NISTIR 6401

COMPUTER-INTEGRATED KNOWLEDGE SYSTEM (CIKS) NETWORK: REPORT OF THE 2ND WORKSHOP

Lawrence J. Kaetzel, Editor
K-Systems
Brownsville, MD

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

NIST

United States Department of Commerce
Technology Administration
National Institute of Standards and Technology

NISTIR 6401

COMPUTER-INTEGRATED KNOWLEDGE SYSTEM (CIKS) NETWORK: REPORT OF THE 2ND WORKSHOP

Lawrence J. Kaetzel, Editor
K-Systems
Brownsville, MD

December 1999

Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

National Institute of Standards and Technology
William M. Daley, *Secretary*
Technology Administration
Cheryl L. Shavers, *Under Secretary for Technology*
National Institute of Standards and Technology
Ray Kammer, *Director*

Computer Integrated Knowledge Systems: Proposed Framework

Thomas Y. Kurihara
National Institute of Standards and Technology
Building and Fire Research Laboratory

1. Introduction

The construction community is represented by a diverse set of private and public organizations and disciplines. The industry lacks consistency in the way it represents, communicates, and interprets information about its products, materials, and systems. There is a need to establish a framework that will improve the service-life and durability of structures and components, and reduce costs associated with construction, operations, and maintenance activities. Industry-scale improvements can result from the adoption and implementation of a framework that includes:

- consistent terms for use by construction industry knowledge users;
- criteria and standards for data quality and formats;
- a standard format for knowledge interchange;
- improved methods for seeking and interpreting knowledge;
- an intelligent interface for users.

This paper outlines a proposed framework to address the needs of the construction industry product, materials, and systems knowledge users involved in operation and maintenance activities, such as condition assessment, material failure analysis, and material selection. This paper is an abbreviated version of the NIST Internal Report (NISTIR-6071), which was provided to all of the workshop attendees and was the basis for the presentation of the CIKS framework.

CIKS is intended to be used for constructed facilities, such as bridges, private and public buildings, etc. Initially, the framework addresses the industrial coating material area. However, the activities and methodologies described will apply to other construction materials, such as cementitious materials, steel, aluminum, composites, and roofing.

Several goals have been established for the implementation of CIKS. These goals provide a context for its development, a long-term vision, and near-term usefulness. It is envisioned that refinements to the framework will occur as user needs change and are better understood by the CIKS developers and partners, and as enabling information technologies emerge over the 5-year development life of CIKS. CIKS will show concept and provide value within a two-year time frame, yet maintain a five-year development life. This will be achieved through the establishment of NIST/construction industry partnerships and the establishment of a test bed whereby partners can test production systems and data for interoperability, and obtain developmental and implementation solutions for incorporation into industry-developed systems.

2. **Goals of CIKS**

- Universal exchange of knowledge

One goal is to help the construction industry share, exchange, and manage knowledge through a neutral knowledge interchange format. A major focus will involve document-based knowledge sources such as handbooks, guides, standards, and dictionaries. These documents provide a clear reference to knowledge sources that have been refereed by industry leaders. Examples of these include the American Society for Testing and Materials (ASTM), the Society for Protective Coatings (SSPC), and the American Concrete Institute (ACI). Use of guides developed by the public sector will result in the creation of digital libraries, and decision-support aids (e.g., expert systems) that will be available to knowledge users, such as practicing engineers. Commercial guides will be incorporated into the CIKS framework by: 1) an interpretation of the guides (contained within an expert system) to aid in engineering practice, and 2) the application of electronic commerce, permitting the sale of documents in electronic form.

- Commercial development and implementation tools

An evaluation of commercial products and information technology research will be conducted with an emphasis on reusability. This will accelerate the development process and reduce the level of effort needed to implement CIKS. The intention is not to conduct new research, but to integrate or 'glue' existing information technologies and research results into a functional framework. If voids exist, then the value of building or researching those missing links will be considered.

- Development and implementation partnerships

Private and public knowledge centers and digital information networks with specific focus areas (e.g., coating, high-performance concrete) hosting their knowledge repository will serve as examples of the CIKS framework. Industry leaders will collaborate as partners to establish and host knowledge bases, identify user requirements, and provide reusable research results. One factor involved in the success of CIKS will be industry's interest and ability to adopt CIKS strategies and, in some cases, reengineer their business process. User demands for value added knowledge in digital form will serve as a driver for product and material manufacturers and information brokers to maintain a competitive advantage. Upon completion, the various stages for implementing the CIKS framework will be submitted to a standards setting body for standardization. Two scenarios can be presented for possible standardization: 1) a U.S. national body such as

ASTM, or 2) a domain specific body such as The Society for Protective Coatings for the coating industry or the American Concrete Institute for cementitious materials. The standardized framework would establish standards and guidance on terminology, data formats, and models for representing processes (e.g., condition assessment, and material selection procedures) in decision-support systems.

