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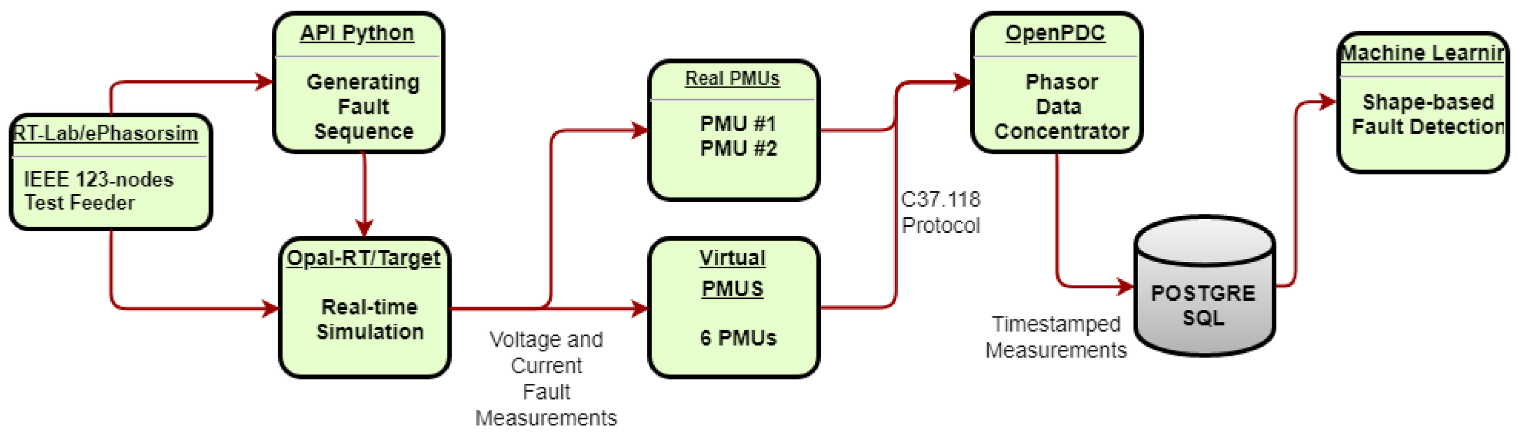
DATA-DRIVEN EVENT DETECTION IN DISTRIBUTION POWER SYSTEMS

Objectives

The study takes advantage of a realistic experimental setup by AIT SmartEST lab together with the new advancements in machine learning to diagnose fault events in distribution networks. This will be achieved with the sophisticated Hardware-in-the-Loop (HIL) and Software-in-the-Loop (SIL) facilities in AIT.

- *Objective 1:* expanding the fault detection scenarios to real world condition using a distribution network model on OPAL-RT HIL and actual Phasor Measurement Units (PMU).
- *Objective 2:* develop a large set of fault events that resemble the real-field mining and streaming of measurements obtained in distribution networks for training, testing and subsequent validation of machine learning algorithms.
- *Objective 3:* analysing the PMU streams collected data using the advanced machine learning algorithms for event detection developed by the user group.
- *Objective 4:* working closely with industry partners and measurement device manufacturers for analysing impact of multi-vendor PMU desynchronization on event detection.

The testbed has the following components:



