



Smart Grid in a Room Simulator (SGRS)

Computer and Communications Platform Design:
Aligning Physical, Economic, and Information
Interfaces

March/30/2015

Martin Wagner

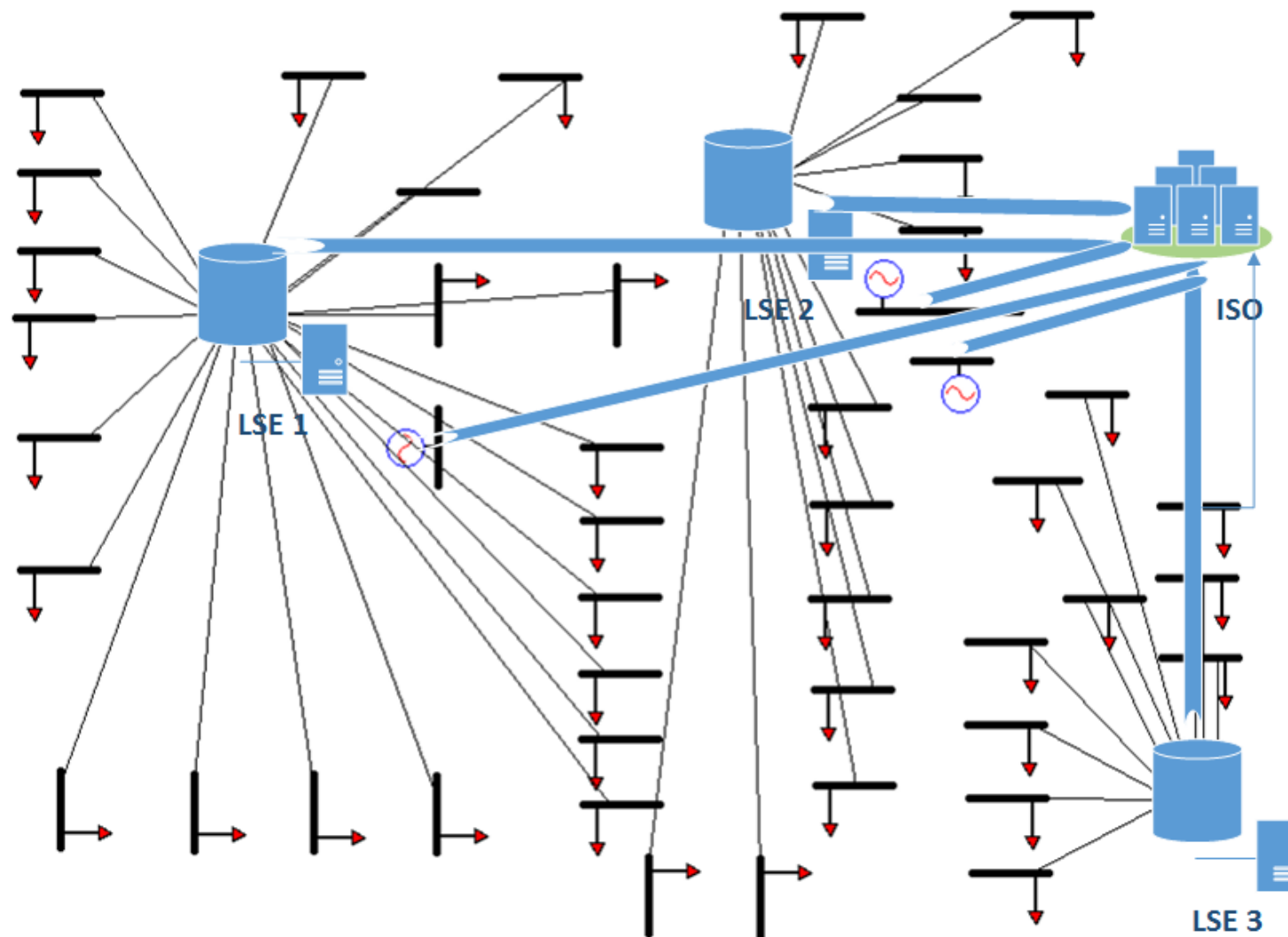
Jovan Ilić

Franz Franchetti

Never Ending Struggle for Computational Speed and Accuracy

- ❖ Different models for different purposes
- ❖ Power system model can be arbitrarily large and/or complex
- ❖ How do we solve this problem?
 - Parallel and/or distributed computing
 - Standard, of the shelf software packages?
 - Custom software to account for physical, communication, and economic specifics

