IEEE PES General Meeting 2007, Tampa, Florida, USA

Session on Ancillary Services. 26 June 2007

Impact of non Coordinated MVAr Scheduling Strategies in Multi Area Power Systems

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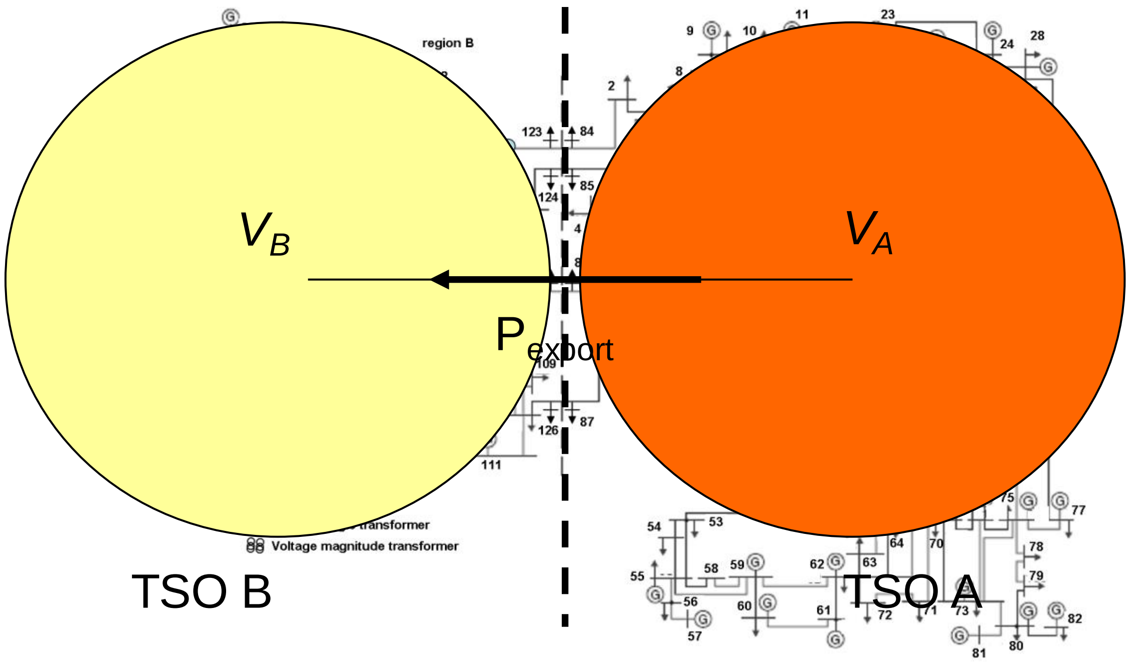
Motivations

- **Problem:** steady state optimization of multi area power systems
- **Focus:** MVAr Scheduling in multi area power systems



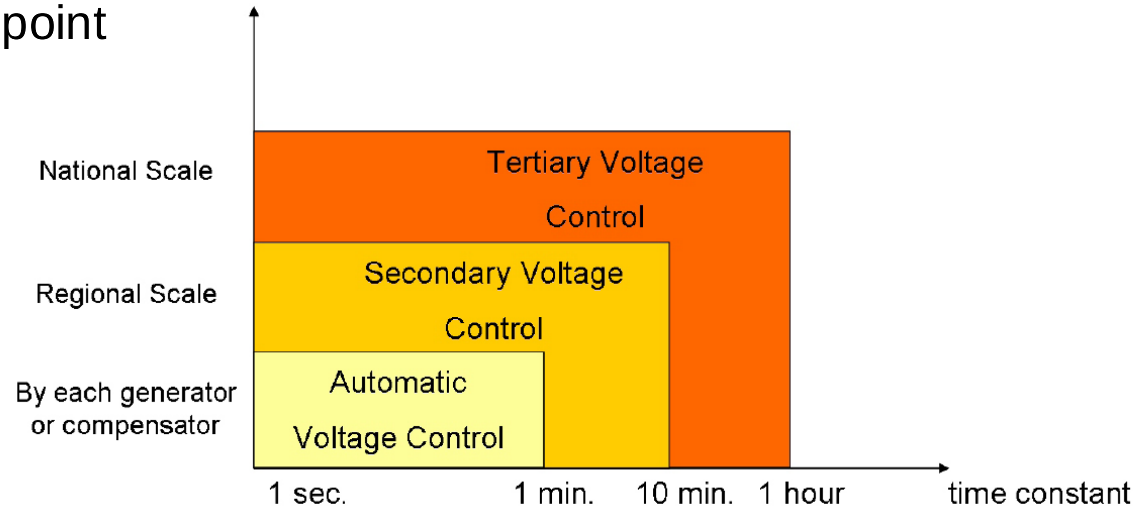
- **Issue:** influence of one TSO's strategy on the other TSOs

MVAr scheduling

- TSOs must assure transmission despite **continuous changes** in the electric power system
- A TSO **controls**:
  - Generator **voltage** set point
  - Compensator **voltage** set point
  - Tap **settings**
- Time space separation

  for **hierarchical**

  voltage control



Strategies for MVAr scheduling (1/2)

- **Steady state** optimization
- Each TSO faces an **optimal power flow problem** : it could be solved manually or by computing a solution of the OPF
- **Parameters**:
    - Active and reactive power demand
    - Active power injections
- **Control Variables**:
    - *V*, for PV-buses.
    - Tap amplitude and phase

Strategies for MVAr scheduling (2/2)

- **Constraints**
  - Load flow equations
  - Min/Max values for *V* and *Q*
- **Objective function**
  - Active Power Losses
  - Reactive power support
  - Other kind of objectives: voltage profile, voltage stability

