

Knowledge-Based VLSI Design Group  
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## Concepts of Lore\*

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*Abstract.* Lore is a knowledge representation system developed by the KB-VLSI project at Xerox PARC and Stanford University. It is being used for representing knowledge in **Palladio**, an expert system for assisting designers of integrated systems. This memo is intended to explain the concepts of the Lore language by example for "knowledge engineers" who will be creating Palladio's knowledge bases. Lore manuals (See the Bibliography) can be consulted for instructions for using the system. Lore is implemented in InterLisp-D.

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*Specifications*  
*Descriptions, Units as*  
*Descriptions*  
*Values - sets as symtoms*

*roles*  
*slot inheritance*

*constraints*

# 1. Introduction

Expert systems can be characterized, in part, by their requirements for representing and using diverse kinds of knowledge. This knowledge is usually difficult to articulate. It is formulated, accumulated, and modified throughout the course of a project. During the development of an expert system, a great deal of time is spent in testing, debugging, and modifying the knowledge. This provides a strong motivation to use techniques that make the knowledge accessible and changeable. Central to these techniques is the use of knowledge bases to explicitly represent knowledge in a *knowledge representation language*. This paper describes Lore, a language that we are implementing to represent knowledge for experimental expert systems.

Our first application of Lore will be the expert system Palladio (See Stefik and Brown [Stefik81b]), an experimental automated assistant for designers of integrated digital systems. The domain of integrated system design provides a diversity of examples of concepts that need to be represented. One source of examples is the description of circuit modules that are created and composed to form digital systems. These modules vary in complexity from inverters to large computer subsystems. Furthermore, the modules need to be represented at appropriate levels of abstraction. This is important for understanding the composition of even simple modules, such as inverters, which can be represented in terms of their logical function or as combinations of more primitive switches. The design process itself is another source of representation examples as it concerns such concepts as goals, alternatives, abstractions, implementations, constraints, composition rules, and tradeoffs. The *knowledge engineering* task is the articulation of the meanings of these concepts and the determination of the relationships between them. Part of this task is the proposing of an epistemology of concepts; another part is the reification of such concepts as structured objects in a representation language.

It is unlikely that the first representations proposed for inverters, goals, constraints, or composition rules will be exactly right. Experience with expert systems has shown that the understanding of how to define and organize domain concepts increases over the course of a project. Hence, such definitions cannot themselves be part of a representation language. Instead, a representation language provides a framework for defining concepts in terms of other concepts. Pragmatically, such a framework must provide methods of composition of concepts as well as an initial set of concepts reasonably close to the domain concepts. To simplify implementation of a representation language and to provide a simple connection to logical foundations, it is appropriate to define a *kernel* of elementary concepts of the representation language. A *bootstrap knowledge base* is then used to bridge the gap between the kernel and the framework for defining domain concepts.

This document is organized as follows: Section 2 describes some basic concepts of the definitional framework and facilities of Lore. This includes a very small set of primitive terms (e.g., units, slots, and relations) for organizing information. Section 3 provides some simple examples of representing concepts from the domain of

integrated circuit design. Section 4 introduces some more powerful definitional concepts. Section 5 proposes part of an epistemology of concepts about the design process. Section 6 describes self-description in Lore, and identifies which concepts are in the kernel and which are defined in the bootstrap knowledge base. Section 7 traces through the historical record to compare Lore to other knowledge representation languages and to acknowledge intellectual debts to other researchers.

## 5. Bibliography

[Feigenbaumxx]

Feigenbaum, E. A. The art of artificial intelligence, IJCAI??

Need KRL, KLONE, PIE, SmallTalk, RLL refs

[Stefik81a]

Stefik, M., Bobrow D., Berlin, D. *Lore Hacker's Manual*, Knowledge-based VLSI Design Group Memo KB-VLSI-81-4, April 1981.

[Stefik81b]

Stefik, M., Brown, H. *Toward a prototype of Palladio*, Knowledge-based VLSI Design Group Memo KB-VLSI-81-6, April 1981.

[Stefik80]

Stefik, M. *Planning with constraints*, doctoral dissertation, Stanford University Computer Science Department, <number>, January 1980.

[Stefik79]

Stefik, M. An examination of a frame-structured representation system, *Sixth International Joint Conference on Artificial Intelligence*, 1979, August, pages, etc..

[Who81]

Who?. *LRS User's Manual*, Knowledge-based VLSI Design Group Memo KB-VLSI-81-?, <Month> 1981.

[Who81]

Who?, *Webster: A knowledge base editor for Lore*, Knowledge-based VLSI Design Group Memo KB-VLSI-81-?, <Month> 1981.

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