On multi-area security assessment of large interconnected power systems

Second Carnegie Mellon Conference in Electric Power Systems:

Monitoring, Sensing, Software and its Valuation for the Changing Electric Power Industry

January 12, 2006

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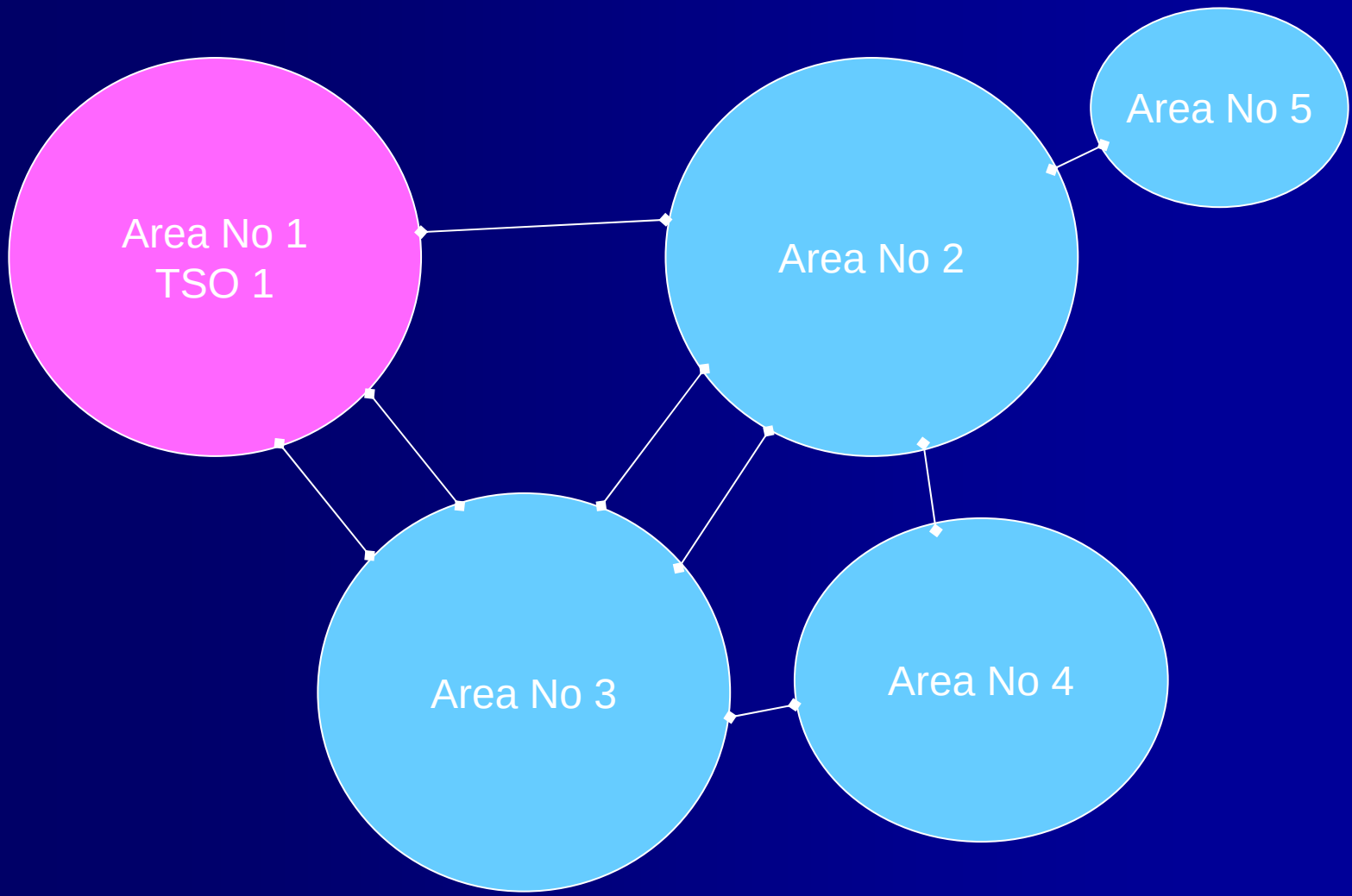
Framework objectives

