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A biologically inspired paradigm for hierarchical cyber-physical smart grid modeling and control

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It is well known that information will play an important role in enhancing emerging smart grid system operation. Questions therefore naturally arise as to when the increased data-dependence may be considered excessive. Two practical considerations emerge: 1) communications and computational overhead, in which redundant and irrelevant information acquisition and use results in heavy computational burden with limited performance return, and 2) increasing risks of power system disruption due to information delay from communication congestion or cyber attack. One strategy to improve smart grid resilience is to determine the appropriate degree of dependence on cyber information to balance performance with overhead and risk. In this paper, we present a hierarchical cyber-physical multi-agent model of smart grid system operation based on flocking theory in the context of the transient stability problem. Through this model, we study strategies that harness a selective degree of cyber technology by leveraging physical couplings. Our formulation enables the identification of large-scale distributed control strategies for robust and resilient power grid operation. We demonstrate the potential performance improvements of our findings on the New England 39-bus power system for case studies involving a variety of system faults and communication delays.

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Analysis of implementation voltage setpoints by synchronous generators in operating points with inverse relation between control variables

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Post mortem blackout analysis, which was characterized by voltage drop, suggests that voltage control can aggravate the voltage level. Synchronous generator voltage control is performed by AVR and, in special situations; it may have the opposite effect of its logic of conception. The AVR has no control logic to differentiate direct and inverse relationship between the controlled voltage and the generator excitation voltage. Therefore, if the relationship is inverse, the AVR control may result to be inadequate (opposite to desired), and may lead the system to collapse due to low voltage, for example. Real cases with inverse relationship between controlling and controlled variables occurred in Brazilian system in 1997, 24 and 25 April blackouts. No event or abnormality that would have caused the problem was registered. Full use of available voltage control resources was noticed. This work identifies the causes that lead the generators to operate with inverse relationship between their controlling and controlled variables. The effect of voltage control actions to achieve a new voltage level from operating points that have generators with inverse relationship was studied. The consequence of operation with direct and inverse relationships was analyzed by time domain simulation.

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