Testbed Overall Scheme

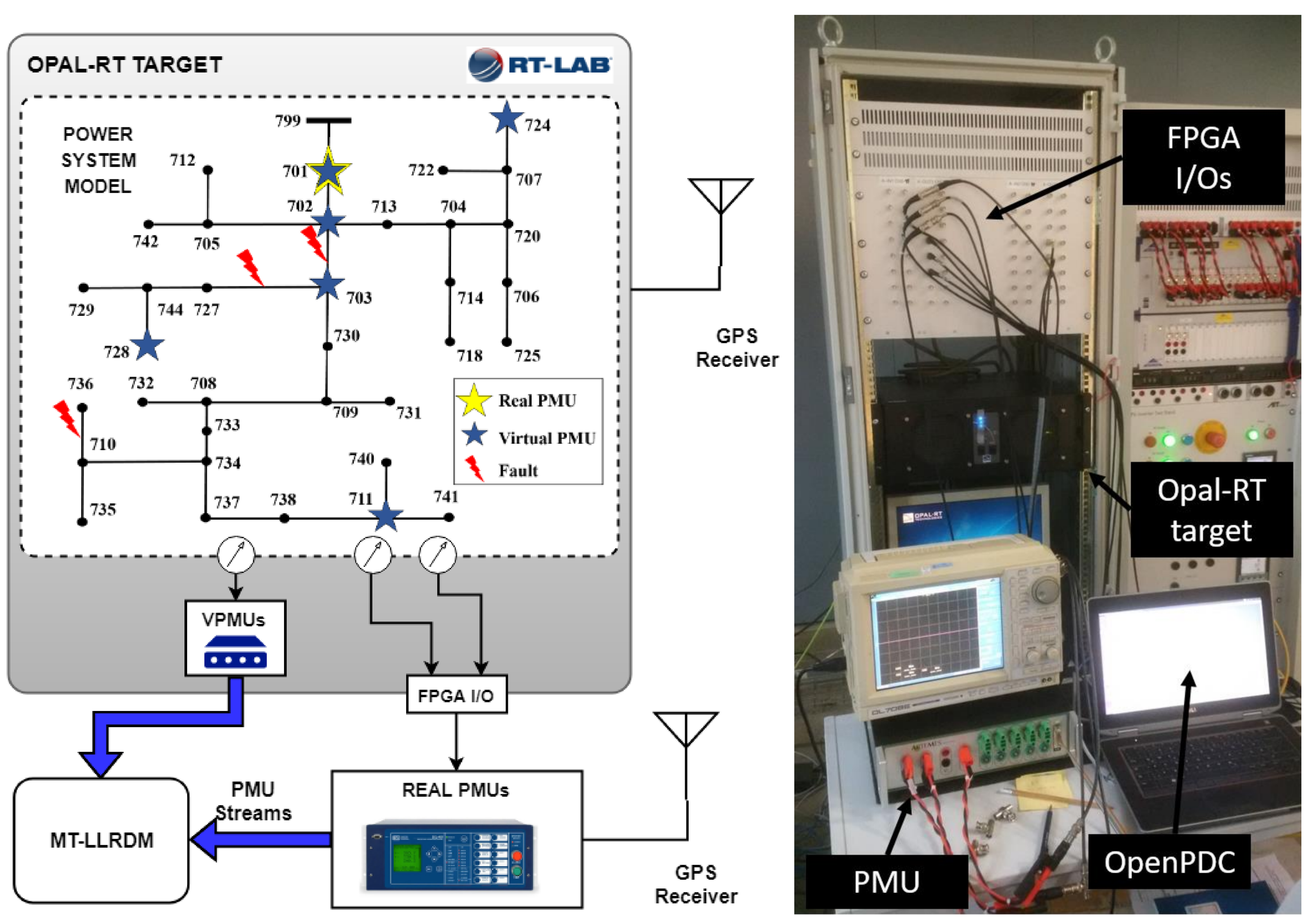
Two different IEEE test feeders were simulated in OPAL-RT/RT-Lab:

Table I. Test feeders setup

Feature	3D-Power	4D-Power
Test feeder	IEEE 37-nodes	IEEE 123-nodes
Simulation tool	Opal-RT/RT-Lab	Opal-RT/RT-Lab
Number of nodes	37	123
Fault locations	3	14
Types of faults	3	7
Real PMUs	3	2
Virtual PMUs	6	8
Synchronization	GPS / PTP	RTS system clock
Measurements	V and I phasors	V and I phasors
Communication	C37.118 in CORE	C37.118
Fault Events	**891**	**9,702**

Data-driven Detection of Events in Power Systems (3D-Power)

