M1: Realization of Advanced Energy Management Applications in T&D

M1.1 Advanced Topology Processor

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Prepared for BIRD Foundation

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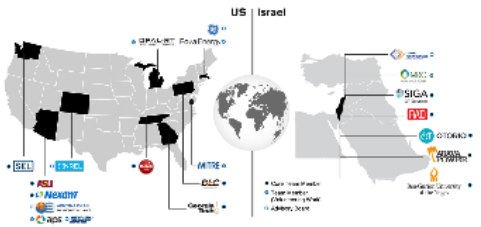


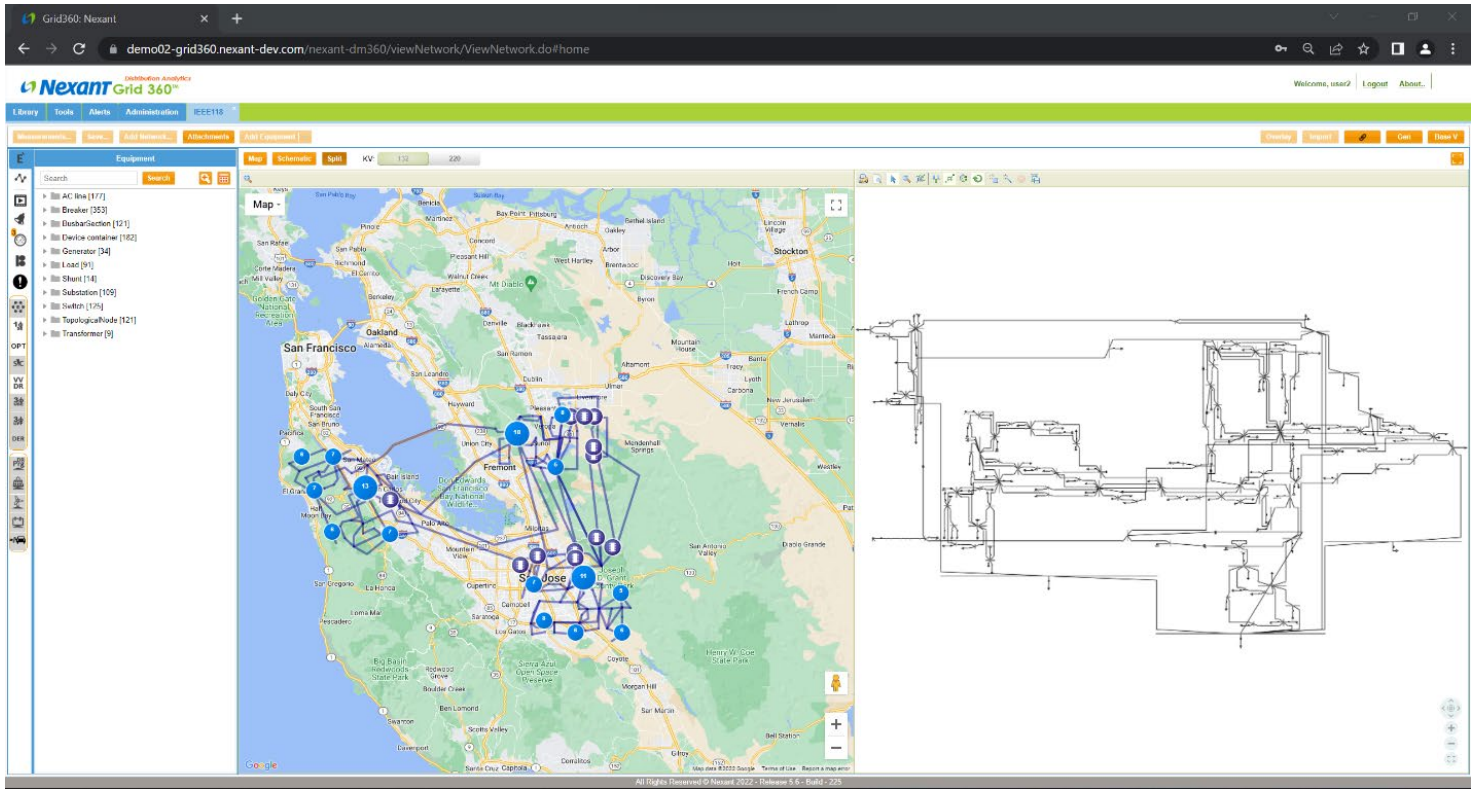
Overview of M1.1 (How the deliverable would look?)