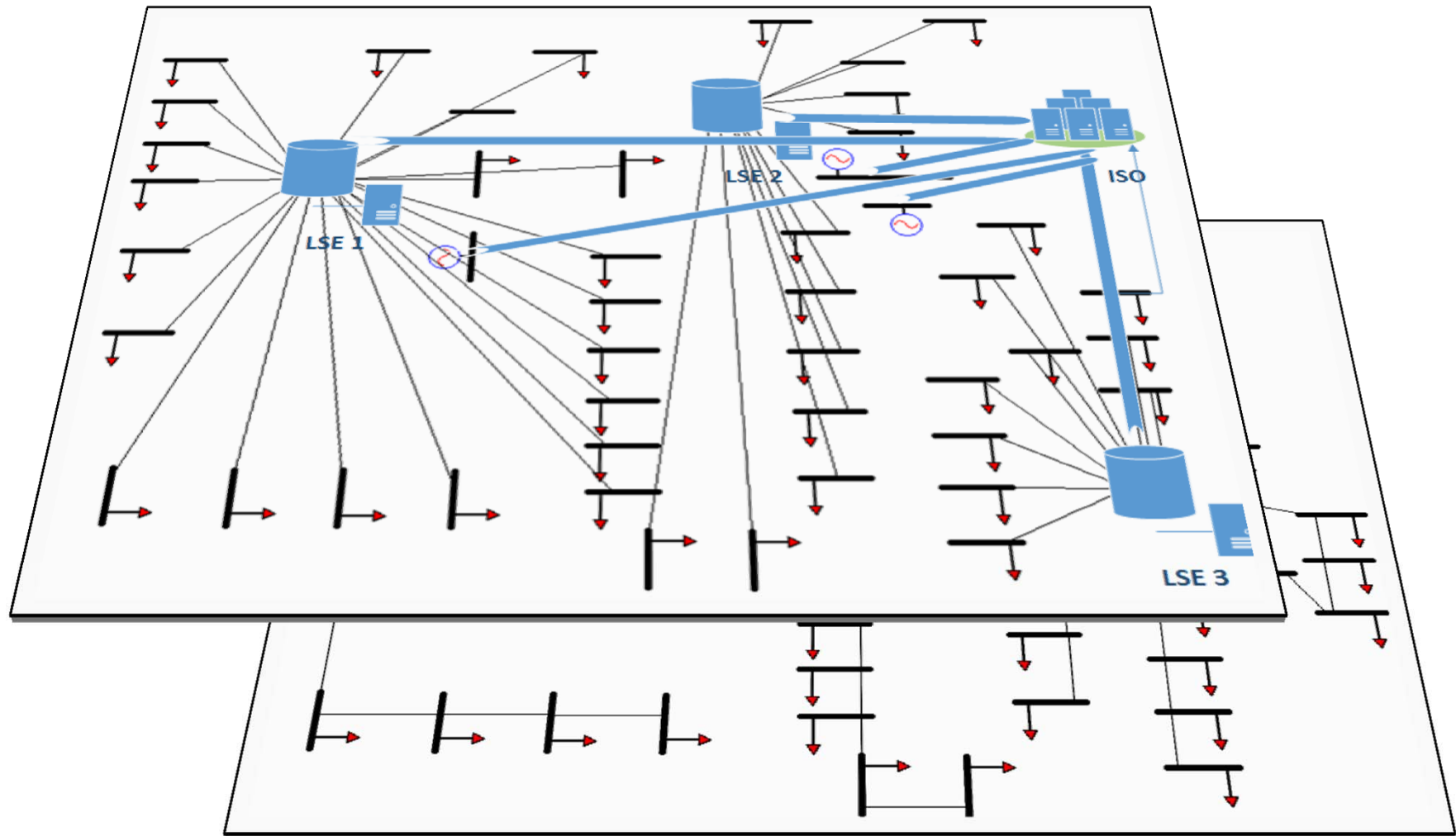
Centralized Communication and Control



Wagner, Ilić, Franchetti

4

Centralized Overlapping Layers



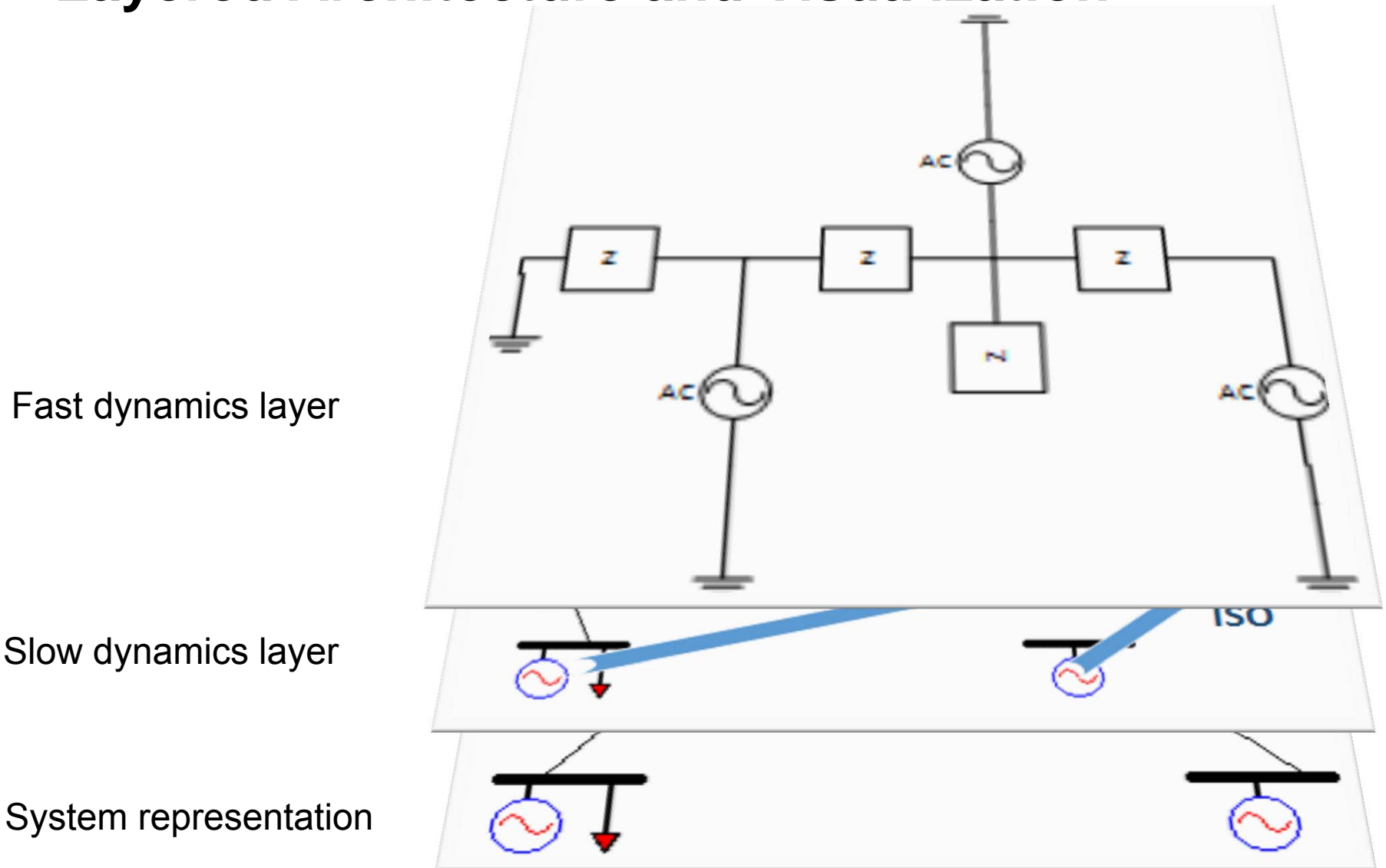
EESG Simulation Approach

❖ Decentralization

- Each physical entity is a separate model for fast dynamics simulation
- Techno-economic layer (PF, OPF) can be partially or fully decentralized for slow dynamics

❖ SGRS is a distributed, not a parallel simulation algorithm

Layered Architecture and Visualization



Wagner, Ilić , Franchetti

What is Gained?

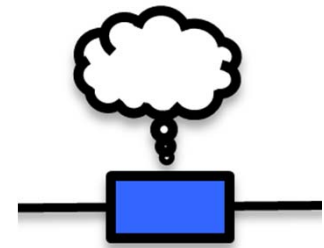
- ❖ Computational speed – supported by fast communication channels
- ❖ Possibility of mixing monitored and simulated data
- ❖ Hardware models are localized
 - Internal, proprietary information undisclosed
 - Expert developed and tested algorithms

- ❖ Bidding strategies can be tested globally without disclosing them
- ❖ Visualizing different dynamics and/org parts of the network
