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Electrical & Computer Engineering

Making the Concepts of Robustness, Resilience and Sustainability Useful Tools for Power System Planning, Operation and Control

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Abstract: Advances in power electronics, computer and communications have opened new avenues for the monitoring, control and protection of critical infrastructures. For instance, the advent of low-cost computer-based sensors and actuators together with wireless communications devices are making possible the development of a new form of control bases on multiagent technologies. If the latter are endowed the ability to take collective actions geared toward a common goal, the control actions exhibiting emergent properties may result. Another level of complexity is attained if the common goal is defined by the agents themselves as a response to an environment evolving in an unexpected way. In this talk, we will define the concepts of robustness, resilience and sustainability for critical infrastructures and we will outline a future research agenda that fosters a paradigm shift in interacting electric power and communications systems using multiagent technologies, microgrids, and power electronic interfaces. Furthermore, in contrast with the definitions of robustness and resilience given in ecology or in complex systems, which are inclusive to each other in that robustness includes resilience or voce versa, we argue that for designed systems such as infrastructures, the definitions of these two concepts should be distinct from each other to become a useful tools during the design/planning process. The robustness of a system to a given class of perturbations is defined as the ability of this system to maintain its function when it is subject to a set of perturbations of this class, which may include changes in its structure. By contrast, the resilience of a system to a class unexpected extreme perturbations is defined as the ability of this system to (i) gracefully degrade its function by altering its structure in an agile way when it is subject to a set of perturbations of this class and (ii) quickly recover it once the perturbations ceased. For instance in electric power systems, robustness applies to the normal and alert states and their transitions whereas resilience applies to the emergency and in extremis states and their transitions. As for the restorative state and its transitions to the other states they call for the definitions of more advanced properties such as self-reconfiguration and self-sustainability. These properties are outside the realm of resilience or robustness since the system needs to self-restore its integrity. Regarding the concept of sustainability, it is defined as the ability of an infrastructure to restore its intended function following a major breakdown while inflicting during its whole life cycle a minimum damage to the earth ecosystem in terms of resource usage and waste disposal.

Short Bio: Dr. Mili is a Proffesor of Electrical and Computer Engineering at Virginia Tech. He received an Electrical Engineering Diploma from the Swiss Federal Institute of Technology, Lausanne, in 1976, and the Ph. D. degree from the University of Liege, Belgium, in 1987. Dr. Mili is a senior member of IEEE, the recipient of a 1992 NSF Young Investigator Award and of 2008 NSF EFRI award. His research interests include risk assessment and management of interdependent critical infrastructures, power systems analysis and control, power system planning, nonlinear dynamics, bifurcation theory, and robust statistics. Dr. Mili is the co-founder of the International Journal of Critical Infrastructures. He worked as an Engineer at the Tunisian electric utility, STEG, from 1976 till 1981, in the Planning Department and in the Test and Meter Laboratory. In 1980, he participated in the start up and commissioning of a power plant in Tunisia. He worked as an invited professor at the Grenoble Institute of Technology (INPG), the Swiss Federal Institute of Technology (EPFL), the Ecole Superieure d'Electricite, and the Ecole Polytechnique de Tunisie, Tunisia.

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