Problem Solving in Frame-Structured Systems Using Interactive Dialog

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ABSTRACT

This paper provides an overview of the process by which problem solving in a particular frame-like knowledge-based system is accomplished. The inter-relationship between specialization traversal and entity processing is addressed and the specific role of the user interaction is described.

I INTRODUCTION

Semantic networks [1] and frame-like systems have emerged as powerful tools in a variety of problem domains [2]. In many of these systems an initial knowledge base is used to drive an interactive dialog session, the goal of which is the instantiation of the particular knowledge base elements which represent a solution to the problem being addressed. In a system developed at the IBM Scientific Center in Palo Alto [3,4], a dialog is generated from a KRL-based [5] semantic network for the purpose of generating a well-formed definition of a medical sensor-based application program. It is intended that the user of the system be conversant with the problem to be solved by the application but not that they be a computer programmer. The overall logic of this process is the subject of this paper.

II THE DIALOG LOGIC

The ultimate goal of the problem-solving dialog session is the complete instantiation of all entities (knowledge units) relevant to the problem solution. To do this the system must be able to create new work contexts (in our case entities) from existing ones and be able to traverse the specialization hierarchies rooted at these entities to accomplish complete instantiation. The logic governing the interrelationships between these two tasks, and the methods of user interaction tend to characterize frame-based dialog systems.

One could, for example, choose to pursue a path of 'least commitment' by processing all relevant references at their highest levels in the specialization hierarchies before attempting deeper specialization traversal [6,7]. This approach seems well-suited to problem domains where the solutions are highly dependant on the interaction of constraints between the processed entities. In the case of our application development system it was felt that the solution process would be enhanced if individual entities were completely specialized as they were encountered, with outside references posted as pending work contexts for subsequent processing.

This 'greatest commitment' approach seems well-suited to semantic networks in which specialization traversal in one hierarchy provides increasingly more specialized references to other hierarchies, and where the constraints between hierarchies are not potentially inconsistent. An example of this can be seen in the relationship between our SENSOR hierarchy, which provides descriptive knowledge about the analog, digital, and keyboard-entry sensors available in the laboratory and the DATA hierarchy, which describes the kinds of data which can be processed. In these interdependant hierarchies, one finds that BLOOD PRESSURE is measurable only by a subset of PRESSURE SENSORs, and that ARTERIAL BLOOD PRESSURE (a specialization of BLOOD PRESSURE) makes even further specializations on that set. Traversal of either hierarchy will implicitly specialize the related hierarchy. Downward traversal of specialization trees is the main driving force of the dialog system.

III MECHANICS OF SPECIALIZATION TRAVERSAL

Entities intended for inclusion in the problem solution are dynamically replicated and inserted into the knowledge structure as an immediate specialization of the entity from which they are copied. As more becomes known about them, these new entities are moved down the specialization hierarchy, always appearing as a specialization of the most constrained model available in the initial knowledge base. These dynamic entities have exactly the same representation as the initial entities and differ from them only in that their constraints can be overwritten in the process of instantiation. If, for example, one of the attributes of a DEVICE is its user supplied name, then the value obtained for that name during the dialog would be placed in the dynamic entity while the corresponding entity/attribute in the initial knowledge base is only constrained to be a name.

The mechanism for migrating a dynamic entity down the associated specialization hierarchy may require user interaction. This interaction is accomplished using a video character display with full screen data entry facilities, a light pen, and program function keys. It has been our experience that non-computer-trained users are very sensitive to the level of human factors provided and it is well worth any effort one can make to facilitate interaction. First the user is prompted to supply values for attributes which have been declared in the knowledge base to be user-sourced. (This is equivilent to the 'lab data' assertion in MYCIN [8]). Having obtained these, a pattern-matching search is performed to see if specialization is possible. If not, the next step is to attempt specialization by allowing the user to choose from a list of the names of the immediate descendants at the current level in the hierarchy. If the user is unable to select the specialization by name, he or she is interrogated for selected attribute values which, if known, would determine a specialization path. This process continues until a terminus in the hierarchy is reached. During the traversal process any references to other entities must be resolved, and these references generate additional work contexts for the system. It is particularly important that the resolution process be able to determine if the reference should resolve to an already existing dynamic entity or if it should resolve to an entity in the initial knowledge base. Some considerations relevant to this problem are discussed below.

IV PROCESSING ENTITY REFERENCES

When a reference resolves to a single entity one of three situations prevails: 1) the reference is to an exactly matching dynamic entity, 2) the reference is to an existing dynamic entity which is less constrained than desired, or 3) the reference is to an entity in the initial knowledge base. In the first of these cases no further processing is required. In the second case, the more constrained form of the attribute is forced into the dynamic entity and a search is performed to see if this new form permits further migration down the specialization hierarchy. In this way values of attributes obtained from specialization down one hierarchy can implicitly cause specialization acitivity in related hierarchies. In the third case a new dynamic entity would be created.

V SUMMARY

Processing entities to their most specialized form is a valid driving function in some knowledge bases, and generating user interaction specifically for this traversal can be a sufficient involvement for the user in the problem solving process. Representing the results of the problem solving session in the same form as, and in direct association with the initial knowledge base has many positive features. Included among these is the ability to use a single search/resolution mechanism to select from either set of entities when building the problem solution. In general, frame-structured knowledge bases, in conjunction with user interaction can provide a powerful problem solving facility.

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