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EnergyVille

Uncertainties in short term power system reliability management

Evelyn Heylen

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Evelyn Heylen

- 2011-2013: Master in Energy, KU Leuven
- PhD student KU Leuven – Energyville since Autumn 2013
  - Research interest: Performance evaluation of power system reliability criteria and their management
- Group: ESAT – ELECTA (Electrical engineering)
  - Electrical energy systems and robust control of industrial systems
  - Power group: Power system reliability & HVDC
- Supervisors: Prof. Dirk Van Hertem & Prof. Geert Deconinck
- Work supported by Research Foundation Flanders (FWO)

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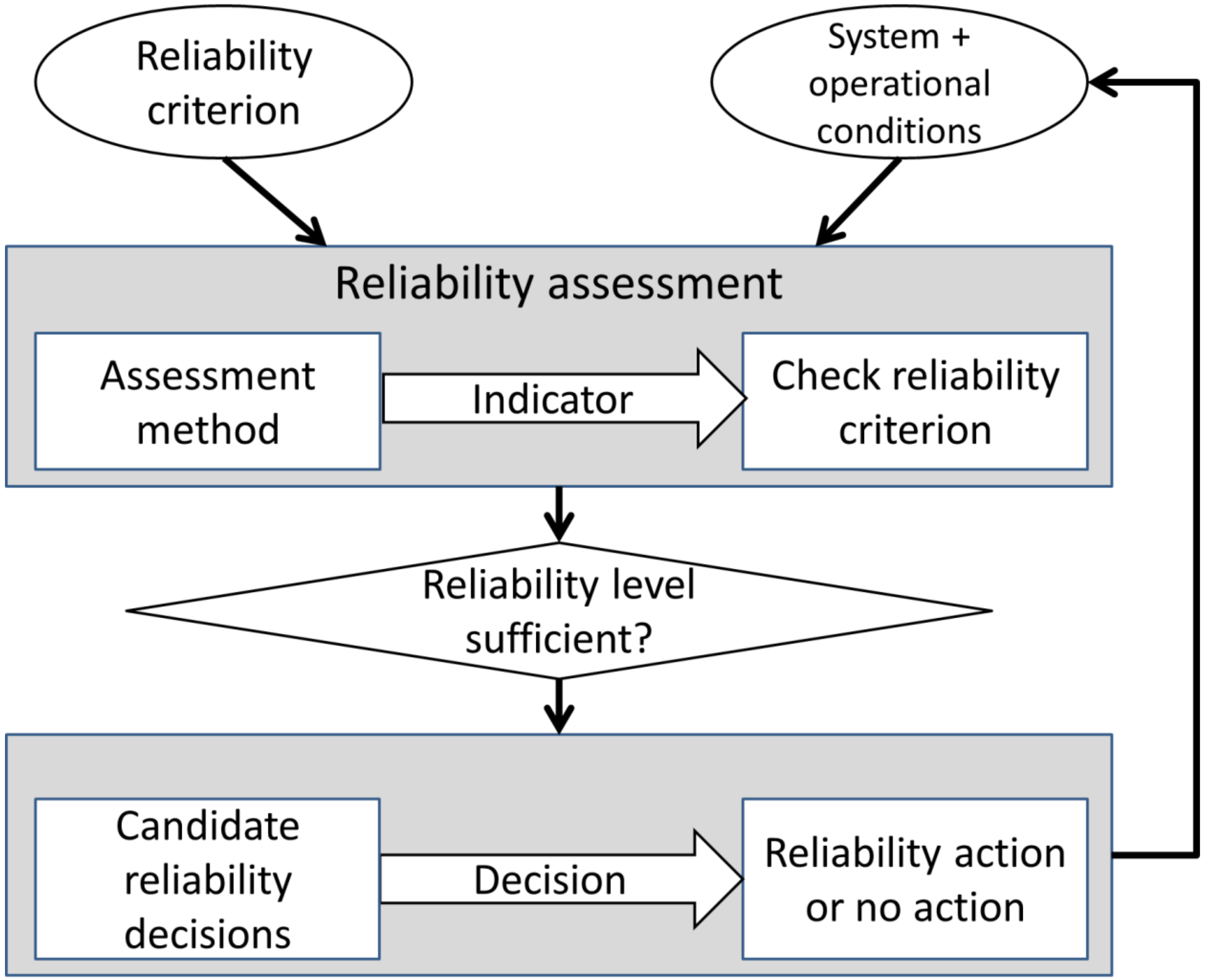
Research Foundation - Flanders

Uncertainties in short term **power system reliability management**

Three main time domains:

- Long term: System development
- Mid term: Asset management
- Short term: Operational planning and real time operation



