Open PhD position at EURECOM/INRIA (Sophia-Antipolis) Mathematical Tools for Smart Grids

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Framework

A number of factors are calling for more intelligence in the electrical power grid, so that the expression "smart grids" has been popularized despite the lack of a common definition. One of the factors is the need to control the increasing input of renewable sources with their high time-variability, unpredictability and distributed generation (often directly at the consumer site). Recent studies [Dro11] show that a naïve replacement of traditional sources with the renewable ones can significantly reduce the reliability of the power grid. Energy production time-variability and the opening up of the market to a large number of competing operators call also for new dynamic pricing features. Another important drive for moving more intelligence inside the network is the potential saving from shifting energy usage to off-peak hours (e.g. to the night). This advantage to reduce peak demand arises from the fact that 1) there is no convenient way at the moment to store energy and 2) energy losses—due to the Joule effect—are quadratic functions of the transmitted power. Future diffusion of electrical vehicles will also require scheduling and control algorithms to efficiently manage their charging.

The economic interest behind smart grids is enormous. This justifies the multiple initiatives from the US governments (see smartgrid.gov) and the EU Technology Platform for electricity networks of the Future, also called SmartGrids ETP. One study sponsored by the US Department of Energy calculated that internal modernization of US grids with smart grid capabilities would save between 75 and 350 billion dollars over the next 20 years [Kan03]. A report from the market research firm Zpryme [Zpr09] valued the Smart Grid industry at roughly $21.4 billion in 2009 and expected it to grow up to at least $42.8 billion by 2014.

Thesis' goal

Smart grids research gains increasing momentum. It spreads over a large set of topics, including monitoring and metering devices, communication infrastructure and protocols, privacy and security issues. Our goal is to apply analytic tools (like stochastic modeling, game theory, stochastic optimal control, distributed optimization) to solve some challenges to deploy future smart grids. In particular the candidate will work on the following two research issues: 1) dynamic pricing and 2) distributed control in smart microgrids.

1. Dynamic pricing

It is very likely that in the future the price of energy for the consumers will change dynamically on short timescales. This is mainly due to the increasing energy contribution from time-varying renewable sources and the economic interest of all the actors: final users, energy producers, power grid operators and appliance producers. While in many cases the smart appliance can simply shift the load to a different moment, heaters and air-conditioners can adapt their power demand with a much finer granularity and the users could specify elastic preferences. These preferences can be easily translated in a utility function that can be used by smart appliances to adapt their power request to dynamic pricing. At the same time the price can be dynamically determined by energy producers and grid operators on the basis of energy production and demand. In order to scale to a large network with multiple energy producers dislocated on the territory prices should be determined in a distributed way.

The problem is very similar to distributed rate control on the internet, where each transmitter adapts its throughput taking into account a local utility function and a price (a congestion signal) that is determined in a distributed way on the path the flow follows. Our idea is then to use similar approaches for load adaptation to dynamic pricing in smart grids. The main challenge here is how to calculate prices in a distributed way and to obtain a pricing mechanism which is robust to imperfect information on user utilities. We plan to investigate whether recent ideas on probabilistic pricing [Loi11, Loi13] can be used to obtain such "good" prices.

2. Distributed Control in Smart Microgrids

A smart microgrid is a cluster of loads and microsources operating as a single controllable system that provides power to its local area. Although it is usually connected to the tradition transmission grid in one point, a microgrid can also operate autonomously. To this purpose the elements of the microgrid need to be able to autonomously support voltage and frequency references and to manage power flow.

Distributed control approaches have been proposed (see [Mon10] and references there): they usually let each controller operate separately, but their design requires a global model of the overall system. In this PhD research we want to investigate if there is room for an intermediate approach between complex control systems relying on a significant amount of communication and independent controllers relying on a global model of the network. Different approaches, that relies on local computation at each node and information exchanges only among neighbors (e.g. [Ned07,Mas11,Alo10,Kau07]) have been recently proposed and we believe they could be advantageously used in smart grids.

Practical information

The PhD is funded by a grant from the labex UCN@Sophia.

The selected student will be employed by EURECOM and will be a member of both the Networking and Security department at EURECOM and the Maestro team at INRIA Sophia-Antipolis. He/She will be registered at the EDSTIC doctoral school.

The duration of the contract is 3 years. The start date should be in Fall 2013 (before Jan 2014).

Requirements and candidate profile

- The candidate must hold a Master degree (or equivalent) in applied mathematics, computer science, electrical engineering or a related field.
- The candidate should have a good mathematical background in probability/stochastic processes, optimization and/or game theory; and a strong interest in doing theoretical work in these areas.
- Knowledge in one or several of the following areas would be a plus: power systems, network economics, distributed optimization, optimal control, and other areas related to the PhD topic.

Application procedure

To apply or to obtain any further information, please contact directly Prof. Patrick Loiseau (patrick.loiseau@eurecom.fr) and Dr. Giovanni Neglia (giovanni.neglia@inria.fr). Your application email should include:

- A short motivation statement explaining why you would like to do a PhD and your relevant past experience (e.g., projects or internships on topics related to the PhD).
- A detailed CV and a complete transcript record of master grades (preferably include transcript record of bachelor/undergraduate grades too).
- The name of two persons (preferably professors or researchers with whom you have interacted) who are willing to provide a reference letter for your application.
- Any other relevant material showing aptitude to carry on research work in a scientific field related to the PhD topic and adequacy to the required profile (papers, etc.).

The position is open until filled. To ensure full consideration of the application, interested candidates should **apply before August 31, 2013**.

References

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