Study Committee C2

Power System Operation and Control

Paper C2-10550

Synchrophasor-based Applications to Enhance Electrical System Performance in the Netherlands

M. Popov[1], N. Kumar[1], A. Boričić[1], M. Naglić[6], I. Tyuryukanov[1], M. Tealane[1], J. Rueda[1], A. Jongepier[2], E. Wierenga[2], M. van Riet[3], O. Baglaybter[4], G. Rietveld[5], J. Bos[6], M. van der Meijden[6], D. Klaar[6], P. Palensky[1]

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Concept of a Distributed Digital Data Platform and Applications

- WAMPAC (Wide-Area Monitoring, Protection, And Control) is one of the most promising enabling technologies to tackle the challenges that modern power systems are facing.
- The developed platform can simulate power system and telecommunication phenomena in real-time and process the measurement data of user-defined applications.
- The platform can be used to test advanced WAMPAC algorithms under realistic conditions.

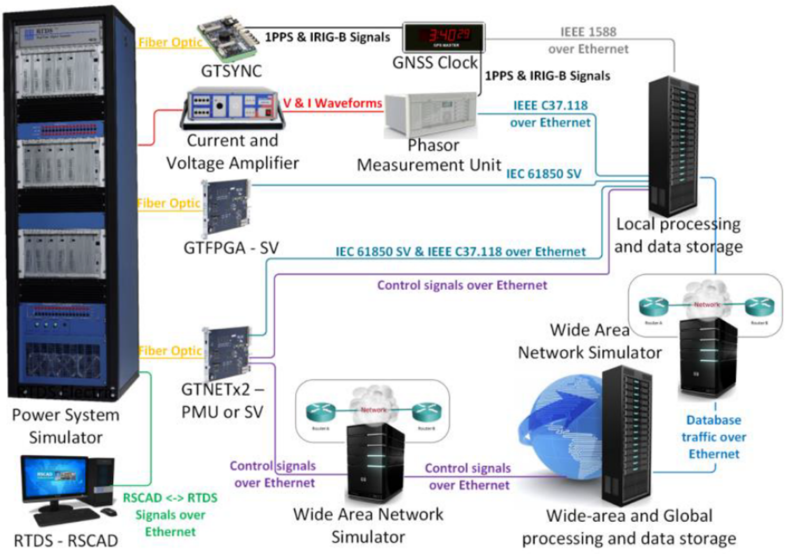

Figure 2. WAMPAC-ready cyber-physical platform for online validation of closed-loop applications

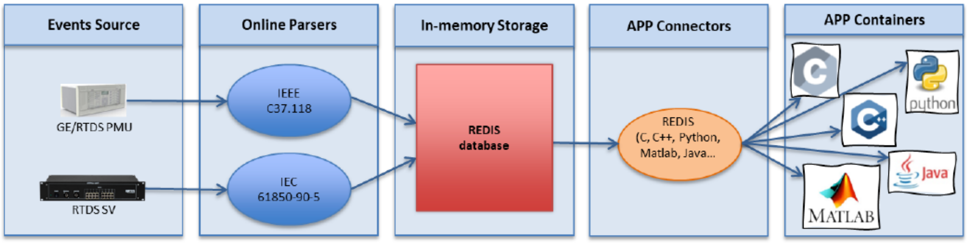

Figure 3. Digital platform for online data collection and processing in user-defined applications

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Stability-Aware Controlled System Separation

- Modern interconnected power systems operate under increasing pressure, which leads to an increased rate of severe events and blackouts in recent years.
- Controlled system separation aims to counteract the cascading chain of events by early detection of instability while minimizing the loss of load and equipment overloads.
- Three main questions: (i) when to split, (ii) where to split, (iii) what to do after splitting.
- The developed WAMPAC algorithms tackle these questions successfully, delivering excellent performance and the ability to improve system stability under critical conditions.

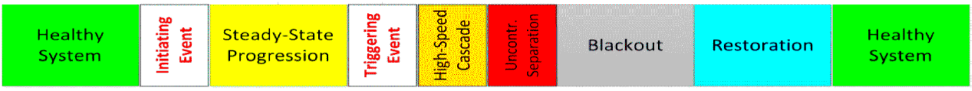

Figure 4. Typical blackout scenario [12]

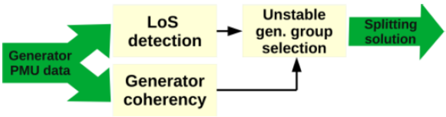

Figure 5. Decision logic of controlled splitting

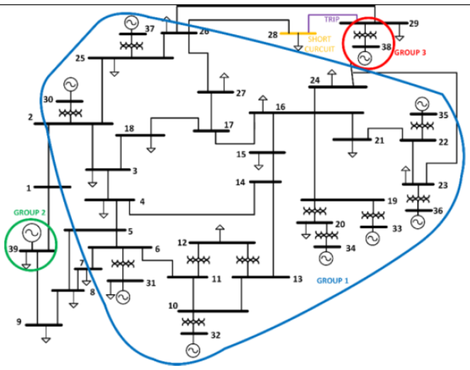

Figure 6. Three groups of coherent generators [15]

