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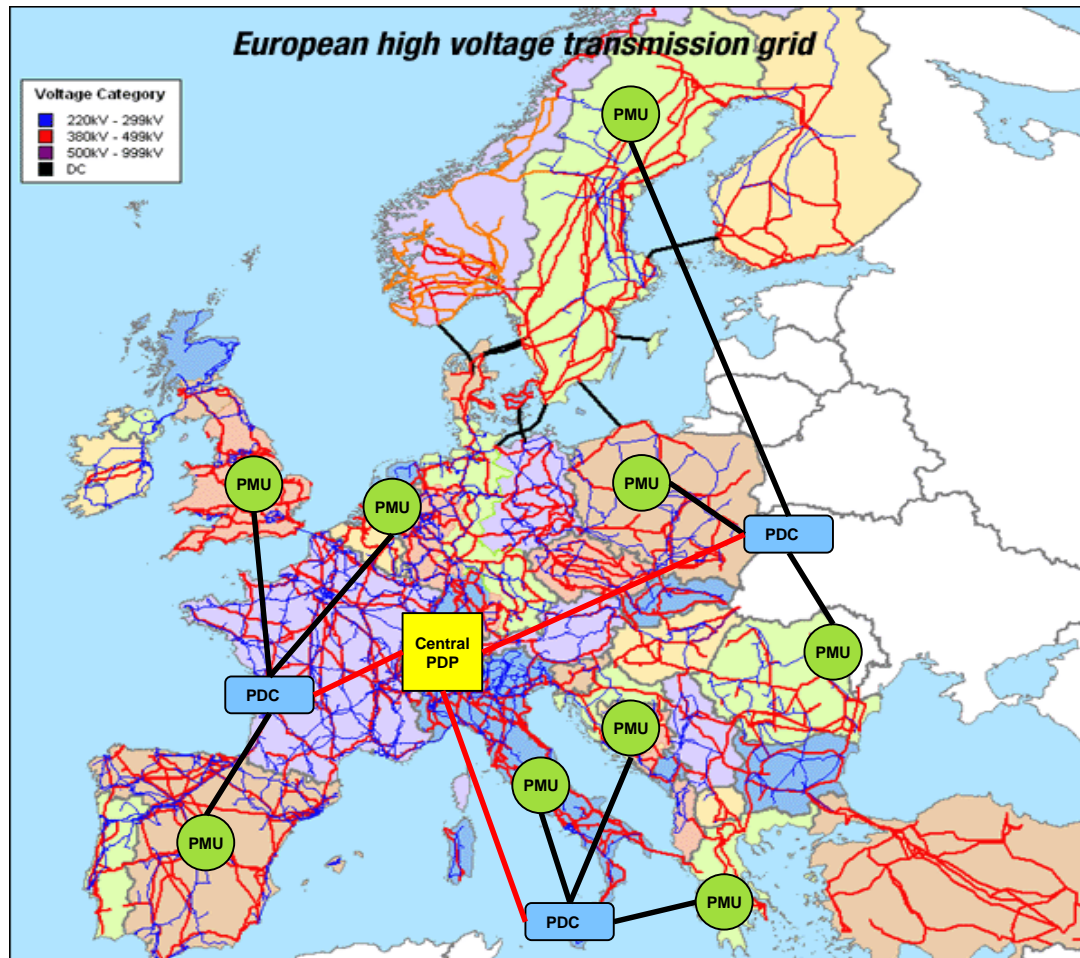
Synchrophasor Systems for Power System Monitoring and Control

