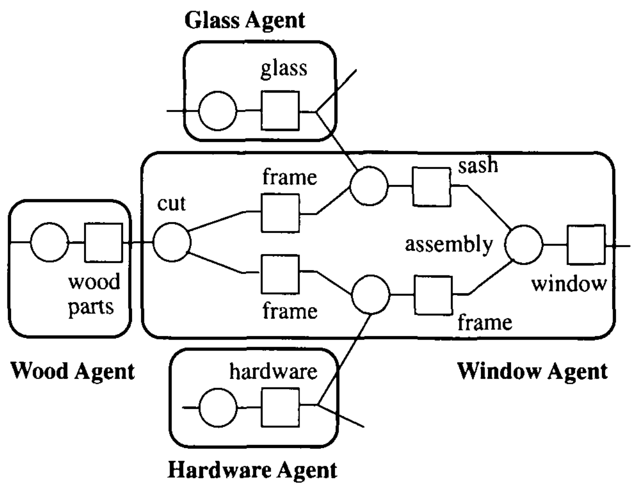
2. Starting with a conventional part/whole diagram, we see, for example, the joining of parts into a whole. e.g. parts making a window are «assembled».



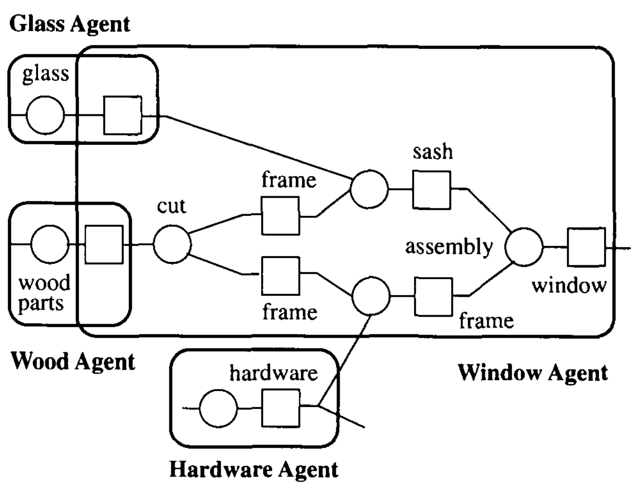
3. «Opening» or specifying a parts symbol, we can see more: here the diagram shows parts making the sash and the frame of the window. Here also, an operation of «cutting» joins the operation of «assembly».



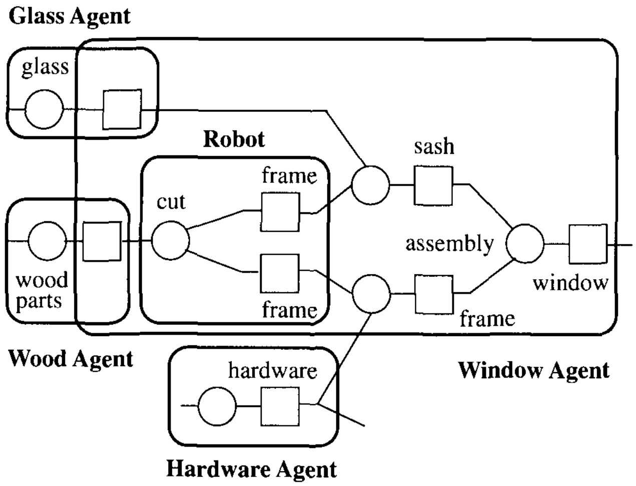
4. We can now bring in agents. Here, several agents are at work. This diagram shows them acting independently, making a dispersed control pattern. Agents are independent entities each controlling parts. This means that GA and WA are producing for inventory.



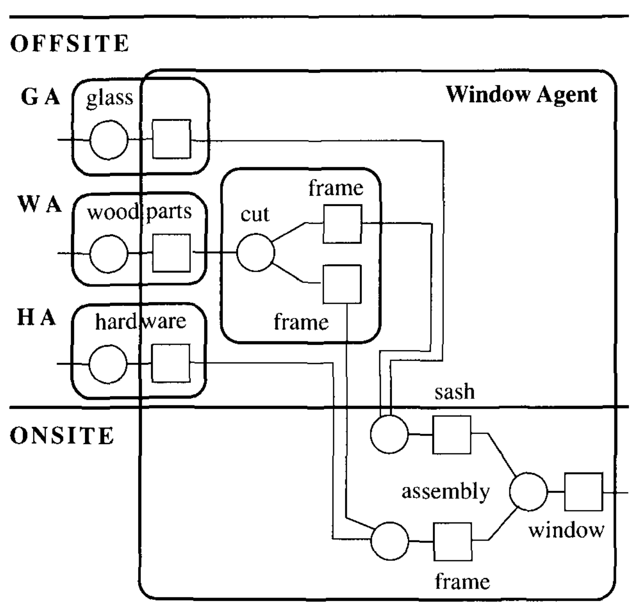
5. Another diagram of making a same window may have agents relating differently. The diagram shows an overlapping control pattern. Here, a «downstream» agent (window agent) controlling some parts specifies other parts controlled by «upstream» agents GA and WA. The control of glass and wood parts by GA and WA is dependent on the indirect control of the window agent. This means that GA and WA act upon the specification or indirect control of the window agent. GA and WA produce for orders.



