NTNU

Kunnskap for en bedre verden

Research on Wide area control and system protection at NTNU

Kjetil Uhlen, 26 May 2021

Outline

- Previous experience
  - Utilization of synchrophasor information for WAMS → 2010
  - Wide area power oscillation damping (WACS) 2011
- (WAMS application research and developments) 2012-2019
- Ongoing research
  - WACS: Adaptive WAPOD using online system identification 2019 →
  - WAPS: System protection with wide area information

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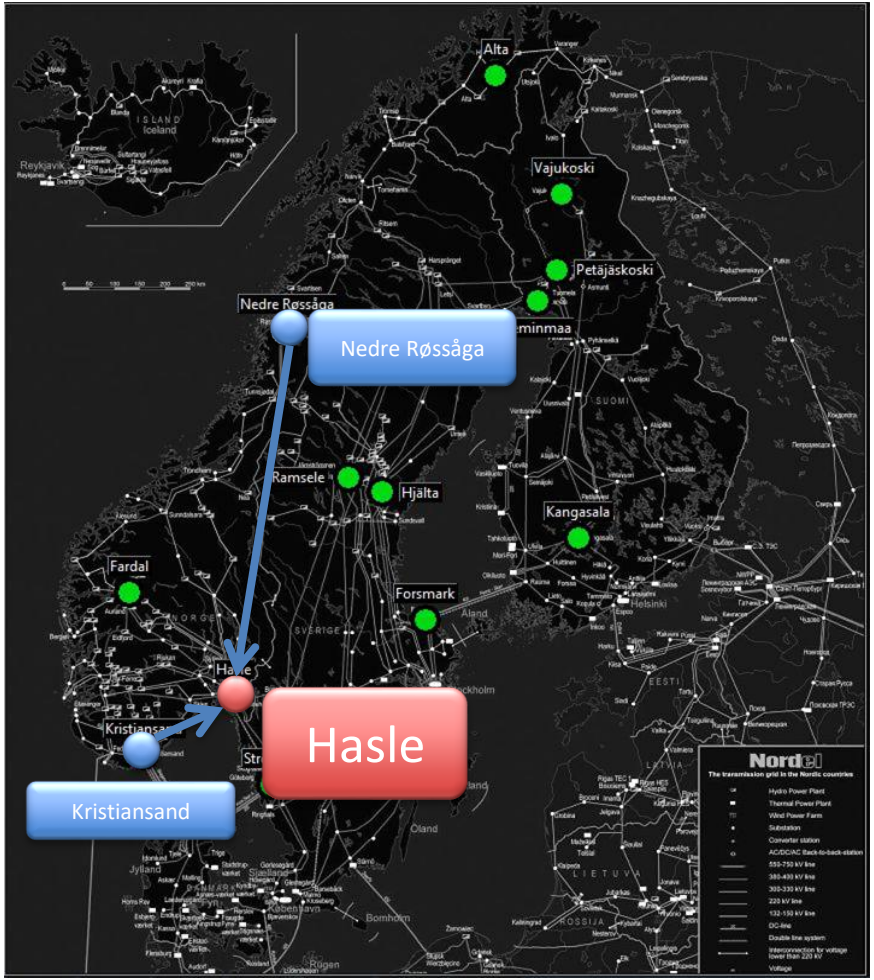
Wide area measurements *for POD Control*

- PMUs streaming phasors from:
  - Nedre Røssåga
  - Kristiansand
- SVC Located at Hasle
  - PDC receiving voltage phasors
    - Extracts voltage phasor angle
  - ABB Mach2 Controller
    - Local control
    - WAPOD Control
    - Switch-over logic