 - Observe slow or fast dynamics
 - Monitor different geographical regions

SGRS –Unified Modeling Approach

❖ Models are designed to be physical entities

- Generator
- EV
- Smart wire

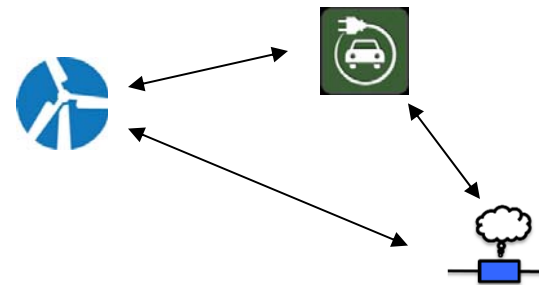


❖ Every entity is described by more than one Model – multi-layered

- Generator (Transactive Energy, Fast Transient, AGC)

SGRS – Communication Framework

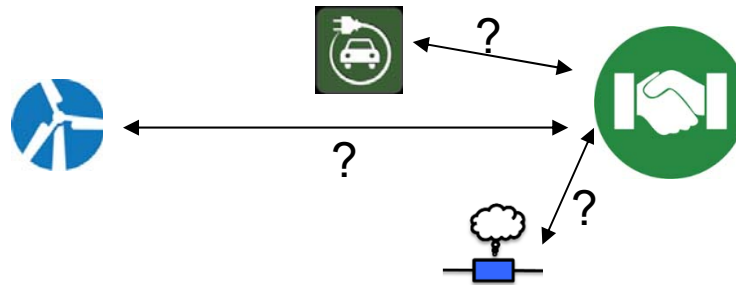
❖ Models can communicate within a layer or between layers



- E.g. (TE <-> Fast Transient)
- Unified Communication Framework
- Communication details abstracted away from Model designer

SGRS – Communication Framework

- ❖ How do objects know where to connect?
 - A Broker knows the connections
 - At simulation startup:
 - ❖ Object registers at the broker
 - ❖ Objects request connection to neighbors



SGRS – Broker/Web interface

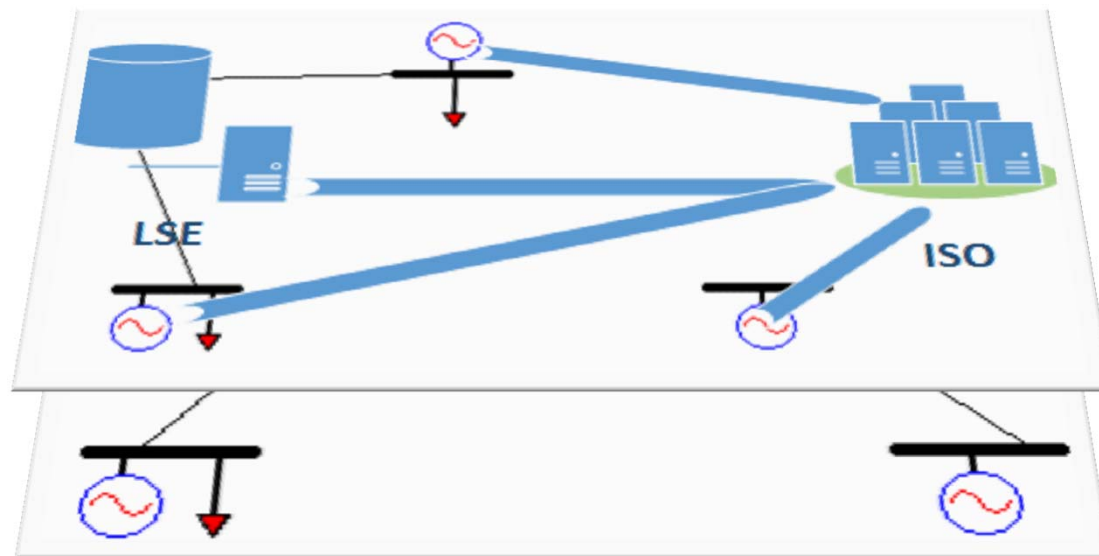
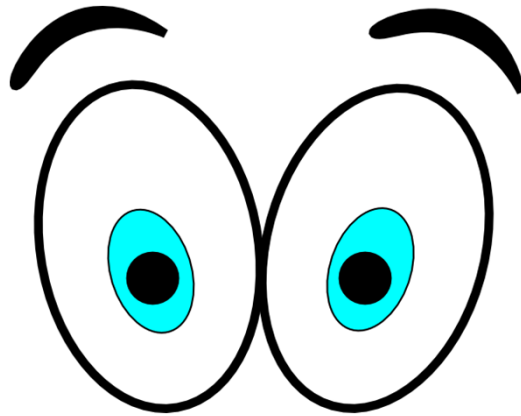
❖ Broker – running on a web server