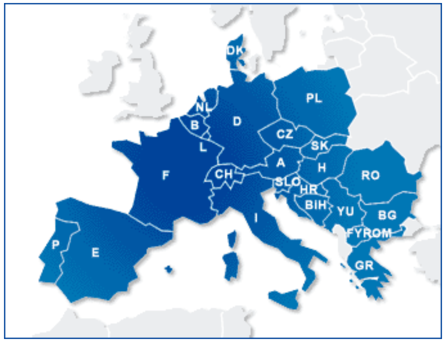
$$C_{Plosses}(\mathbf{u}) = \sum_i |P_{Gi} - P_{Di}|$$

$$C_{Qsupport}(\mathbf{u}) = \sum_i |Q_{Gi}|$$

MVAr scheduling in a multi area power system

- **Tertiary Voltage Control = local optimization**
  - Local objective
  - Partial knowledge of the system
- **Issues:**

1. What is the **impact of this local optimization** in face of a global optimization?
2. What kind of **coordination** is possible?
3. What would be the **effect on a large scale system** such as UCTE for example?



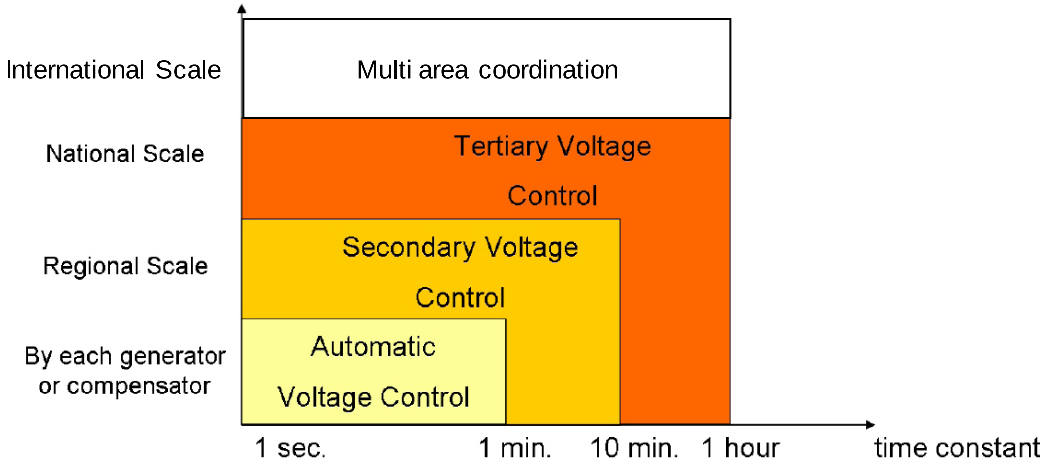
UCTE system

Centralized optimization scheme

- **Serves as a reference** to evaluate the efficiency of decentralized control schemes
- But **non realistic** because it assumes:
  - **Perfect** knowledge of the state of the entire system
  - **No conflict** among objectives of VAr control of participating TSOs
- New **OPF problem** similar to local MVAr scheduling with:
  - A global objective function
  - Same constraints
- Plus a **new economic constraint**:
  - Active power exports

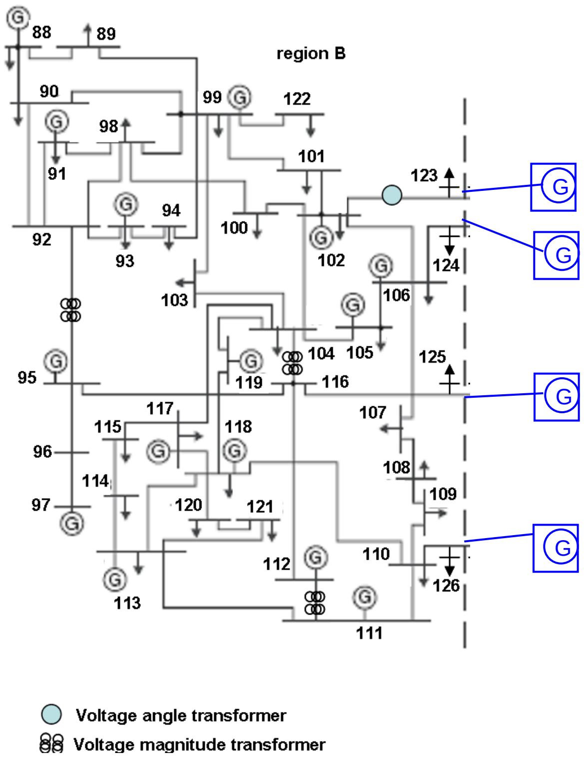
Decentralized optimization scheme (1/5)

- **Problem faced by each TSO**
  - Have their own objective function
  - Must assure active power exchanges with other TSOs
  - At a satisfactory cost/security
- **A higher level of voltage control**