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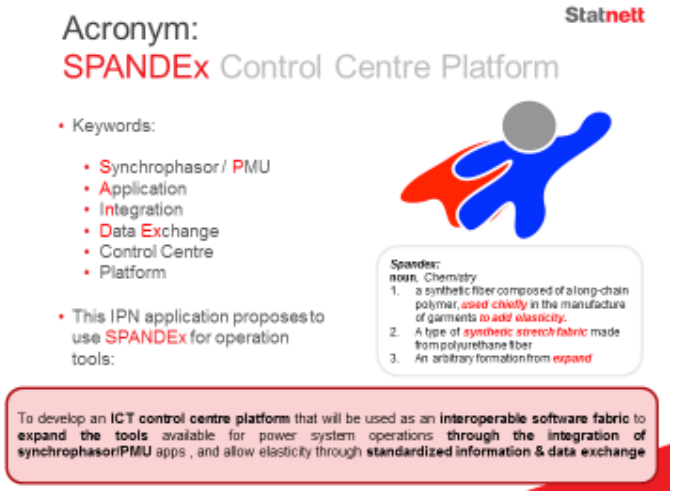
“The future control centre”

..tidligere FoU-aktiviteter

Nordic R&D collaboration

Statnett pilot project



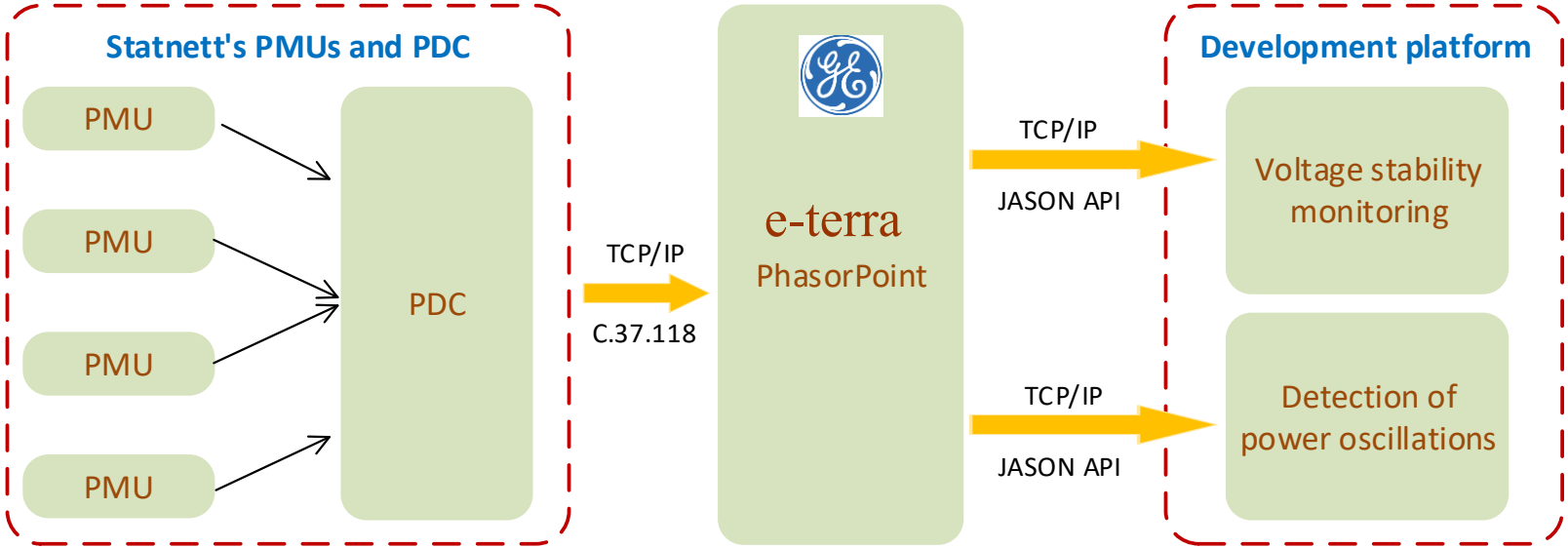
Controlling the grid:

Increased complexity requires better information and more automation!

