Adaptive Data Management - a Path to CAE Integration

by

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ABSTRACT

Integration of Computer-Aided-Engineering (CAE) activities is the major priority for the 1990's for both users and developers of CAE software. This paper outlines some of the issues and past approaches toward CAE integration and outlines a proposed approach toward integration utilizing a vendor independent "Object-Oriented" data base system with the ability to adapt the data format and structure to the specific application (ie. FEA, Solids, NC, BOM, Drafting, etc...).

Introduction

The past ten(10) years have produced tremendous technological advances in the areas of finite element applications, solids modeling, CAD, NC, process planning, automated bill of materials, and several other engineering applications. Despite these technological advances integration between disciplines and applications continue to be the major problem associated with implementation of CAE (Computer-Aided-Engineering) applications. Integration of CAE activities is the major priority for the 1990's for both users and developers of CAE Software.

This paper will discuss past and current attempts toward integration of CAE activities highlighting some of the complex issues associated with this integration. An alternative approach toward CAE integration will also be proposed and will be referred to as Adaptive Data Management.

Islands of Automation

The initial technological advances in software for engineering applications were made with no concern for integration of activities. Engineering application software was developed as if each application existed in a vacuum with no need to communicate to other engineering applications. This resulted in an engineering computing environment known as "Islands of Automation" in which several application areas were highly automated with little to no communication between application as illustrated in Figure 1.

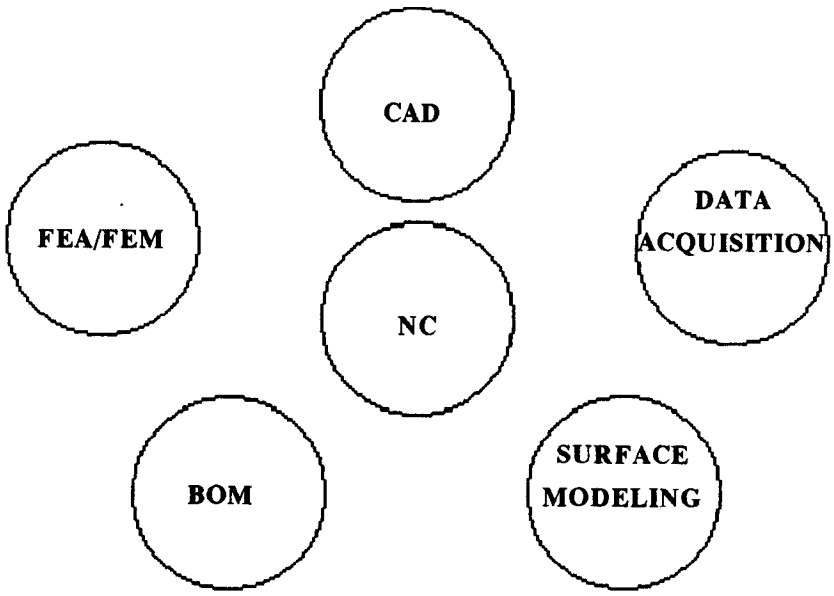

Figure 1: Islands of Automation

This approach led to the rapid development of depth of functionality in each application domain but with no communication between applications. This resulted in the regeneration of the same or similiar data for various application models and introduced a tremendous data commucations problem.

This data communications problem was further complicated by the fact that a common data structure was not available even within each application domain. Each area application would include several alternative commercial software packages each with their own data structure. This is illustrated for the CAD application domain in Figure 2.