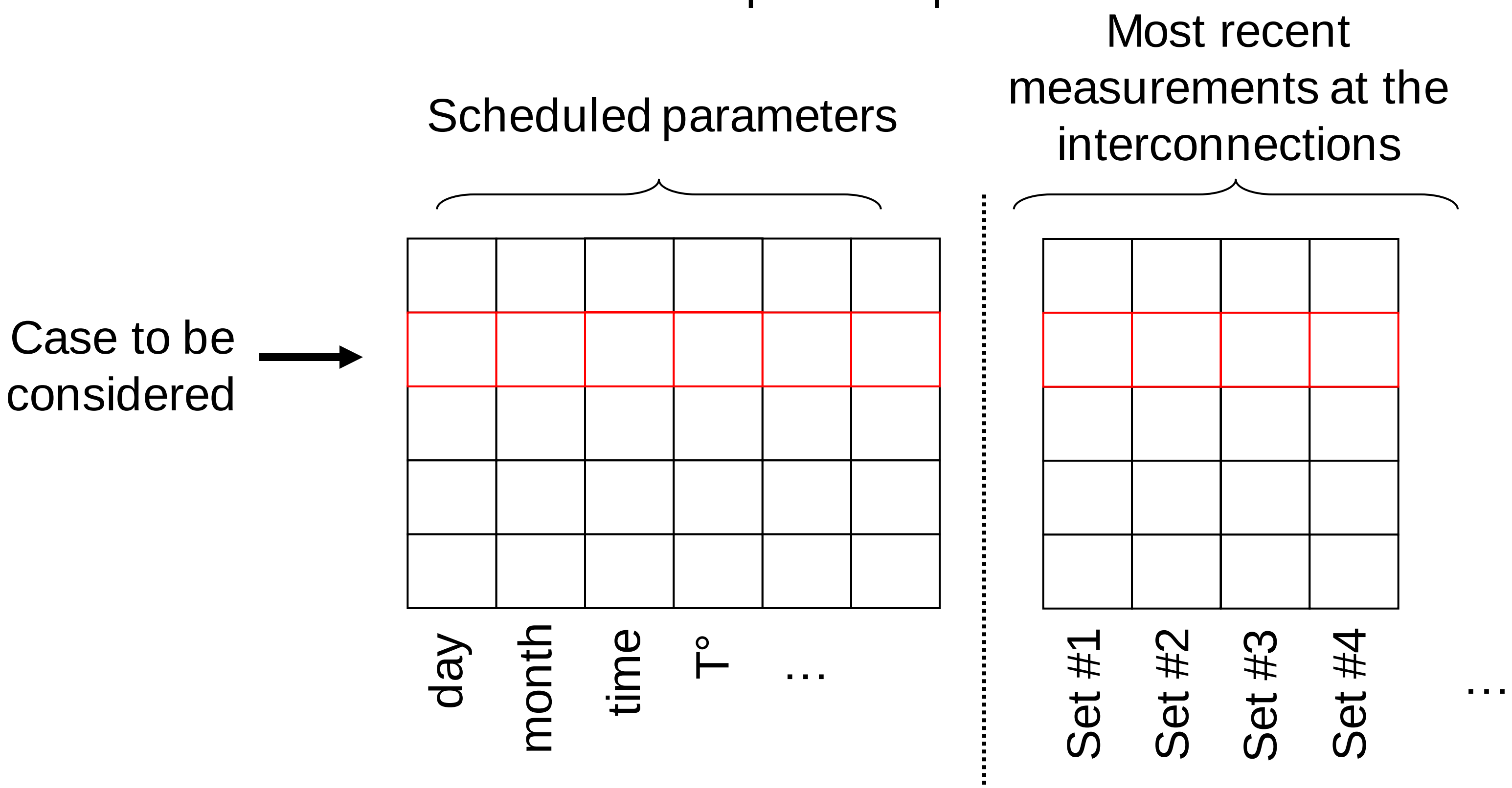
Decentralized optimization scheme (2/5)

- **Representation of Neighboring areas**
  - Simple equivalents
  - More complex equivalents
- **PV equivalent**
  - Each interconnection line is represented by a PV bus
  - Equivalents parameters is fitted to past observations
- **Other kind of equivalents possible**
  - PQ
  - Thevenin
  - REI



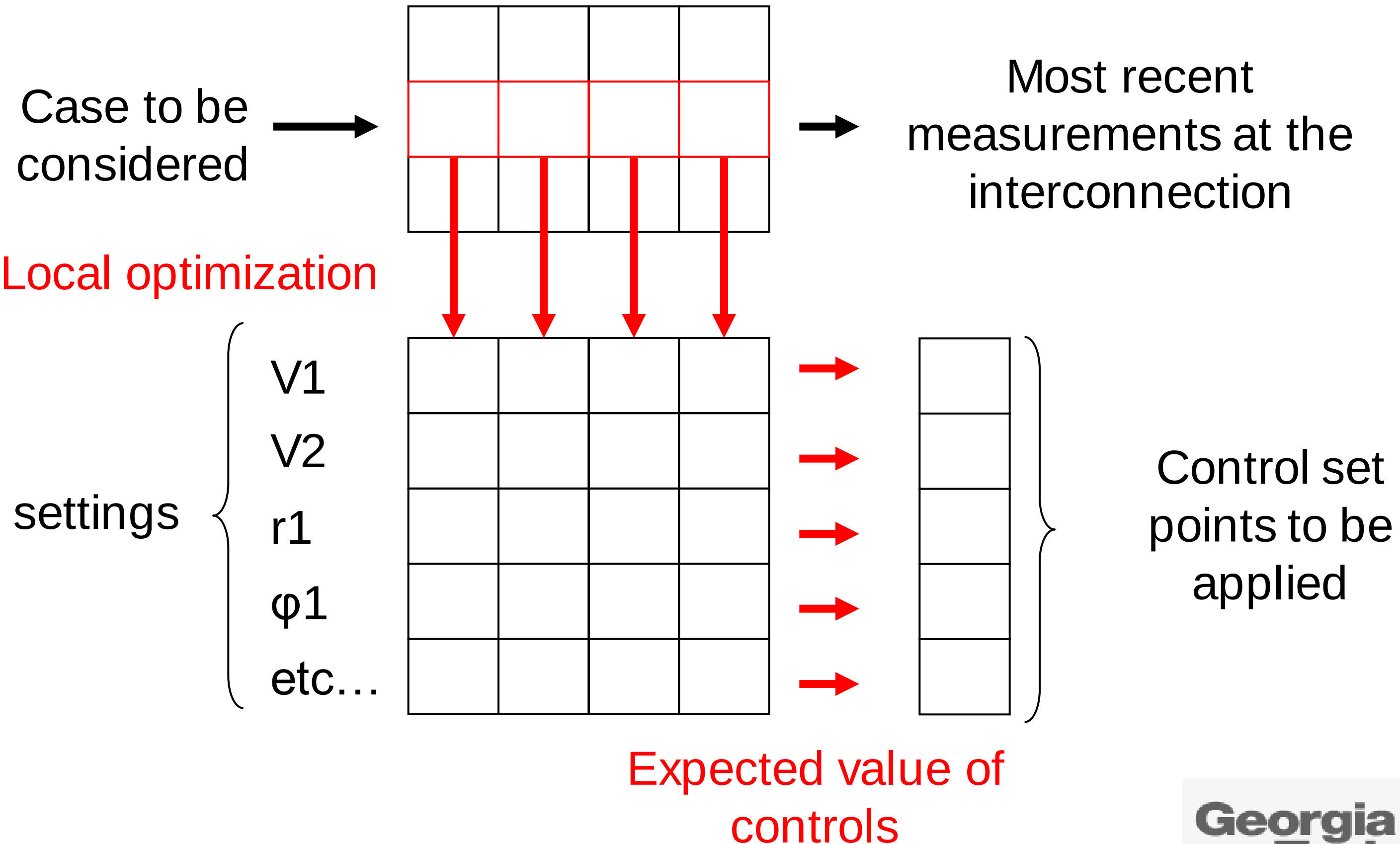
Decentralized optimization scheme (3/5)