- We need:
  - «full» awareness of the process
  - "full» control of the process
    - In all states…
    - From normal operation to extreme disturbances
    - At all times....

Spandex

Development platform for new control room applications



8

Spandex

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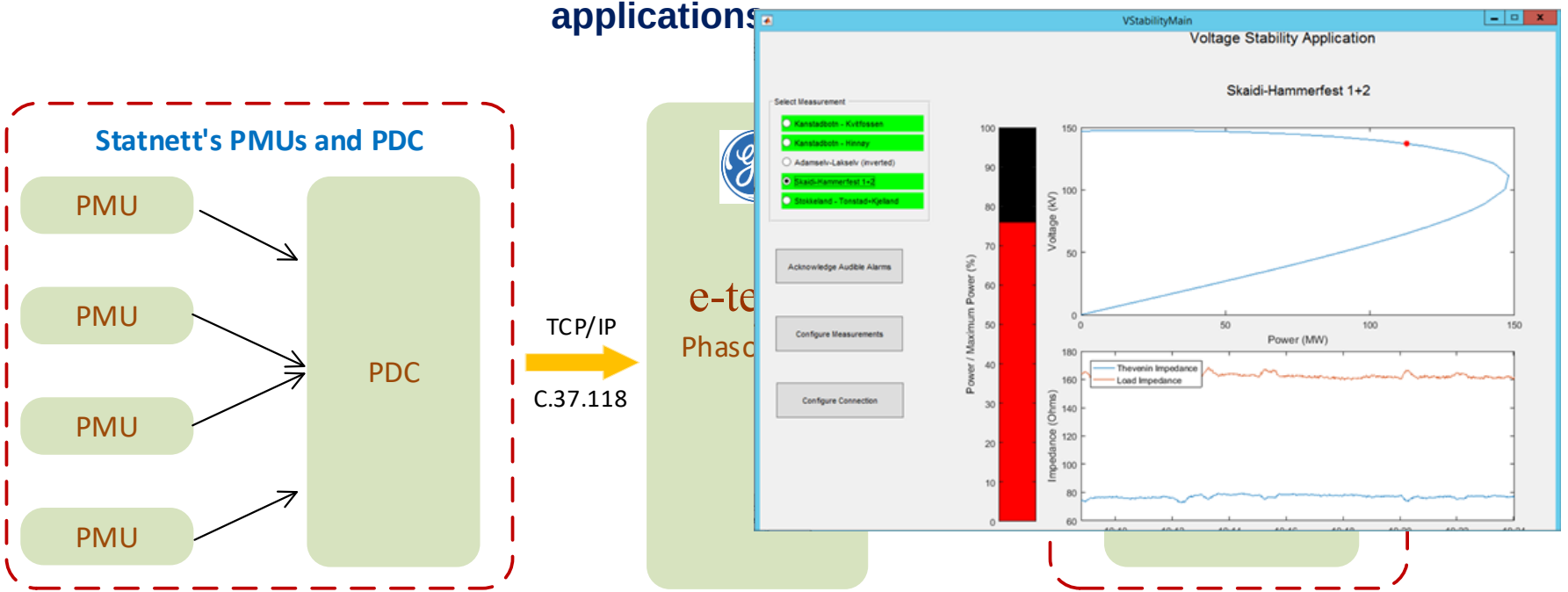

