American-Made Data-Driven Distributed (3D) Solar Visibility Prize

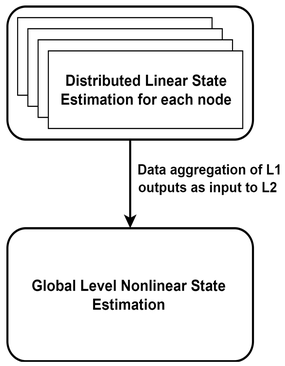
Team Name: 3D_DSSE_PV_Intel (WVU, V&R, ComEd)

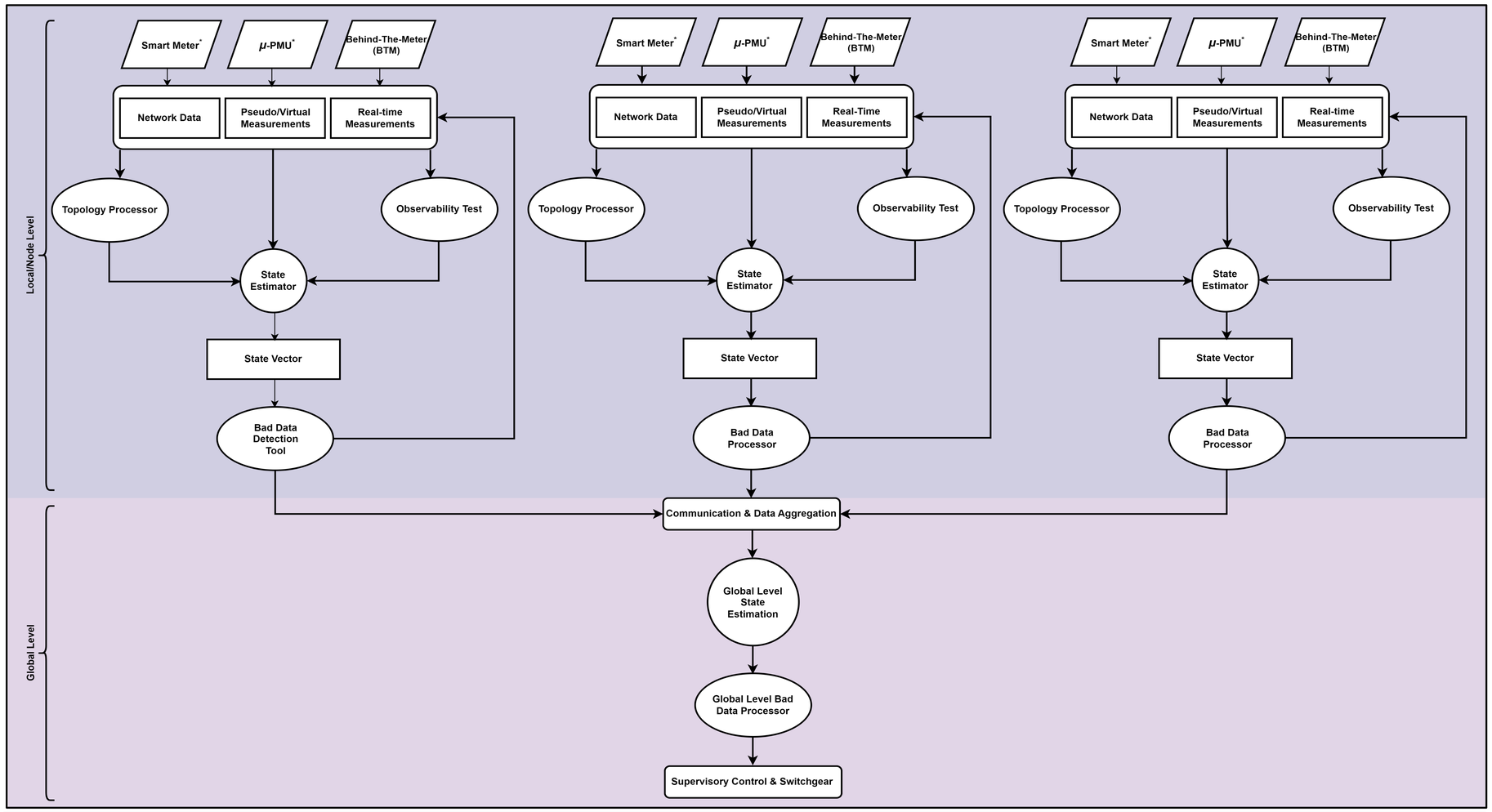
Objective

- **The development and deployment of a Distribution System State Estimation (DSSE) tool.**
- **The provision of accurate and real-time information about solar generation in Power Distribution Network (PDN).**

