

# Synchronism mechanisms for the real-time observation and protection of active distribution networks

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## Aim of the research

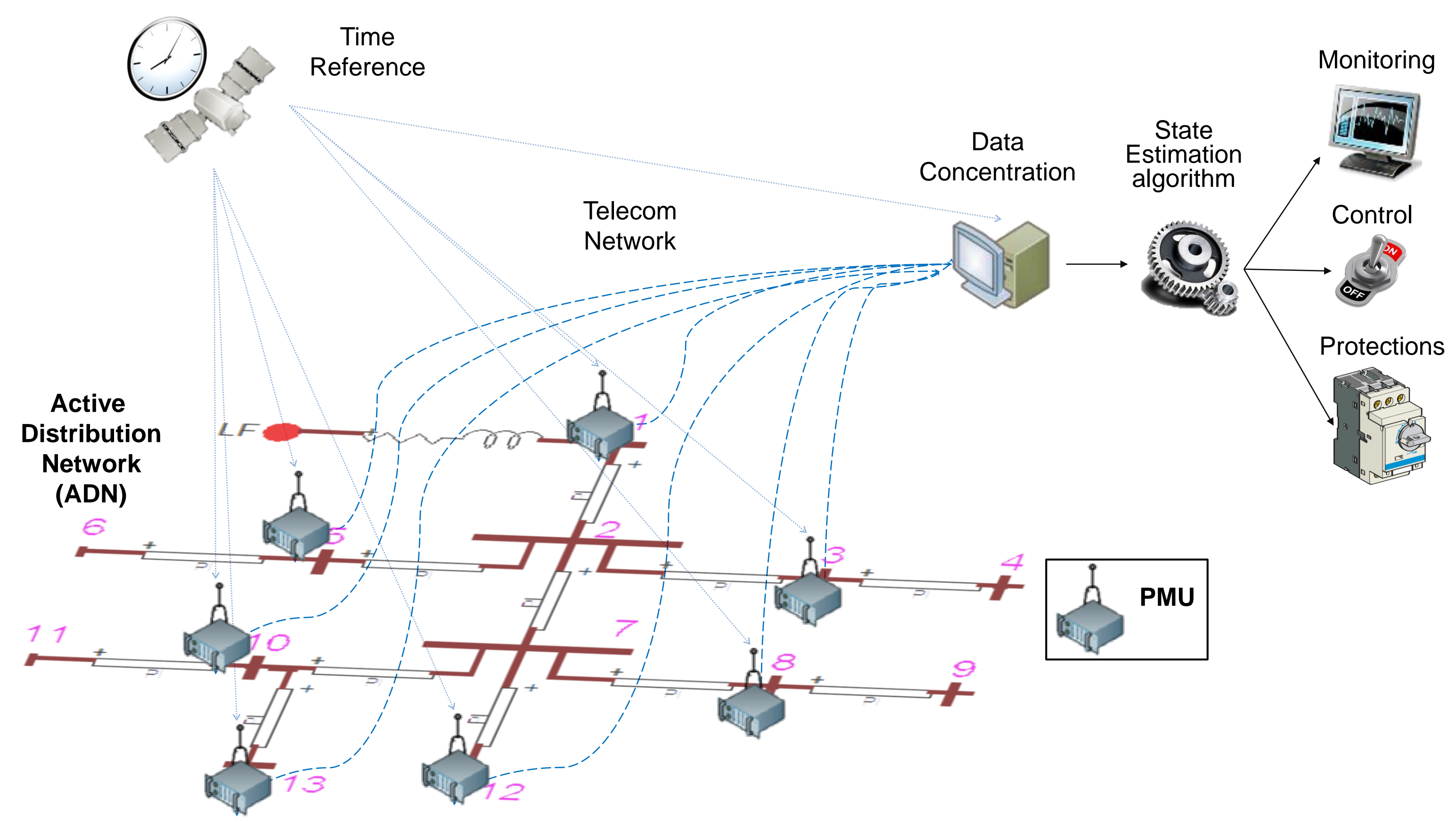
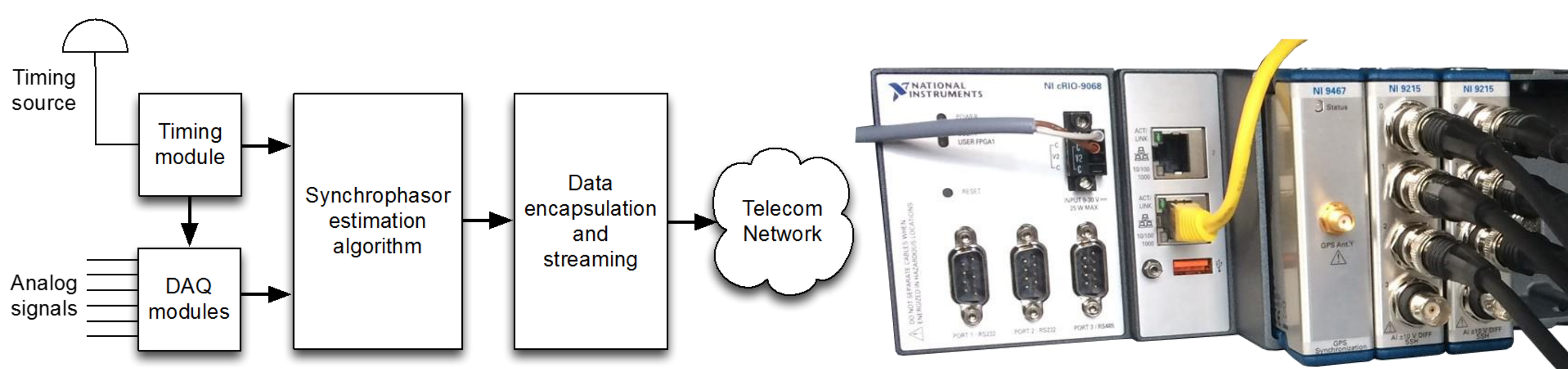
The progressive penetration of renewable energies in electrical distribution networks calls for a large deployment of advanced monitoring tools in order to allow the network operators to manage the increasing complexity of the electrical systems. The purpose of this research is to enable an optimal control of the network condition during normal operations and then successfully continue the network management even during emergency conditions. Since the target is protection and control of the network, the decisions have to be taken in real-time.