❖ Additional to establishing connections it can:

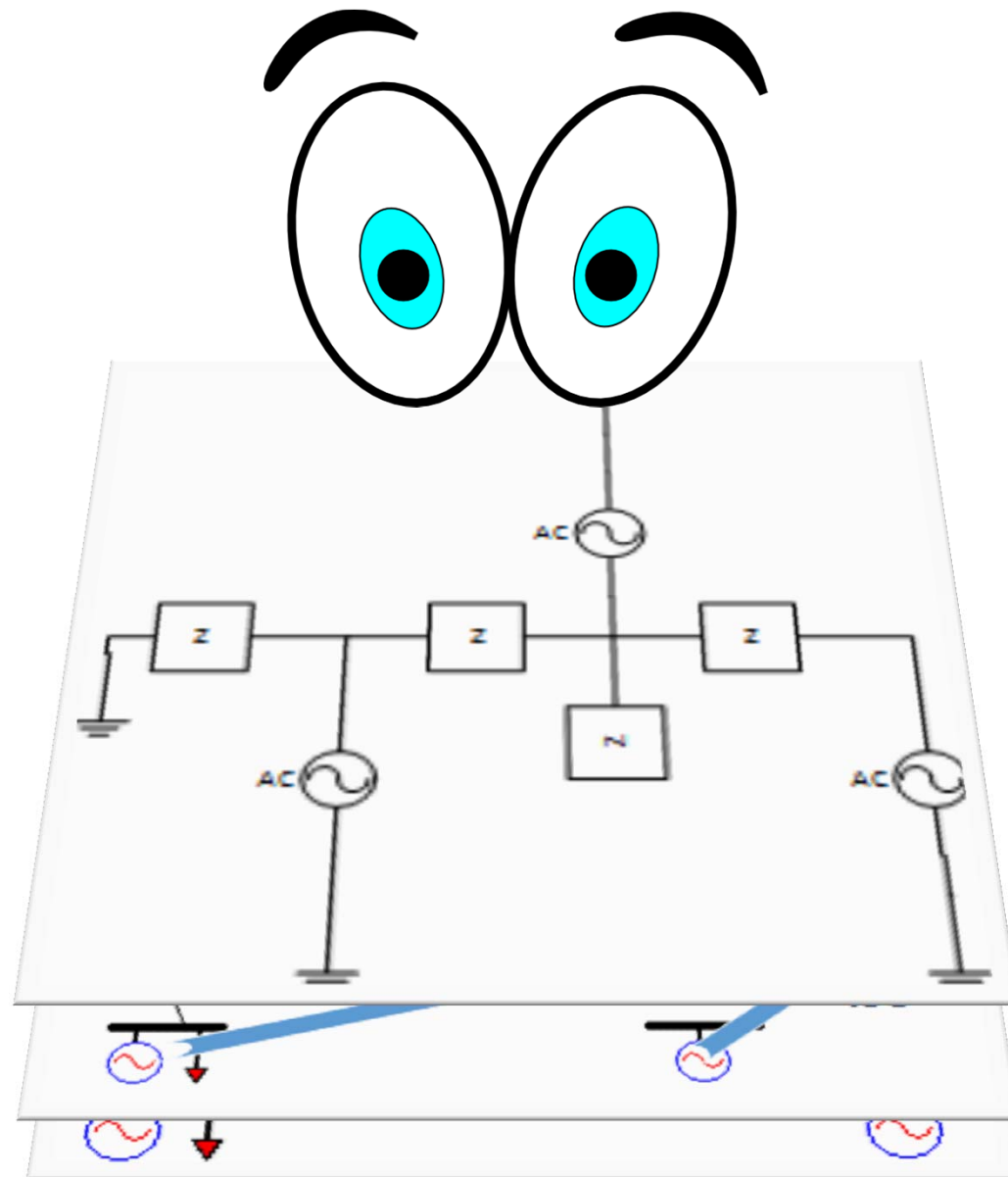
- Load defined simulations from Simulation Database
- Start/Stop/Clear the loaded simulations
- Provides live plotting of logged variables to check for possible errors

Interested in live market clearing data (slow time)?



Wagner, Ilić , Franchetti

Or maybe simulated fast dynamics?



