Applied Math for Energy Systems

Hoa Dinh NGUYEN

Degree: PhD (Information Science and Technology) (The University of Tokyo)
Research Interests: Smart Grid, Distributed Optimization, Multi-Agent System, Artificial Intelligence, Control Theory.

My current research is on Applied Math for Energy Systems which intersects between energy systems, optimization, artificial intelligence, and control systems. The goal of this research is to derive proper approaches for the modeling, optimization, and control toward low-carbon, decentralized and autonomous energy systems. To achieve that, a variety of mathematical approaches such as dynamical systems, linear and nonlinear optimization, graph theory, machine learning, reinforcement learning, robust and optimal control, etc., will be employed to tackle complex problems in energy systems across physical and cyber layers, and different time scales (see Figure 1).

In order to cope with climate changes caused by greenhouse gas emissions, renewable energy is increasingly integrated into energy systems to replace traditional fossil-based fuels. However, deep penetration of renewables poses significant challenges to the operation and management of energy systems due to their intermittent and fluctuating nature. In addition, technological advances such as information and communication technology, smart sensors, smart meters, etc., not only provide novel concept to energy systems (e.g. smart grid, prosumer, demand response), but also increase the complexity, where thousands of devices can interconnect and exchange information. Last but not least, the highly interconnected structure of energy systems within themselves (e.g. power network and heating and cooling network) and with other infrastructure such as water network and transportation network (e.g. vehicle electrification) brings both opportunities on having cleaner energy systems and challenges on managing such complex systems. To deal with those issues, mathematical optimization, multi-agent system (see Figure 2), artificial intelligence, and other applied mathematical frameworks will be utilized to develop hierarchical and decentralized approaches for the control and management of energy systems and related infrastructure.

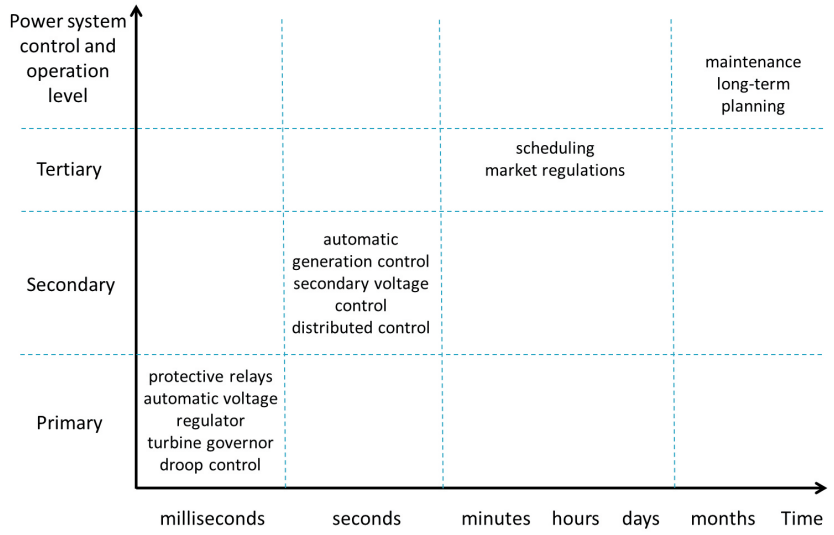

Figure 1. Illustration for power systems decision and control over different time scales.

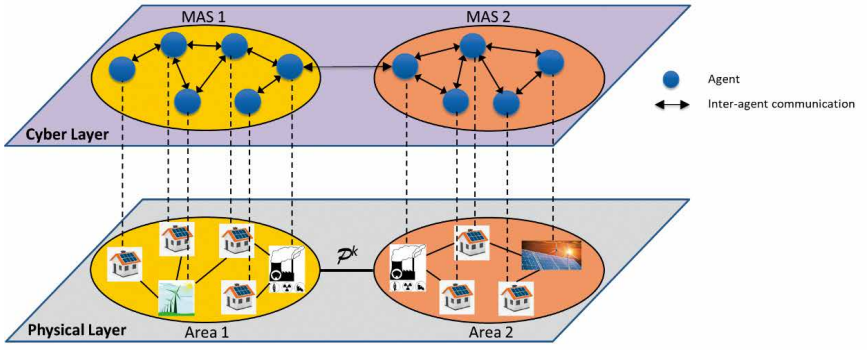

Figure 2. Illustration for the use of multi-agent system (MAS) for energy systems.