9

Spandex

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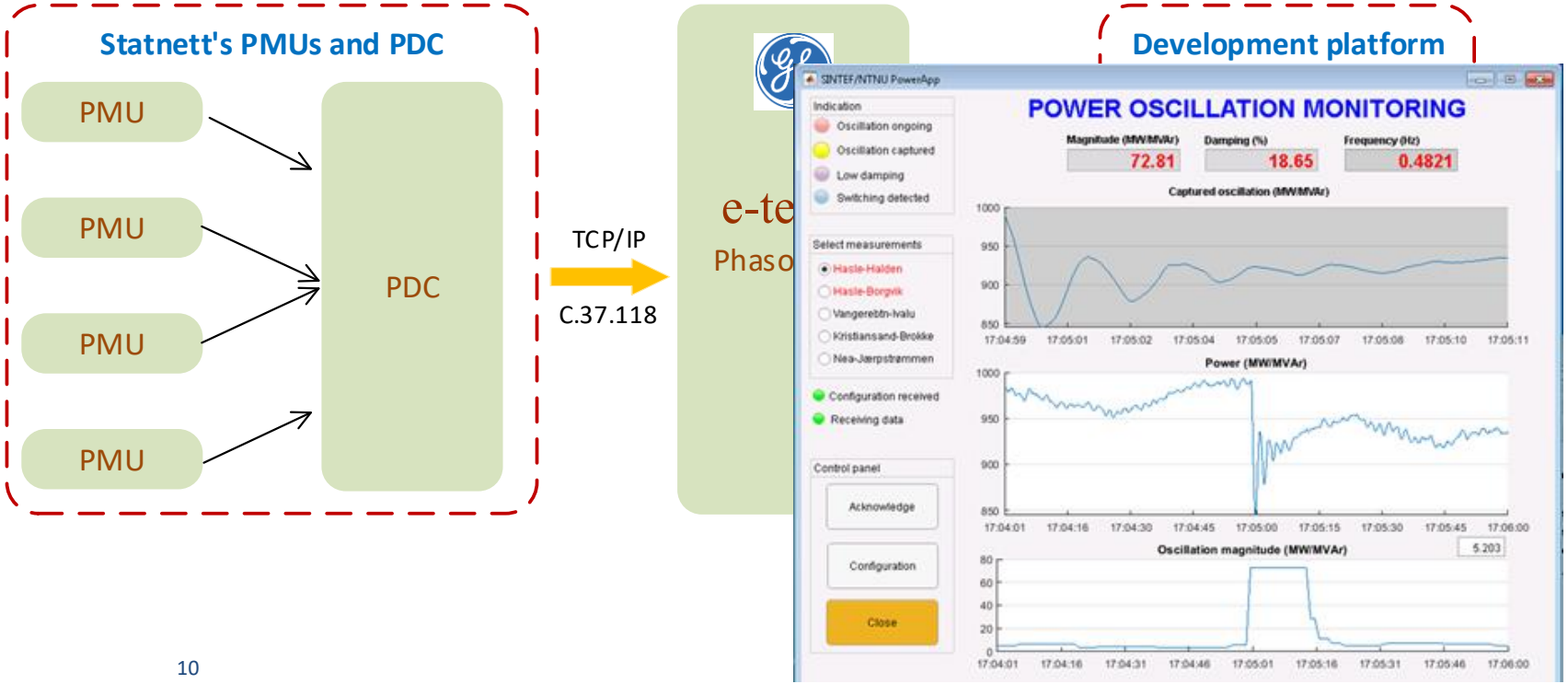

