Modelling Conflicts Between Agents in a Design Context

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Abstract. This paper discusses the use of fine-grained agents to investigate conflicts during multi-agent design, reasons for the occurrence of conflicts, as well the reasons for studying them.

1 AGENTS IN A DESIGN CONTEXT

The goal of our work has been to make conflicts explicit during design activity. By having design knowledge represented by many fine-grained agents we are able to realize this goal.

The goal was originally conceived by the realization that many conflicts in the multi-agent design systems, and design support systems, that we were building were "internal" to an agent. In addition, many of the conflicts were being compiled out at system-building time [3].

By "breaking open" these systems into fine-grained agents the conflicts became visible, and thus available for study. Hence, internal conflicts, with their hidden resolution, become visible conflicts with visible resolution -- intra-individual conflicts become inter-individual.

In addition, by deliberately avoiding encoding only "normal" solutions we paved the way for more unusual designs. Also, as success and failure are the standard stimuli for learning, conflicts and lack of conflict -- now revealed more clearly -- can be used to investigate learning in multi-agent systems that do design.

Another important realization was that when we were building design systems we had been providing each agent with a specialized task, and a particular target (e.g., some portion of the design to complete, or check). While making the agents finer grained, it was clear that we were also giving agents a "point-of-view".

Consequently, our agents are Single Function Agents (SiFAs). A SiFA is an agent that performs a single function on a single target from a single point of view [3]. Figure 1 shows some agents in this three dimensional space.

The function performed by a SiFA determines its type. At present only a limited number of functions have been used for design problems. We conjecture that a set of agents with these functions is sufficient for most design problem solving activities. The key agent types with which we have worked are Selector, Estimator, Evaluator, Critic, and Praiser.

The target of a SiFA is a single parameter of the design. The point of view of an agent is some aspect of the design that the agent considers while doing its work. Usually, the point of view of the agent is a goal that the agent is trying to satisfy or optimize. Examples of points of view for design agents are cost, strength, and style.

2 WHAT IS A CONFLICT?

Conflicts in SiFA systems are indicated by pairs of Selectors, Estimators or Evaluators producing apparently different responses (i.e., values, estimates, or evaluations) for the same parameter; by a Critic objecting to a Selector's value; by opposing opinions (i.e., Praise and Criticism); or by an agent discovering that a previously decided value that it wants to use to perform its function is incompatible with its knowledge.

Conflicts occur in SiFA systems for a variety of reasons:

- Conflicts from agents having different points-of-view.
- Conflicts from agents having different knowledge.
- Conflicts from agents not providing the right information (e.g., less accurate than required).

At present, SiFAs do not contain plans, and consequently conflicts between plans cannot occur. However, acting with a point-of-view (e.g., the goal of keeping cost low) could be seen as an intention, and point-of view conflicts could be seen as weak clashes between intentions.

A Conflict can be thought of as a process. It has actors, location and a duration. The location is, loosely, the object of the conflict (values, evaluations etc.). This is important for characterizing conflicts. A conflict can be thought of as existing until the conflict resolution process is complete.

3 WHAT IS THE FUNCTION/ROLE OF CONFLICTS?

The main role of conflicts in a SiFA system is to detect and drive the exploration of the search space -- in particular, examination of the possible boundaries of the acceptable design space. We refer to "possible boundaries" as, due to conflict resolution via negotiation, the boundaries may well be flexible. These conflicts usually correspond to (hard or soft) constraint violations. Conflicts can also indicate the incompleteness or incorrectness of an agent's knowledge.

In addition, although this has not been explicitly implemented in SIFAs (although it was in DSPL [2]), a conflict may indicate a mismatch between the current situation and the conditions under which an agent's knowledge should be used. In such a case the conflict is between the request for an agent to act and the inability of that agent to act.

Another important role of conflicts, as indicated above, is as a trigger for learning. As conflicts and their resolution involve resources, agents may wish to avoid them. This might be accomplished by inductive learning about the general and specific situations in which conflicts occur [4], and by learning why they occur, using exchanged design rationale.

4 HOW ARE CONFLICTS POSSIBLE?

Conflicts are possible in SiFAs because there is no assumption that the design knowledge comes from a single, consistent source. There might be a different source of knowledge for each agent. Hence, even for a single parameter, there might be agents that have completely different methods for producing a value, and different

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underlying (deep) knowledge or assumed models (i.e., for the role that parameter plays in the function, structure or behavior of the artifact). In addition, the experience that formed (compiled) the knowledge of each source will be quite different.