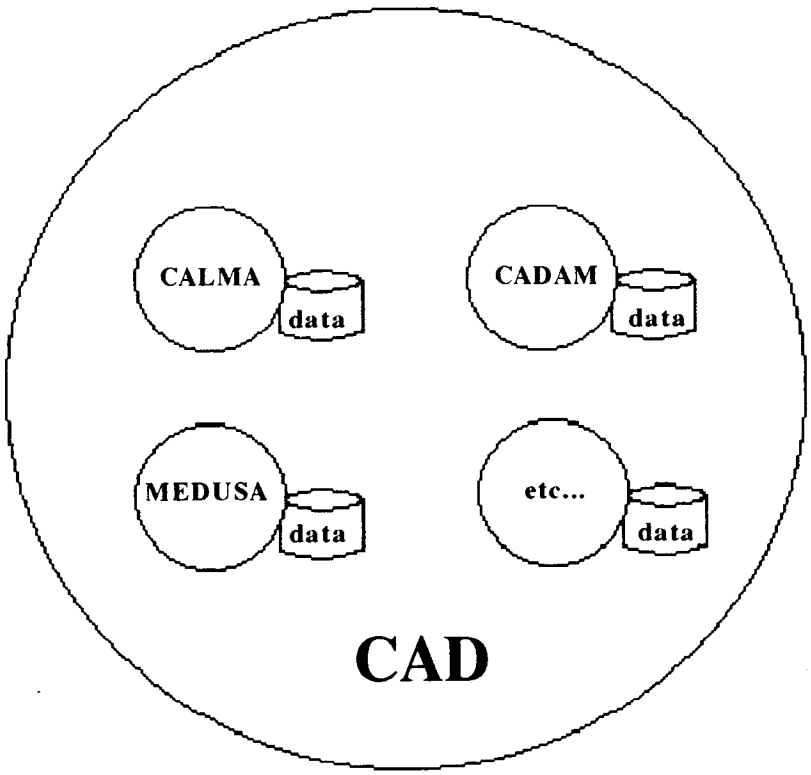

Figure 2: Separate Data Structures

The lack of communication between application domains and complexity of data structrues within each application domain led to the proliferation of application "experts" within engineering organizations. The existence of these specialists led to increasingly advanced usage and development of each application technology with very little impact on the overall engineering process. Benefits from each application domain were often lost in time to communicate to other application areas.

Initial Graphics Exchange Specification (IGES)

IGES was introduced as an attempt to provide a communication link for the transfer of graphics data between systems. IGES has had some success in translating data between CAD systems but has proven to be totally inadequate for transferring data across application domains. This is due to the fact that communication between application domains requires both a translation of data and a transformation of data content and grammar to meet the receiving application domain requirements.

Single Vendor "CAE Wheel"

Several software vendors attempted to resolve the integration problem by supplying a broad range of products based upon one(1) central core product. This approach offered a breadth of "integrated" products from a single software vendor and led to the introduction of the "CAE Wheel."

The "CAE Wheel" has been offered in many varieties. The first version was the CAD based "CAE Wheel" as illustrated in Figure 3.

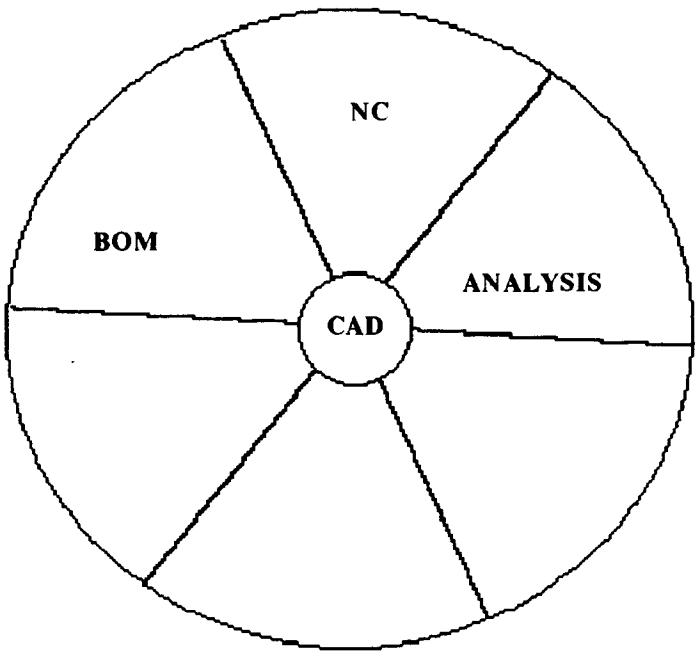

Figure 3: Cad Based "CAE Wheel"

This interpretation of the "integrated" CAE system from a single vendor soon gave way to the solids based "CAE Wheel" with 3-D solids models as the core. The solids based "CAE Wheel" is illustrated in Figure 4.