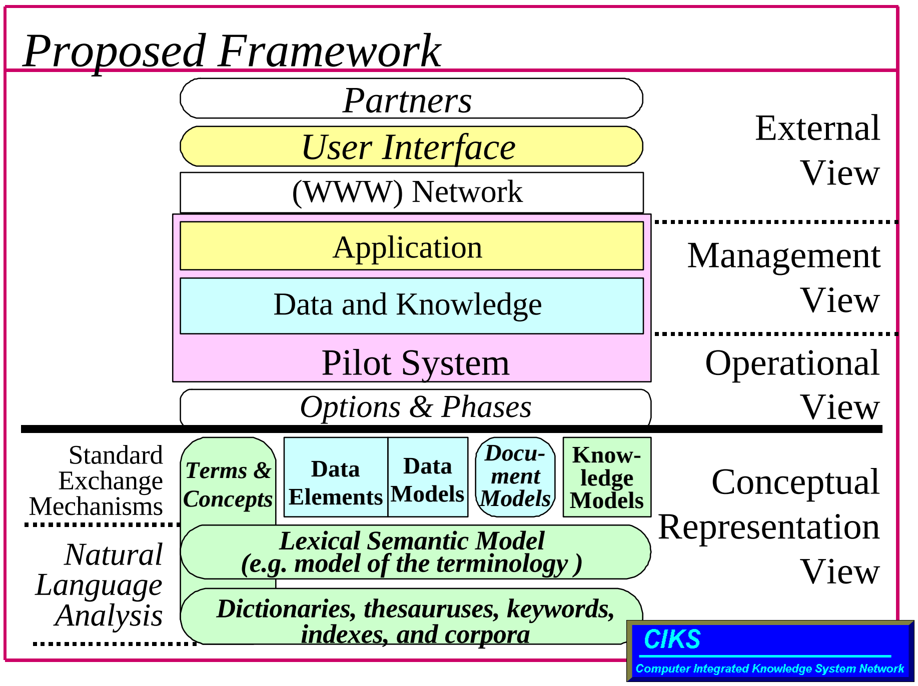

Figure 1

3. CIKS Proposed Framework

Figure 1 shows the different views and their respective parts. The proposed framework contains the *external, management*, and *operational views*. The *external view,* includes the partners, user interface, and network. Partners are the organizations or knowledge centers with whom we will collaborate. The computer user interface is how users would access the data and knowledge. The network is the digital communication infrastructure that enables users to connect to knowledge bases hosted at the knowledge centers.

The *management view*, describes the application, data, and knowledge management. The application management area addresses user applications that help the user improve the performance of knowledge work using commercial products, and research applications focusing on agent and knowledge acquisition technology. The data management area addresses standards, data elements, models and tools. The knowledge management area focuses on terminology, document and knowledge exchange technology. The knowledge exchange approach will include evaluating the Defense Advanced Research Program

Agency (DARPA) Knowledge Sharing infrastructure as a practical option. The *operational view*, describes a pilot system, options that need to be considered, the different development phases, and outlines the steps for building an example of the framework.

The foundation of the framework is built on the conceptual representation which includes dictionaries, a lexical semantic model (a model of the relationships contained in the dictionary), standard terms, data elements, data models, document models, and knowledge models. (The square shapes in figure 1 refer to formal or engineered items and the curved shapes refer to natural or human aspects.)