10

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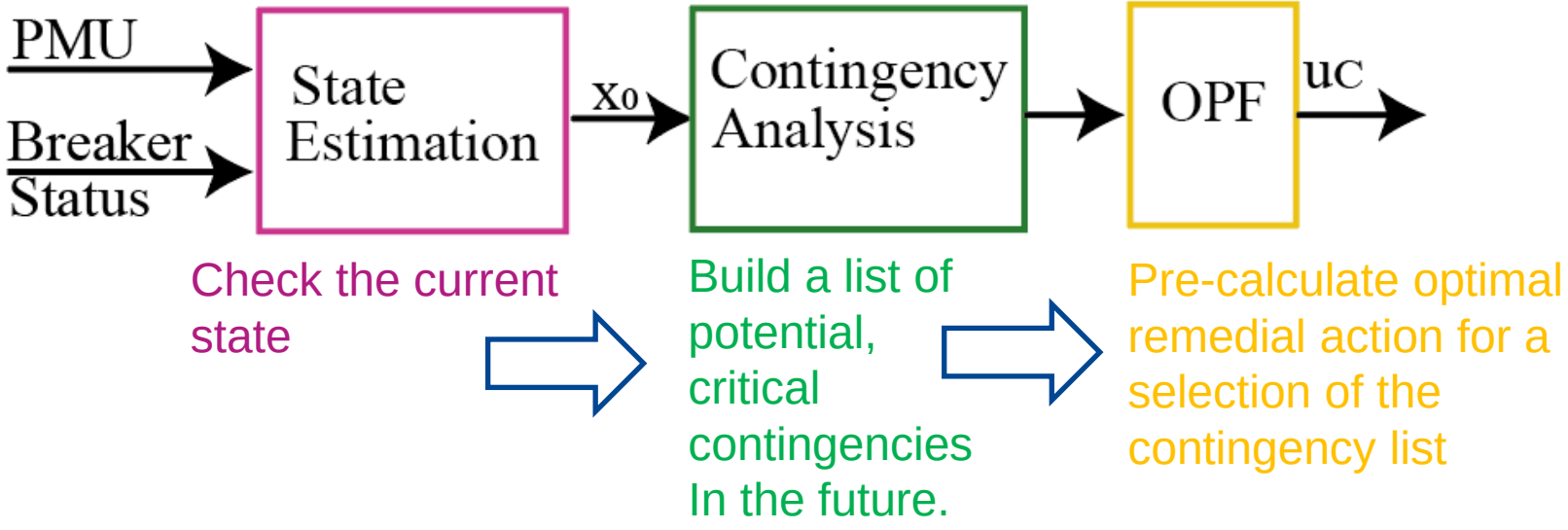
System Protection Schemes (SPS)

Motivation: Most of installed SPS are rather response based (pre-defined action for a predefined event) [1]. The objective is to design them more adaptive with a mathematically proofed optimal control action.

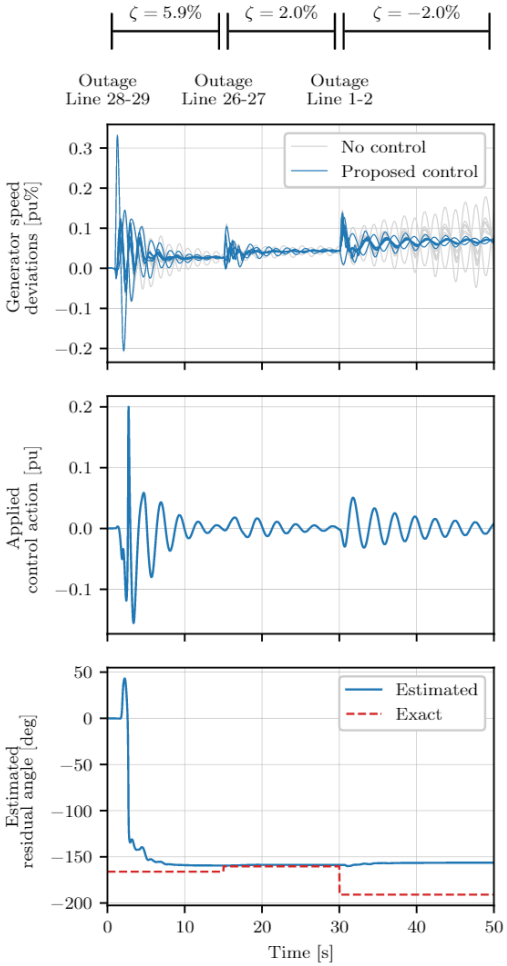


[1] E. Hillberg, F. Trengereid, Ø. Breidablik, K. Uhlen, G. Kjølle, S. Løvlund, & J. O. Gjerde, (2012). System integrity protection schemes – increasing operational security and system capacity. Paris: CIGRE.