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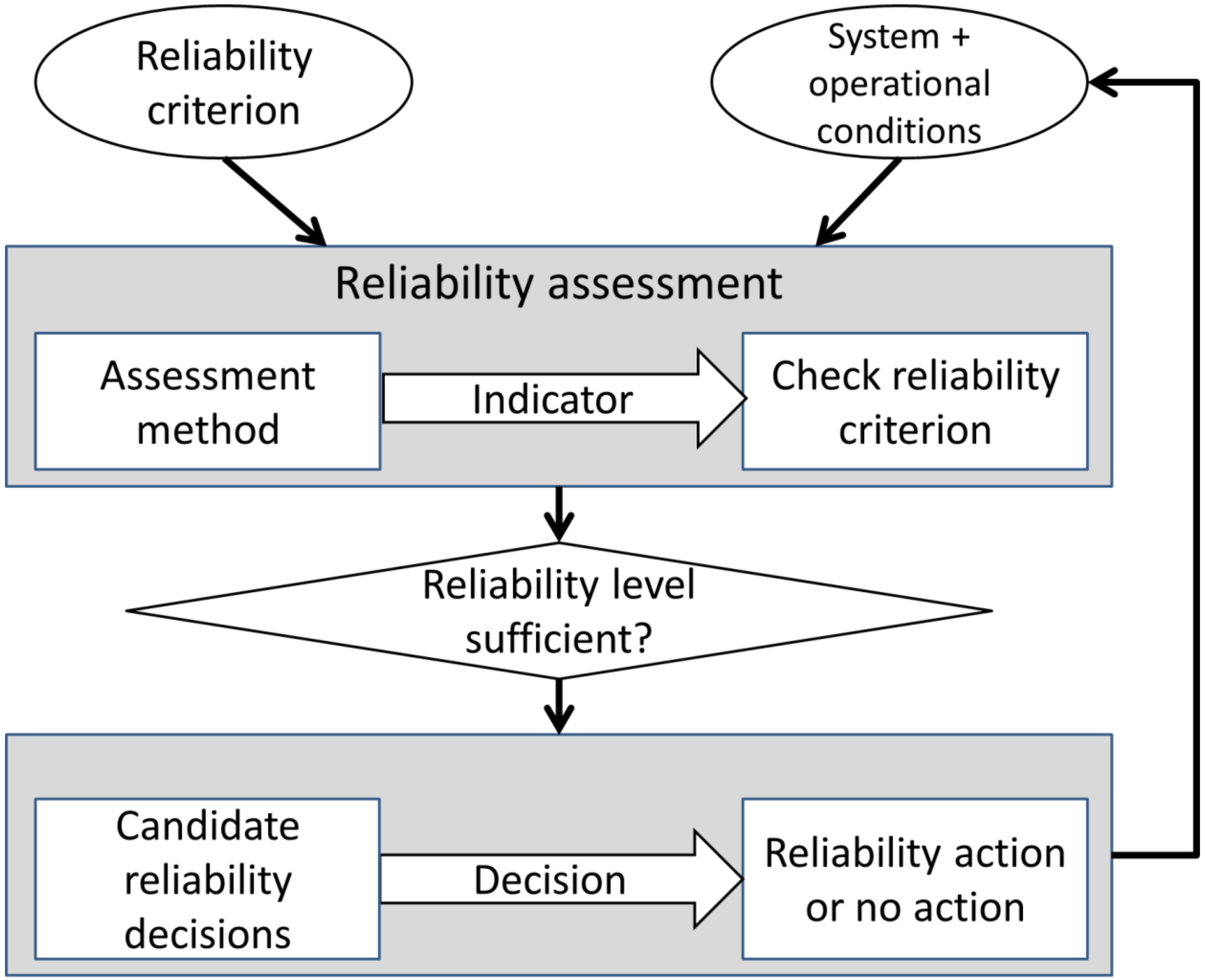

