

## **Report on the Visit to CNR-IEIIT**

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The objective of the visit was to carry out the project aiming at the development of security techniques to protect power systems from cyber attacks. We focused on the problem of the so-called state estimation, which is critical for the real-time control and monitoring of large-scale power systems. If the sensor measurements are attacked and falsified during their communication over networks, the behavior of the overall system can be negatively affected. Our specific interest lies in constructing distributed estimation algorithms robust against attacks which are potentially stealthy.

During the visit, we had discussions from various aspects regarding this problem and also had interactions with other researchers within the Institute as well as the Politecnico. These activities are briefly summarized in the following:

- The highlight of the visit was the small workshop entitled “Brainstorming Session on Systems, Control and Networks,” which took place on November 27th with three speakers: Fabio Fagnani, Simone Garatti, and myself. The talks were related to distributed and randomized algorithms that were recently introduced for problems in power systems and sensor networks as well as robust optimization. These topics were at the center of most of the discussions that took place during my visit, as can be found below. The workshop was lively with interesting discussions, attracting attendees from different research backgrounds.
- We looked at some robust statistics methods which have been applied to robustify state estimators. An interesting connection was found between those methods and recent results in the areas of systems identification and randomized algorithms. We discussed several problems to apply the worst-case type results to the power systems problem since they can bring new tools and viewpoints.
- There was an enjoyable interaction with the power systems group people led by Prof. Ettore Bompard. Their research area is broad, but centers around the issue

of security at the scale of nation-wide transmission grids in European countries, which includes cyber security. Their presentation was based on the systems approach, with which we are very familiar with. In particular, some of the topics on graph theoretic problems of sensor placement and the new notion of electrical betweenness were very interesting and we plan to study more closely.

- Regarding distributed algorithms, we studied how the techniques we developed earlier can be applied in a natural way to the power systems problem. This however brought some new insights into the formulation as in power systems, it is often desirable to view the grid network to be composed of multiple subgrids which can be monitored only locally.
- For carrying out distributed computations on sensor network type applications, it is important that the sensor devices share a common clock. We met people from the computer group of the Institute and Dr Stefano Scanzio presented their recent research in this direction. While this is a topic familiar to us especially from the algorithmic viewpoint, their studies have specific requirements on the achievable precisions and necessarily involve critical issues in implementations taking account of time delays in the processors, which can vary depending on the environmental conditions.

At the end, I would very much like to thank Fabrizio Dabbene and Roberto Tempo for the warm hospitality, the organization of the many meetings, and the interesting discussions that took place throughout my stay in Torino.