6. Another relation between agents is shown in a diagram in which one agent is completely included or dominated by the other. This may be the situation of a single purpose programmed robot. To show an agent entirely included may indicate a condition in which that agent's efforts, as far as its control of the part is concerned, are entirely governed by the specifications of the «downstream» agent. The wholly included agent has no autonomy in regard to its control.



7. In addition, the tool can be used to locate control either on or off-site: here, the site is the jig table where the window is assembled. The pattern of control is as in 5 above.



These diagrams show some of the simple notation concepts.

They show us any individual part in its larger parts context, and the agents who control parts. Using such notation, we can identify which agent is controlling which part(s). This is useful in accounting for responsibility. It is also useful for comparing shifts of control, as for example when one agent extends its control, taking over the control of previously independent agents. We can see in the diagrams whether these agents have relations with other agents or not, and of what kind. We can name kinds of agents, and associate them with kinds of parts and operations. We can see what operations are used to control a part, and whether or not the work is done on or off-site.

We can also distinguish indirect control from control. We see that indirect control occurs in patterns of overlap, a situation in which agents relate to each other through mutual but different interests in a given part. In situations of indirect control, one (maker) agent controls the part on the basis of another (user) agent's indirect control or specification of it.

In indirect control, we already have the basis for discussion of designing and the concept of a design agent.

THE PLACE OF DESIGNERS

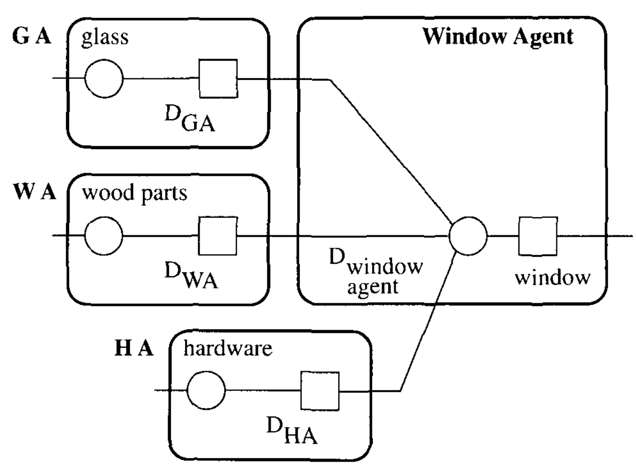
Having established a way of showing chains of parts, and agents controlling and indirectly controlling parts, we have a diagramming context in which designers can be placed.

This enables us to discuss the relation of design agents to artifacts they propose, to production operations, to control agents and to each other.

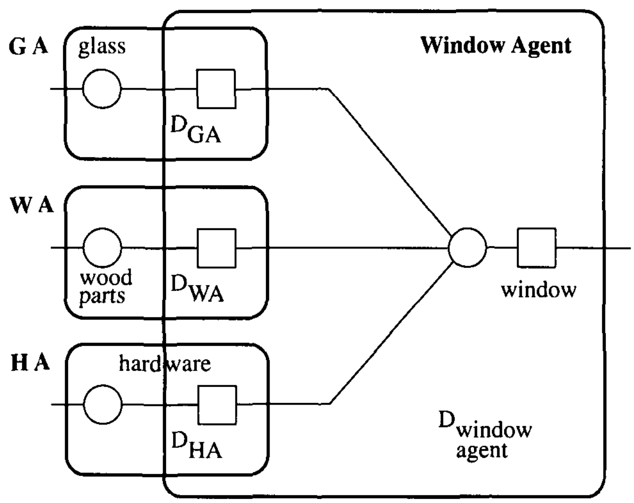
Designers formulate proposals specifying the position and dimension of elements, as their way to influence parts. The word influence is used intentionally, as distinct from control. Influence has to do with modifying or affecting what is actually physically changed, and may include elements of the regulatory environment and resources of various kinds. 239

The following two diagrams show how we may indicate design agents in control diagrams.