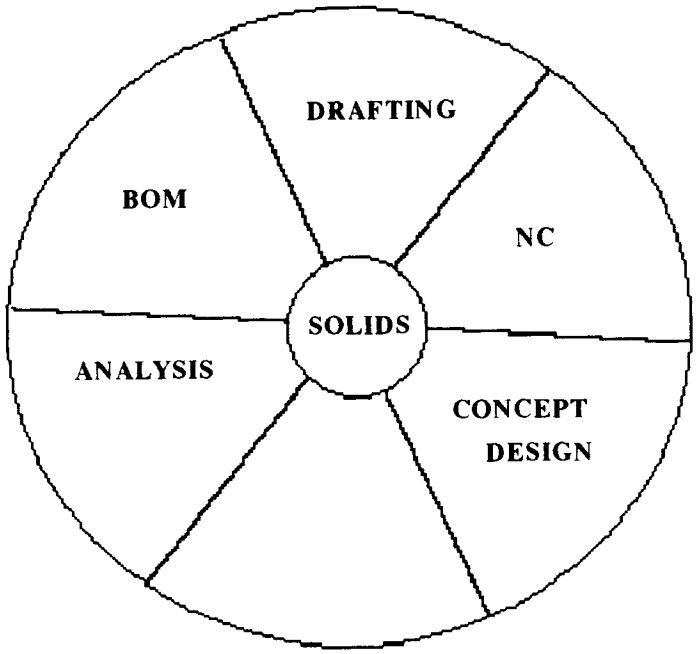

Figure 4: Solids Based "CAE Wheel"

The emphasis in recent years for single vendor systems is to use a common data base and structure as the key to integration and therefore as the core product. This database centered "CAE Wheel" has become the standard approach today for single vendor CAE integration. Figure 5 illustrates a database centered "CAE Wheel" based upon one(1) CAE vendors depiction of software architecture.