- **Numerical Identification** of the equivalent parameters



Decentralized optimization scheme (4/5)

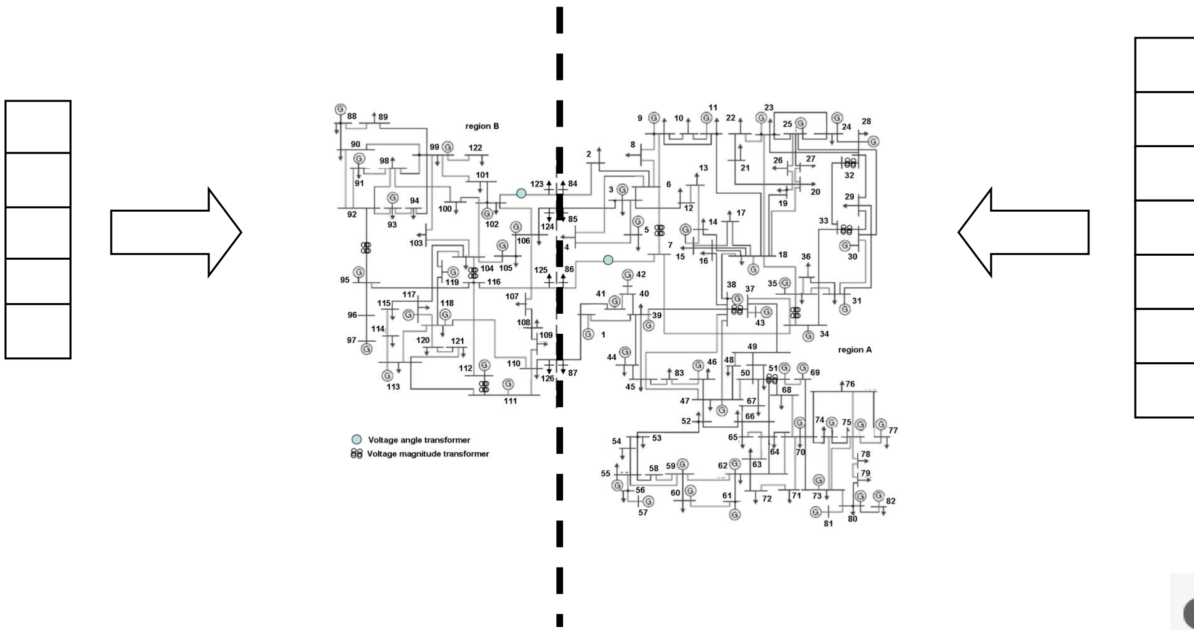
- **Summary of the identification procedure** for of the equivalent parameters



Decentralized optimization scheme (5/5)

- **Application** of locally optimized controls
  - Controls are introduced in the interconnected system
  - a Load Flow with respect to active power exchanges assesses TSO costs in each area

