3. Separate the content from interactive strategies used to teach and access the content via reference, tutorial, or presentation modes.

The first task in the conversion project was to lay out the architecture and design of the software engines. The system architecture was based on a preliminary analysis of the content. First, common "types" of information were identified, such as service procedures, product identification, or features and benefits of a product. Then software templates could be designed for teaching these different types of information. The types of information, including the structure and relationships among unique pieces of content, were stored in a special database called a knowledge base.

The MIM Content Knowledge Base links information based on structure and relationship, rather than specific content. The MIM software engines access the knowledge base and retrieve content according to its structure and relationship. Predefined templates are used to teach and present the different types of content. Each unique content type or structure uses its own templates. For example, product comparisons are consistently taught using the same instructional strategies. The strengths of this approach are threefold:

1. Templates can be reused, reducing development costs for subsequent programs.
2. Design time is reduced, which shortens product development cycles.
3. The quality of training is ensured across a large development team.

The system architecture appears in Figure 1.

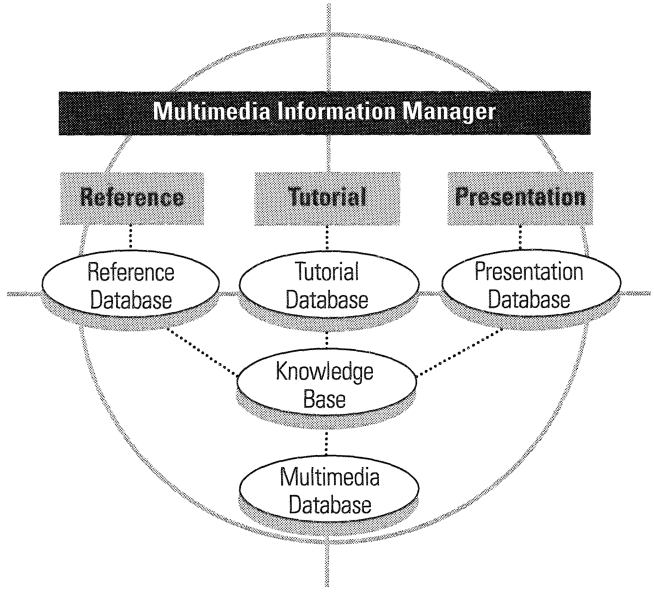
The multimedia database contains all multimedia assets. Multimedia assets include all the graphic, video, animation, and text files. The knowledge database contains all the content knowledge and the relationships between the pieces of content. The content in the knowledge database is classified into different types of information elements, and those information elements are linked to each other through different types of relationships.

The reference database contains data sets for various reference templates specific to the reference engine. Such data include a table of contents, display formats, and hypertext entries.

The tutorial database contains data sets for various instructional templates specific to the tutorial engine. Such data include display formats, test items, feedback, and instructional options.

The presentation database contains data sets for various presentation templates for the presentation engine. Such data include display formats and options.

Figure 1. System architecture.



Training Design Model and Information Structure

The knowledge database contains the information elements that the MIM uses to automatically generate the content organization and information displays. This section describes the theory behind the classification of the training content so that the MIM can automatically build interactive multimedia information products.

Information Elements

In MIM, information elements (IE) is the term to describe the database records or objects that are stored in the knowledge base. Each IE has a name, and its content can be text, graphics, sound, video, animation, or an external program file. The primary purpose of an IE is to group a set of multimedia assets together to provide a piece of meaningful information.

Although an IE groups related multimedia assets according to their content, the power of the MIM knowledge base is in the type, structure, and organization of individual IEs. IE type defines the kind of information an IE contains. IE structure defines how several IEs are linked together to represent an information structure, such as a proce-

dure or a process. IE organization defines how IEs are organized into tables of contents, such as chapters, lessons, or modules.

Types of Information Elements

The knowledge database uses four main types of information elements. These four basic categories are as follows:

- *Overview IE.* The overview information element provides an overview or brief description of a larger body of content that the MIM presents. Overview IEs are used in the conversion effort as an advance organizer and as a means of building a content outline for a module. The overview IE gives students a big picture of the content in a particular portion of the course so they can decide if the information they want is available in that section.
- *Introduction IE.* The introduction information element introduces a key idea. It typically corresponds to a learning objective and groups all the information related to the learning objective into a meaningful information element structure (IE structure).
- *Primary IE.* A primary information element defines a piece of information that is associated with an IE structure. Primary information elements are the focus of the instructional designer's content-development efforts. The primary IEs, like parts of a device or steps in a procedure, are used to package and deliver the content of a given subject matter in a meaningful way.
- *Supporting IE.* A supporting IE provides additional information to an introduction or primary IE. Additional information may not be required for learning the content but may enrich the learning experience.

For the Caterpillar conversion effort, content developers had to analyze their assigned content modules and develop a content outline that used overview IEs to lay out the scope of the module. Once content was further defined, developers used introduction, primary, and support IEs to present the content information. The introduction, primary, and support IEs can each be used in different information element structures. Definitions of these IE structures follow.

IE Structure

IE type and IE structure relate to the second MIM premise: separate the content from the underlying knowledge structures. Content related to any subject can be categorized into various types, and that content linked together using certain structures.

- *Parts IE Structure.* Content developers used a parts IE structure to represent information that could be organized into a part-whole relationship. Examples of parts structures include parts of a loader bucket, parts of a 9-hose assembly, or parts of a connecting rod. Each IE in a parts structure represents information on a single part or a group of related parts. For a given part, the information may include its name, location, description, and function.
- *Procedure IE Structure.* The developers used a procedure IE structure to classify content about performance of a task or procedure. Examples of procedure structures include procedures for assembly of equipment and the steps to generate a report. Each step in the given procedure is a separate IE. For a given step, the content information may include the step name, the description of how to perform the step, and its sequence location in the procedure. Each step may also contain a list of actions required to perform the step.
- *Process IE Structure.* A process IE structure was used to teach how something worked. Examples of content that could be classified using a process structure include operation of a hydraulic pump, information flow within an organization, the flow of a fluid through the engine, and other content that consisted of linked processes or phases. Each phase of the operation or process is a primary IE. Frequently a process is composed of simultaneous events. In those cases, the primary IE contains all the concurrent information.
- *Comparison IE Structure.* The developers used comparison IE structure when the nature of the content suggested that students were learning product information by comparing the similarities and differences of different categories of a product. For example, learning how six types of hose differ from one another is basically a comparison of different features. In the MIM, the features were defined as attributes of the object. Attributes include items like weight, color, or fabrication method. Every attribute has a unique value for a particular category. For example, when Hose *X* is green and Hose *Y* is black, the attribute discussed is "color."
- *Relation IE Structure.* A relation IE structure describes the relationship between two or more lists of information. An example of relationship-oriented content is a list of engine failures and the respective causes of each failure plus the repair options available for each failure. Each element in a set of information (e.g., an engine failure, its causes, and how to repair the failure) is related. The relation structure defines a one-to-many relationship, where the comparison structure defines a many-to-many relationship.