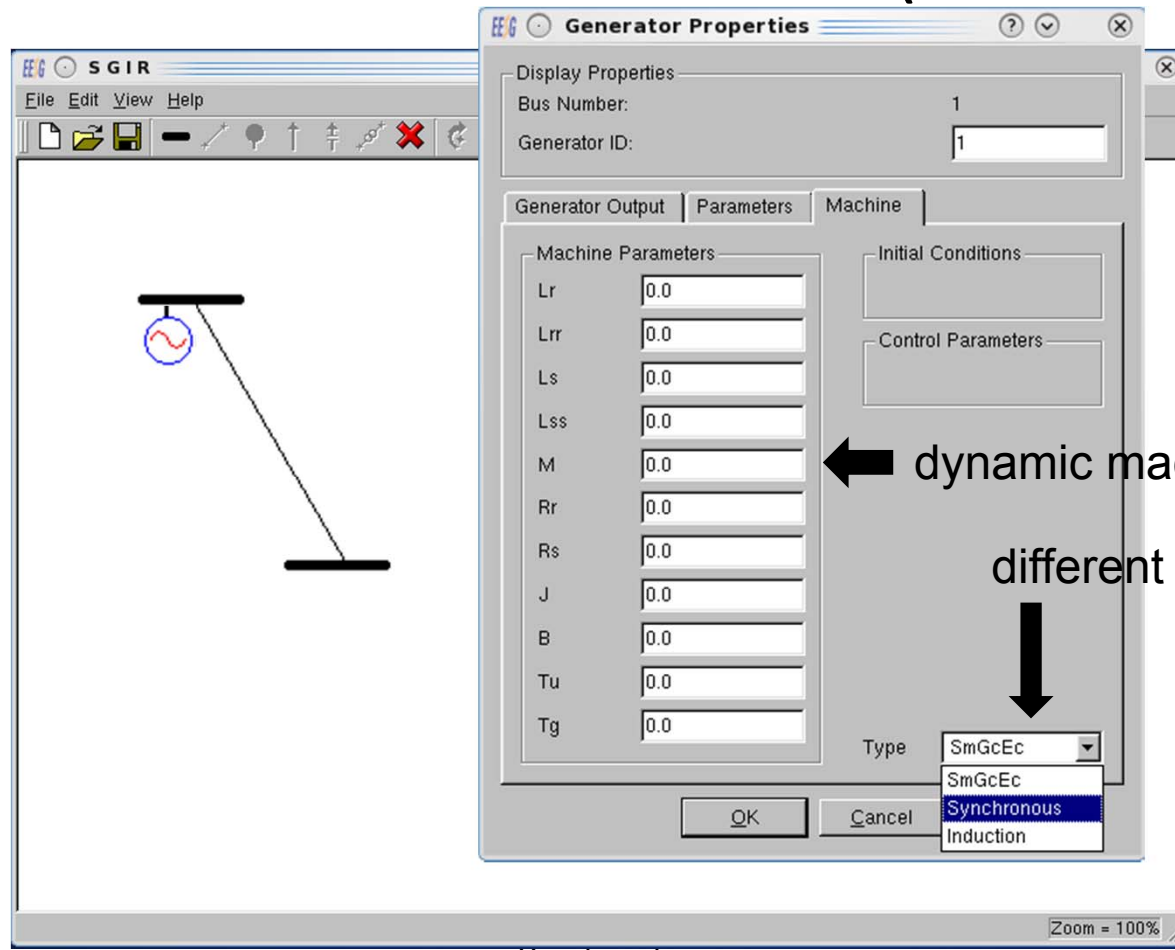
Wagner, Ilić, Franchetti

Building and Running a Simulation

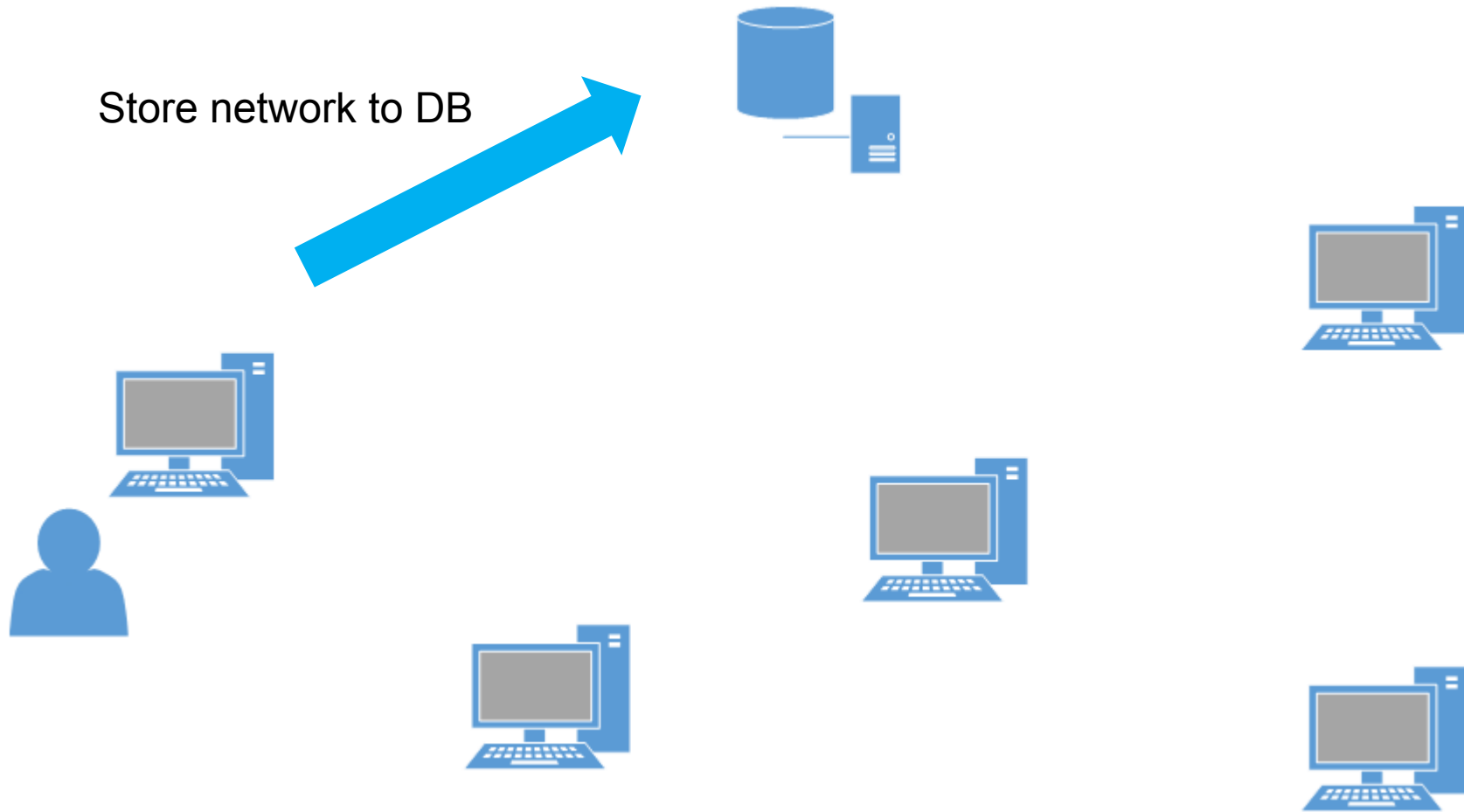
- ❖ User enters network topology, components, and component parameters using EESG GUI
- ❖ Network is stored in an online database
- ❖ User requests from the server to distribute the simulation among networked computers
- ❖ While components are simulated locally, the entire system is simulated through local info exchange
- ❖ User monitors components of interest