Mihai Gavrilaş

"Gheorghe Asachi" Technical University of Iaşi

What are Synchrophasor Systems ?
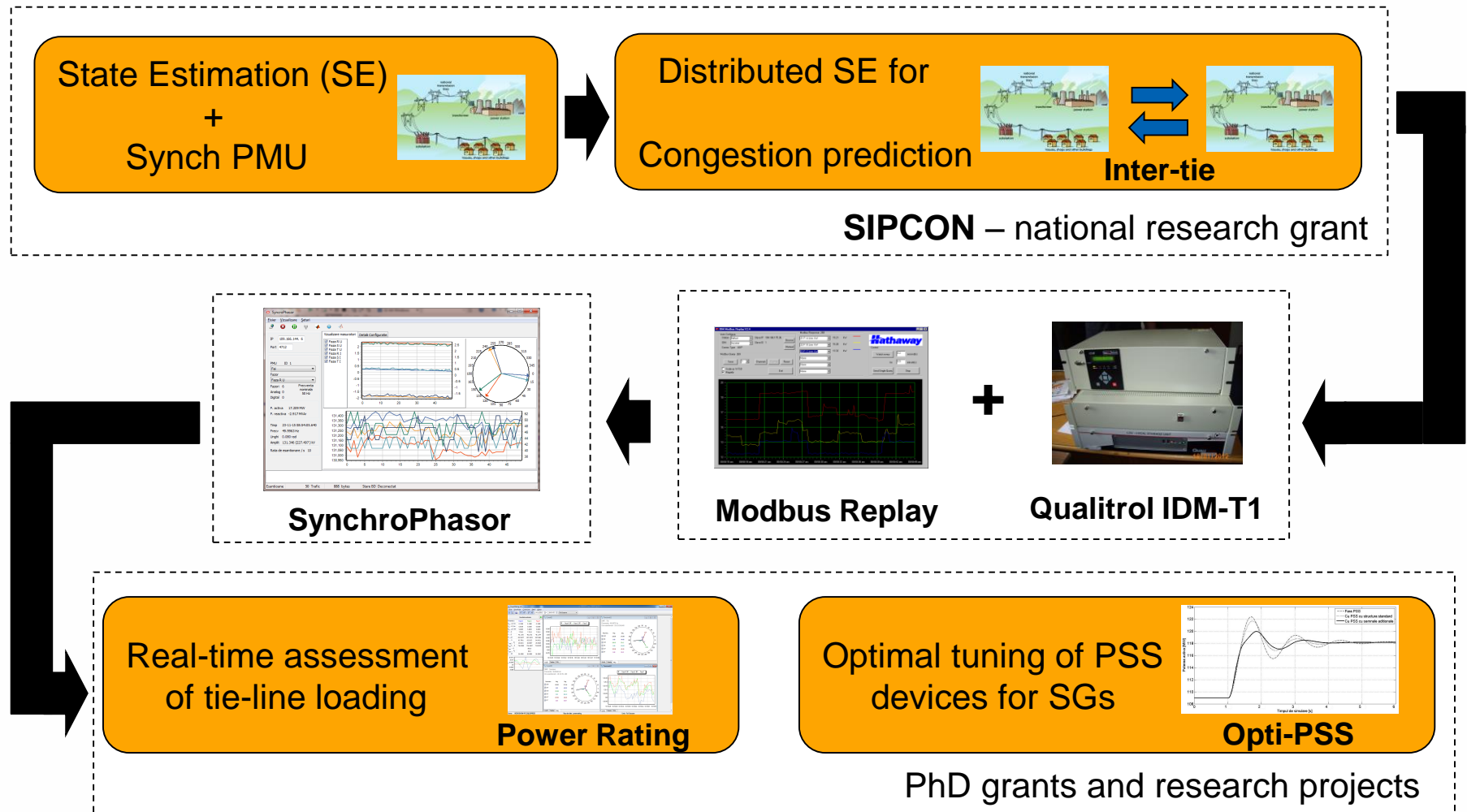

European high voltage transmission grid

- Electronic measurement equipment synchronized by GPS with other similar equipments to produce synchronized phasors.
- They can be used in electricity transmission and distribution networks, mainly for real-time monitoring and control.

PMU – Phasor Measurement Unit; **PDC** – Phasor Data Concentrator; **PDP** – Phasor Data Processor

Sumarry

This presentation is a review of the results obtained by a group of researchers at the Power Systems Department at "Gheorghe Asachi" Technical University of Iasi in the field of Synchrophasor applications in power system monitoring and control.