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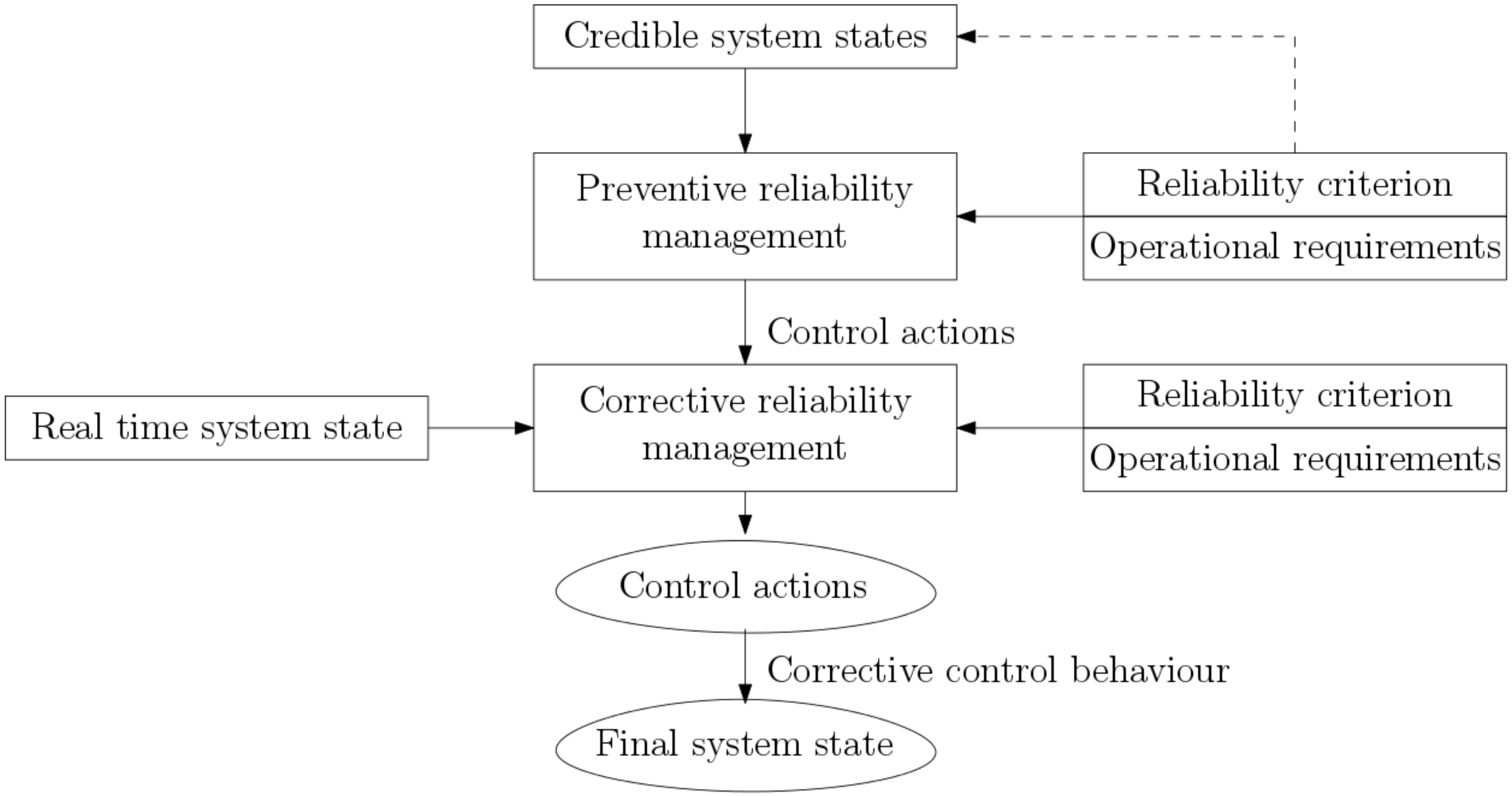
