3-level measurement data validation system

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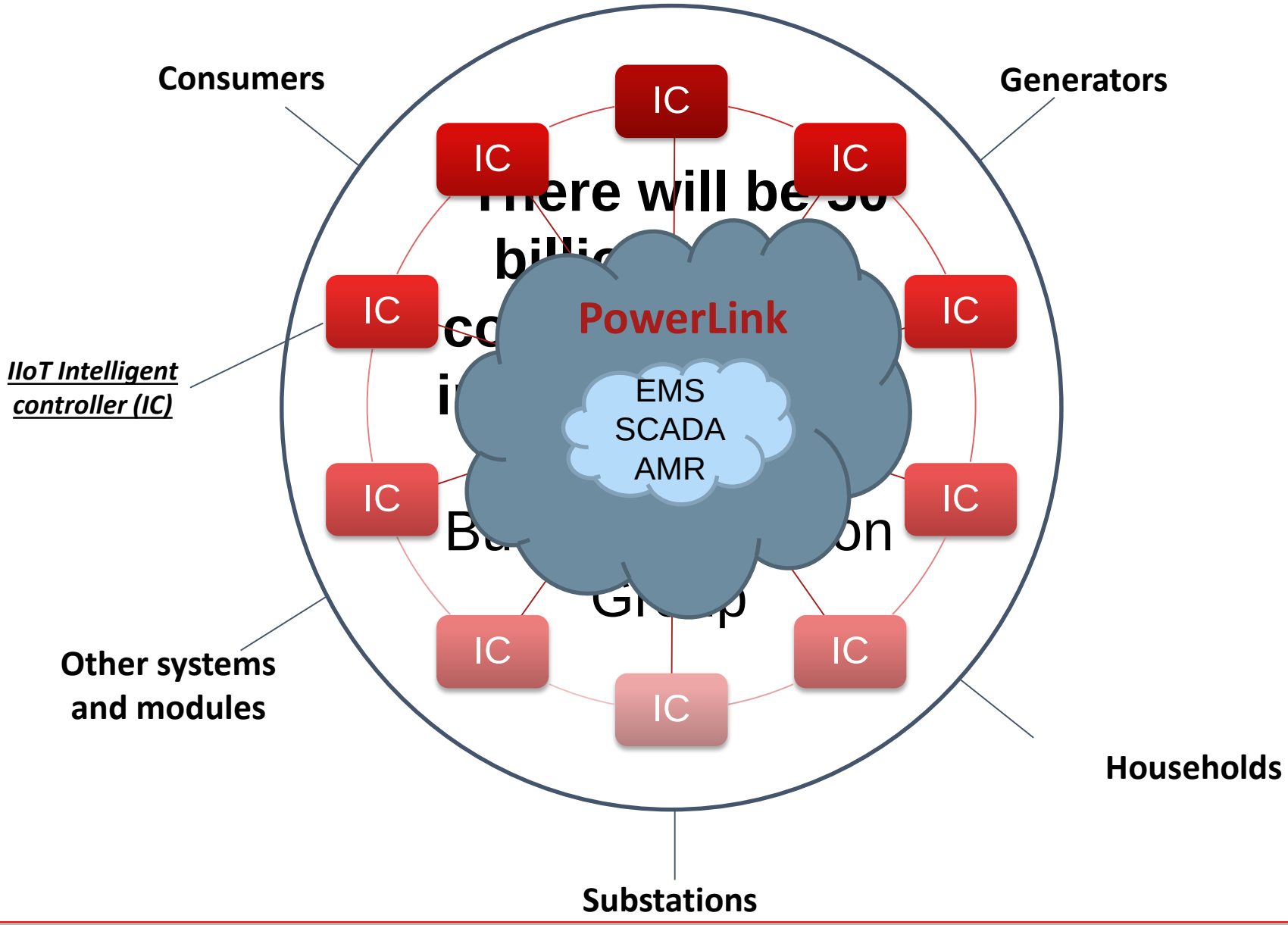
Design, Develop and Deploy digital transformation solutions for an Interconnected World.