- Define information exchange scheme to allow each area
  - To carry out security assessment locally
  - To appreciate security level of whole interconnection
- Coordinate preventive and emergency control among TSOs

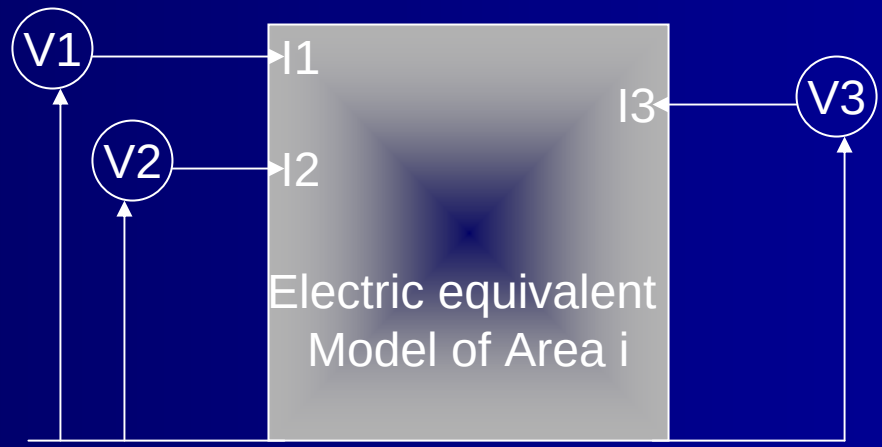
NB: general framework, but declined in the context of static security assessment, for the sake of simplicity