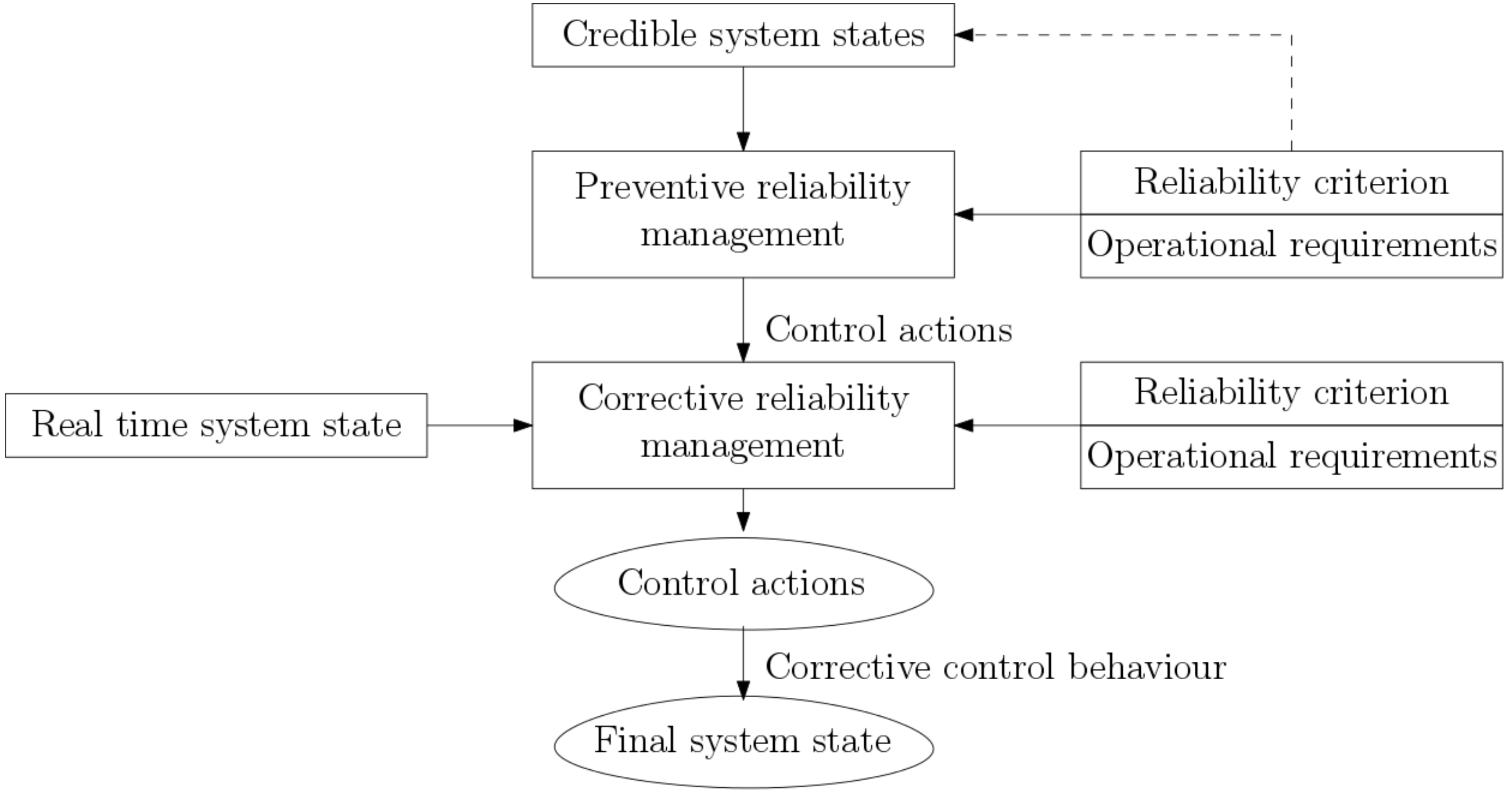
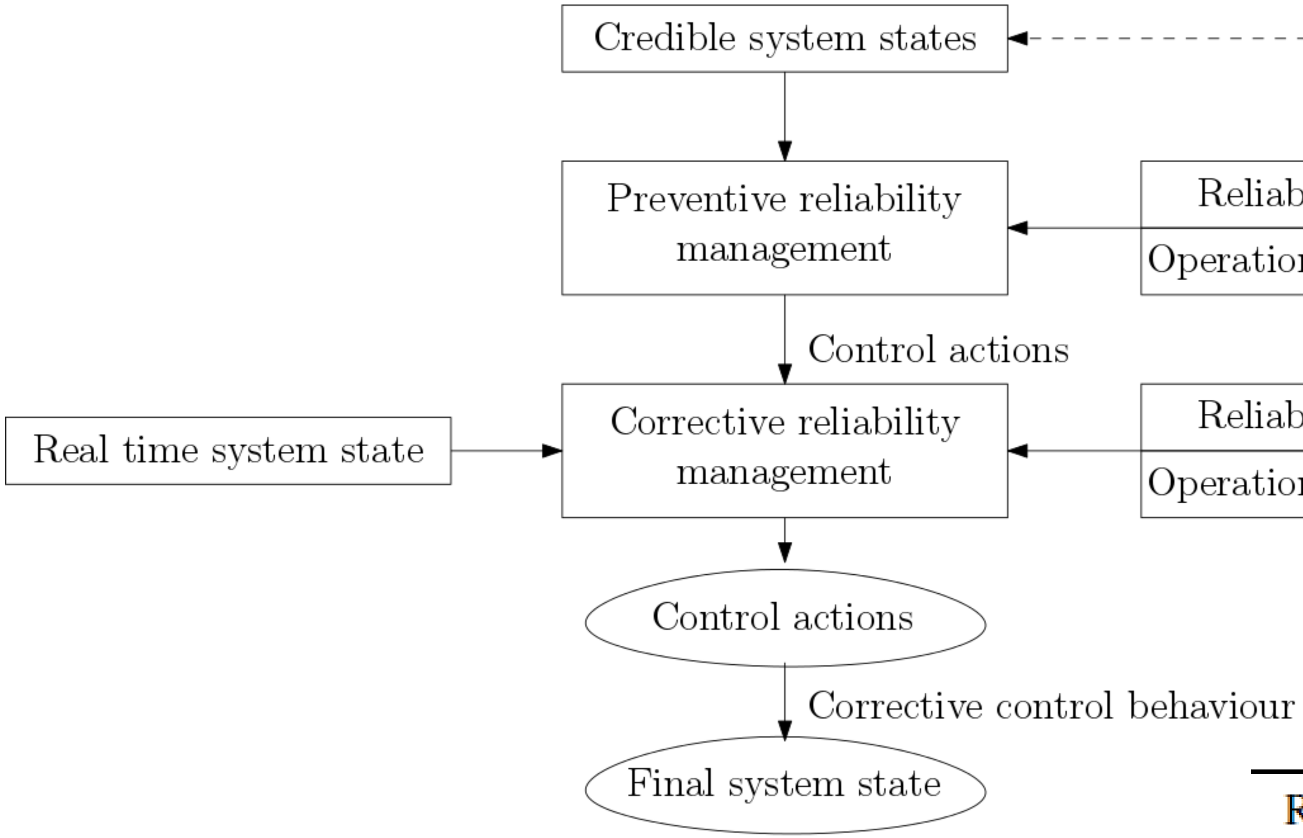