Network modeling, simulation and analysis platform.

Transmission + distribution: system planners and operators

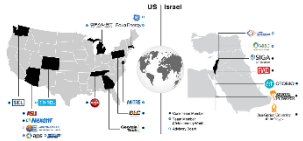
Goal: Using such a software
→ Recover the system info, e.g., feeder-panel mapping
→ advanced algorithms,

Grid360 from Resource Innovations



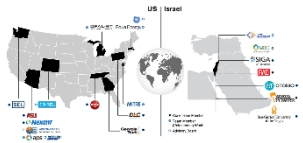
IEEE 108 bus system

Background – Loopholes and Challenges



- Electric residential distribution systems have loopholes → False data injection
- Utility smart meters are outside premises → accessible to anyone
- Cyber criminals may inject false data into the external smart meters.
- Validation required, e.g., solar meters (inside premises)
- Utility requires consumers to get permission on the amount and size of PV installation.
- However, some consumers may not report to the utility and may feed power into the grid.
- In such a case, a utility cannot identify if false data is injected into the utility smart meter.
- Information of all PV connected to the system → Not available to utilities!

Systematic Approach

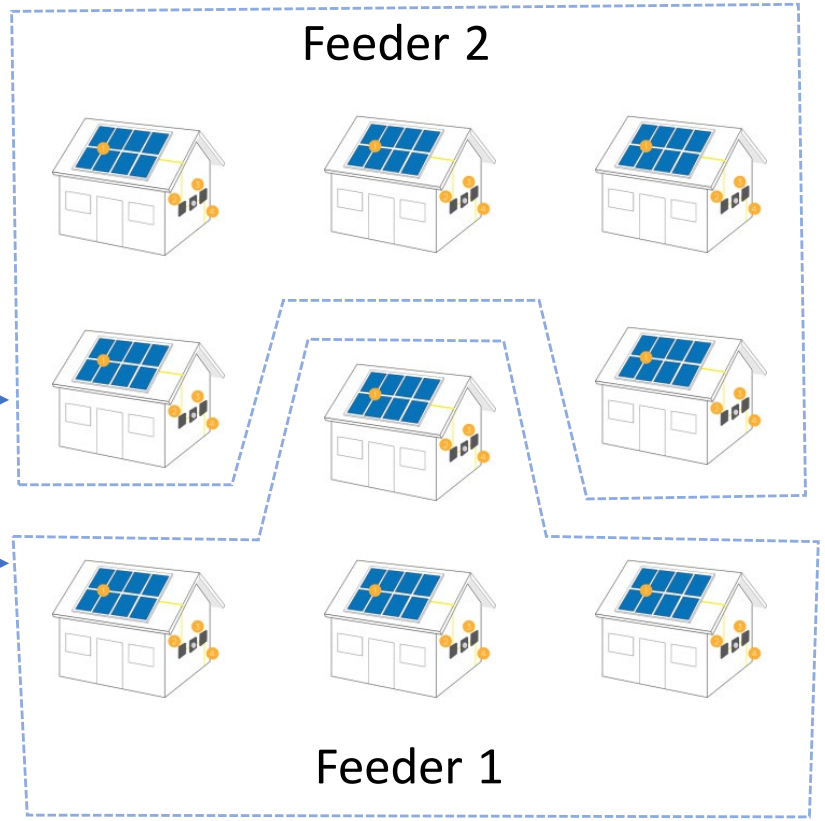


Utility's Database

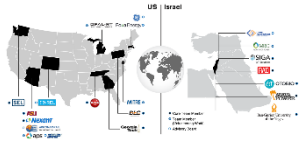
Solar Panel Company's Database

Combine Datasets using Data Mining Tools for Information Discovery

Solar Panel's affiliation to different feeders

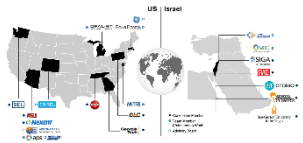


Real Data Availability: Utility Data

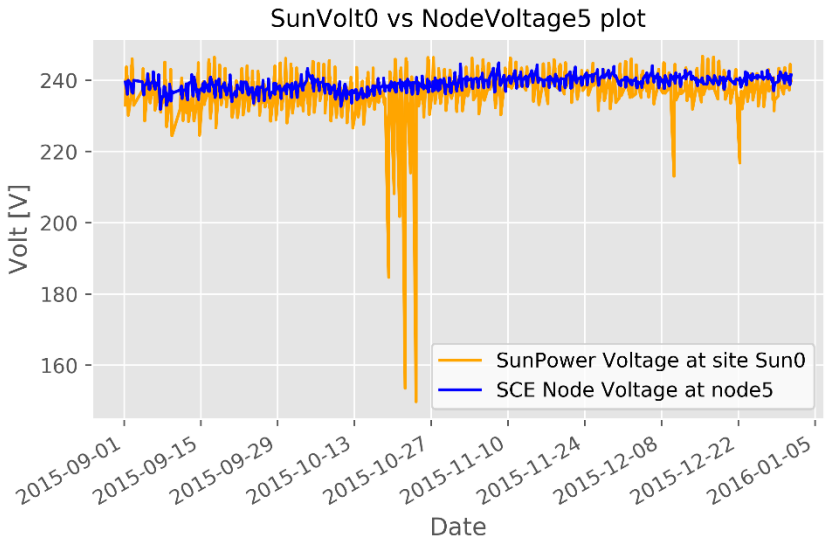


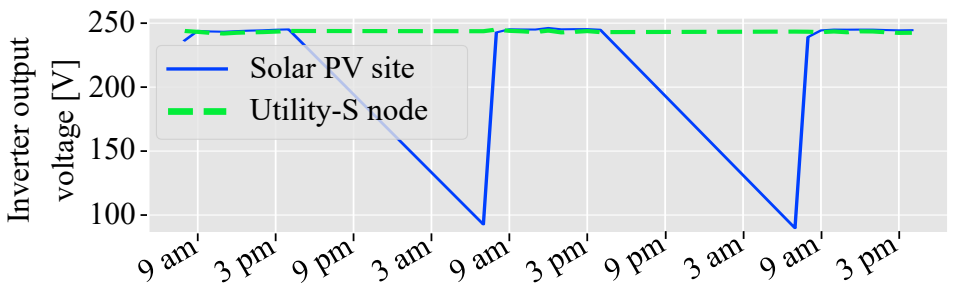
- **Utility data:** data from primary distribution feeders of a substation
- The information from the utility AMI is available in a tabular form, e.g., large MDB (Microsoft Access) files.
- It contains nodes' information in the primary distribution, i.e.,
  - hourly averaged voltage values at the utility nodes, and
