

Centre for intelligent electricity distribution - to empower the future Smart Grid





SMART-GRID OPERATION

SMART GRID-OPERATION

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Distribution grids are under-instrumented



Distribution electric power grids undergo big changes!

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http://lig-membres.imag.fr/krakowia/Files/MW-Book/Chapters/Admin/admin-body.html







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The electric grid

... in the future ...



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Changes ... add flexible resources





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Add "smart" sub-stations





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Add "smart" breakers

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ICT infrastructure trade-offs

Security of Supply?Automation? To what extend?Security?Interaction grid vs comm netw.Low Latecy?Distributed vs centralised?Industrial grade IoT?Private vs Public Networks?Communication technology?

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Consequenses











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Modelling approaches

• Dynamic models:

- (Stochastic) PetriNets
 - Stochastic Reward Networks [SRN] (tool: sharpe - <u>https://sharpe.pratt.duke.edu</u>)
 - Stochastic Activity Network [SAN] (tool: Möbius - <u>https://www.mobius.illinois.edu</u>)
- Markov models
- +++

•Structural models

- Reliability block diagrams
- Fault-trees
- +++

[SRN] Jogesh K. Muppala, Gianfranco Ciardo, Kishor S. Trivedi. "Stochastic Reward Nets for Reliability Prediction". https://pdfs.semanticscholar.org/16ec/a0a203e7349350cde9f01fc084639f60fa8d.pdf [SAN] William H. Sanders and John F. Meyer "Stochastic Activity Networks: Formal Definitions and Concepts". https://www.perform.illinois.edu/Papers/USAN_papers/01SAN02.pdf





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Discrete Event Simulation (DES)

- The system dynamics is given by discrete events
 - The system state is distinct and will only change at a specific time instance
- Simulations of discrete events
 - Need only to simulate the events that changes the system state
 - A finite number of events will take place in a finite interval of time

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Co-simulation

- Using dedicated simulators to model each subsystem in one simulation.
- Needs to have synchronous and deterministic communication and time between them.



Fredrik Bakkevig, PhD student, NTNU IIK







Consequenses









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Where should we place the new sensors and controllers?

Kalpanie Romina Intelligent Electric Device (IED) Controller (sv P 6---) Breaker/Relay (hw Michele Fredrik

Is 5G an enabler for low latency, high reliable communication?





Dependability of interdependent, embedded, interacting electric grid and ICT systems



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Centralised, or de-centralised grid operation?



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CINELDI will ensure that we are building the smart energy system of the future