Application 1: Enhanced State Estimation using PMUs

Buses:27		Lines:31		Genera-tors	Trans-formers
400 kV	220 kV	400 kV	220 kV	1	4
15	12	20	11		

Buses	WLS classic		Errors [%]		WLS + PMUs		Errors [%]	
	U [kV]	θ [grd]	ε_U	ε_θ	U [kV]	θ [grd]	ε_U	ε_θ
Gutinas 400 kV	413.884	0.000	1.11	0.00	412.117	0.000	0.67	0.00
Barbosi 220 kV	233.256	1.904	0.94	3.16	232.382	1.914	0.56	3.74
Cernavoda 400 kV	412.902	8.114	0.90	1.50	411.487	8.168	0.56	0.84
Dumbrava 220 kV	233.692	-1.867	1.28	2.05	232.365	-1.885	0.70	1.11
Focsani 220 kV	234.804	-0.753	1.05	6.34	233.836	-0.761	0.64	5.35
G. Ialomitei 400 kV	412.323	6.204	0.92	1.35	410.893	6.244	0.57	0.70
Iasi 220 kV	234.567	-4.410	0.90	2.75	234.036	-4.443	0.67	3.51
Lacu Sarat 400 kV	412.139	3.912	0.94	0.59	410.689	3.936	0.59	0.03
Medgidia Sud 400	412.446	7.860	0.91	1.41	411.028	7.912	0.56	0.76
Munteni 220 kV	234.901	-3.880	1.13	2.10	233.880	-3.915	0.69	1.23
Pelicanu 400 kV	409.543	5.340	0.94	0.85	408.098	5.374	0.58	0.21
Smardan 400	411.702	3.356	0.84	1.40	410.288	3.377	0.49	0.77
Suceava 220 kV	233.550	-4.608	0.90	2.51	233.017	-4.642	0.67	3.25
Suceava 400 kV	402.981	-1.777	1.11	2.34	401.259	-1.794	0.68	1.41
Vulcanesti 400 kV	417.037	4.028	1.23	3.72	415.775	4.054	0.92	3.10

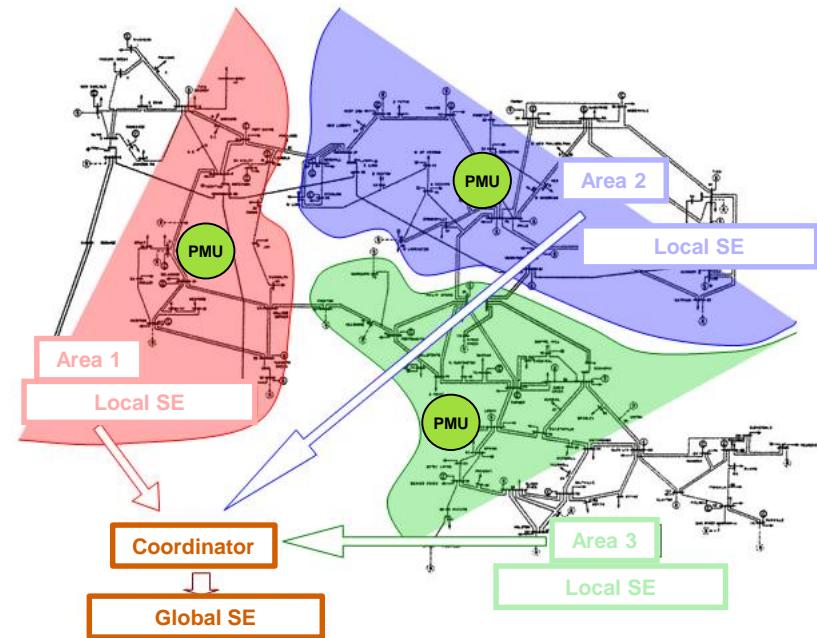|								
	max.	1.34	6.34				0.92	5.35
	min.	0.84	0.00				0.49	0.00
	mean	1.02	2.20				0.64	1.75

Approach:

- The whole system is divided into subsystems/areas.

- Each subsystem makes its own local SE.

- A coordinating entity synchronizes results to estimate power flows on the tie-lines and to obtain the overall SE.

Benefits:

- Convenient method considering competitive electricity markets

- It reduces the computational effort

- Each subsystem can use independently its own SE algorithm.

