CPS: Breakthrough: Collaborative Research: WARP: Wide Area assisted Resilient Protection

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Project Details

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Abstract: The electric power grid experiences disturbances all the time that are routinely controlled, managed, or eliminated by system protection measures-designed by careful engineering studies and fine-tuned by condensing years of operational experience. Despite this, the grid sometimes experiences disruptive events that can quickly, and somewhat unstoppably catapult the system towards a blackout. Arresting such blackouts has remained elusive - mainly because relays (protection devices) operate on local data, and are prone to hidden faults that are impossible to detect until they manifest, resulting in misoperations that have sometime been precipitators or contributors to blackouts. Inspired by the Presidential policy directive on resilience -- meaning the ability to anticipate, prepare, withstand, and recover from disruptive events, this project proposes "WARP: Wide Area assisted Resilient Protection", a paradigm that adds a layer of finer (supervisory) intelligence to supplement conventional protection wisdom - which we call resilient protection. Exploiting high fidelity measurements and computation to calculate and analyze energy function components of power systems to identify disturbances, WARP would allow relays to be supervised - correct operations would be corroborated, and misoperations will be remedied by judiciously reversing the relay operation in a rational time-frame. The project also envisions predicting instability using advanced estimation techniques, thus being proactive. This will provide power grid the ability to auto-correct and bounce back from misoperations, curtailing the size, scale and progression of blackouts and improving the robustness and resilience of the electric grid -- our nation's most critical infrastructure. In WARP, disruptive events are deciphered by using synchrophasor data, energy functions, and dynamic state information via particle filtering. The information is fused to provide a global data set and intelligence signal that supervises relays, and also to predict system stability. Resilience is achieved when the supervisory

signal rectifies the misoperation of relays, or endorses their action when valid. This endows relays with post-event-auto-correct abilities ?- a feature that never been explored/understood in the protection-stability nexus. Architectures to study the effect of latency and bad data are proposed. WARP introduces new notions: global detectability and distinguishability for power system events, stability prediction based on?the sensitivity of the energy function components and uses a novel factorization method: (CUR) preserving data interpretability to reduce data dimensionality. All the proposed?tools will be wrapped into a simulation framework to assess scalability and accuracy-runtime tradeoffs, and quantify the degree of resilience achieved. The effectiveness of the proposed scheme during extreme events will be measured by reenacting two well-documented blackout sequences. In addition, simulations on benchmarked systems will be performed to assess scalability and accuracy-runtime tradeoffs, and quantify the degree of resilience achieved.