- Power system and industrial automation
- Business Analytics, Data Warehousing and Big Data
- Information Security and Compliance

GRT Sample Clients

Edge Computing Paradigm



Steps to enhance data quality

Step 1

- Implementing three level data validation technology

Step 2

- Rectifying the equivalent circuit parameters using synchrophasors (off-line and online) and splitting the state estimation model

Step 3

- Implementing node load valuation method

Step 4

- Combining State Estimation (SE) with robustness methods

Three level data validation

- The progress of data validation (state estimation)
  - 3 levels of multilevel data validation technology according to the resolution and duration of estimated data
    - Object-level: raw 10+ kHz sampling rate data for protection and relay due to the transient (at the substation or power plant). Hardware solutions (IED, protection and relay)
    - Region level: time synchronized data exchange between neighboring objects
    - Interconnection level: “conventional” telemetry and PMU data validation at Control Centers with advanced algorithms

Implementation

- Three independent parts
  - 1st level:
    - Raw data is to be validated on site, the functionality is implemented as IED built-in software
    - Validated data is used for control action automation: protection and relay on site, and higher level emergency control systems
  - 2nd level:
    - Time synchronized data exchange between neighboring objects (substations or power plants). Special software solution is introduced at the substation SCADA level
    - The solution provides disturbance source detection and low-frequency oscillations identification. The information is employed in LFO damping automation

Implementation

- Three independent parts
  - 2nd level (continued):
    - The 2nd level information is utilized for the state estimation model verification and Waiting Factors adjustment
    - Synchrophasors improve the power system model quality, dynamic power flow calculations, emergency automation, AGC, etc.
  - 3rd level (Control Centers):
    - Implemented as part of SCADA/EMS/DMS
    - 1st and 2nd levels information enhance “conventional” SE accuracy
    - Improved dynamic equivalent circuit verification capabilities

Control Center State Estimation (SE)

Challenges:

- The major challenge of SE is lack of raw data processing capabilities
- Asynchronous nature of raw data from various sources
- To address the challenges, the substitute data is used based on the grid equivalent circuit
- The data is obtained from SCADA or as reference values, and from 3rd party measurement infrastructure (commercial meters)
- The data from PMU provides capability of using voltage angles in order to implement a split-model SE with higher accuracy and perform equivalent circuit parameters verification in real time

Control Center State Estimation (SE)

CHALLENGES

- lack of raw data processing capabilities
- asynchronous nature of raw data from various sources

SOLUTION

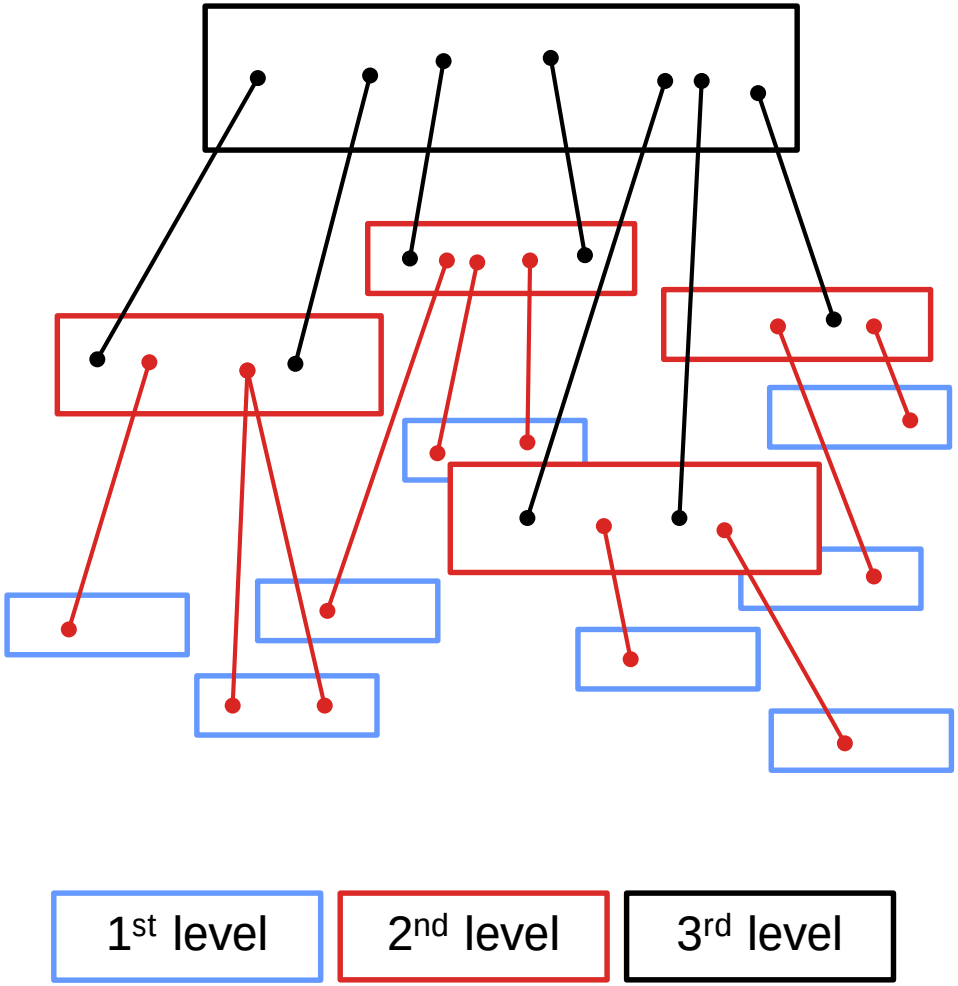
- substitute data is used based on the grid equivalent circuit
- Substitute data sources - SCADA or commercial meters

