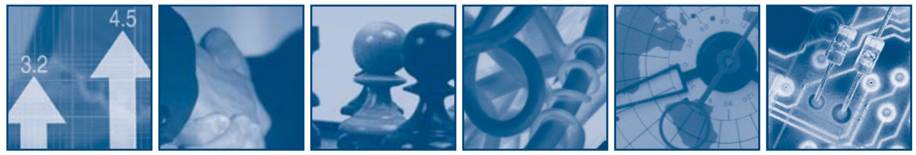
Executive Summary



The Future of Connective Technology:

Greater Integration Through Semantic Modeling

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Cutter Consortium Business Intelligence Executive Summary Vol. 5, No. 1

We are surrounded by data. In fact, the success of business depends on the underlying flow of data and information for effective management. By some estimates, the amount of data generated each year is growing by as much as 40%-60% for many organizations. And rapidly emerging technologies such as Auto-ID and the Electronic Product Code (EPC) combined with interactive sensor networks will create even larger data streams of greater complexity.

Semantic Modeling has great potential for dealing with this ever-increasing amount of data that organizations will encounter in the future. However, making Semantic Modeling a reality requires the development of a new set of computer languages and protocols to connect models to other models, data to models, and data to data.

The mission of the Data Center, a new research initiative at MIT, is to create innovative ways of making sense of all this data. Specifically, David L. Brock, principal research scientist, is developing a new computer language called M that is designed to facilitate interoperable modeling.

The accompanying *Executive Report* discusses Semantic Modeling, which provides a general description of these new technologies that will eventually connect data and various mathematical models together for improved analysis, business decision making, and better day-to-day operations within large and small systems.

Greater connectivity will spur new waves of productivity as managers learn to take advantage of the models and data within and outside their organizations.

The report also focuses on the framework, details, and background of proposed standards for M that will enable computers to describe and share models and to assemble new models automatically from a general repository. This will substantially increase the speed of modeling and the computational efficiency of applying models to perform the functions of "sense," "understand," and "do" that compose the underpinning of creating smart objects within supply chains. The new computer language infrastructure includes open standards with two specific purposes: (1) communication of models between computers to create interoperability; and (2) the ability to run distributed models across the Internet.

In a sense, this effort is a step beyond linking the physical world (the underlying concept that has made Auto-ID technology successful). Networks, of physical objects or of abstractions like models, share the premise that leaps in productivity arise from the free flow of information. Creating an Intelligent Modeling Network will accelerate the flow of information to the great advantage of many businesses and will form the backbone of a new type of Internet.

The report introduces some real-world examples that hint toward

Semantic Modeling's future (such as Amazon's A9 technology) and then concentrates on the problems with current Internet search engines, which are based on keywords.

It is important for IT managers to understand the direction of various types of connective technology research as a means of planning for future computing systems. This is an important first step in organizing computing functions to accommodate the increasing amounts of data expected in the next several years.

In addition to providing a detailed analysis of the computer architecture needed for building an interactive modeling system, this report includes detailed examples from supply chain management to demonstrate the concept of model interoperability with respect to data. These examples are from real-world situations in the consumer-goods industry, documented by the authors as part of ongoing research that has spanned more than 20 years.

Finally, the last section of the report outlines three business applications of Semantic Modeling under development at the Data Center: enterprise resources planning (ERP) systems, retail direct marketing, and agricultural modeling.

Currently, most organizations implement packaged ERP software that contains a single model for a specific business process. If the model does not fit exactly, substantial business process modification is required. Managers often complain that this process of adaptation reduces overall organizational productivity. Researchers at the Data Center are building a network of ERP models that can automatically match to data within organizations. These models include forecasting, production planning and scheduling, lot sizing, logistics, and financial systems. The ultimate goal is an Intelligent Modeling Network that would partially replace packaged ERP software providing a more flexible modeling environment for decision making in business.

The second application deals with retail direct marketing; because large quantities of data exist and there are many opportunities to apply models from management science to determine proper inventory levels, this offers an interesting case for the application of M. In general, retail direct marketing companies have impressive data management systems to support day-to-day decision making. Retailing is a data-rich environment; however, so many different models could potentially apply to retail data that the need exists for a flexible modeling system like M.

Since most retailers carry a large assortment of items, many with relatively short lifecycles and seasonal sales, inventory management is a complex issue. Given the uncertain demand for these items, determining the proper lot size of merchandise to order is a common problem. With thousands of different demand patterns, the goal of optimizing risk in terms of customer service and excess inventory becomes a complex challenge in matching the right model to the right data.

The final application discussed in the report deals with modeling various aspects of the agricultural supply chain. Numerous agricultural models have been developed at land grant universities that could potentially help growers and agribusiness with logistics, planning, and resource optimization. Connecting these various models together with data from weather services and governmental agencies such as the US Geological Survey and the USDA Forest Service could lead to the next wave in agricultural productivity.

One particular area of interest, harvest risk, offers the potential of introducing models traditionally used in business to optimize harvest operations. The results could include better utilization of harvest assets, fewer crop losses, and improved crop quality.

In conclusion, while the Internet has proven to be useful in connecting information through the use of search engines, the next logical step is to connect abstractions (mathematical models) that cannot be easily described by keywords. Semantic Modeling and M hold the potential to accomplish this in practice, releasing new waves of innovation in the analysis of data.

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