Purpose:

To estimate the power flows on the tie-lines between subsystems to forecast congestion.
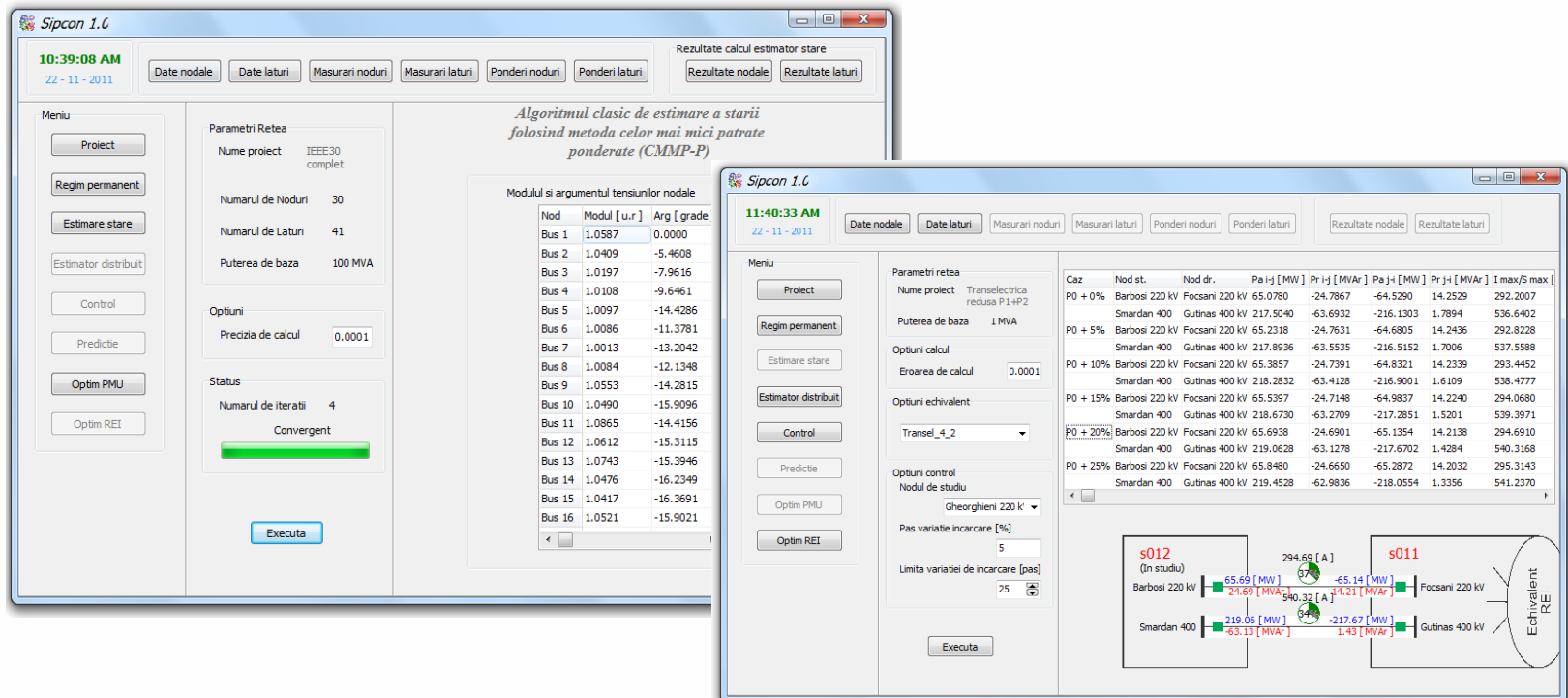

Subsystems can be modelled using REI (Radial, Equivalent, Independent) equivalents.

Application 3: SIPCON

Intelligent System for Congestion Prediction and Control in Transmission and HV Distribution Networks

– State Estimation w/wo Synchrophasors.

– Construction and optimization of REI network equivalents w/wo Synchrophasors.

– PMU placement optimization to improve State Estimation accuracy.

– Distributed State Estimation for congestion prediction on the tie-lines between subsystems.