Control settings for TSO B



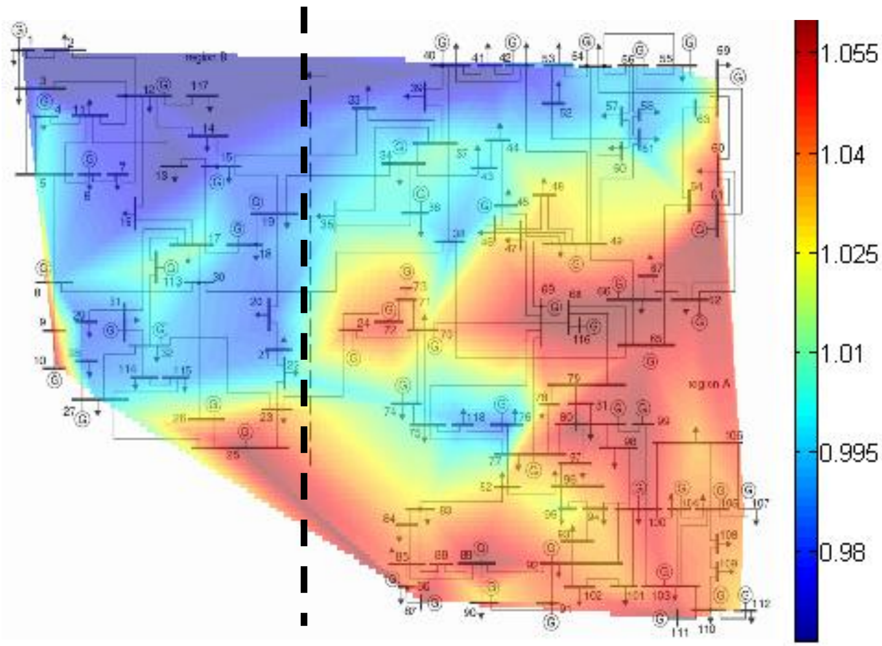
Control settings for TSO A

Outline of the simulations

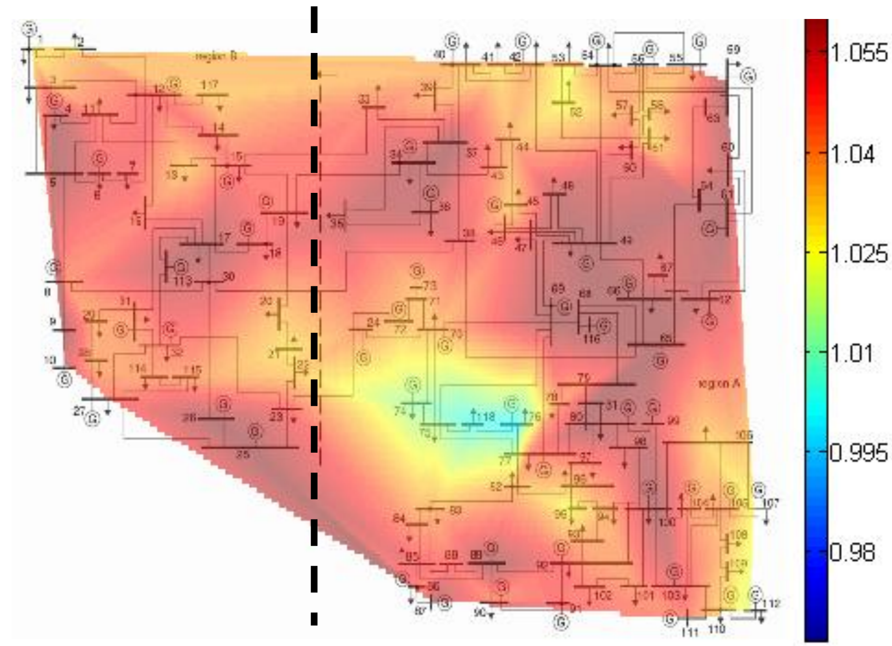
- **IEEE 118 bus system with 2 independent TSOs**
- **2 possible objective functions** for each TSO
  - Minimization of active power losses
  - Maximization of reactive power reserves
- Each TSO represents the neighboring area with **PV equivalents**
- Simulations run:
  - **Centralized** optimization with the **2** possible objective functions
  - **Decentralized** optimization with the **4** possible combinations of objective functions

Simulation results (1/7)

- Voltage by centralized optimization



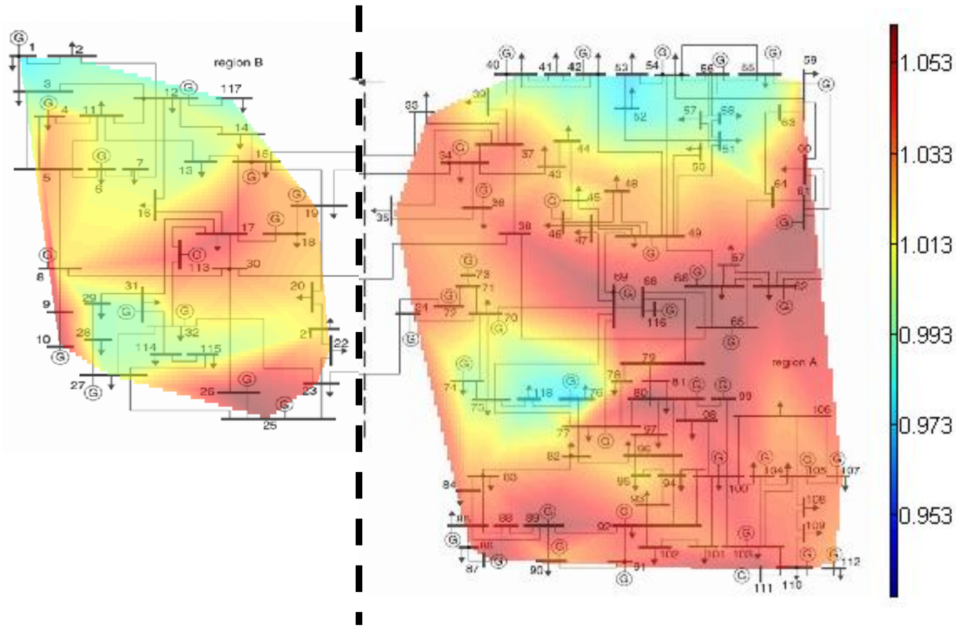
Maximization of reactive power reserves



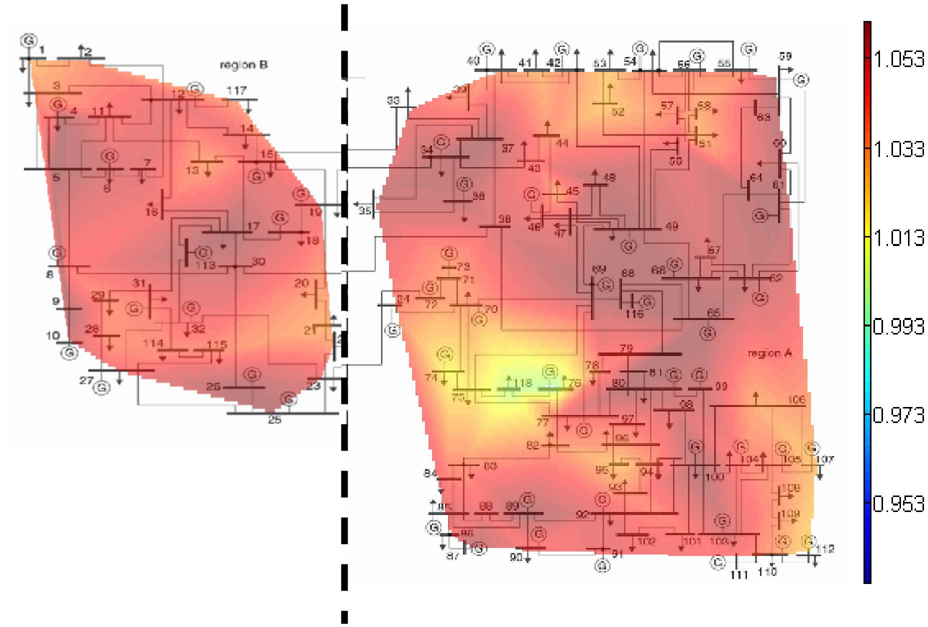
Minimization of active power losses

Simulation results (2/7)