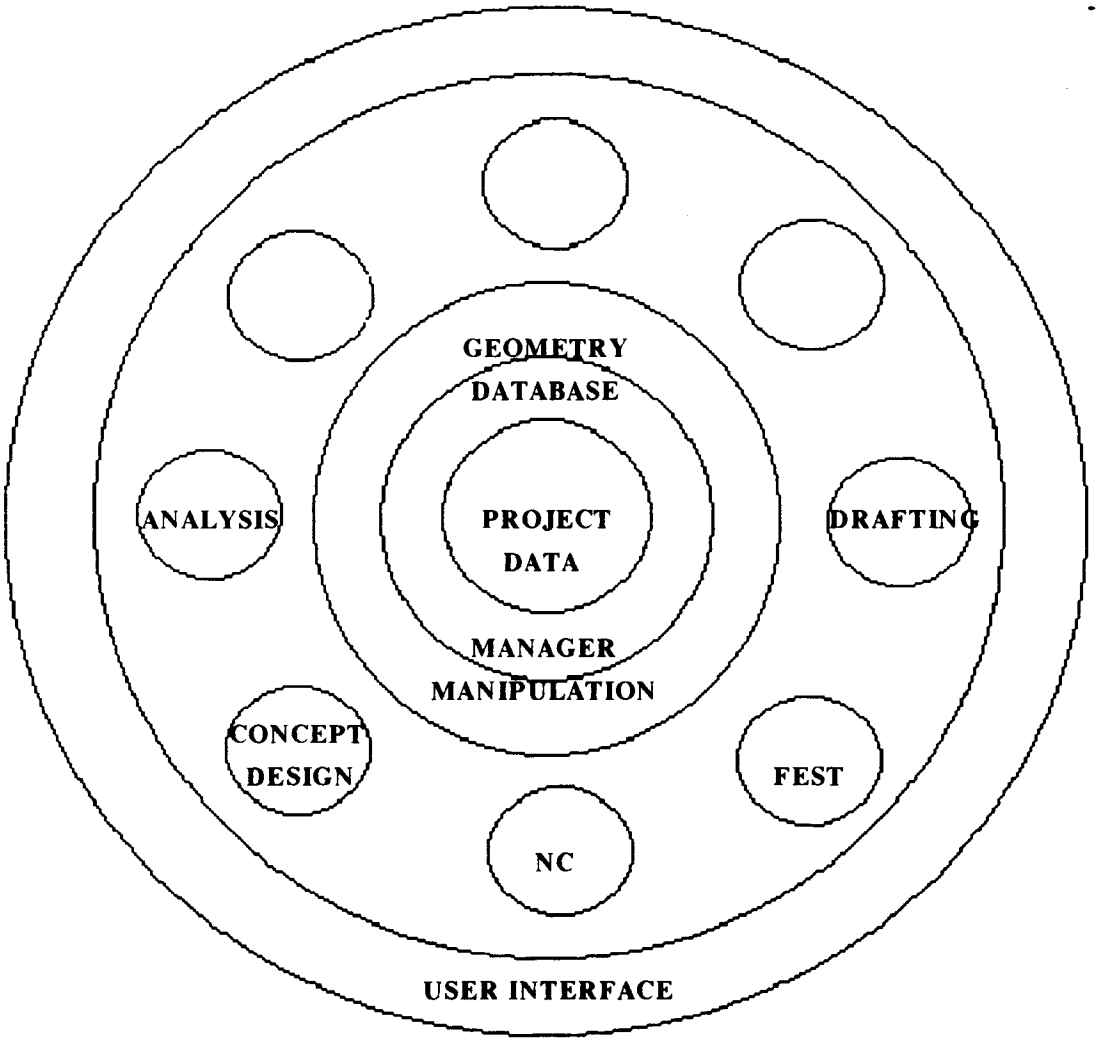

Figure 5: Database Centered "CAE Wheel"

The "CAE Wheel" approach to integration has not been as widely accepted as the software vendors had initially hoped. This approach did offer significant benefits of integration across a breadth of applications but at the sacrifice of depth of functionality within application domains. Therefore, gains in integration were offset by loss in functionality (ie. limited to linear static FEA) and additional software systems were required for advanced applications, or new applications not envisioned by the "CAE Wheel" software vendor. These additional software systems do not integrate with the "CAE Wheel" re-creating the communications problems between applications. It is generally accepted among CAE market analysts that no one software company currently has the resources to provide full breadth of CAE functionality while maintaining depth of functionality within all application domains.

Product Data Exchange Specification (PDES)

A new format for exchange of product data between application domains is currently under investigation with the PDES initiative in the US and the STEP initiative in Europe. The intent is to define a scheme of data structure and communication to transfer across dissimilar application domains.

The current PDES initiative as understood by the author of this paper includes a three level database approach as illustrated in Figure 6.

