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Purdue Engineers Define 15 Dimensions Of 'E-Work'

ScienceDaily (Dec. 20, 2004) — WEST LAFAYETTE, Ind. – An industrial engineer at Purdue University who coined the term "e-work" in 1999 to describe activities that require computer networks, has now defined 15 e-dimensions of e-work to help people and machines collaborate over global networks.

Such e-work systems are needed for applications ranging from manufacturing to telemedicine.

"When we say e-work, we mean work that depends on the collaboration of people, machines and computers," said Shimon Nof, a professor of industrial engineering. "Many times, these various elements of e-work are distributed around the world and are tied together via computer networks."

The elements might include robots and sensors in manufacturing operations, miniature devices that monitor a patient's heart and collect other medical data, software and hardware for e-commerce, and complex databases for architects and engineers using "virtual design" to create buildings and mechanical parts totally in a computer.

"The nice thing about the 15 e-dimensions is that they allow you to put all of the elements of e-work into context," Nof said. "You can see how to design a system because you can identify the separate components, you know what they are capable of and you can determine how they will interact with each other.

"Any scientist or engineer who is designing e-work systems can look at those 15 dimensions and examine which dimensions are needed for their particular systems and what roles those dimensions will play."

Nof unveiled the 15 e-dimensions earlier this year and gave a talk about the most recent developments in e-work research during the Third Conference on Management and Control of Production and Logistics, which took place Nov. 3-5 in Santiago, Chile.

"Without effective e-work, the potential of emerging and promising electronic work activities, such as virtual manufacturing and e-commerce, cannot be fully materialized," said Nof, who is working with students and other Purdue faculty in the PRISM Center, which stands for Production, Robotics, and Integration Software for Manufacturing & Management.

Researchers working in the PRISM Center have discovered key principles to manage e-work systems by exploiting the 15 e-dimensions, Nof said.

"One goal is to create software tools to improve the efficiency of e-workers," he said. "For example, we have learned how to use these dimensions to improve how companies and people collaborate over networks, how various operations work smoothly together in parallel and how to prevent design conflicts by automatically

alerting engineers and other professionals to potential design problems early in a project's development."

Because they are linked via computer networks to each other and to sensor-laden facilities and equipment, these e-workers have a wealth of data at their fingertips. Too much information, however, can lead to dysfunction, Nof said. At the same time, people are performing more tasks because computer networks are becoming increasingly complex.

"Today's networks have enabled more sophisticated communications and collaborations between companies and individual entities within companies, whether those entities are people or automated systems that use robots to carry out tasks," Nof said. "This added sophistication, however, often leads to an increasing number and complexity of tasks for e-workers.

"We need to reduce this information and task overload by properly designing e-work systems."

The 15 e-dimensions address issues such as how to seamlessly integrate the workings of computers and how to help people and computers mesh properly, how to enable "knowbots" to automatically carry out tasks for people, how to provide systems that alert workers to design conflicts, and how to ensure that work flows smoothly in manufacturing operations.

The dimensions are split into four "domains," which are illustrated as four overlapping circles that represent the totality of e-work.

The domains are e-work; distributed decision support; active middleware; and integration, coordination and collaboration.

The e-work domain includes a dimension called agents and protocols, which could be sensors, robots and software that enable tasks to be carried out autonomously.

"If you are using Google, an example of an agent is a program that searches over many computers to find the documents you need," Nof said. "During the course of searching for and retrieving documents, the program is automatically interacting with other agents, whether they are software or hardware.

"Meanwhile, you are going about your business, doing your own work while the system works in parallel to search for your documents. Protocols and agents are both tools to work in this parallel layer so that they do things automatically that we don't want to do or that we cannot do.

"But organizing and managing the operation of agents for autonomous information systems is complex. First of all, what precise roles do you want the agents to perform, and how do you enable these agents to interact with each other?"

The domain of distributed decision support includes dimensions focusing on helping collaborators solve problems, using mathematical models and simulations to arrive at the right decisions.

The middleware domain includes software and hardware that allow companies and institutions to use a combination of old and new computers so that the older machines can be kept in service, saving money.

"Companies have invested millions of dollars in computing, and they don't want to waste their investment," Nof said. "But getting all of those old and new computers to talk to each other requires a pretty substantial interface –

both software and hardware.

"We call it active because the middleware is not just passively facilitating this interface. It's also making some decisions on its own, providing services while it's performing this translation between computers. For instance, it might check to make sure that the information is secure and that it is relevant to the company's needs. If information is found to be irrelevant, maybe the company can get rid of it, freeing up computer resources."

One e-dimension of active middleware is grid computing, in which researchers can remotely access complex simulations and databases located on powerful computers without having to download and learn how to use specialized software needed to run the programs. Learning how to use software for some scientific applications can take months and require the services of a graduate student, so grid computing saves time and speeds research.

The domain of integration, coordination and collaboration involves methods for helping people, computers and companies effectively interact with each other.

"Coordination and collaboration are key issues when you have a large system with complex activities and companies outsourcing services to other corporations," Nof said. "A shoe company might outsource the design of its products to a company in Italy, while manufacturing the shoes in South America, and marketing might be done separately in each sales region.

"In fact, modern communications and networks have enabled companies to outsource. Why wasn't outsourcing popular in the '70s and '80s? It's because information technology and computer networks did not exist. If you did outsource a service, it would be like letting other people come into your factory without having any control over what they did. You had no computer control or communication mechanisms to monitor what they were doing."

Nof said PRISM's future work will include efforts to develop an international e-work research project with engineers in Japan and Chile.