- Decentralized optimization scheme: results of local optimizations



Maximization of reactive power reserves



Minimization of active power losses

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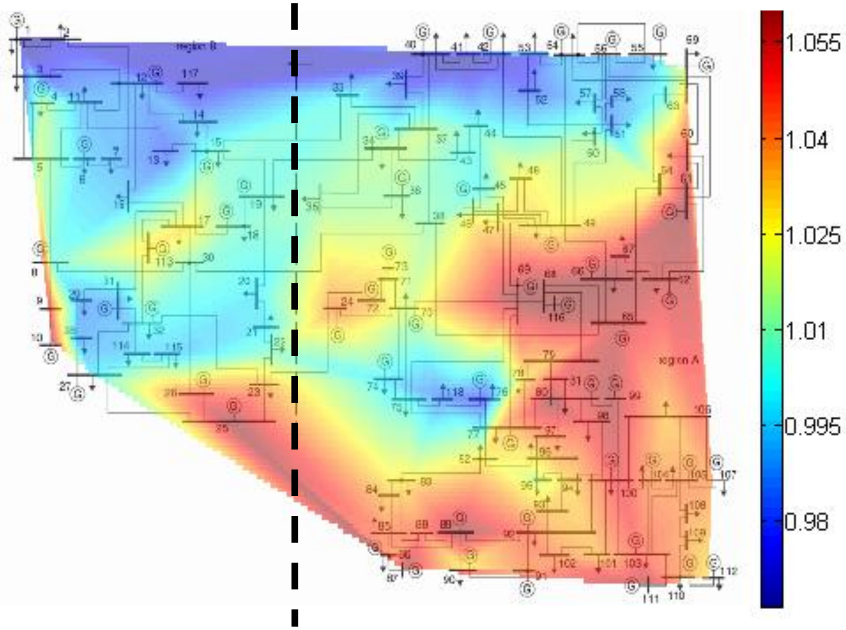
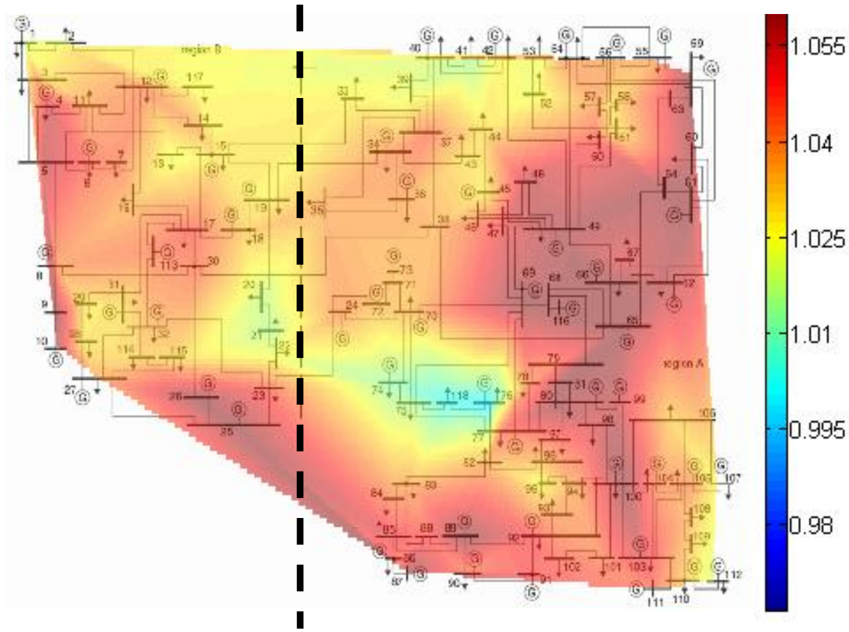
Simulation results (3/7)