– Advanced GUI + Graphical & Numerical data visualization + Advanced MS SQL data base storage.
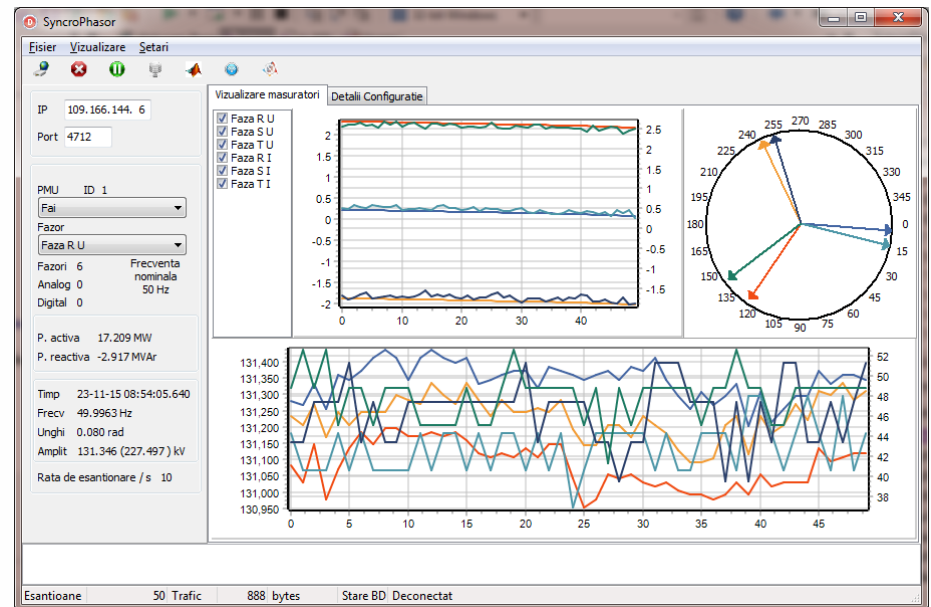
Application 4: SynchroPhasor vs. Modbus Replay

Digital Fault Recorder Qualitrol IDM-T1 with PMU capabilities

Modbus Replay interface and communication software with limited capabilities has been replaced with a software tool developed independently - **SynchroPhasor**.

- Based on IEEE C37.118-2011 communication standard.

- Data storage capabilities based on MS SQL database technology.

- Advanced GUI and data visualization.

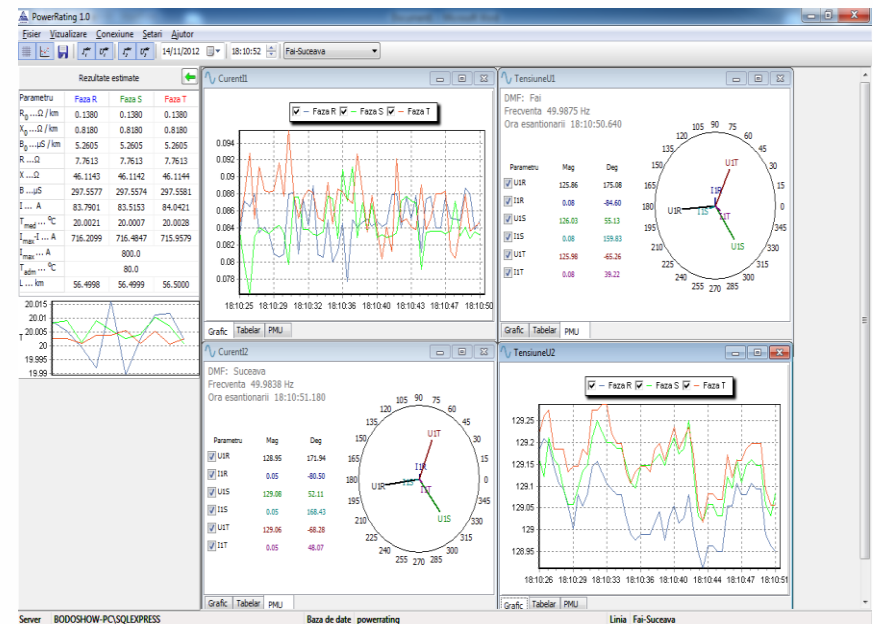- Matlab-Simulink and DIgSILENT-PowerFactory communication capabilities.

Application 5: PowerRating

Since the electrical ampacity rating of an overhead transmission line varies with real-time environmental conditions (temperature, wind speed, sunshine and cloud cover etc), it is possible to apply a controlled line overloading procedure.