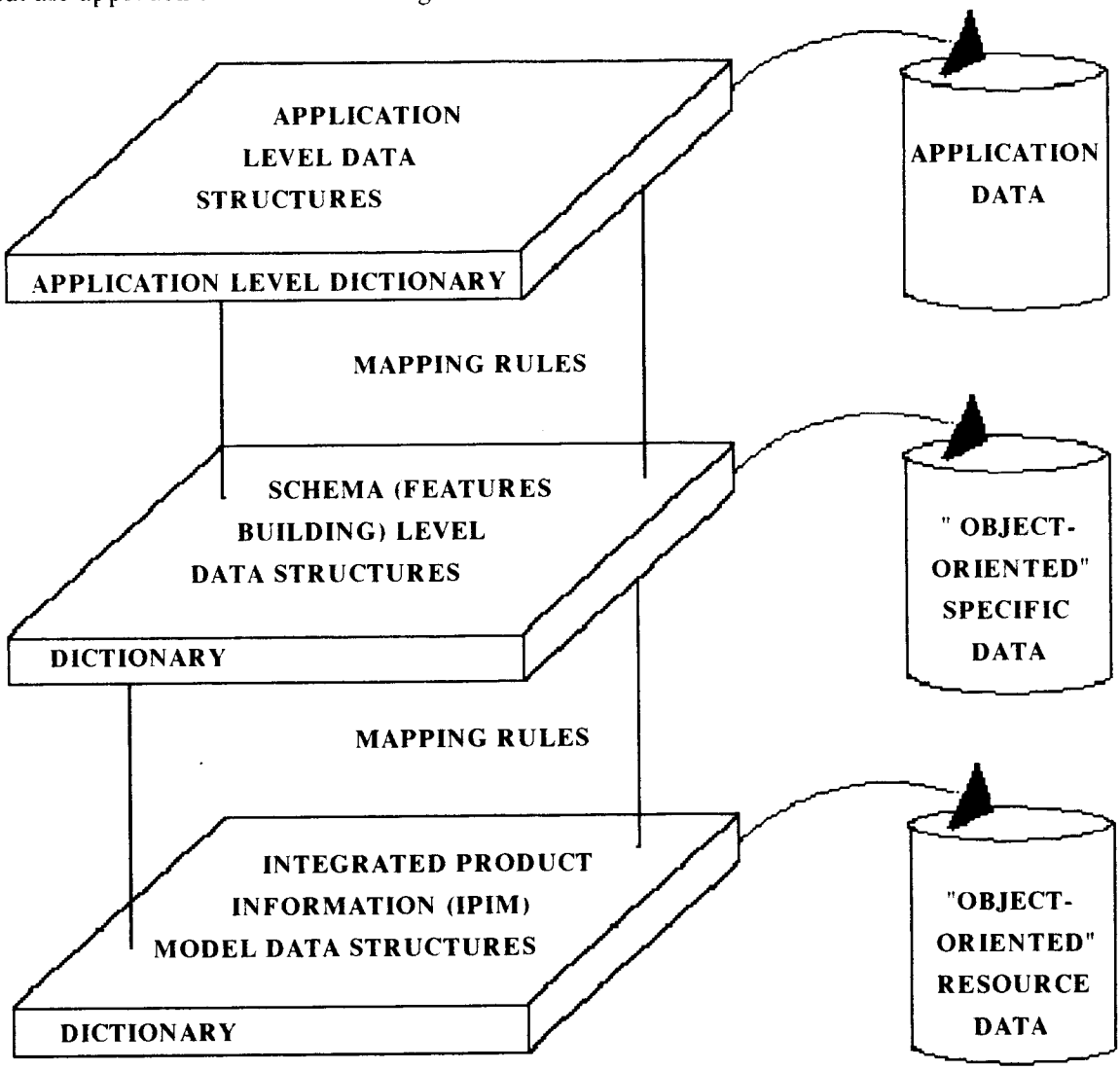

Figure 6: PDES Levels of Data Structures

The PDES initiative also places heavy emphasis on "object oriented" "knowledge based" structures in which entities are accessed as objects. These object definitions contain attributes and a hierarchicial structure whereby attributes are inherited by lower level objects. These objects are then coupled by rules (or grammar) to form a knowledge base. (refer to Figure 7).

