What's with the delay?

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Professor Rifat Sipahi is lead author on a new paper exploring delays in control systems. Photo by Mary Knox Merrill.

In his classes, Rifat Sipahi often challenges his engineering students to explore a problem that is literally out of this world. For example, he notes that operators in Houston control NASA's Mars Exploration Rover, but it takes several minutes to transmit steering instructions from Earth to the vehicle — which presents challenges for scientists, who must wait to see the rover actually move before sending its next command.

But, asks the assistant professor in Northeastern University's Department of Mechanical and Industrial Engineering, what if complex algorithms could be designed that account for the time delay, enabling optimally efficient management of complex processes and systems, like the NASA Rover.

That is the basis of a new paper presenting a dynamic snapshot of the

field of control systems with time delays. The overview paper — featured on the cover of *IEEE Control Systems* Magazine's February 2011 issue — examines the drawbacks and benefits delays present across a wide spectrum of areas, including supply chain management, traffic flow and human biology. It also notes the massive financial, safety and health outcomes that hinge on stabilizing systems with time delay.

"There may be no way to remove the delay as a player in the game. So that's where we start," Sipahi says. "How can we find an intelligent algorithm that understands some information is delayed, and uses that information in a very effective way?"

Human reaction delays exist for drivers, for instance, because they must observe a reason to brake before actually stomping on the pedal. These delays often lead to numerous traffic flow issues, from stop-and-go traffic to collisions.

In the supply chain management industry, Sipahi continues, a company may experience a dramatic spike in sales, and order another huge shipment of product in anticipation that the trend will continue and profits will soar. But inherent delays between the product being manufactured and reaching inventory could botch the whole plan.

"The tendencies of customers can shift much faster than the speed of these products becoming available," Sipahi says.

Sipahi has studied systems with time delays for a decade, and says not all have negative effects. In supply chain management, adding delays could add stability to these systems by allowing managers more time to observe market trends, which would ultimately aid decision-making. In biology, algorithms could help researchers discover inherent delays in how tumors and other diseases grow and spread, which could lead to the development of new treatments.

Sipahi was the paper's lead author, and collaborated with researchers from the University of New Mexico, Southern Illinois University-Edwardsville and institutions in France and Belgium.

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