The point-of-view of an agent might be concerned with any phase of the life-cycle: for example, design, manufacturing, assembly, packaging, distribution, use, servicing, or recycling.

Point-of-view derived goal-goal conflicts can easily occur during the design process. For example, concern with strength may imply using more material, which increases cost. Thus, agent's goals are linked by dependencies. Lack of knowledge of these dependencies, due to the lack of a global model, is an underlying cause of conflict.

Conflicts can be implicit or explicit. There can be many possible, implicit conflicts. As agents attempt to complete a design to everyone's satisfaction, each agent can be thought of as searching through their space of allowable responses. The path is shaped by preferences or constraints. Preferences distort the surface of the space, making some areas more appealing. The path produced is also shaped by conflicts. Conflicts with other agents cause unexpected changes in direction. These changes, due to the interaction that results from attempting to resolve conflict, may then lead to other conflicts with other agents. Thus explicit conflicts emerge.

5 HOW CAN CONFLICTS BE MODELED?

We are studying and categorizing conflict types in terms of SiFA types. We have started to investigate types of conflicts and their possible resolution by considering all possible pairs of SiFA types. By building a matrix with SiFA function types as both the row and column we can systematically attempt to fill in the elements of the matrix to explain how such a conflict might occur [3].

These conflicts can also be arranged in a domain-independent taxonomy [1]. A version of this is shown in Figure 3. The fine-grained nature of a SiFA means that cause of the conflict is closely related to the types of agent involved.

6 HOW CAN CONFLICTS BE HANDLED BY MACHINES?

In order to properly record all the information that SiFAs can generate, and to easily allow the detection of conflicts, SiFA systems use a Parameter Block [1]. This is shown in Figure 2.

The root of the parameter block is the name of a parameter. The first "level of reference" has two entities. These are the parameter's value and estimated value. The second level of reference has evaluations, criticisms, and praises of the value and the estimate. There can be multiple criticisms, praises, and evaluations of the same value or estimate.

The third level of reference has evaluations, criticisms, and praises of second level evaluations, criticisms, and praises. These entities refer to the second level entities which refer to the first level entities. These "chains of reference" uniquely determine what each entity refers to. So at the third level, there exist entities such as the evaluation of the criticism of the value of the parameter. The third level entities typically contain meta-level information about the design.

Possible conflicts are indicated in simple, mostly knowledge-free, ways -- such as two agents both trying to store a value for the same parameter. Detection of actual conflicts from those indicated is a knowledge-based task. For example, an agent may accept the wood "Oak" as equivalent to "Walnut", despite it being a different value.

Negotiation is the method used for conflict resolution. Typically, agents relax their constraints or insist less on their preferences in order to solve conflicts. So far, Negotiation between SiFAs has only been studied in the simplest cases.

Avoidance of conflicts has been studied by having SiFAs learn which of their choices lead to conflicting responses from other agents, and in which context. Each agent inductively builds a model and uses it to avoid conflicts [4].

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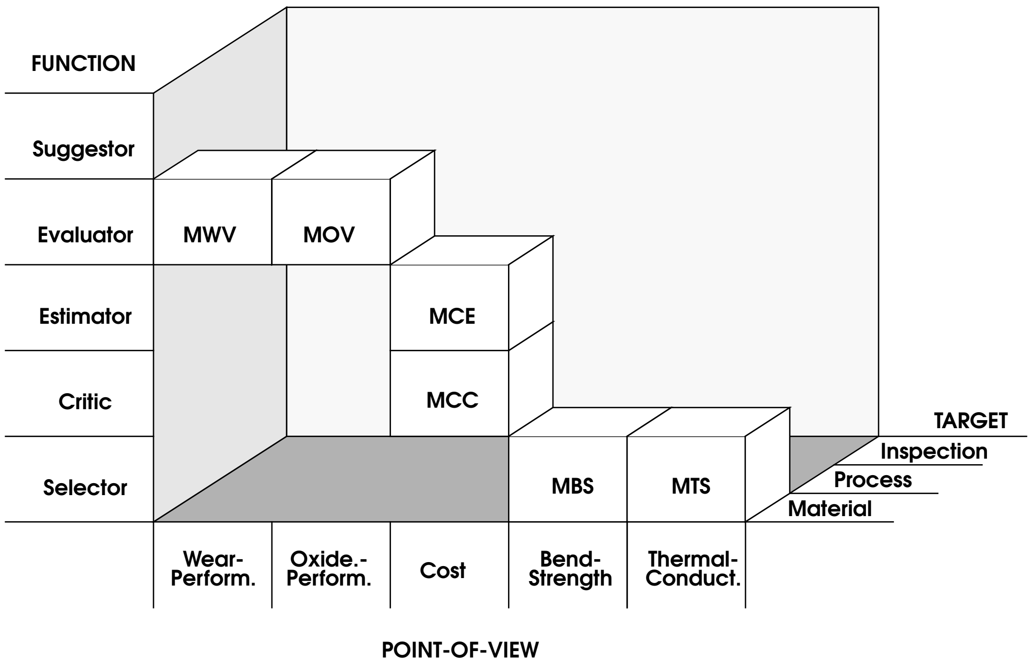