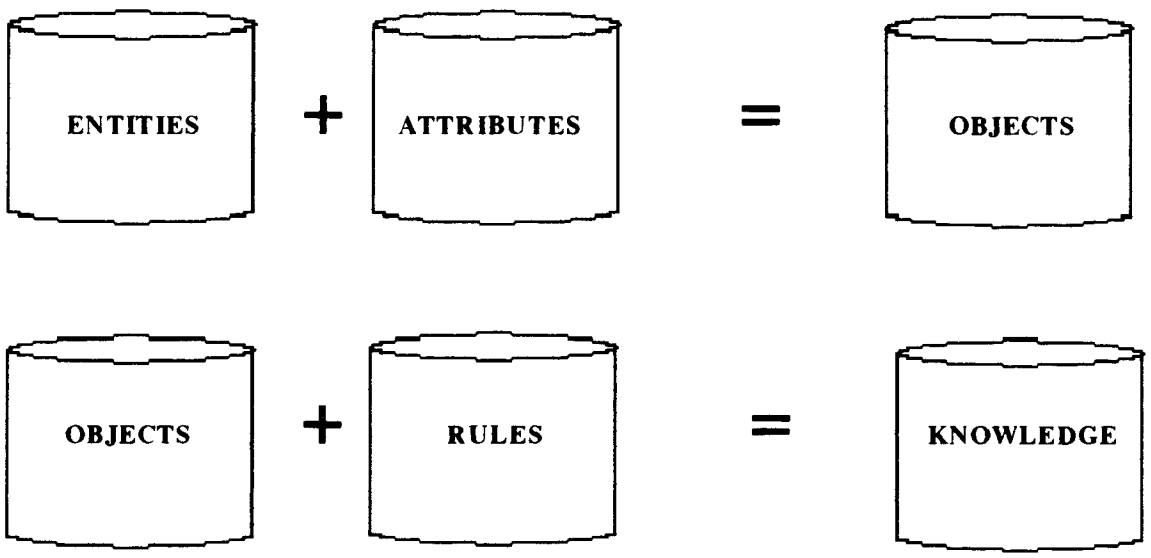

Figure 7: Simplified Illustration of "Object Oriented" "Knowledge Based Data Structures

Adaptive Data Management

The PDES implementation of data structures affers a great deal of promise and is anxiously awaited by the CAE user and vendor community. However, it is the opinion of this author that PDES is not the solution to integration but is instead an "enabling technology" providing one of the major tools of a data/knowledge management system. The design of this management system also needs to be considered.

This paper proposes the design of such a management system called "Adaptive Data Management" in which the data/knowledge is stored at the lowest level of commonality and adapted to specific applications as needed. Figure 8 illustrates the Adaptive Data Management "CAE Wheel."