8. Returning to an abstracted view of diagram 4, we may introduce a design agent D. There may be a D associated with each control agent, as shown. Since the control agents are independent, we understand that DWA may be informed about downstream and lateral situations of control, but is not in a position of certainty about them. Thus, what should DWA propose to control agent WA as a design for the wood parts? The question is, what will the window agent want to do with the wood parts and thus what should their design be to help the window agent exercise control? If there are many downstream users of the wood part, agent DWA must generalize all possible uses in determining the specification for the wood part.



9. Abstracting diagram 5, and placing designers in it, we see another situation of interest to designers. Here, the work for Dwindow agent is substantially greater than before. This agent is now responsible for specifying both wood and glass parts in addition to window parts. Further, this agent must apparently discuss these proposals with the D agents associated with the glass and the wood parts. What is the role of the D agents associated with the upstream control agents GA, HA and WA, if their associated parts are specified by another D agent?



These are two examples of modeling the position of design agents in production chains. They show us a more complete picture of agents, agent's relations and relations of agents to parts.

The second example (diagram 9) gives the design agent for the window much more scope for influence (not control, because design agents do not control) than the first (diagram 8), but also represents more work and more demand on her design knowledge. It may increase her scope of responsibility. More people must be coordinated, and more technical information is needed.

The reverse is apparently the case for design agents working for GA, WA and HA (diagram 9).

The reason to do this modeling is to compare maps of complex situations of control. As designers, we are interested to understand where we contribute in production chains, and our relations to patterns of control. The purpose is not to advocate before hand a particular way of organizing control or distributing design work. Instead, the purpose of the tool is to offer a method for accounting for who does what. Once we see what is actually going on, we are in a better position to discuss changes to current practice and evaluate new trends and opportunities.

A NOTE ON WHY CONTROL HAS BEEN NEGLECTED UP TO NOW IN TECHNICAL DISCOURSE

The studies leading to the development of PAct indicated that the concept of control as «physical change of an object by a human agent» is largely ignored in studies of parts making, and in diagramming of assembly or manufacturing processes. It seems important to consider why this has been the case.

Generally, organizational and information theory attends to patterns of behaviour among units of organizations and information flows between them. Production theory attends to patterns of assembly and their required information and resource flows. The tradition of directed graphs is well established in both these domains, but interestingly, the concept of agent has not been central or more than a marginal concept in studies of assembly or production.

Technical thinking apparently does not deal comfortably with control. Perhaps this is because the expansion or contraction of a control pattern in a value chain is not strictly accountable in scientific terms. We cannot compute control patterns because they are inextricably connected with sociopolitical issues and are consequently not mathematically predictable.

Secondly, efforts to automate production are basically concerned with eliminating human intervention in «making» processes. This occurs in two ways. First, humans are to be replaced by programmable robotic devices. Second, decision levels are to be eliminated to streamline decision making processes. An understanding of the first is vital to social and individual wellbeing, as well as to entire subcultures of skills and knowledge. An understanding of the second is critical to issues of the distribution or concentration of control, a matter of concern for the continuance of professional classes and efforts to restrain the encroachment of experts into positions of dominance over laypeople.

Both of these clusters of issues are not easy to touch from a technical perspective and are therefore often pushed aside.

Further, and perhaps most difficult, is an apparently pervasive view of the artifacts any single agent makes as «correct» and immutable objects. Such a view corresponds with a view of «use» as a passive activity or an activity of consumption. Strange as it may seem, it is rare to find clear thinking about the movement of an artifact from one hand to another —from one person to another, or one company to another— in a chain of making. There seems to have developed a fixation on the finished object, not the object as something to be transformed or controlled by another agent. This goes along with the effort of marketing forces to create passive consumers of millions of finished products, which we are to believe are made just for our needs and require no further making for use.

But everyone knows instinctively that we abhor parts which we cannot control. People who actually make buildings also know that the idea of immutable parts is a fiction from their viewpoint. Their work is to change parts. So, of course, is the job of designers to propose changes to what is already there.

The cool commercial exchange of an industrially produced product to be used as it is found, or shaped to uses unforseen by its maker; or the artful specification of a part for a particular use by a party who knows what should be made but cannot make it, all entail complex chains of control of parts the understanding of which is a good key to understanding the world of artifacts.

This knowledge is vital to designers, and is therefore vital to design education. Our basic responsibility as educators is the development of intuitive capacity in our students to empower them to take part with others in designing, in the context of complex and changing circumstances. Paying explicit attention to and understanding the context of designing should not be seen as contradictory to this objective.

Bringing the concepts of control and agents into the discourse about technical matters may unlock new insights into the possibilities of active engagement with the artifacts we propose to share space with.