Figure 1: Function, Target and Point-of-View

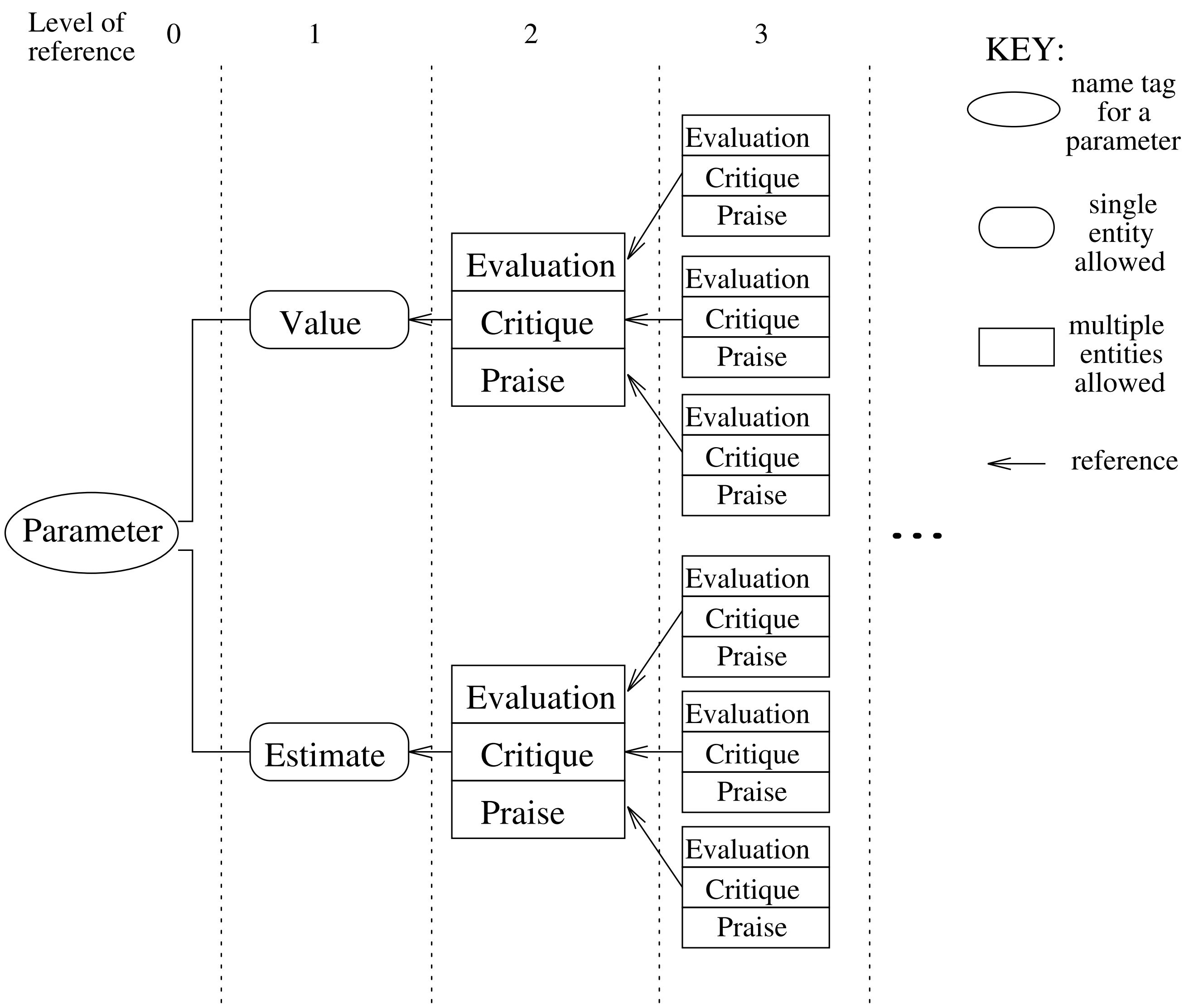