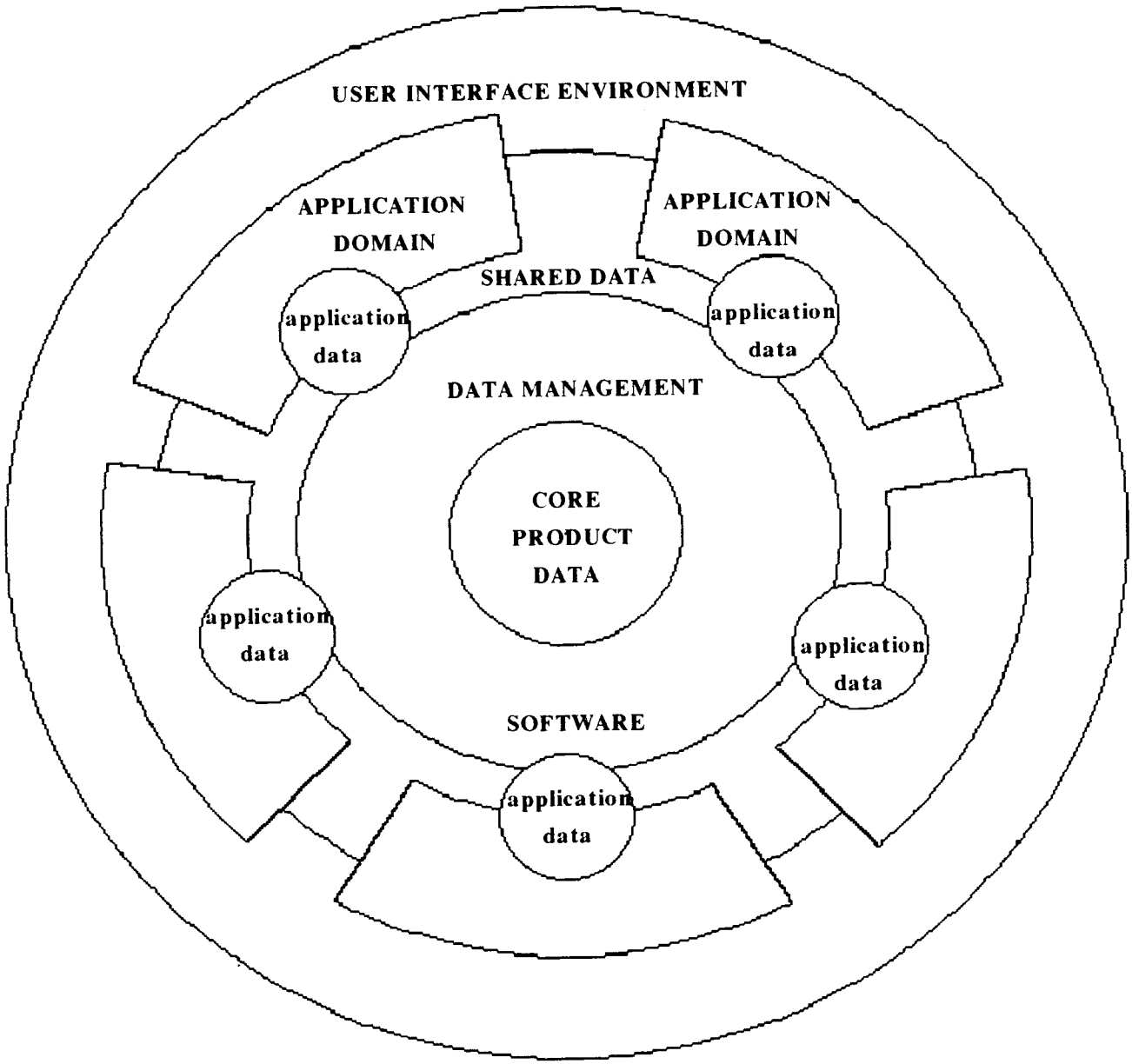

Figure 8: Adaptive Data Management "CAE Wheel"

The components which would make up the Adaptive Management System are as follows:

Core Product Data Structures - "Object-Oriented" database containing core product and process data/knowledge in a neutral, context free data structure. (This appears to correspond with the PDES IPIM data structure.)

Shared Data Structures - Object-Oriented database containing interapplication data and rules which are shared by multiple application domains. These objects and rules should be stored in hierarchical reference to the objects resident in the Core Product Data Structures. Any change made in the Core Product Data is then automatically incorporated in the Shared Data. The user will also require the ability to explicitly change Shared Data objects and rules without affecting the Core Product Data. (This appears to correspond with the PDES Schema data structure.)

Application Data Structures - Object-Oriented application specific data and rules for a particular application domain. These objects and rules should be stored in hierarchical reference to the objects resident in the Shared Data and Core Product Data. Any change made in the Core Product Data and/or the Shared Data will be automatically incorporated into the Application Data. The user will again require the ability to explicitly change Application Data objects and rules without affecting Core Product Data and/or Shared Data. This will allow the user to investigate "what-if" conditions within the bounds of his particular application domain. The user will also require a mechanicism to automatically change Core Product Data and Shared Data as a function of changes made and investigated for performance at the Application Data level. (This appears to correspond with the PDES Application data Structure.)

Application Domains - Major application areas such as FEA/FEM, Solids, Drafting, BOM, Process Planning, and others. The Application Domain consists of application programs and and program specific data as illustrated in Figure 9. This arragement allows application programs from various software vendors to be fully integrated into a CAE system, thereby, providing both breadth and depth of application.