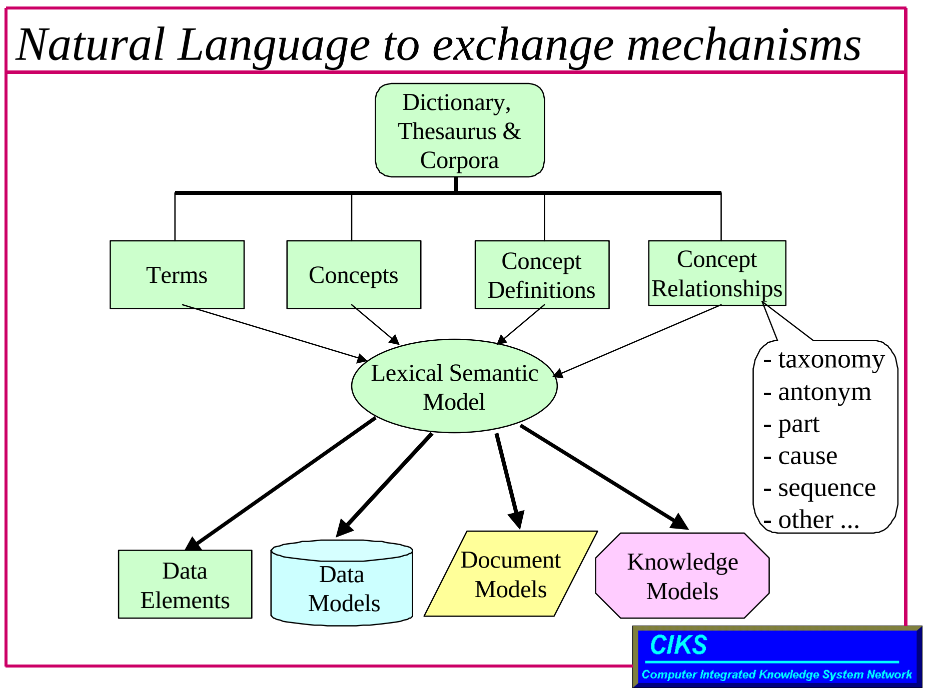

Figure 2

Figure 2 shows that dictionaries, thesauruses, and corpora or machine-readable text are the inputs to creating the lexical semantic model, a foundation of the framework. This figure also shows the relationship of the lexical semantic model to the implementation of data, document, and knowledge exchange mechanisms (through standard models) and its role as the foundation upon which all of the other models are built. The current exchange models provide only a syntactical exchange mechanism, while the lexical semantic model provides the foundation for a much more powerful semantic exchange mechanism. However, the intention is not to conduct natural language research, but to incorporate the research results into a functional framework.

Table 1 shows how the proposed CIKS framework could be implemented while the column headings of crawl, walk, and run identify the different development phases to represent a progression. The rows identify the type of research applications, user applications, data, documents, terminology, and knowledge management components that would be developed and made available through a pilot system.

Headings	*Crawl Phase*	*Walk Phase*	*Run Phase*
Research Applications		• Software Agents	• Automated Knowledge Acquisition • Intelligent Agents
User Support Applications	• Information Retrieval • Collaborative Environment	• Decision Support • Computer-based training	• Expert Systems
Data	• Web-enabled database • Standard metadata • A few standard data elements	• Many standard data elements • Simple standard data models • Complex data models	• Complex standard data models
Documents	• Web-enabled document management system (or system of systems)	• Simple Standard Document Models (DTDs)	• Complex standard document models
Terminology	• Standard terminology • Adapt existing lexical models	• Existing standard concepts • Thesaurus • Align differences in selected lexical models	• Standard lexical model or ontology
Knowledge			• Standard knowledge model • Knowledge base

Table 1: Development Phases

An abbreviated "crawl" phase example could include determining the remaining service-life of a coating, performing coating failure analysis, and then identifying the optimal corrective response. The optimal response will be based on life cycle costing and could include doing nothing, providing in-house or an out-sourced repair, or an in-house or out-sourced replacement action. This example could initially proceed as described below:

1. The first step is to identify coating dictionaries as the standard for the terminology that is used in the specific application area. If a coatings dictionary does not exist, one could be developed (though this could be very time consuming).
2. The next step is to begin collecting machine-readable documents that address the area of interest. The subjects for this example would include how to: assess the condition of a coating, perform failure analysis, and make economic decisions when the existing coating system must be repaired or replaced.
3. In parallel, decisions about how all of these documents will be managed (e.g., using a file system, an existing database, or a dedicated document management system) must be made and implemented. This would include selecting the web-enabled database and document management system that will be used. If it is not possible to select a single system or type of system for managing all documents, then it will be necessary to develop specialized interfaces between different systems.
4. All documents should be contained within the document management system (or system of systems) and in a format that permits searches using information retrieval technology. This would be the beginning of a digital library of relevant engineering knowledge or know-how documents concerning condition assessment, failure analysis, and economic decisions.
5. The next step requires reviewing metadata (data about data) standards and deciding which standards will be adopted.
6. After that step, identifying a few standard data elements is similar to agreeing on terminology, but within the database context.
7. Finally, assuming that how-to or knowledge documents are created by the organization, a collaborative environment should be defined and implemented, which could be as simple as using email, some workflow package, or selecting a web-based collaborative document editing environment.

Managing an organization's knowledge requires a major effort from the basic methods used by libraries (as the original knowledge repository) to the development of a knowledge management framework. This framework provides a phased approach for an evolutionary process, from developing a digital document library to completing an agent-enabled distributed knowledge base. An indicator of the success of this framework will be its adoption by construction materials organizations that will test the framework in the conduct of their business or practice. Finally, the framework will continually evolve and improve as new research is made available. For additional details refer to the NIST Internal Report (NISTIR-6071) titled Computer Integrated Knowledge Systems (CIKS) for Construction Materials, Components, and Systems: Proposed Framework.