## PMU-based monitoring and their synchronization

The network monitoring is based on Phasor Measurement Units (PMUs). PMU: device that produces synchronized measurements of phasor and frequency from voltage and/or current signals based on a common time source (typically GPS).

The research focuses on:

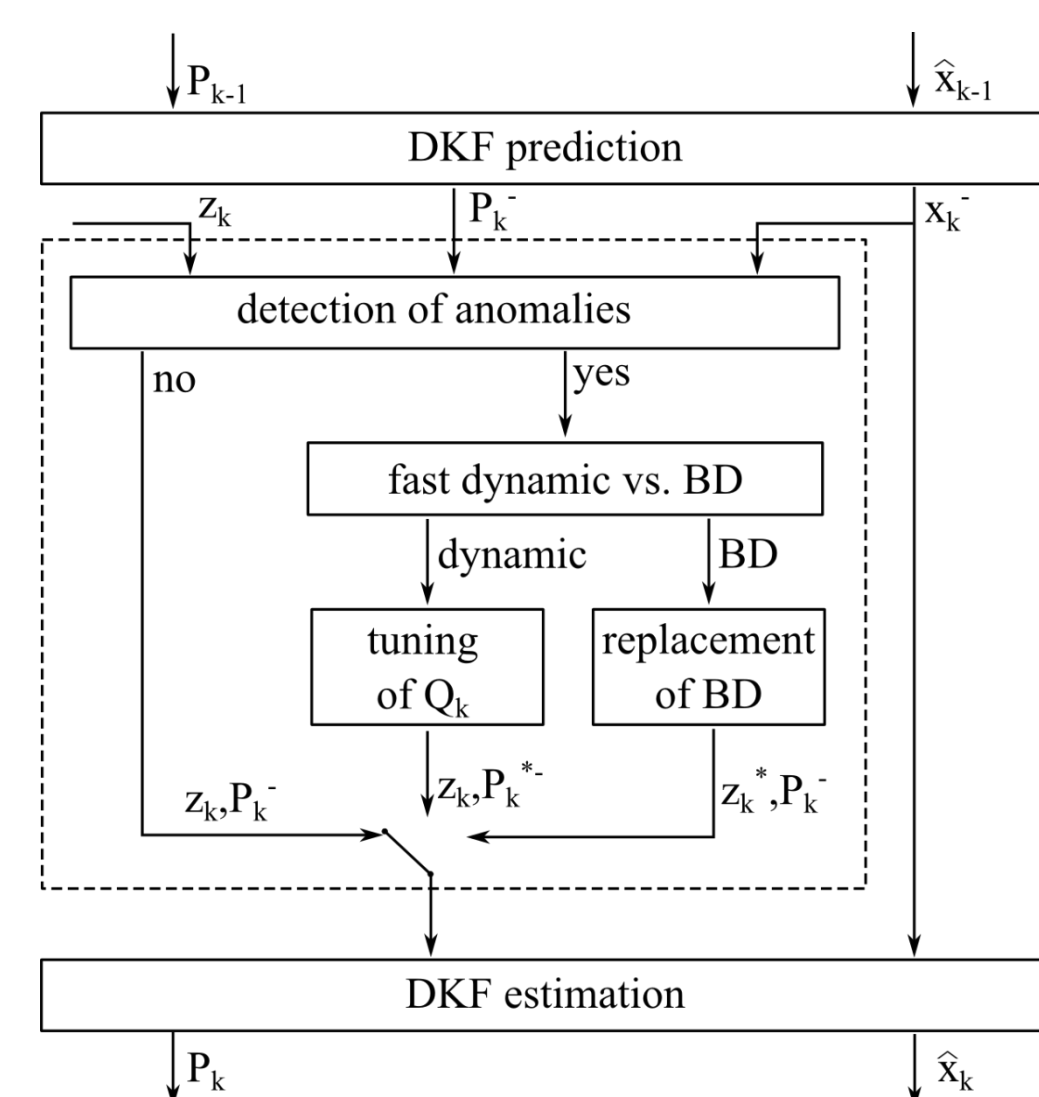
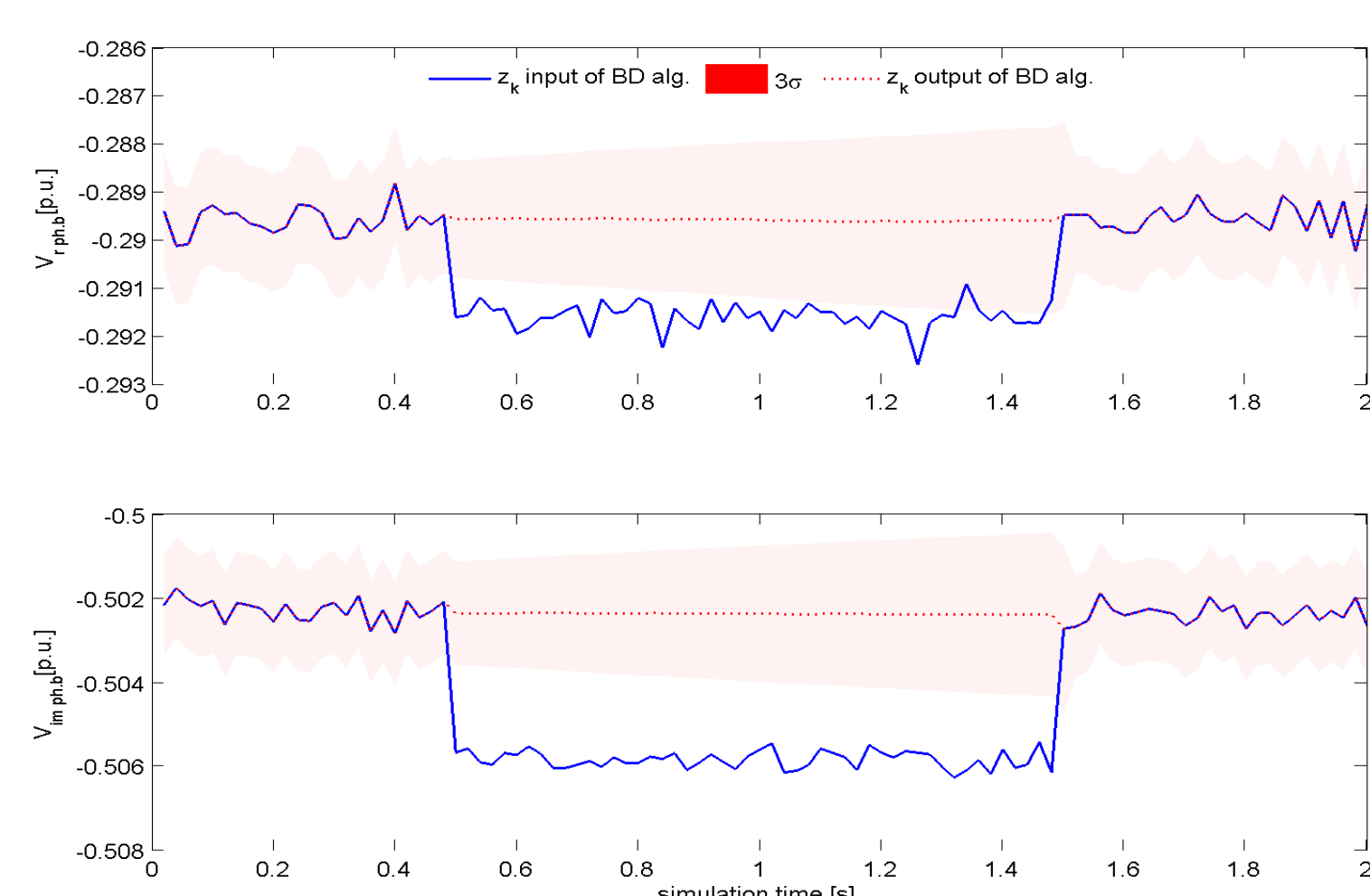
- development of enhanced algorithms for the synchrophasor estimation;
- study of robust and GPS-independent time synchronization methods for PMUs.