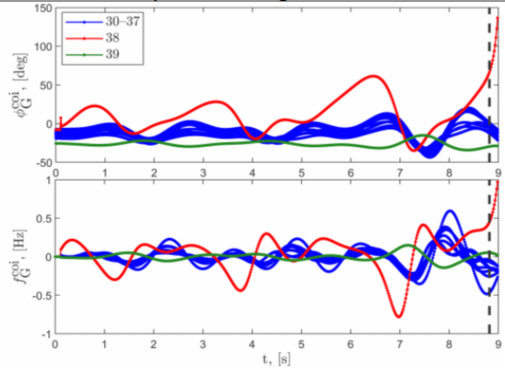

Figure 7a. Unstable transient

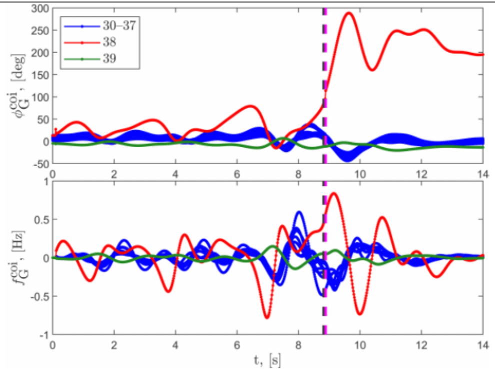

Figure 7b. Splitting transient

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Event Detection, Localization and Classification

- A possible futuristic capability of the WAMPAC platform is to achieve a high degree of situational awareness – real-time detection, localization, and classification of disturbances.
- An incremental deep learning classification algorithm is developed, with good performance.

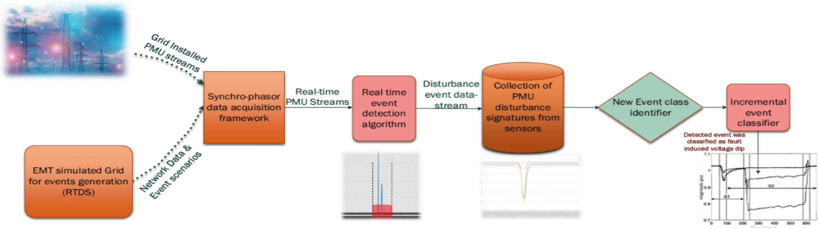

Figure 8. An expert system comprising Real-time disturbance event detection, classification and localization

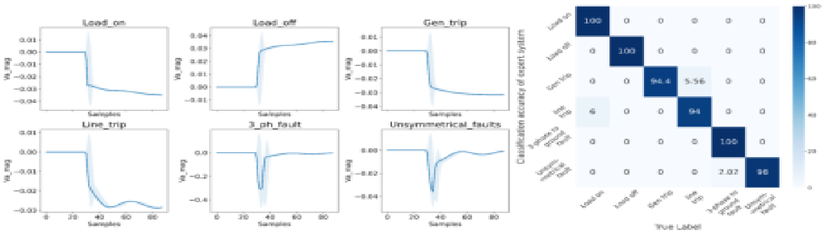

Figure 10. (a) Disturbance Events after pre-processing. (b) Incremental Learning accuracy after classification

Power Systems Vulnerability Analysis

- Vulnerability is a risk level with respect to the occurrence of cascading events. With the decrease (increase) of synchronous (inverter-based) generation, this risk level notably rises.
- By monitoring and quantifying system strength and ADN-impact, dangerous grid states can be detected in real-time, providing the opportunity for preventive WAMPAC measures.

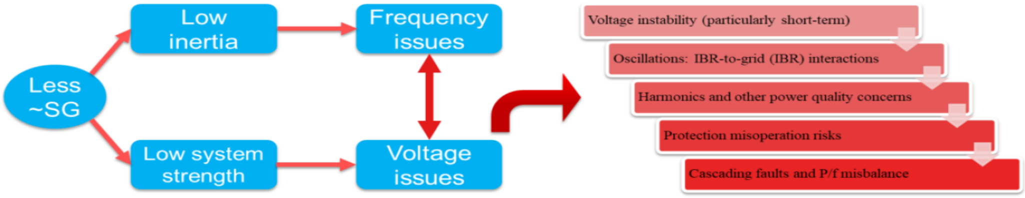

Figure 13. Fundamental system impacts due to the reduction of synchronous generation

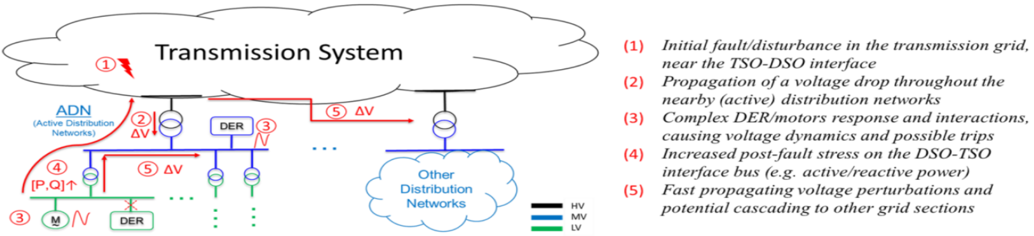

Figure 12. Exemplified impact of Active Distribution Networks (ADN) on the post-fault resilience