- Decentralized optimization scheme: different combinations of strategies

Case 1



Case 4



TSO A = Maximization of reactive power reserves

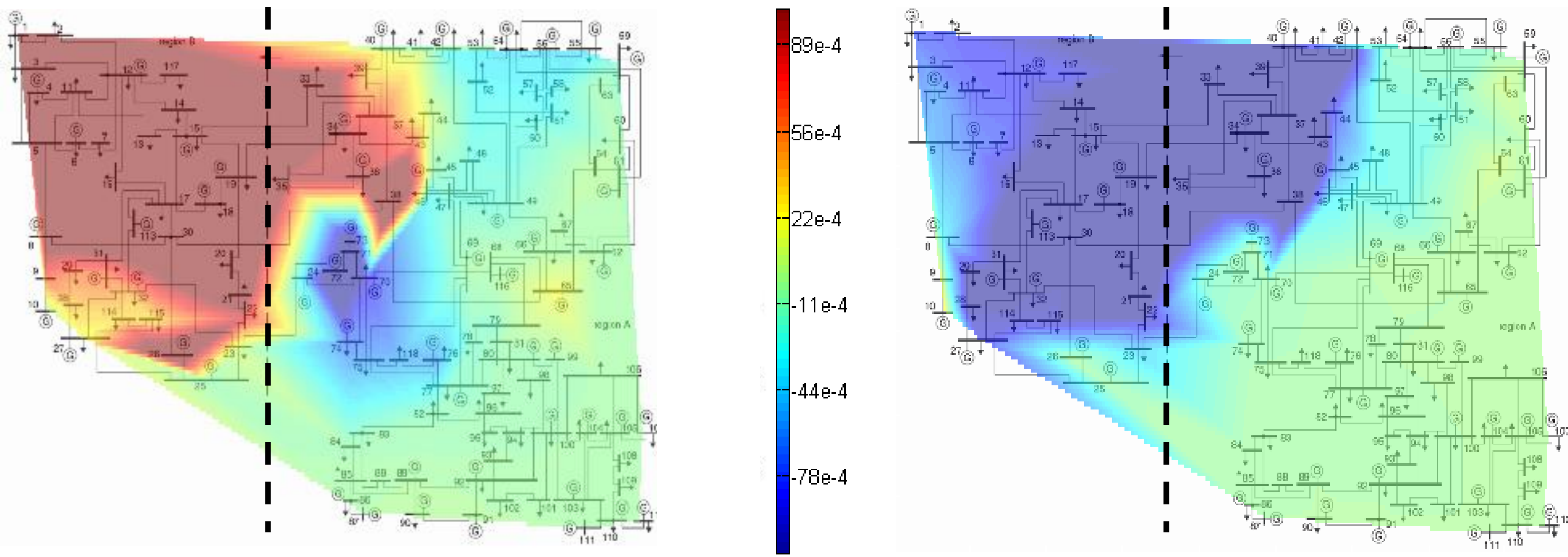
TSO B = Maximization of reactive power reserves

TSO A = Minimization of active power losses

TSO B = Minimization of active power losses

Simulation results (4/7)

- Decentralized optimization scheme:
  different combinations of strategies in the 2 TSO benchmark



TSO A = Maximization of reactive power reserves

TSO B = Maximization of reactive power reserves

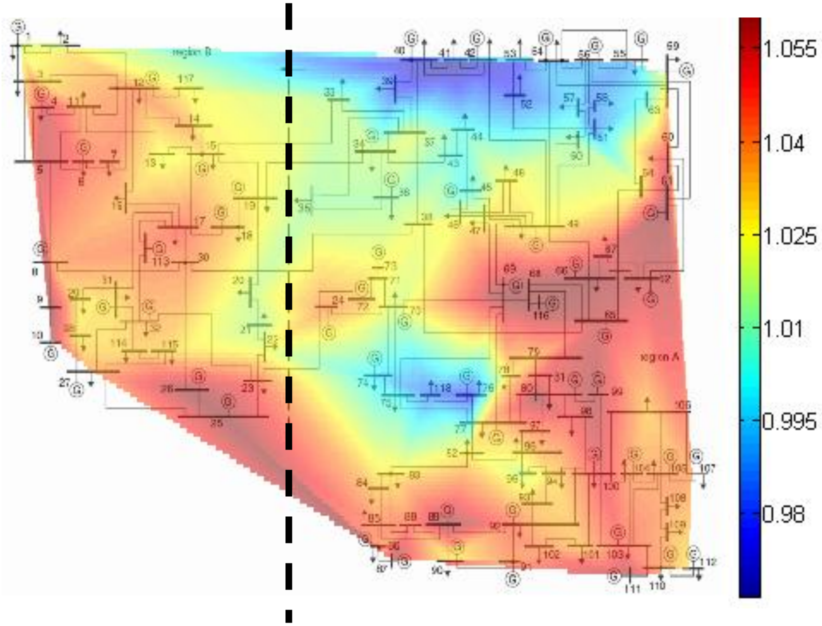
TSO A = Minimization of active power losses

TSO B = Minimization of active power losses

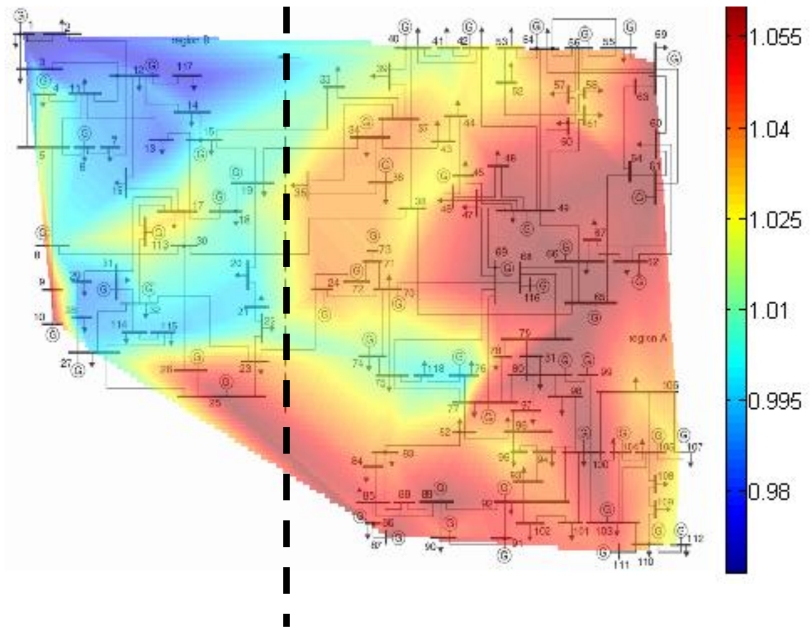
Simulation results (5/7)

