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PhD Dissertation Announcement

A QUICKEST DETECTION FRAMEWORK FOR SMART GRID

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The smart grid technology has significantly enhanced the robustness and efficiency of the traditional power grid network by exploiting the technical advances in sensing, measurement, and two- way communications between the suppliers and customers. However, the integration of such smart functionalities into the power grid also poses many risks such as increasing system complexity, network security risk, enduser data privacy issues, uncertainty of the renewable energy generation, and etc. Although the smart grids have been investigated heavily in many directions and aspects when it was raised for the first time, the research on the power system issues and the quickest detection techniques on smart gird networks is still limited.

In this dissertation, we like to explore specifically in three areas: system status, security issue, and resource management in smart grid networks. First, we propose a CUSUM-based defense strategy against the false data injection attack in smart grid networks. In comparison to classical approaches, the advantages of the proposed CUSUM-based defense mechanism include the capabilities of tackling the unknown parameters via the low complexity approach, using multiple online samples/observations for better decision accuracy, and developing a Markov chain based approach for performance guarantee. The accuracy of the analytical model and detection with performance guarantee are also discussed. Second, we propose a quickest estimation scheme to determine the network topology as quickly as possible with given accuracy constraints from the dispersive environment. Unlike the conventional topology estimation requires a long process of status analysis that the sensor at each bus senses, collects, analyzes, and then finally, sends the status measurement to the control center. It helps detect and identify the topological error efficiently and promptly for smart grid state estimation via just using online power measurement, and furthermore, reduce on vulnerability on system failure. The performance is evaluated through both analytical and numerical simulations with the MATPOWER 4.0 package. It is shown that the proposed scheme achieves the minimum average stopping time, but retains the comparable estimation accuracy and false alarm rate. Finally, we investigate the energy profile allocation scheme for enduser that is capable of determining the best choice of energy profiles as few samples as possible for long-term usage under the accuracy constraint while balancing the exploration and exploitation. From the simulation results, we can show that a user can effectively switch and select the best energy profile with the minimum delay while balancing the exploitation and exploration. The proposed technologies concerning different aspects of smart grid issues, such as the cyber security issues, network topology problem, alternative renewable energy resource allocation can provide a lot of benefits to power grid society, and will enhance the grid reliability and stability, utility services, emission control, and enduser experience in enabling better communications access to the grid, which could potentially translate into effective efficient utility operations and better living environment for human being.

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