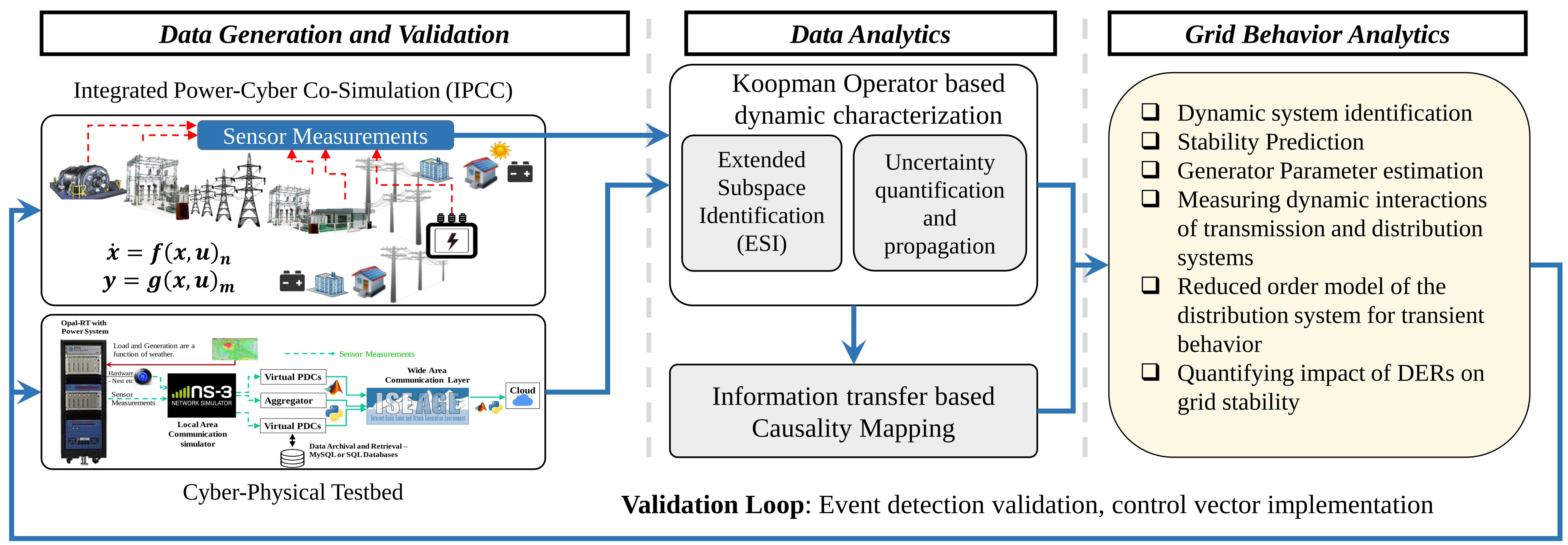
CPS: Medium: Data-driven Causality Mapping, System Identification and Dynamics Characterization for Future Power Grid

Venkataramana Ajjarapu (PI) | Manimaran Govindarasu (CoPI) | Umesh Vaidya* (CoPI)
A.R.R. Matavalam | Pranav Sharma | Mohamed Elnasry (GRA) | Bhagyashree Umathe* (GRA)

Challenges:

Utilize high proliferation of sensor measurements in the electric grid for dynamic behavior characterization and root cause analysis of dynamic events.

- ➢ Use of output measurements to overcome the challenge of non-measurable system states
- ➢ Characterize highly nonlinear dynamic behavior of the underlying power system.
- ➢ Replicate interactions of transmission-distribution and communication components of an electric grid.
- ➢ Quantify uncertainty propagation in dynamical systems



Solution (Key outcomes):

- ➢ Developed a Koopman operator based novel robust Extended subspace identification (ESI) approach for identification of nonlinear dynamics for power systems using sensor measurements (outputs of the system).
- ➢ Developed a data-driven approach for uncertainty moment propagation through the nonlinear power system dynamics
- ➢ Developed an open source multi-timescale transmission and distribution co-simulation framework along with communication layer that is tested for large T-system & multiple D-system.
- ➢ Developed a data-driven controllability gramian that acts as indicator for the source location for an oscillatory input in a dynamical system.

Scientific Impact:

- ➢ Address the emerging challenges of 'highly dynamical systems' and 'data revolution' in CPS framework.
- ➢ Real-world dynamical systems have limited observables, developed techniques will enable quick transition for field implementation.
- ➢ Applicable for practical CPS systems with sensor measurements capturing dynamic behavior of the system.

Broader Impact:

- ➢ Incorporated the research findings and developments on Integrated Power-Cyber Co-Simulator (IPCC) in courses for graduate students in electrical engineering at Iowa State University.
- ➢ Developed data-analytical and co-simulation framework is shared with industry collaborators, electric Utilities and independent system operators (ISOs) .

Iowa State University and *Clemson University | vajjarap@iastate.edu | Award ID: 1932458 | Award Date: 09/2019