## Phasor Data Concentration and Bad Data analysis

The data streamed from different PMUs are received in a Phasor Data Concentrator (PDC). The PDC decapsulates, time-aligns and forwards the data to upper layer applications with the minimum delay.

An algorithm to identify Bad Data (e.g., missing data, wrong measurements due to electromagnetic compatibility, etc.) analyses each set of incoming information. In case a BD is identified, proper countermeasures are taken.



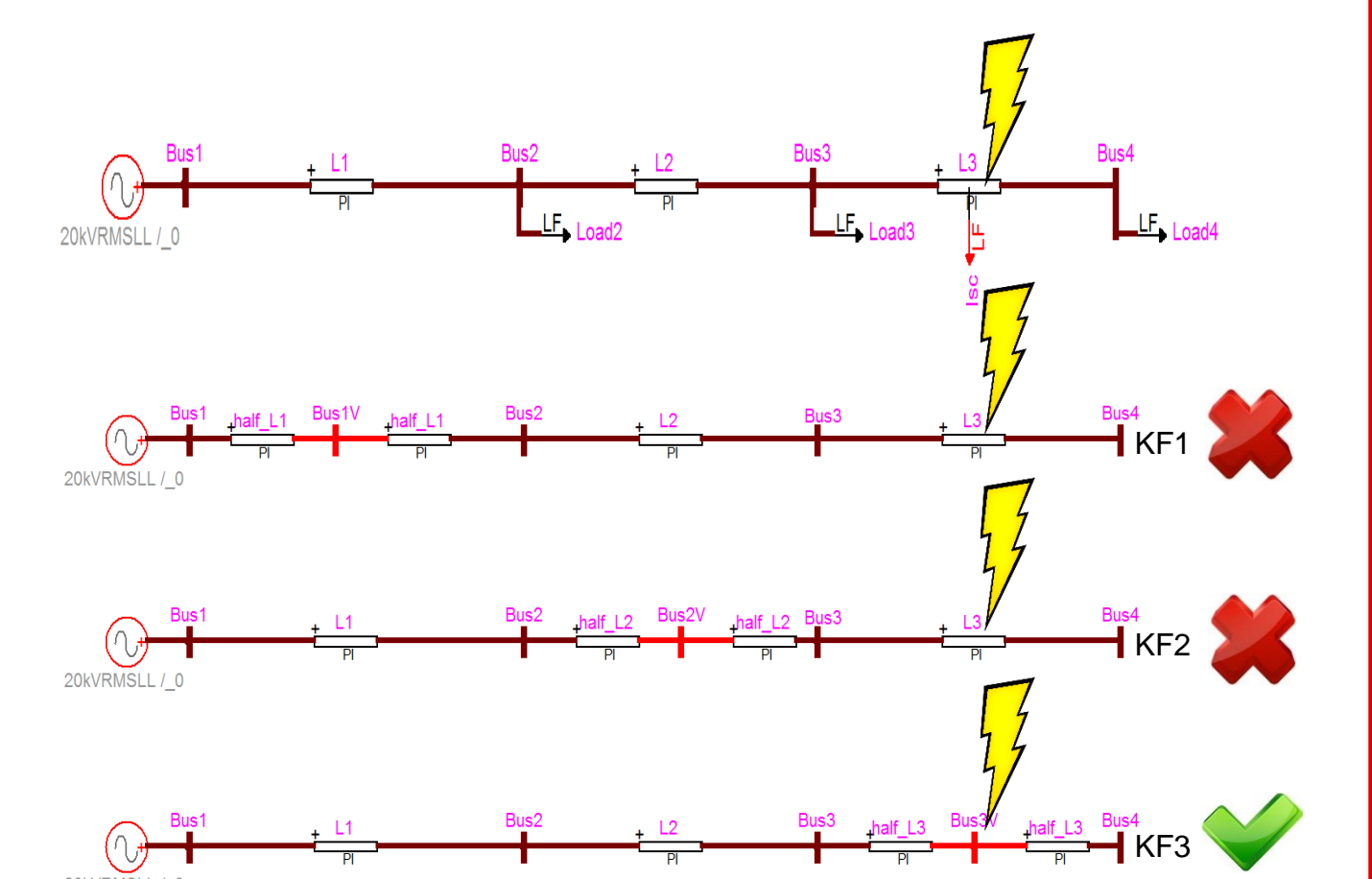
## Applications

The state of the electrical network (i.e. the voltage phasors in every bus), is estimated by means of a state estimation algorithm that runs in real-time every 20ms.

Based on the estimated state, several applications can be developed to help the system operation in normal and emergency network conditions

### Fault identification and location:

The algorithm is based on the concept of *virtual protections*. Dedicated protection devices are substituted with a centralized algorithm that detects the fault and takes decisions.