Building the Network

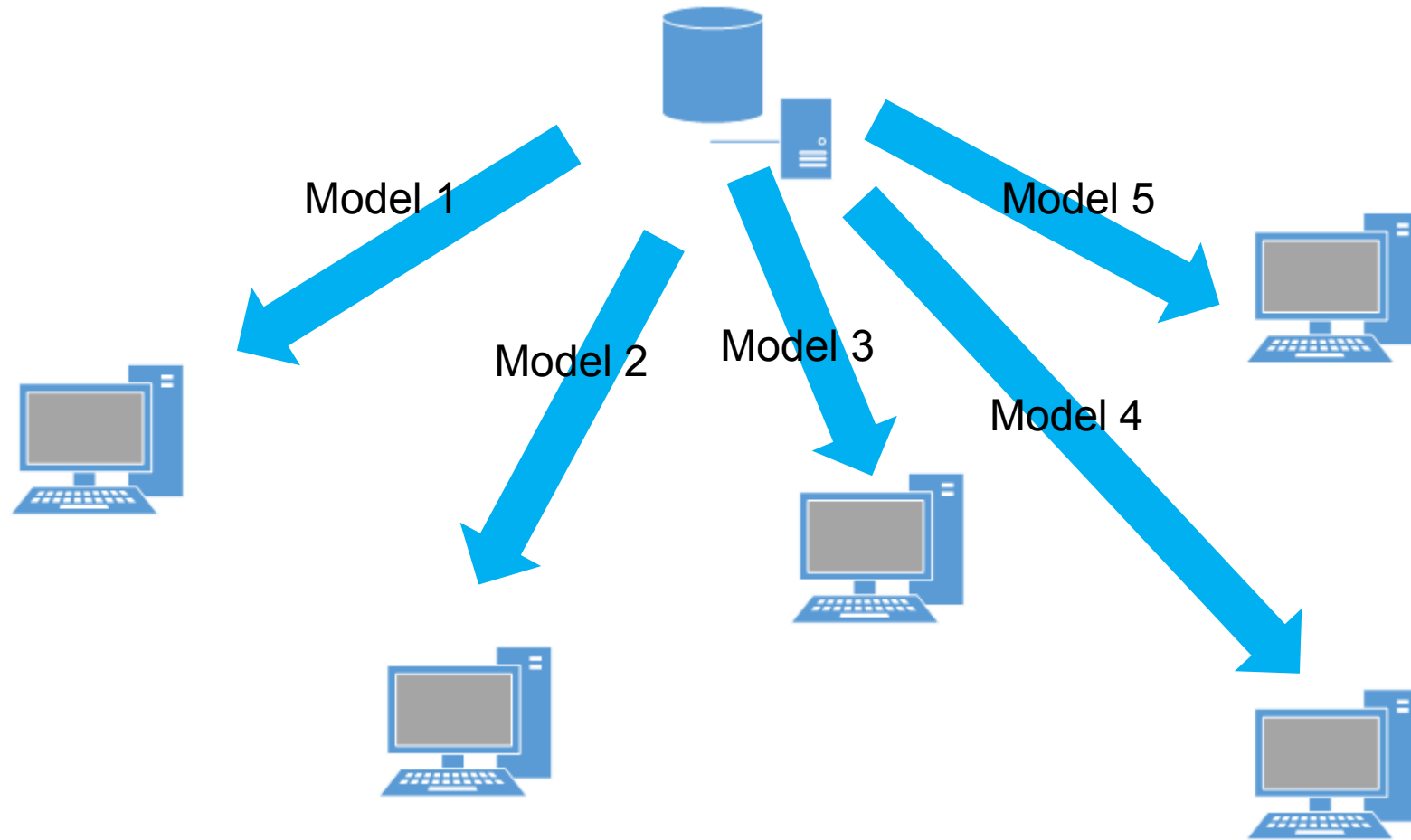
- ❖ GUI or textual format
- ❖ Exported to different formats (work in progress)