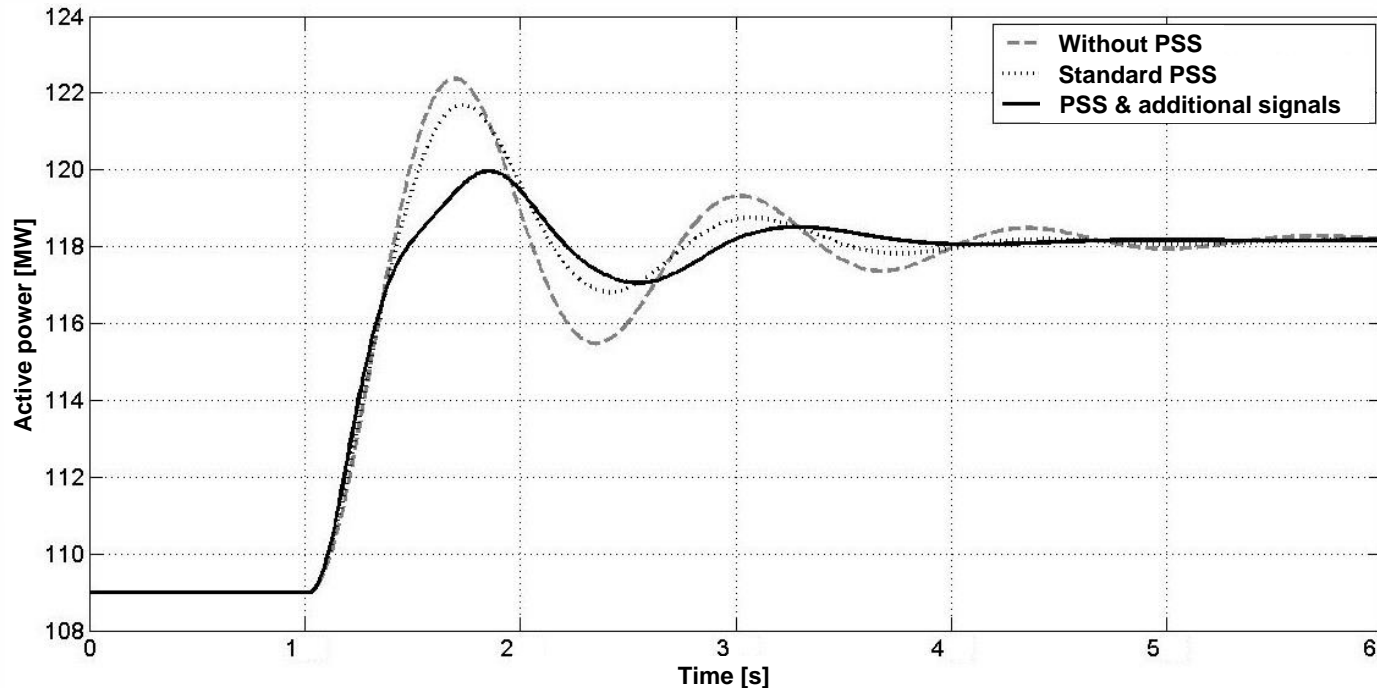**PowerRating** – the real-time assessment of the thermal loading capability of overhead electric lines.

This tool uses measurements from PMUs located at the two ends of the line to estimate the actual parameters of the line and to determine the available transmission capability for momentary weather and network loading conditions.

Application 6: Opti-PSS

PSS (Power System Stabilizer) is used to enhance the damping of rotor angle swings and/or electro-mechanical oscillation of SGs. PSS is a supplemental control component in the Automated Voltage Regulation loop of the SG.

PSS performance can be enhanced if additional information (active power, rotor angles, rotor speed, frequency, voltage phasors etc) is fed to the PSS input from remote locations. This information can be provided by Synchrophasor systems.

Conclusions & Further work

Synchrophasor systems are increasingly present in the electricity transmission and distribution networks worldwide.

The availability of voltage / current synchrophasors in a network enables us to increase accuracy of existent methods or to imagine new methods and approaches for the performant monitoring and control of the grid.

Results produced by researchers at the Technical University of Iasi led to the development of strong and effective algorithms focused on these areas of interest.

Further work: applications of Synchrophasor systems in distribution network.

Thank you for your attention!

Contact:

Mihai Gavrilas

Power Systems Departement
"Gheorghe Asachi" Technical University of Iasi
21-23 D. Mangeron Blvd., 700050 Iasi, Romania

E-mail: mgavril@tuiasi.ro