OVERALL PROCESS

- **Two-level Distribution State Estimation (DSE).**
- **Multiple BTM estimates is fed as input to nonlinear centralized DSE (V&R/ComEd).**
- **Intermediate processes:**
  - **BTM-PV estimation**
  - **Topology Processor**
  - **Observability Test**
  - **Bad-data detection and identification**
- **Two-level DSE is employed to improve 3D solar visibility.**





* - PMU and Smart Meter to be replaced with competition data for initial computations

BTM-PV

- **Hybrid neural network model to estimate behind-the-meter (BTM) PV generation**
- **Historical PV power generation data and weather forecast data to train the model**
- **Pseudo-measurement generation based on BTM-PV estimation**

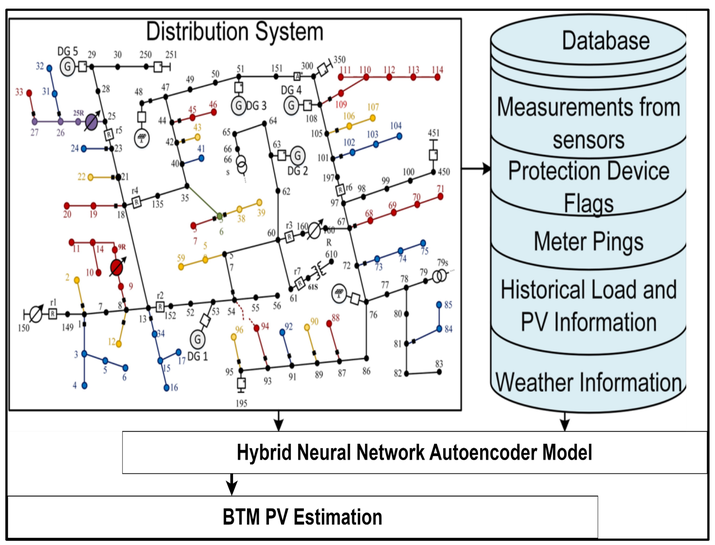


Figure: Figure: Overview of BTM-PV Estimation Model

Bad Data Detection

- **Chi-squared-based bad data detection is proposed for linear decentralized DSE.**
- **Data-driven autoencoder-based anomaly detection with chi-squared-based bad data detection is proposed for non-linear centralized DSE.**
- **While the local chi-squared method detects the bad data in the decentralized zones, the efficiency of the bad data detection and identification increases when followed by the Data-driven autoencoder-based anomaly detection as shown below**

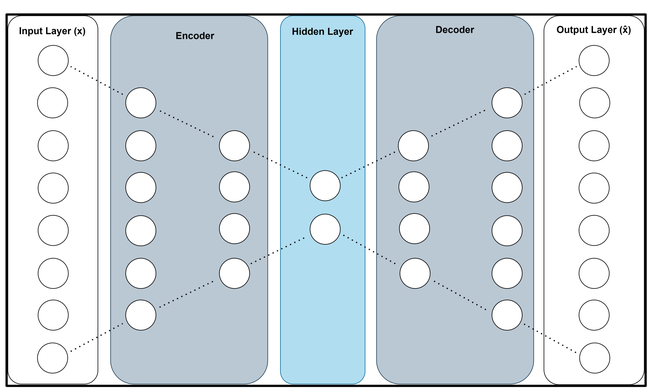


Figure: Proposed autoencoder model

Topology Processor & Observability Test

- **Topology Processor**
  - **Analyzes and maintains knowledge of current network topology.**
  - **A graph theory-based topology processor for DSE is proposed.**
- **Observability Test**
  - **Validates whether the current set of measurements is sufficient to estimate the state of PDN.**
  - **PDN is observable if state estimation can be performed with the available data.**
  - **The Spanning Tree Observability Test is proposed.**

Key Deliverables

- **User-friendly software interface to**
  - **predict real-time PV generation**
  - **perform a robust distributed system state estimation**
  - **detect bad data and topology changes in PDN**

Selected References

1. Ahmad, Fiaz, et al. "Distribution system state estimation-A step towards smart grid." *Renewable and Sustainable Energy Reviews* 81 (2018): 2659-2671.

2. R. Liu, A. K. Srivastava, D. E. Bakken, A. Askerman and P. Panciatici, "Decentralized State Estimation and Remedial Control Action for Minimum Wind Curtailment Using Distributed Computing Platform," in IEEE Transactions on Industry Applications, vol. 53, no. 6, pp. 5915-5926, Nov.-Dec. 2017