RESULT

Split-model methodology provides better accuracy for the SE and the real-time circuit parameters verification

State Estimation area partitioning

- One PMU in each subsystem is enough to synchronize voltage phase angles
- The nodes with PMUs are adopted as base nodes for each subsystem
- Measurements from PMU coordinate the results of data validation for each subsystem



Node load estimation method

- Node load is a sum of consumers' loads and power losses
- Loads may be divided into:
  - Total consumption of the power system
  - Generation
  - Load
  - Power flow between interconnections
- Information about node load allows for estimating the grid section state under insufficient raw telemetry data conditions

Computing equivalent circuit parameters using PMU measurements

- HVAC lines and transformers parameters depend on many factors, and they are constantly changing
- Data validation errors are unavoidable
- It's well known that the difference between the factory-defined equipment parameters and the actual values are
  - up to **15%** for resistance and **10%** for reactance of HVAC lines and transformers
  - **25%** for capacitance and over **100%** for active conductance
  - the transformation ratio is up to one step of control range
- Improved SE results

State estimation methods robustness

- Algorithm convergence - find and identify the bad measurements (data errors)
- Modified Newton's method improves the computational performance of a non-square function
- Huber non-square function solves this problem by inner point method

Summary

- The 3-level data validation system significantly improves the data validation
- The 3-level data validation system is a step towards the power systems digitizing, i.e. enabling the transition from outdated analogue solutions to the advanced digital environment.
- The selection of the validation level depends upon the covered territory – object, region or interconnection

Q&A

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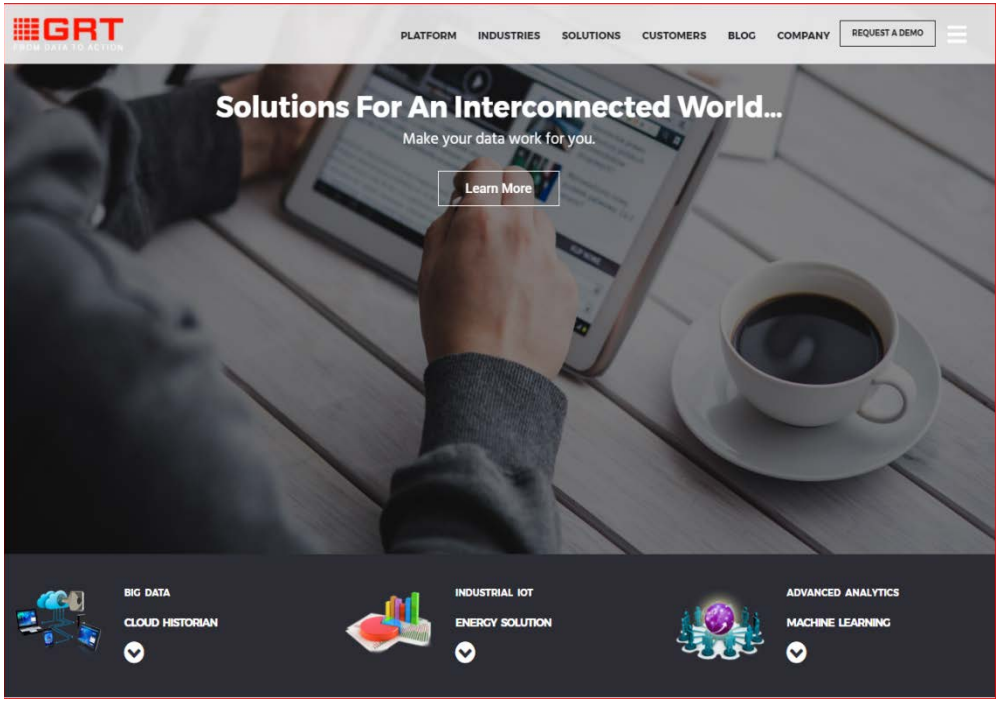

Thank You

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