Let’s adopt the viewpoint of TSO 1

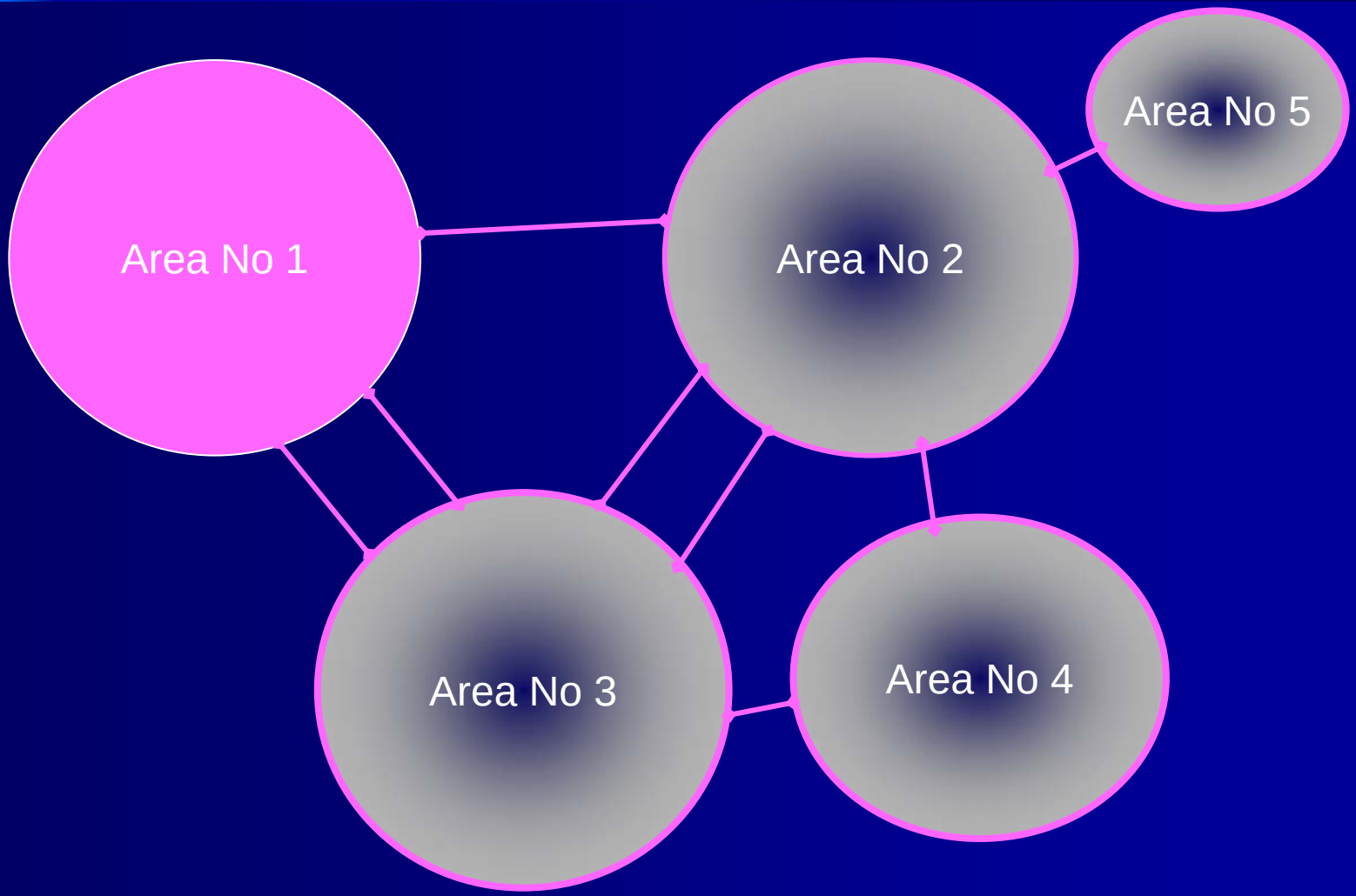


Nota Bene:
Electric equivalent model of an area

- A (black-box) model of the voltage-current relationships at the receiving ends of the interconnections of that area, which can be plugged into a power-flow computation



Power system model used by TSO 1



Three types of contingencies (from the viewpoint of TSO 1)

- Internal contingency in area 1
  - Loss of line or generator (etc) in area 1
- External contingency to area 1
  - A contingency internal to another area
- Loss of an interconnection line
  - Anywhere in the overall system, i.e. not just those directly connected to area 1

Two types of effects
(from the viewpoint of TSO 1)

- Internal effects
  - Currents and voltages in area 1, subsequent to contingency occurrence
- External effects
  - Active/reactive current flows through the interconnections, subsequent to contingency occurrence

Computation of effects

- Internal contingency or interconnection trip

  Use detailed model of area 1 and interconnections

  + equivalent models of other areas

- External contingency

  Use detailed model of area 1

  + post-contingency interconnection currents computed by area of origin of contingency

Information exchange protocol

- The TSO of each AREA posts on the “WEB”
  - An equivalent model of his area
  - Results of his own security analysis
    - For each internal contingency considered
      - Likelihood of the contingency
      - Summary of internal effects (e.g. harmless vs harmful)
      - Detailed external effects (i.e. post-contingency currents in all the interface lines of the whole interconnection)
    - For each external contingency considered
      - Summary of internal effects (e.g. harmless vs harmful)
    - For each interconnection tripping
      - Detailed external effects and summary of internal effects

Interconnections

- All information about all interconnections, measured, or computed, could be considered as public information
- All TSOs could anticipate any problem that could appear on any interconnection
- If the equivalent models are of good quality, the information computed by all the TSOs about all the interconnections will be coherent

Security control issues

- Responsibilities of TSO 1 to handle harmful contingencies
  - In preventive mode
    - All contingencies having internal effects in area 1
    - All contingencies internal to area 1
    - All interconnection losses
  - In emergency mode
    - All violations internal to area 1
    - All violations at the interconnections to area 1
- Negociation/coordination if a contingency or a violation “affects” several TSOs

Refinements

- All information that has changed since the last update must be posted ASAP
- Computations must be done to respond to new information (internal or external) within deadline
- Motivations for good quality equivalents
  - Each TSO has the possibility to check quality of equivalents, by plugging his detailed model, computing interconnection currents, and comparing with ‘equivalent’ information published by others
  - Providing a good quality equivalent of area 1 to other TSOs is a necessary condition for predicting correctly the impact of external contingencies on area 1

Simplification

- Each TSO also publishes ‘safe bounds’ on his area
  - →Bounds on the interconnection flows into his area within which he can guarantee that no internal violation will appear
- All TSOs would then publish only those external effects that fall outside of the bounds of any other area
- This would allow to reduce significantly
  - The computational burden
  - The amount of information to share