- *Lab-setup:* with real and emulated PMUs



3D-Power Physical Testbed

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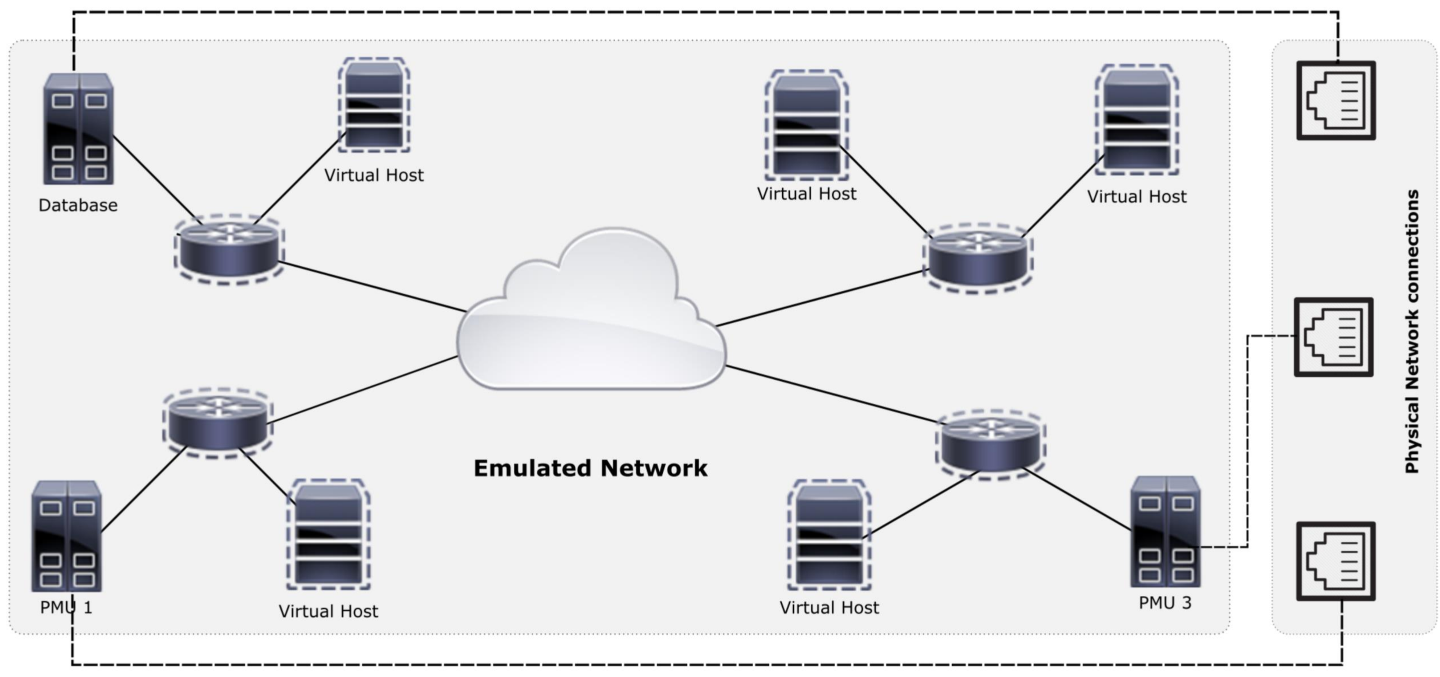
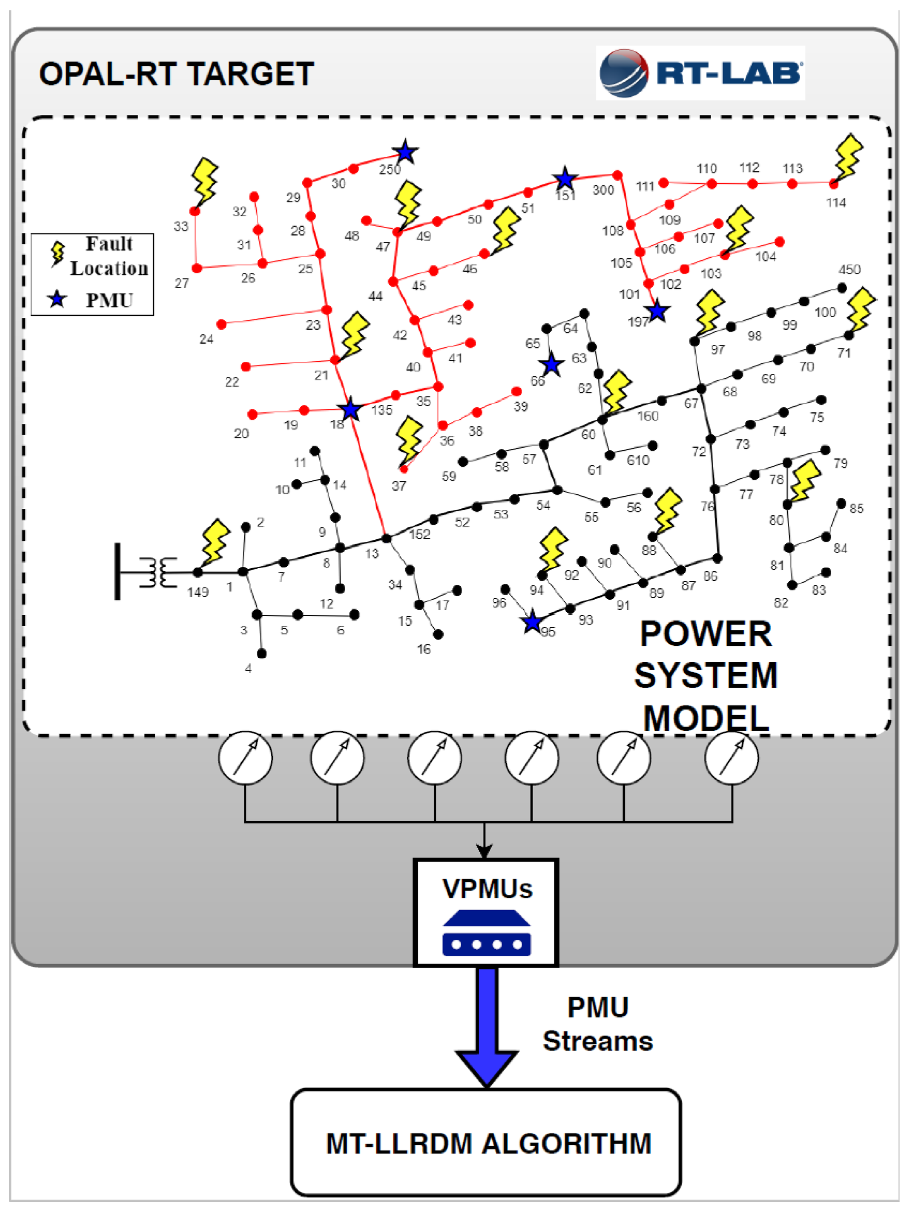
- *Communication Network:* real-time data was streamed complying the IEEE C37.118 standard for PMU Global Positioning System (GPS) synchronized measurements and then gathered in an open source Phasor Data Concentrator (OpenPDC) for its online visualization. Taking advantage of the SmarTEST lab at AIT, an OMNET++/CORE communication network setup was implemented to emulate the real distribution network latencies.



