The FUSE Microgrid: Academic Research on Critical Infrastructures using the PI System

Presented by: Dr. Joachim Fabini, Senior Scientist, TU Wien, Austria
About TU Wien

• TU Wien is one of the major Austrian universities
  – Founded 1815
  – Focus: natural sciences and technology
  – Teaching and research
  – About 4,800 employees (3,300 scientific), 30,000 students
Institute of Telecommunications: CN group

- Institute: about 80 employees
- Four full professors, six research groups
- Research ranges from physical-layer communications (5G, vehicular, antennas) to higher layers, including security.
- Communication Networks (CN) group
  - Research focus: anomaly detection
  - Lead: Prof. Tanja Zseby
  - Data analysis, (real-time) algorithms, measurement methodologies, hardware, ...
  - Data methods (feature selection, clustering, ML, DL, ...)

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The Challenge of (Micro)Grid Management

**Microgrid**: geographically restricted electricity network
- Generators and Loads
- Connected to the (macro)grid
- May disconnect and operate in isolation (islanded mode)
The FUSE Project in a Nutshell

• **FUture Secure Energy Networks**
  – TU Wien internal project, 4 years
  – Three TU Wien research groups
  – Lead: Prof. Tanja Zseby
  Phd student: Evangelia Xypolytou

• **Project objective:** Testbed for microgrid research
  – Self-organizing energy networks (IT and Energy)
  – Intra- and Inter-Microgrid Management
  – Microgrid security and protection
The FUSE Microgrid Architecture

Symbols and Acronyms

- Grid Component
- IT Component (optionally hybrid IT/Grid)
- Breaker
- Sensor-Actuator
- IP-Level Network Trace
- Energy Network
- IT Network (IP-based protocols)
- IT Network (proprietary, non-IP protocol)

PV: Photovoltaic Generator
Wind: Wind Energy Converter Emulator
Storage: Energy Storage (e.g., battery)
Load: Microgrid Load Emulator
NwSim: Energy Network Simulator
PMU: Phasor Measurement Unit
PDC: Phasor Data Concentrator
SMi: Smart Meters 1..n
DC: Data Concentrator (SM)
Li: Load Connected to SMi
FUSE Monitoring: Interfaces to the PI System
Coresight FUSE System Display
Coresight Display: Details

- Phase Angle
- Voltage
- Frequency

- 1133_PMU-1_PM1:V
  230.59 Volts
- 1133_PMU-1_PM5:V
  233.02 Volts
- 1133_PMU-1_PM3:V
  230.64 Volts

- 1133_Pmu-1_Phasor Volt CH-A + Voltage Magnitude
- 1133_Pmu-1_Phasor Volt CH-B + Voltage Magnitude
- 1133_Pmu-1_Phasor Volt CH-C + Voltage Magnitude
Coresight State Comparison: PMU External vs. Internal
FUSE Allocation of Instances to VMs (or Physical Servers)

- Data Archive
  - Dedicated server
- PDC, Interfaces, AF
  - Dedicated VMs on one physical server
- Coresight, Data Export
  - Dedicated VMs on one physical server
- **Challenge**: traceability
FUSE: Future Work

- Separate data archives
  - Fast vs. slow sensor data
- Combine sensor data
  - Network traces
  - Sensor values
- Complex analytics
- Feedback loop
Benefits for Academia: Visualization

• Data archive and export
  – Variety of sensors
• Graphical presentation of research results
  – Key factor (often missing) for “selling“ research results to potential project partners
• Bring research to the classroom
Lessons Learned

• Academic research is different
  – Focus on feasibility, traceability, extensibility, ...
  – Project plans change on the fly
• OsiSoft has provided excellent support and guidance
  – OsiSoft trainings highly recommended
  – Challenge: Windows operating system timing (w32time)
• Use of Windows Server 2016 or later imperative
Leveraging Future Secure Energy Networks: The FUSE project and testbed

**COMPANY and GOAL**
TU Wien is one of Austria’s major universities. Two TU Wien Institutes set up the FUSE testbed as an experimental platform to support research and teaching on secure electrical grids.

**CHALLENGE**
Develop novel algorithms to control decentralized, autonomously operating microgrids as part of the electrical grid
- Centralized power generation vs. renewables in the electrical grid
- Security and resilience aspects
- Main challenge: control break and rejoin operations with grid

**SOLUTION**
Build a microgrid featuring generators (PV, wind), load, monitoring and control infrastructure
- Experimental platform to test novel architectures and algorithms
- PI System for monitoring
- Future extension: Use PI System to control microgrid operation

**RESULTS**
First components installed and connected
PI System collecting PMU and sensor data.
- Aiming at real-time feedback and control when testbed is fully set up
- Open issues: achievable reaction time and end-to-end security
- Future: Sensor aggregation and feedback loop
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