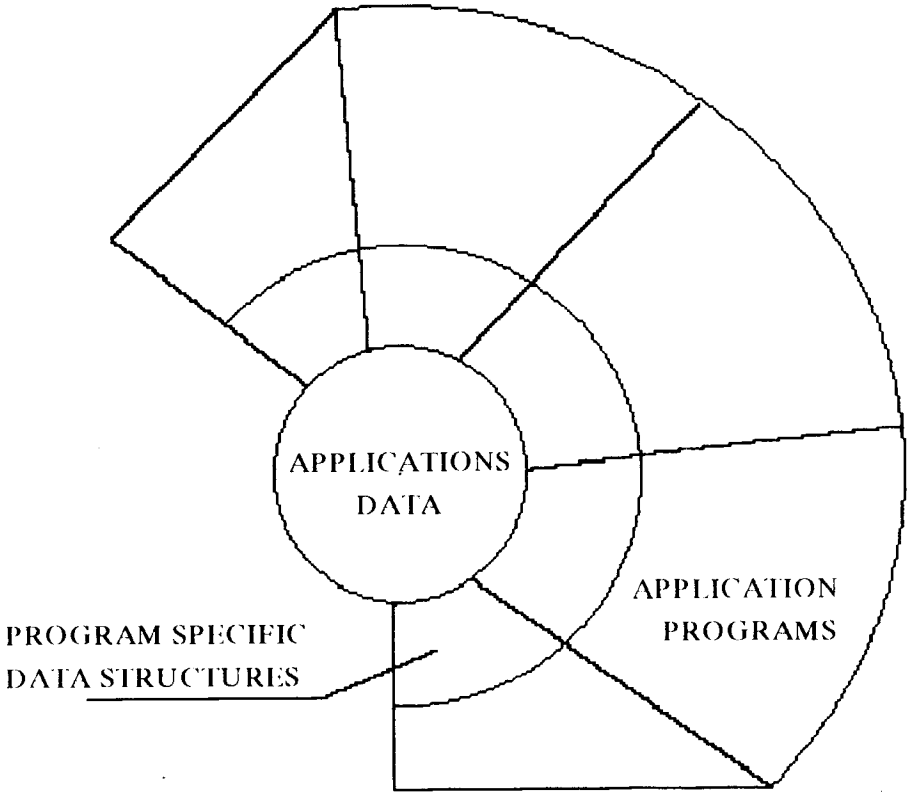

Figure 9: Application Domain

Data Management Software - Artificial Intelligence (AI) based software modules which account for the rules to map from core product data to shared data, from shared data to application data, from application data to program specific data. This mapping process must involve both translation of data entities and transformation of objects and implied abstractions and idealizations between different data dictionaries. The data structure relationship is illustrated in Figure 10.

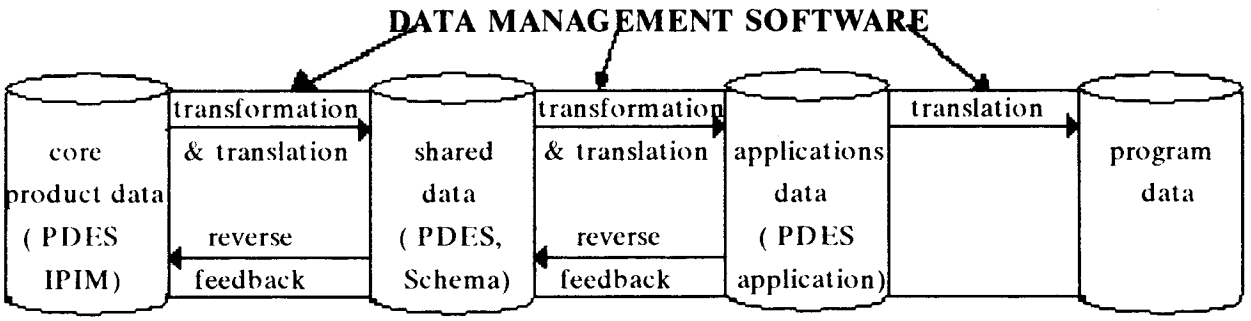

Figure 10: Data Structure Relationship

The data management software would also require the ability to process feedback in reverse to accomodate explicit changes in shared data and application data as reflected in the core product data. Applications such as optimization will require this reverse feedback loop to be triggered not at every explicit change but only at completion of several iterations.

User Interface Environment - A constant user interface which is independent of the application domain and application program being utilized.

Conclusion

Implementation of an Adaptive Data Management System (or any successful CAE Integration Scheme) would require the development of a complex AI based data management system to work around a multi-level "object oriented" database scheme such as that being currently considered in the PDES initiative. Development of this data management system will require a consortium consisting of major CAE software vendors and users working cooperatively toward this end.

The development of an application domain and program independent user interface would also require this same level of combined effort from vendors and users.

The adaptive data management system proposed provides the benefits of full breadth and depth of application to the user in a multi-vendor integrated software environment with a flexible growth path. The system also provides the vendors with the ability to focus on further development of functionality in their application programs without having to deal with database design, integration and user interface issues.

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