Electrical & Computer ENGINEERING

SEMINAR

THURSDAY
AUGUST 30, 2007

Hamerschlag Hall
Room 1112

12:30 p.m.
Refreshments will be served.

Complex Networks as Control Paradigm for Complex Systems: Design for Resilience of Networked Critical Infrastructures

MIHAELA ULIERU
CANADA RESEARCH CHAIR

Since 2005, Professor Mihaela Ulieru has held the NSERC Canada Research Chair in Adaptive Information Infrastructures for the eSociety in the Faculty of Computer Science at the University of New Brunswick. In 2005 she also established and now leads the Adaptive Risk Management Laboratory (ARM Lab) researching Complex Systems as Control Paradigm for Complex Networks to develop Holistic Security Ecosystems. Her current research is focused on the Cyberengineering of resilient eNetworks (Cyber-Physical Ecosystems) and their applications to security (critical infrastructure protection, emergency response management), e-Health (pandemic mitigation) and networked manufacturing.

Professor Ulieru obtained her PhD (1995) in computational intelligence applied to systems diagnostics under the illustrious supervision of Professor Rolf Isermann at Darmstadt University of Technology, Germany. She was awarded the Junior Nortel Chair at the University of Calgary in 1998. She founded in 2001 the Canadian GAIN (Global Agents Integration Network) that joined the research efforts of 19 Universities and Research Institutes across the Country working together with the industry to develop intelligent web services for collaborative virtual organizations. In 2002 she founded the Emergent Information Systems Laboratory at the University of Calgary which she led until 2005.

Professor Ulieru is an expert in distributed intelligent systems, topic on which she is a frequent Keynote and Tutorial speaker as well as distinguished visiting professor internationally.

With the ICT pervading everyday objects and infrastructures, the 'Future Internet' is envisioned to leap towards a radical transformation from how we know it today (a mere communication highway) into a vast *hybrid network* seamlessly integrating physical (mobile or static) systems to power, control or operate virtually any device, appliance or system/infrastructure. Manipulation of the physical world occurs locally but control and observability are enabled globally across an *overlay network* that we refer to as an 'eNetwork'. eNetworks enable the spontaneous creation of collaborative societies of artifacts, referred to as "cyber-physical ecosystems" (CPE). In such "opportunistic ecosystems", single devices / departments / enterprises become part of a larger and more *complex* infrastructure in which the individual properties or attributes of single entities are dynamically combined to achieve an emergent desired behavior of the ecosystem. . . .

It is extremely hard – if not impossible – to control the large scale eNetworked CPE by building a global logic 'top-down' system able to rapidly adapt to changes adequately by instructing each element what to do at each step. Using latest knowledge of complexity science however we can envision strategies that mimic natural adaptation of highly evolved robust systems. When one gets a collective behavior as an emergent character of a multitude of elements, adaptation comes naturally, and only in regions where it is needed. To date no standard theory and practice exist for designing systems that emerge self-organized complexity bottom-up into resilient structure ensuring overall system robustness under unexpected failure or malicious attack.

The main conceptual limitations of the current 'smart cooperative systems' approach is that it tries to divide the global task into small independent segments taken care of by independent agents. This division and stream-lining of tasks preserves some of the rigidity and weakness of the logical tree centralized methods. The challenge is to design the right interaction protocols and feedback mechanisms that will ensure self-organization of the work in an optimal way. Using methodologies developed to study complexity phenomena one can design complex behaviors in artificial systems.

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