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RESEARCH ARTICLE

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An approach for economic design of wide area monitoring system by co-optimizing phasor measurement unit placement and associated communication infrastructure

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Summary

Wide area monitoring system has been implemented in power systems to improve control and protection aspects by carrying out the continuous synchronous measurement. It consists of phasor measurement units (PMUs) along with communication infrastructure (CI) to connect all PMUs to the phasor data concentrator (PDC). In this work, simultaneous optimization of PMU count thereby its cost and CI cost has been taken as the objective while ensuring entire system observability. To incorporate the effect of zero injection bus, an improved model has been adopted. A modified objective function has been proposed which enhances maximum observability and further improves the reliability of system monitoring. Dijkstra's algorithm has been utilized for designing optimal CI as well as to identify the location of PDC. Practical operating scenarios such as N-1 contingency and the presence of pre-installed PMU or fiber optic have also been simulated. Binary dragonfly algorithm has been applied to solve the considered optimization problem. To demonstrate the efficacy of the proposed method it has been implemented on different IEEE standard test cases. A comparison of obtained results has been presented which indicates the superiority of the proposed method over other methods reported in the literature.

List of Symbols and Abbreviations: O_1, cost associated to PMUs; O_2, cost associated to CI; C_p, cost of single PMU without extra channel; C_l, cost per extra current measurement channel; EC_n, number of extra channels associated with nth PMU; NC_n, total number of the channel associated with nth PMU; NB, total number of buses present in the system; C_{fb}, per km cost of fiber optics; CL_i, fiber optics length from ith bus to PDC in km; CP, set of buses where PMU is present; C_{sw}, cost per switch; SW_j, binary variable refers to the presence of switch at bus j; OB, refers to the observability of buses; U_n, refers to a binary variable that shows the presence of PMU at nth bus; C, connectivity matrix; ΔX_u, step vector for the search agent in the uth iteration; u, iteration number; a, weight for separation; A_j, jth search agent's separation; b, weight for alignment; B_j, jth search agent's alignment; c, weight for cohesion; C_j, jth search agent's cohesion; d, factor for food source/prey; D_j, jth search agent's attraction toward the prey; e, factor for enemy; E_j, jth search agent's distraction from the enemy; w, weight factor for step vector ΔX; X_j, current position of the jth search agent; X_i, neighboring search agent ith's position; N, total count of search agents in the neighboring swarm; V_i, neighboring search agent ith's velocity toward alignment; D_l, position of the prey; E_l, position of the enemy; x, random value having *values* between [0, 1].

Please note, as a symbol for voltages use U, u, rather than V, v, in accordance with the international standard.

[Correction added on 1 August 2021, after first online publication: Peer review history statement has been added.]