Communication Network Layer Simulation (CNS)

Data-driven Detection of Events in Distribution Power Systems (4D-Power)

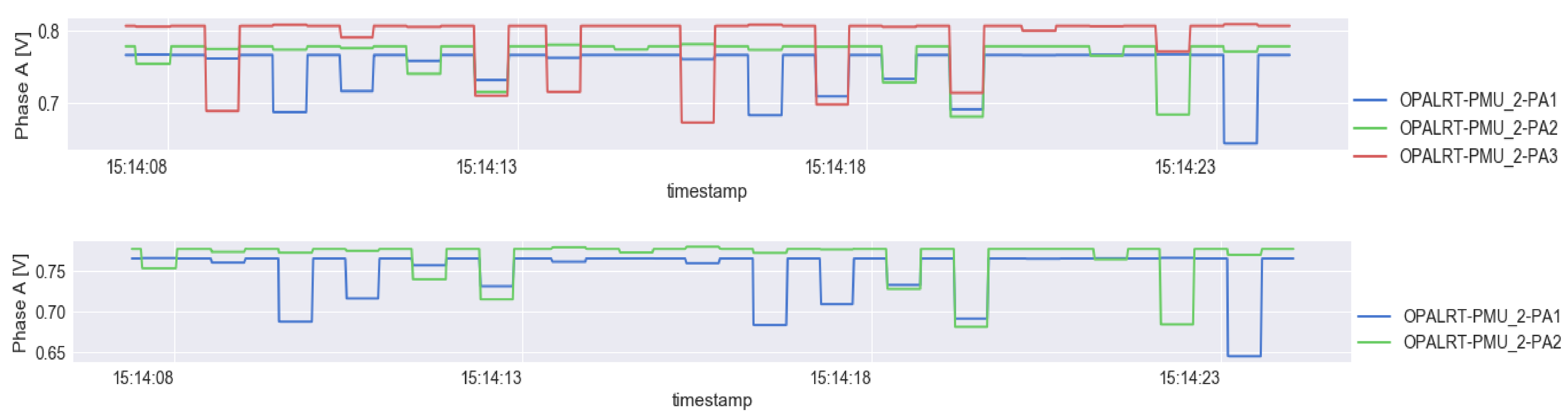
- Development and validation of a event detection algorithm (i.e., MT-LLRDM)
- Implementation and testing in a power distribution grid (i.e., IEEE 37-nodes test feeder)
- Real-time emulation of the whole lab setup with OPAL-RT/RT-Lab



4D-Power Physical Testbed

Automatic Fault Detection

- Automatic fault detection by the evaluation of PMU streams



Fault events sequence PMU streams

Table II. Confusion matrix for fault detection for IEEE 37-nodes test feeder using shape-based event detection

Method	FRAPD	B-FRAPD	FRAD	FRPD	SVM	NN
False Positive	**2.69**	13.43	0.00	26.93	18.52	33.34
False Negative	**1.68**	10.25	25.93	0.00	16.16	33.33
Total Error	**4.37**	23.68	25.93	26.93	34.68	66.67

References

[1] J. Cordova, C. Soto, M. Gilanifar, Y. Zhou, A. Srivastava and R. Arghandeh, "Shape Preserving Incremental Learning for Power Systems Fault Detection," in IEEE Control Systems Letters, vol. 3, no. 1, pp. 85-90, Jan. 2019.

[2] J. Cordova, C. Soto, M. Gilanifar, Y. Zhou, A. Srivastava and R. Arghandeh, "Shape Preserving Incremental Learning for Power Systems Fault Detection," in 57th IEEE Conference on Decision and Control (CDC 2018), Dec. 2018.

[3] M. Stifter, J. Cordova, J. Kazmi, and R. Arghandeh, "Real-Time Simulation and Hardware-in-the-Loop Testbed for Distribution Synchrophasor Applications," Energies, vol. 11, no. 4, p. 876, Apr. 2018.