Uncertainties in **short term** **power system reliability management**



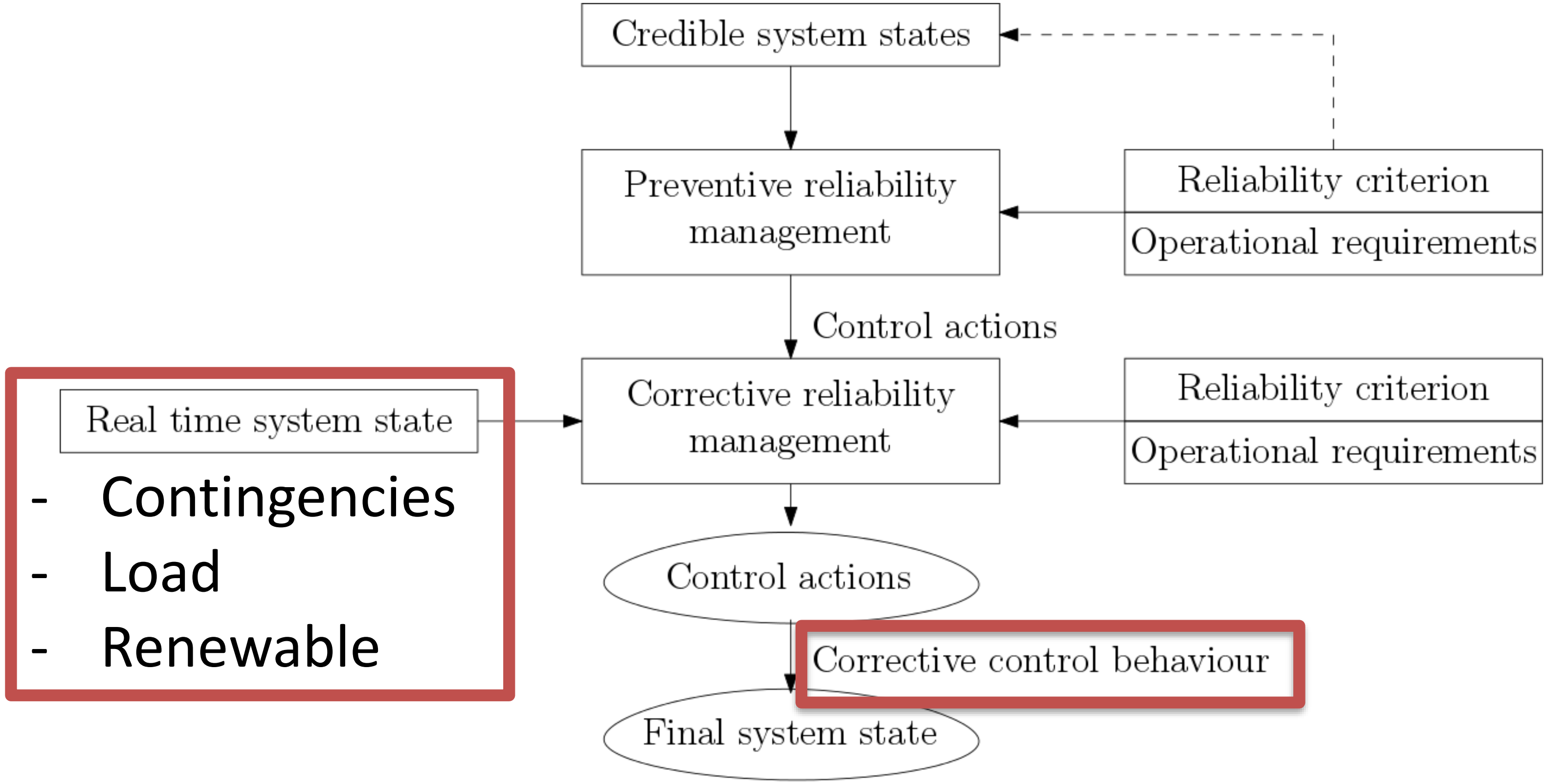
Operational planning
No action
Contracting reserves
Contracting flexibility
Generation rescheduling
+ Actions real time operation

Uncertainties in **short term** **power system reliability management**



Real time operation	Operational planning
No action	No action
Generation redispatch	Contracting reserves
Load curtailment	Contracting flexibility
Bus bar and line switching	Generation rescheduling
Transformer tap changing	+ Actions real time operation

Uncertainties in short term power system reliability management



Uncertain!!!

Current approach to handle uncertainties in preventive reliability management: Deterministic N-1

The system should be able to withstand at all times the loss of any of its main elements without significant degradation of service quality