  - hourly energy delivered to the secondary circuit at each of the nodes.
- Data irregularities: temporarily missing voltage or power information for some load spots
- **Solar data:** Instantaneous voltage and power information from our solar partner, at a faster rate of 5 minutes.
- Data is available in the form of python pickle files (.pkl), separately for each solar power site.
- Data irregularities: Missing timesteps in the data.

Graphical Representation – Voltage dips

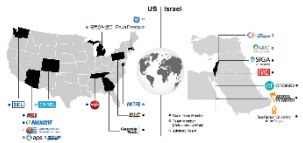


- We observe sudden dips in the voltage measurements from the solar power company
  - Voltage dips appear at the same time daily,
  - E.g., the output voltage of the inverter is half or less after sunset and before sunrise.
  - No power produced in this time.
- After sunset, inverter is turned off to save switching losses → measurements are erroneous.
- Filter out the timestamps during this interval to clean the data.





Metrics for Association Rule Mining?



Consider a transactional database

- set of items $I = \{i_1, i_2, \cdots, i_m\}$
- any transaction is $T \subseteq I$
- dataset is the set of transactions $D = \{T_1, T_2, \cdots, T_k\}$
- # of transactions with an itemset A is denoted by frequency.

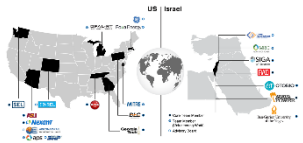
$$frequency(A, D) \doteq |\{T \in D | A \subset T\}|.$$

- Support of a set A is the ratio of frequency of A to the total transactions in D

$$support(A) \doteq \frac{frequency(A, D)}{|D|}.$$

- An itemset is frequent if its support is higher than a threshold

Validation of the Algorithm and Thank You



- We use a modified IEEE-4 bus system.
  - Two feeders, each with 3 buses,
  - One reference bus, so 7 buses in total,
  - Use real load data to simulate voltage data.