Adaptive Power Oscillation Damper

- Estimate optimal phase compensation during changing operating conditions
- Kalman Filter estimator

Conv. Phasor POD + State Space Theory ⇨ Adaptive Phasor POD

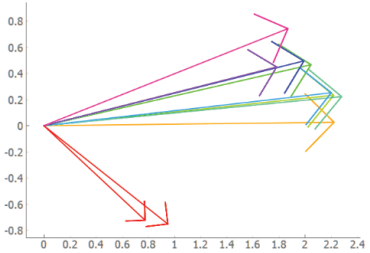


Simulation tool in Python

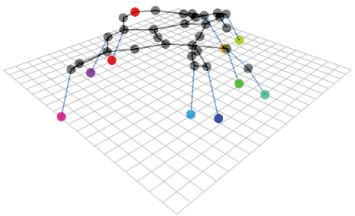
for testing of WAMPAC Applications

- «Real-time» simulation
- RMS quantities
- C37.118

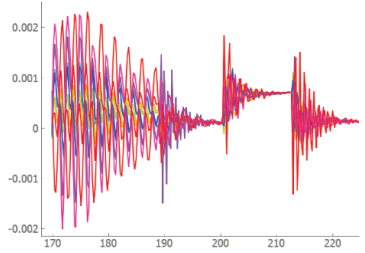
Phasor plot



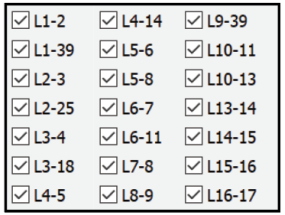
Grid plot



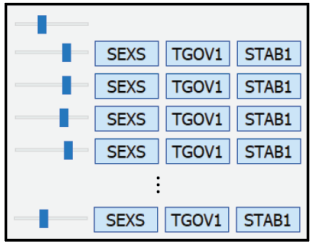
Time series plot



Line control



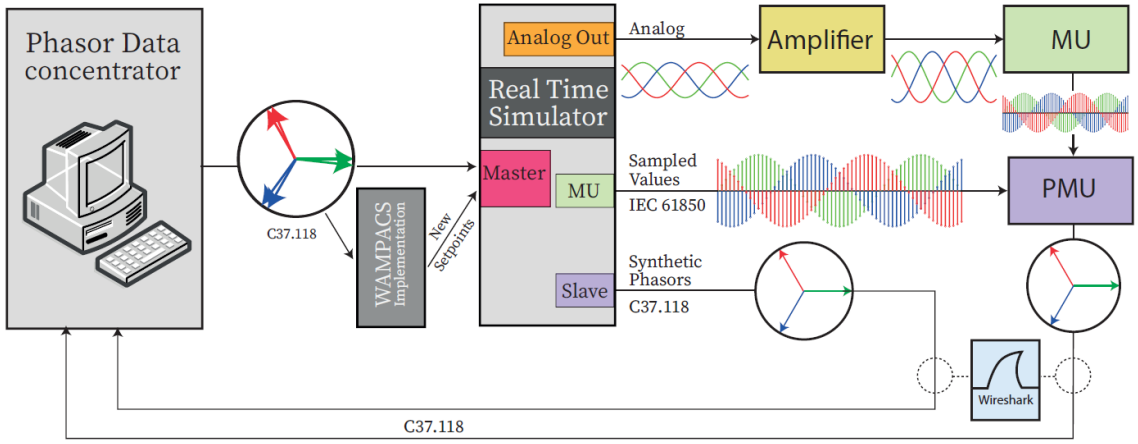
Generator controls



Event log

```
t=175.6s: PSS on G8 activated.
t=176.0s: PSS on G9 activated.
t=188.9s: Line 2-25 connected.
t=200.4s: Line 2-3 disconnected.
t=212.7s: Line 2-3 connected.
```