- Decentralized optimization scheme: different combinations of strategies

Case 2



Case 3



TSO A = Maximization of reactive power reserves

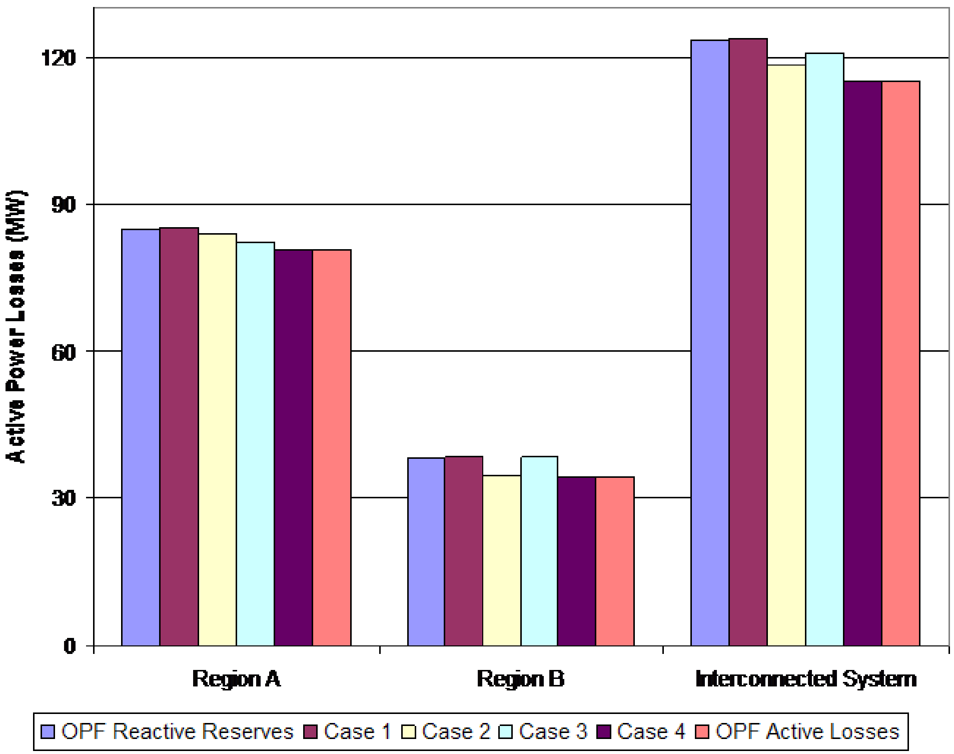
TSO B = Minimization of active power losses

TSO A = Minimization of active power losses

TSO B = Maximization of active power reserves

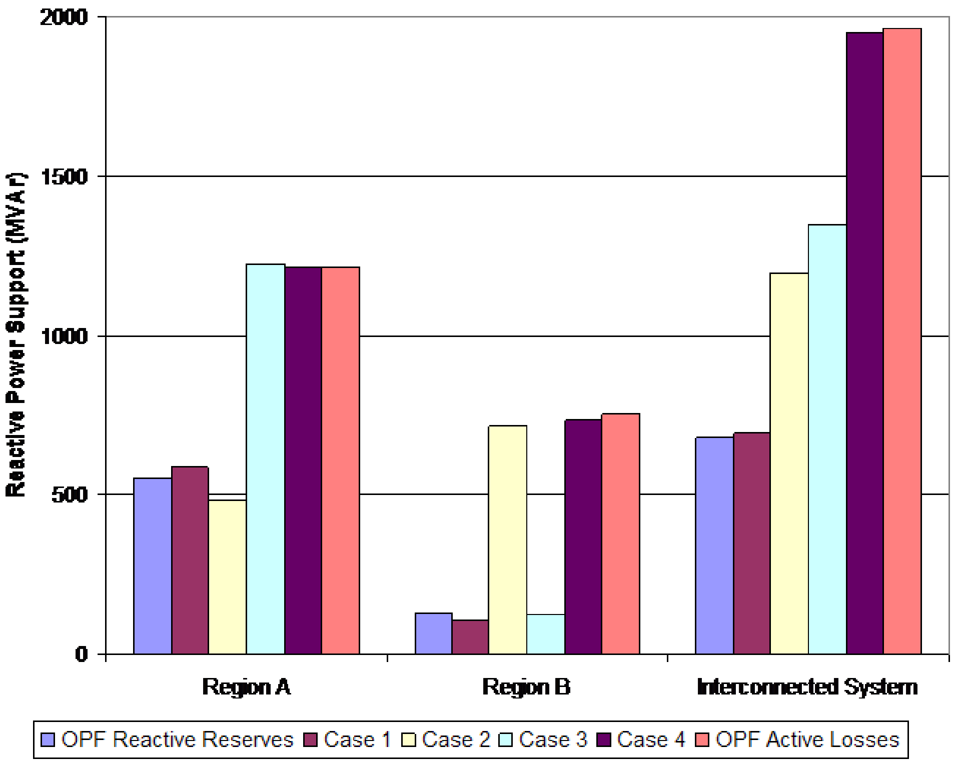
Simulation results (6/7)

- Decentralized optimization scheme:
  A comparison with centralized optimization



Simulation results (7/7)

- Decentralized optimization scheme:
  A comparison with centralized optimization



Analysis of the results

- **Lack of coordination** of the regional MVAr strategies **is a concern** in a multi utility environment: one TSO's choice may affect the other TSOs
- Minimizing reactive power reserves is a **more conflicting objective**: it may be more efficient for one TSO, but it may increase the costs of the interconnected utilities
- Conflicting strategies cause **stress at interconnections.** In this case, the lack of coordination may be critical
- Better coordination between TSOs is one promising strategy toward a **more efficient MVAr scheduling**

Conclusions and further work

- Need for a **coordination of objectives**
- Need for a **suitable choice of models of equivalent interconnections**:
  - Some simulation results will be presented at IEEE Powertech 2007
  - An iterative decentralized control scheme is explored, showing promising results
- Conditions for real-time application of coordination strategies are still to be defined in connection with:
  - dynamics of the power system
  - Identification of the parameters of equivalent interconnections