Figure 2: The Parameter Block

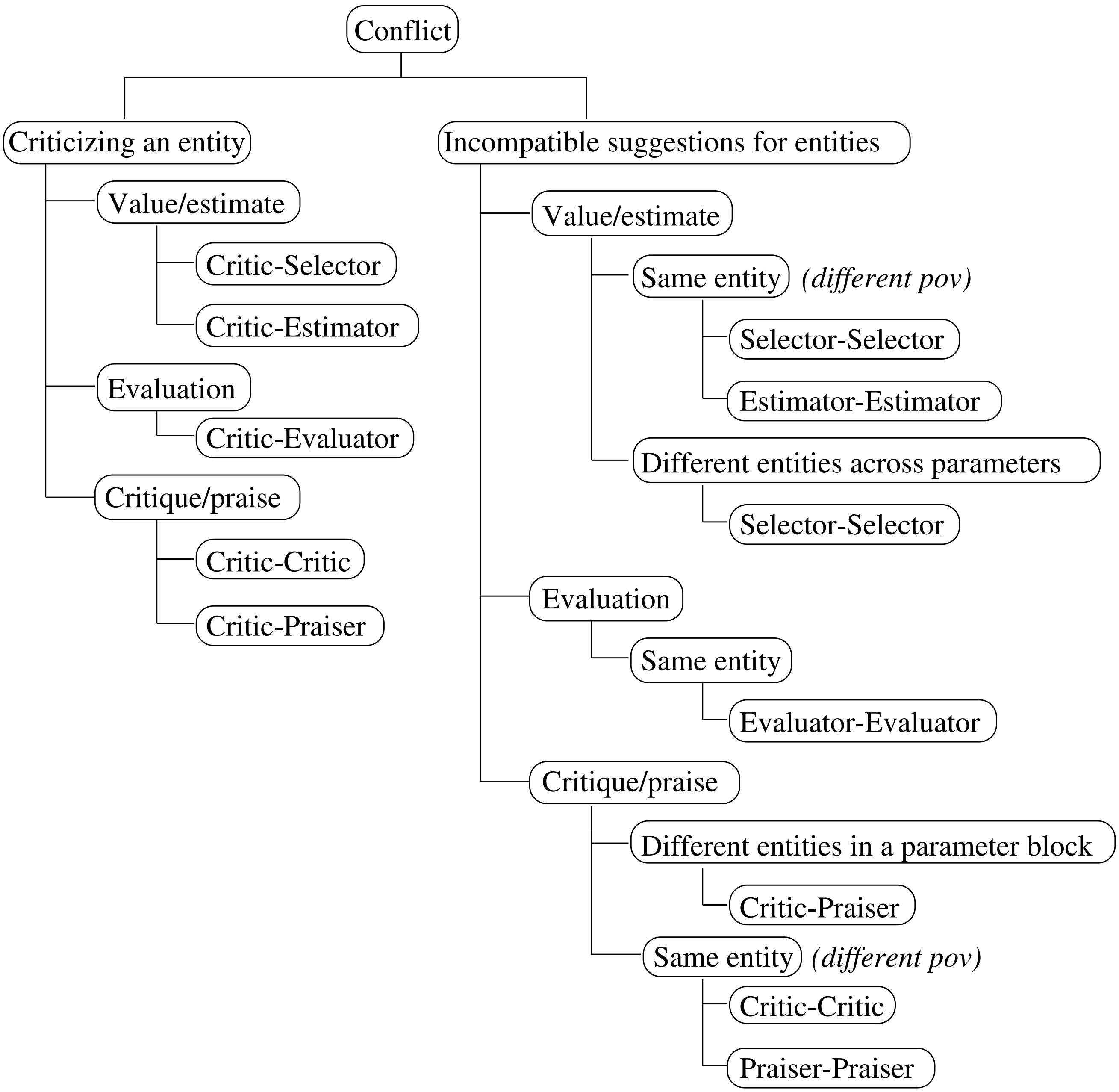

Figure 3: A Classification for SiFA Conflicts