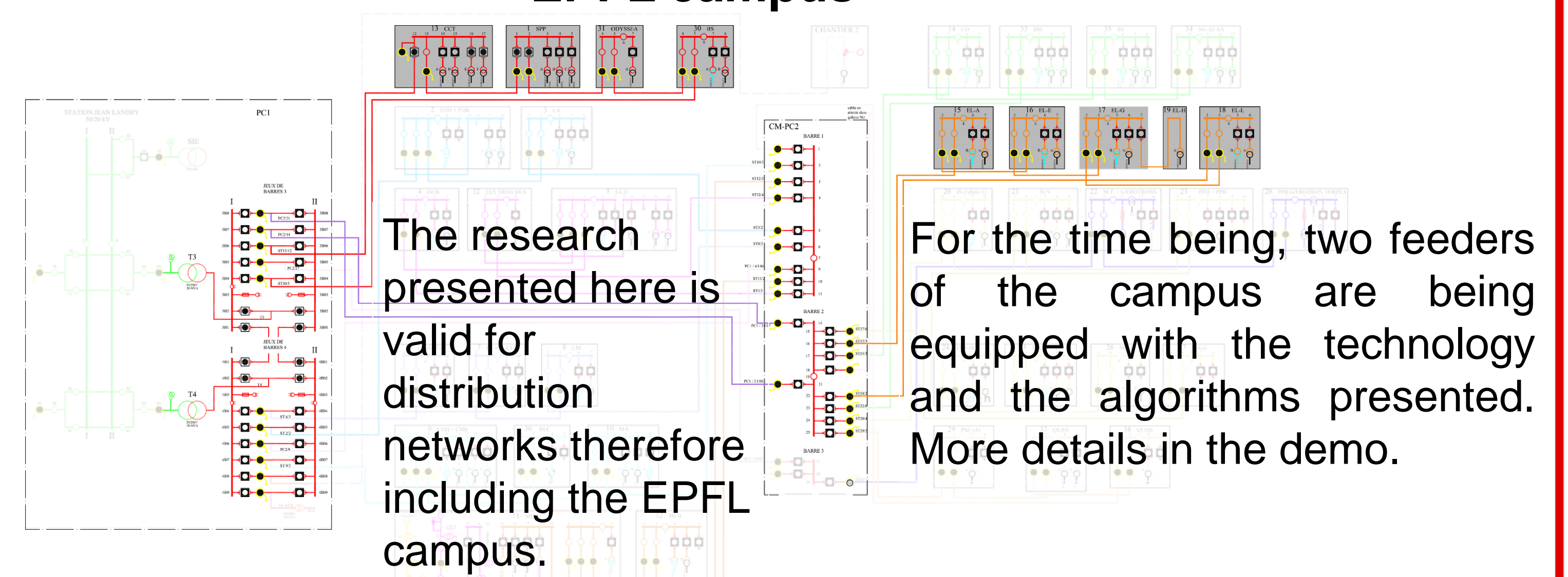
## Experimental validation

### Simulated networks



The algorithms that require the network to be in particular and non-desirable conditions (fault location, GPS attacks, etc.) are firstly tested by using a real-time digital simulator (RTDS). It allows the simulation of the network in any condition generating scaled analog output of the physical phenomena in real-time. PMU prototypes and all the chain described above can then be physically connected to the RTDS and tested.

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### References

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- M. Pignati, L. Zanni, S. Sarri, R. Cherkaoui, J-Y. Le Boudec, M. Paolone, "A Pre-Estimation Filtering Process of Bad Data for Linear Power Systems State Estimators using PMUs", accepted for presentation at the Power System Computation Conference (PSCC), Wroclaw, PL, Aug. 18-22, 2014.
- M. Paolone, M. Pignati, P. Romano, S. Sarri, L. Zanni, R. Cherkaoui, "A hardware-in-the-loop test platform for the real-time state estimation of active distribution networks using phasor measurement units," Cigré SC6 Colloquium, Yokohama, Japan, Oct. 7-9, 2013.