Laboratory Work

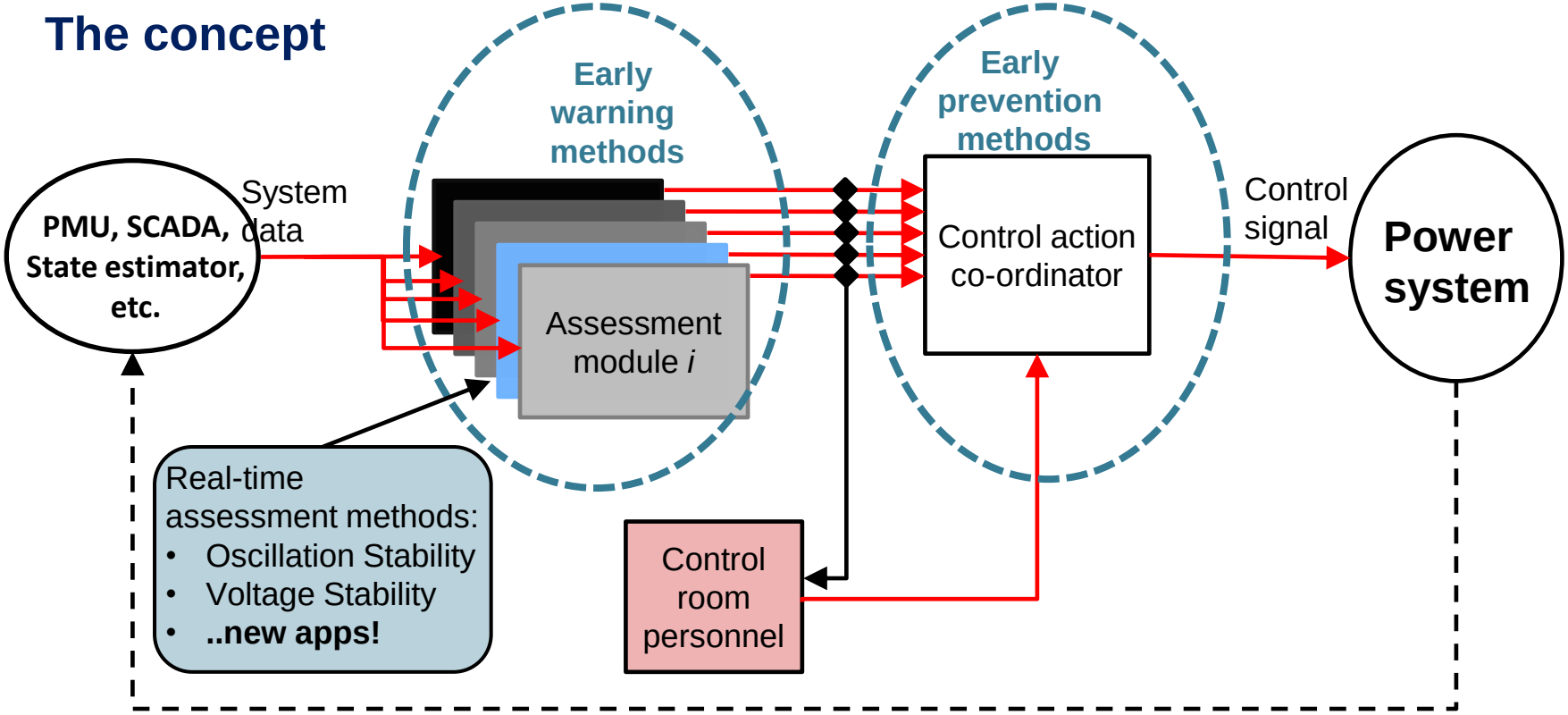


Description:
Characterization of the different approaches how PMUs can be included in our real-time setup.

Purpose:
Evaluate the different paths regarding their behavior (e.g time delay).

Objective:
Identify how these differences influence a potential application.

New Nordic R&D project:

NEWEPS - Nordic Early Warning Early Prevention System

The concept