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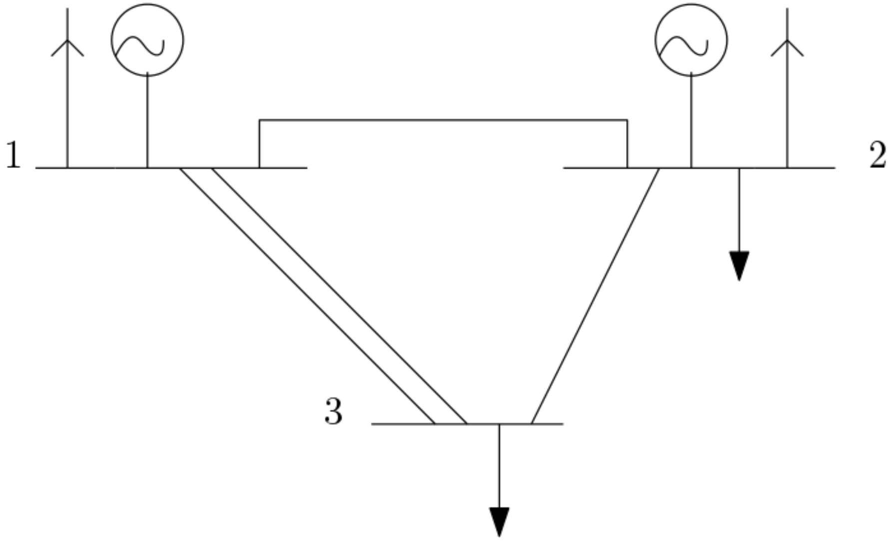
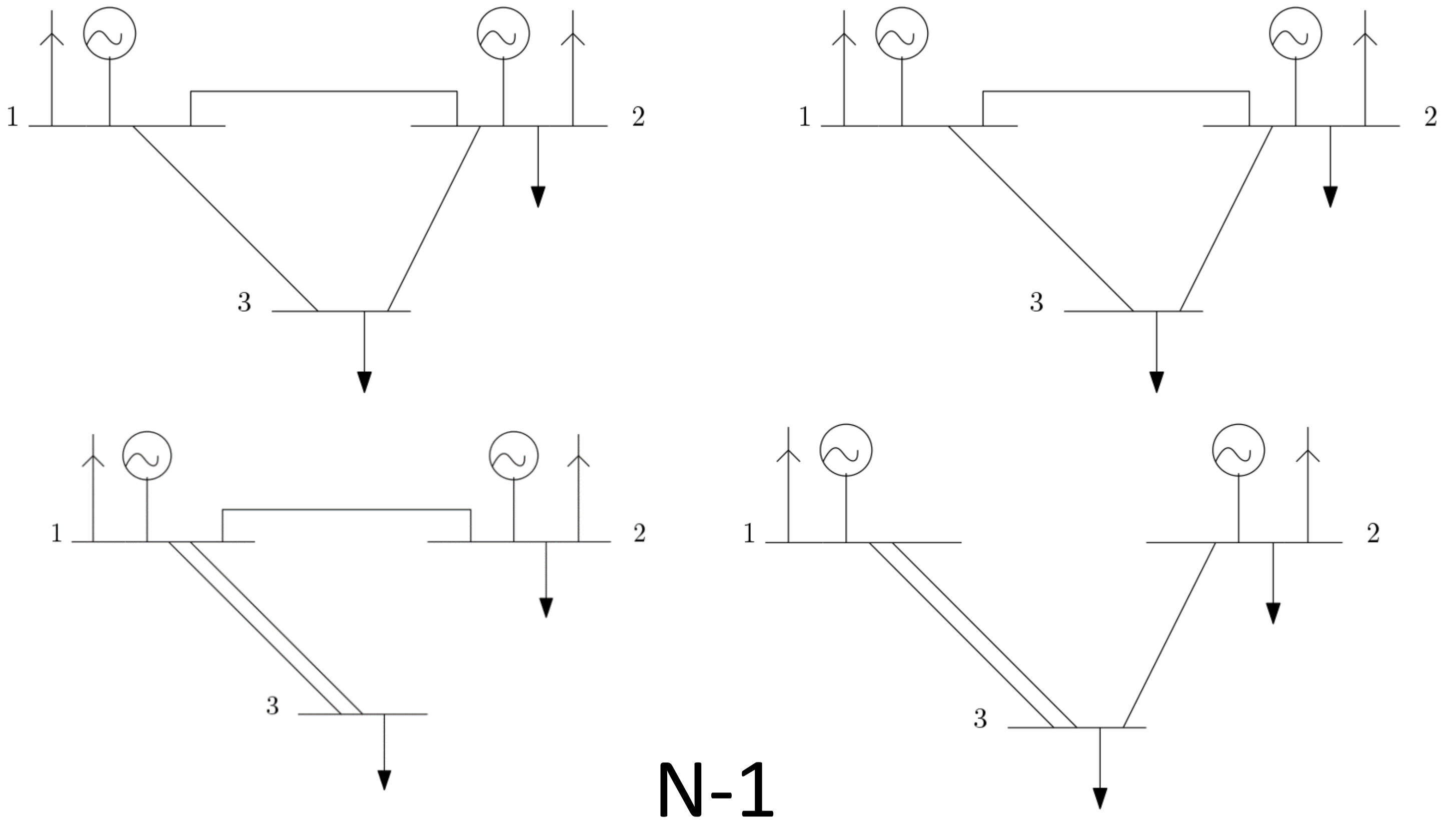


N-0



N-1

‘Challenges’ with deterministic N-1

- Only single contingencies
- Only single renewable generation and load scenario
- Ideal corrective control behaviour
- All credible states assumed to be equally probable and severe
- No economic incentive

However… transmission system operators (TSO) are not eager to change:

- Transparent
- Good results so far

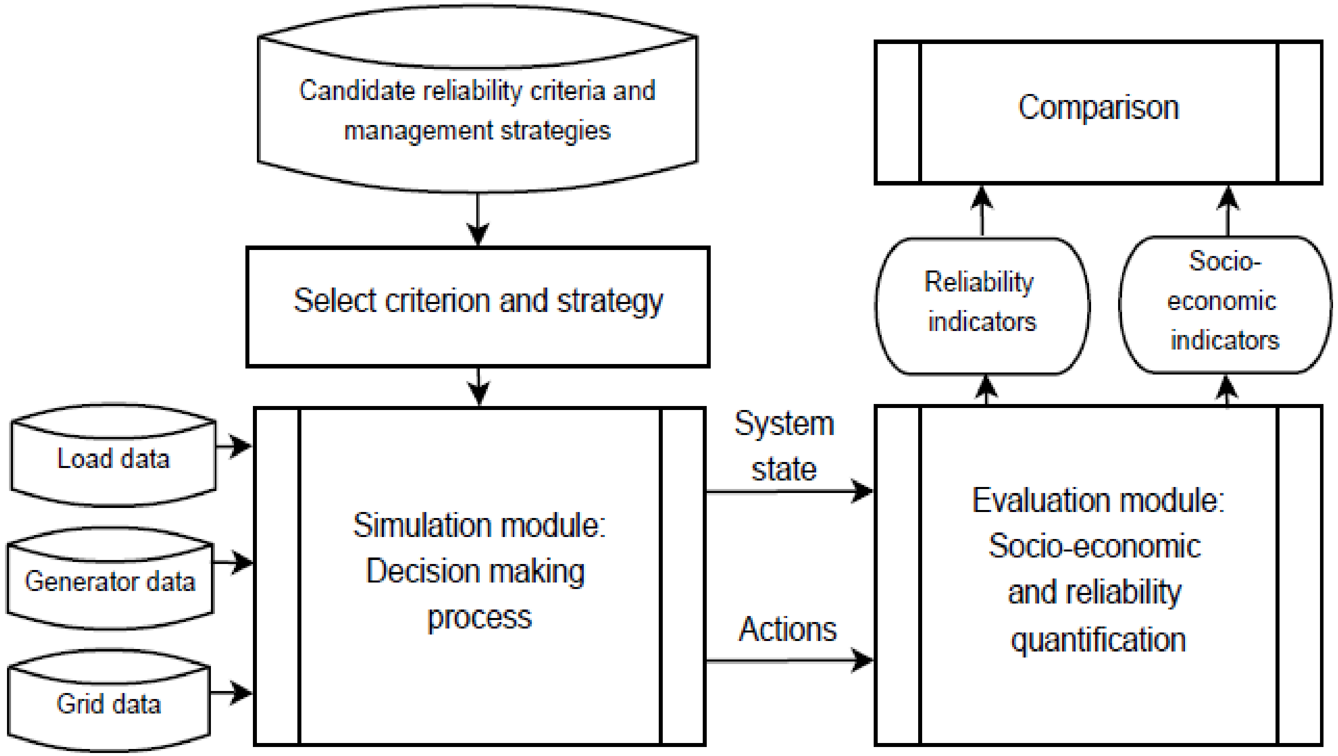
→ **Convince TSOs that alternatives are ‘better’!!!**

Alternative probabilistic approaches should consider uncertainties in more “clever” way

- Improve probabilities of contingencies
- Consider multiple load and RES scenarios
- Consider more decision stages
- …

How much better do these alternatives perform and in which conditions? Should the TSO change? → Quantification platform

- Focus on short term reliability management
- Tool to compare performance of different power system reliability criteria and their management



Simulation module

Mixed integer linear optimization

- Operational planning

$$\min_{a_p, a_c^s, P_{curt}} C_{OP}(v) = \min[\, C_{prev}(a_p) + \sum_{s \in S} \pi_s (C_{corr}(a_c^s) + P_{curt}^s(c).\, v)]$$

$$s.t. \, operational\ limits\ \forall\ s$$

- Real time operation

$$\min_{a_c^{RT}, P_{curt}^{RT}} C_{RT}(v) = min_{a_c^{RT}, P_{curt}^{RT}}[C_{corr}(a_c^{rt}) + P_{curt}^{rt}(c).\, v]$$

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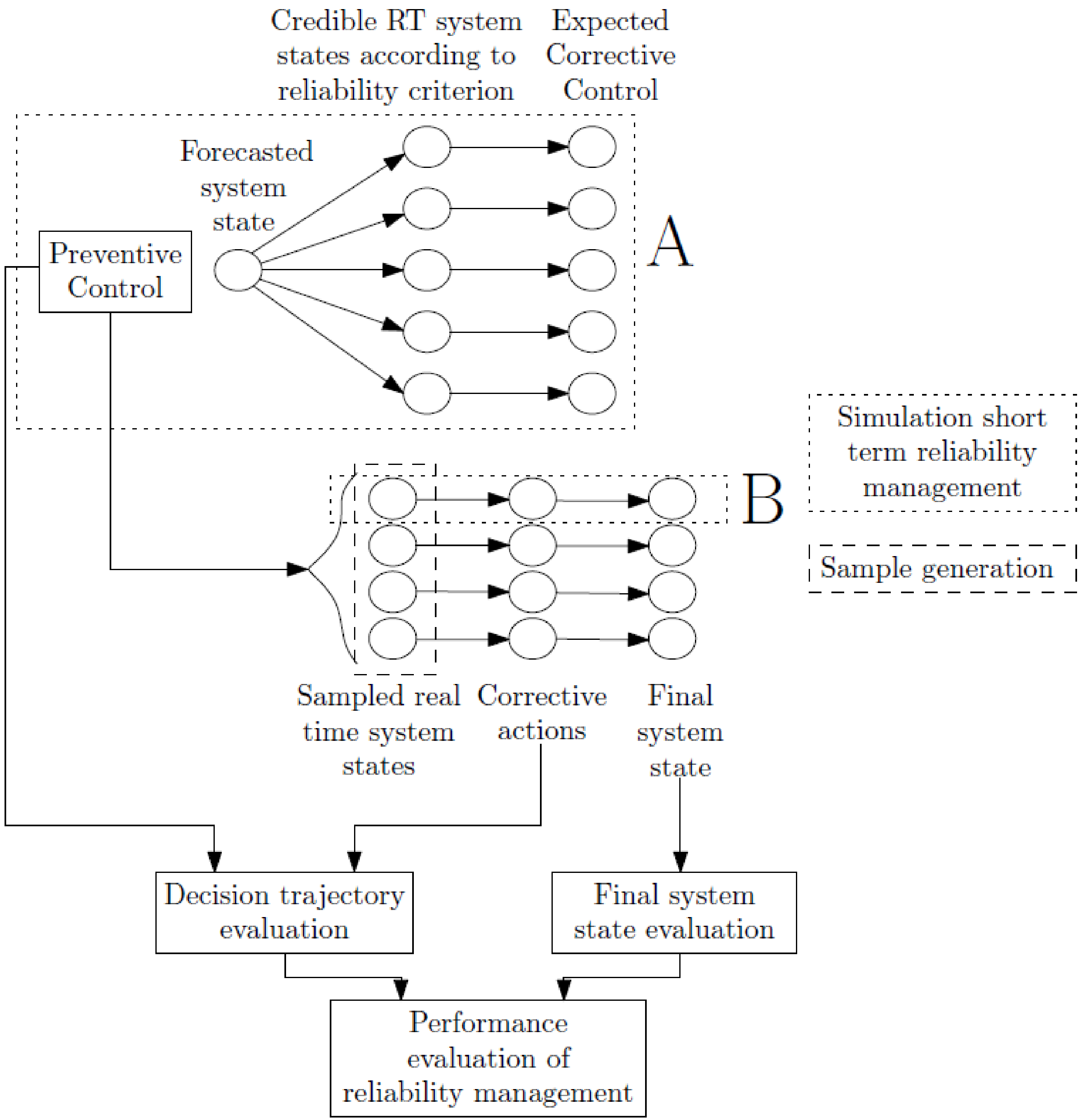
Computationally intensive for large systems!!!

Evaluation module

- Evaluate performance indicators for various states defined by:
  - Contingency
  - Load realization
  - Renewable power generation realization

- Performance indicators:
  - Total system cost
  - Reliability level
  - Equality between consumers


Credible RT system states according to reliability criterion
Expected Corrective Control
Forecasted system state
Preventive Control
A
B
Simulation short term reliability management
Sample generation
Sampled real time system states
Corrective actions
Final system state
Decision trajectory evaluation
Final system state evaluation
Performance evaluation of reliability management

Challenges in the evaluation module

- Select appropriate system states to evaluate to obtain reliable and unbiased performance evaluation?
    - Contingencies: Very few data → No exact failure probabilities

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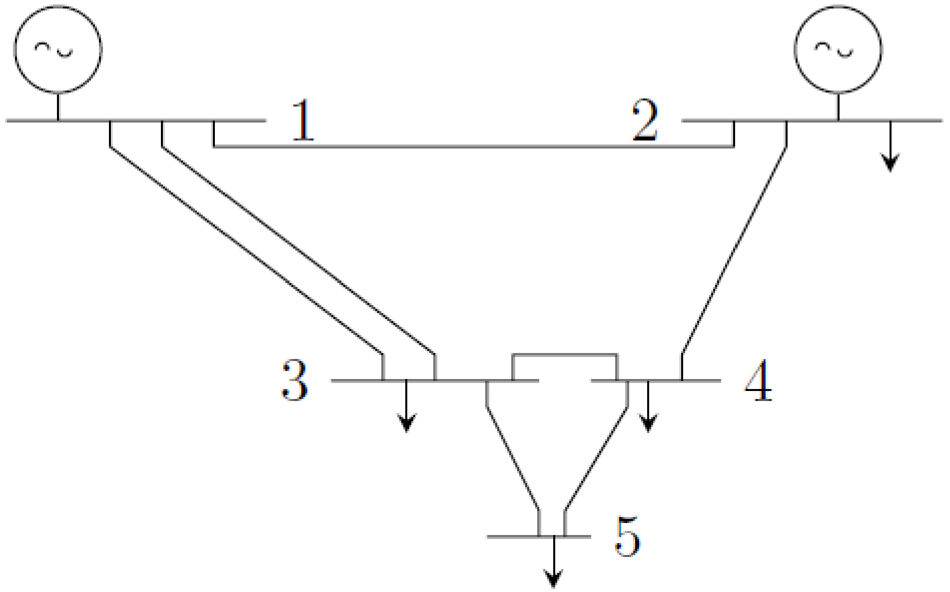
    - Depending on type of consumers



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- *How to show quality of the result?*
- *How to convince decision maker?*

Current approach

- Contingencies
  - Two state component models: constant failure rates & repair times
  - Most probable contingencies up to particular cumulative probability

Current approach

- Contingencies
- Corrective control behaviour
    - Perfect behaviour

Problem: Real time load and generation from renewable energy sources

- For all load points (1000) in the system we get 100 samples of active power per node given a particular forecast value
- Loads are spatially correlated
- The type of consumers at the nodes is not known

- Similar data for renewables, but let’s focus on load now!

Discussion

- *Are 100 samples sufficient to obtain a reliable performance evaluation or can we reduce the number samples?*
- *How to efficiently select a representative number of states? (e.g. Categorize similar nodes in terms of distributions? How to consider correlation and unknown consumer groups?)*
- *Can we combine simulations of the N-1 and alternative approach with practical N-1 outcomes to improve the performance evaluation, also for the alternative method?*
- *Can we use the samples to improve alternative reliability management strategies?*

Thank you!

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