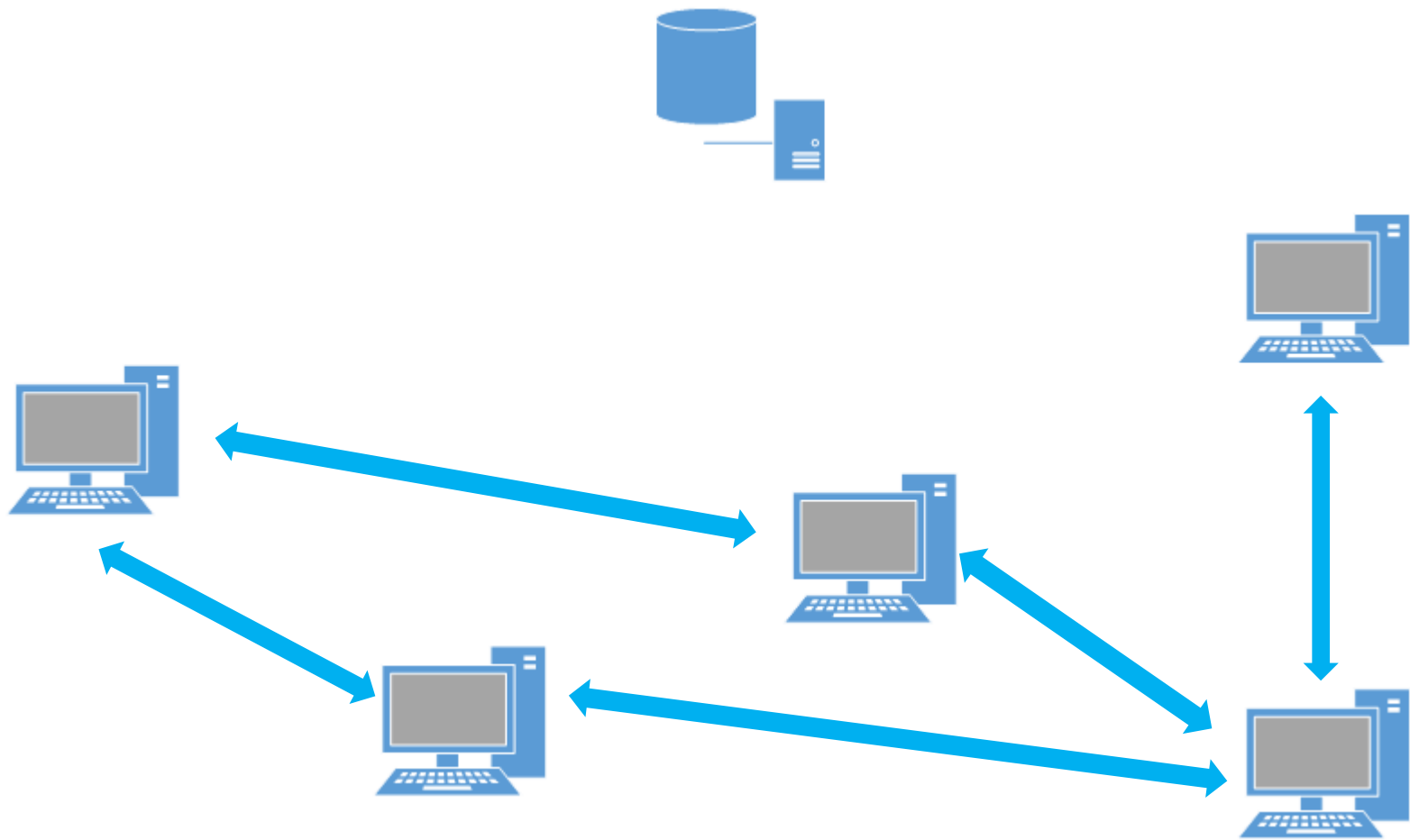
System Model Stored in a DB



Distribute the Simulation

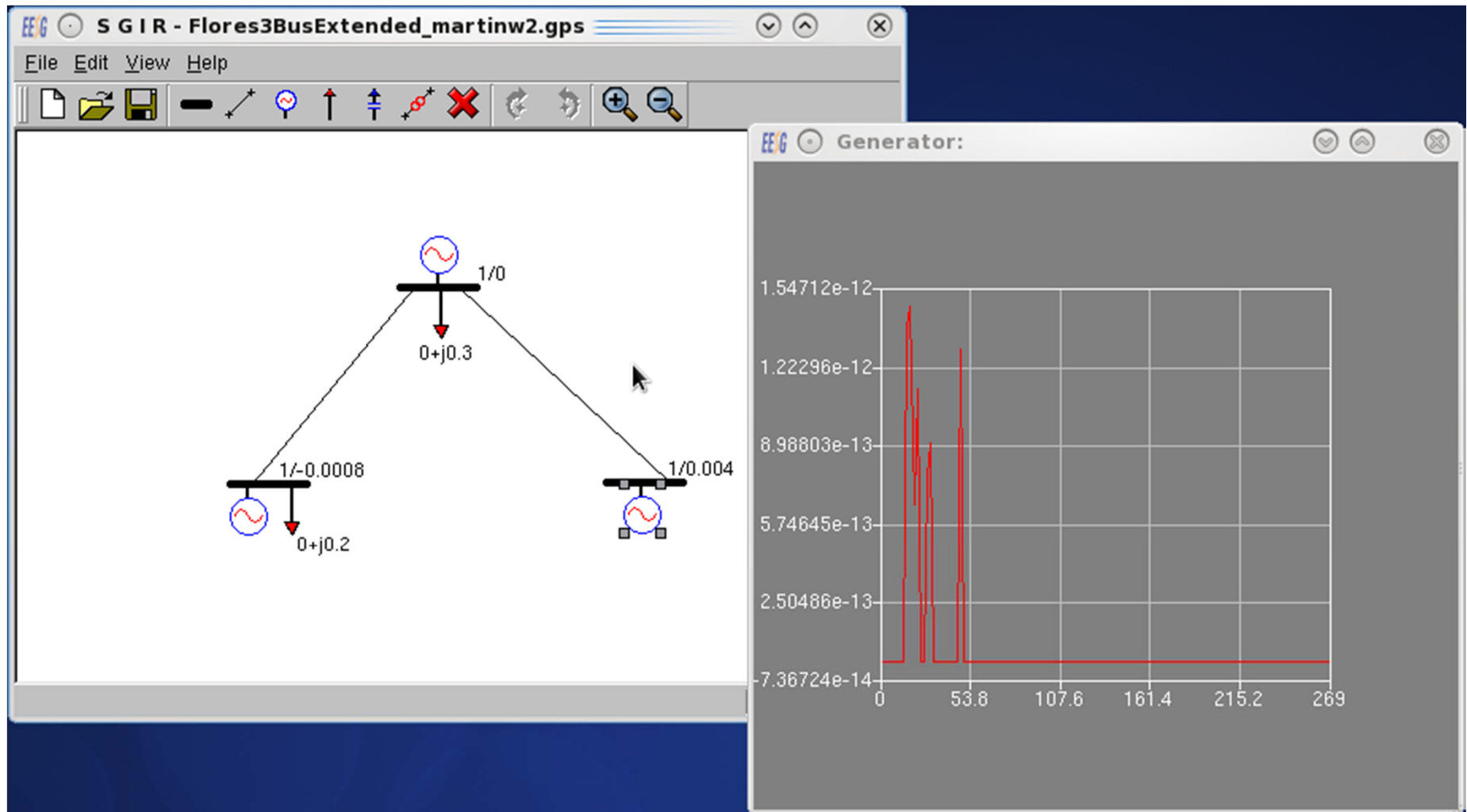


Simulation Executes



Wagner, Ilić , Franchetti

User monitors components of interest



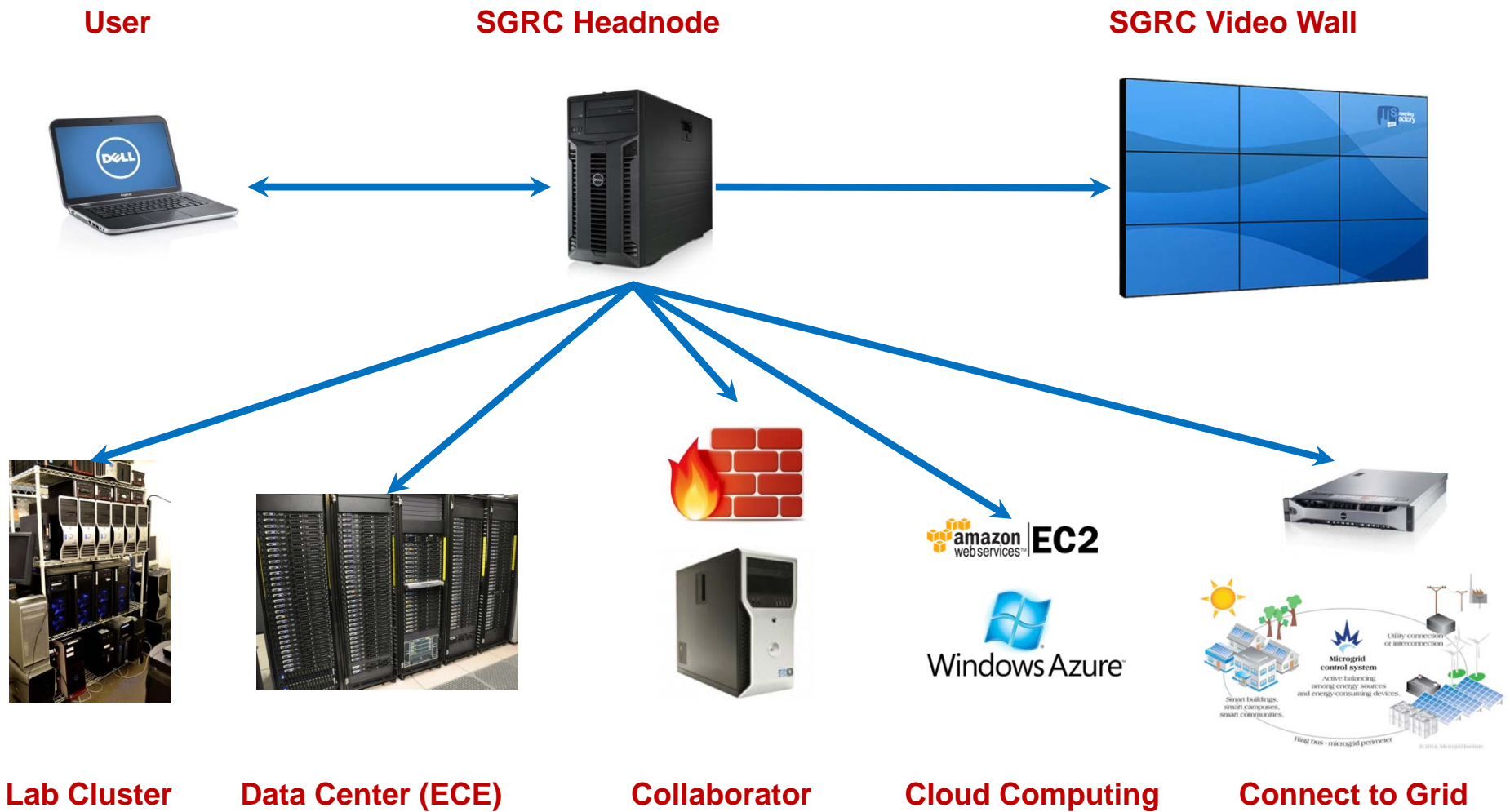
Issues and difficulties

- ❖ Communication bandwidth
- ❖ Data exchange standardization
 - Similar to FMI, CIM, etc.
 - Custom
- ❖ Multirate/multistep simulation

Design Principles

- ❖ **Utilize a wide range of worker machines**
local machine, local server, local cluster, central cluster, cloud service, remote server at collaborators
- ❖ **Utilize power system topology to speed up simulation**
DYMONDS approach is key to scalability and security
- ❖ **Remote servers choose which data to share**
Physical, IT, and physics-based security
- ❖ **Hardware-in-the-loop/digital twin**
Can connect to true data sources to drive simulation

Scalability of the SGRC Simulator



Lab Cluster

Data Center (ECE)

Collaborator

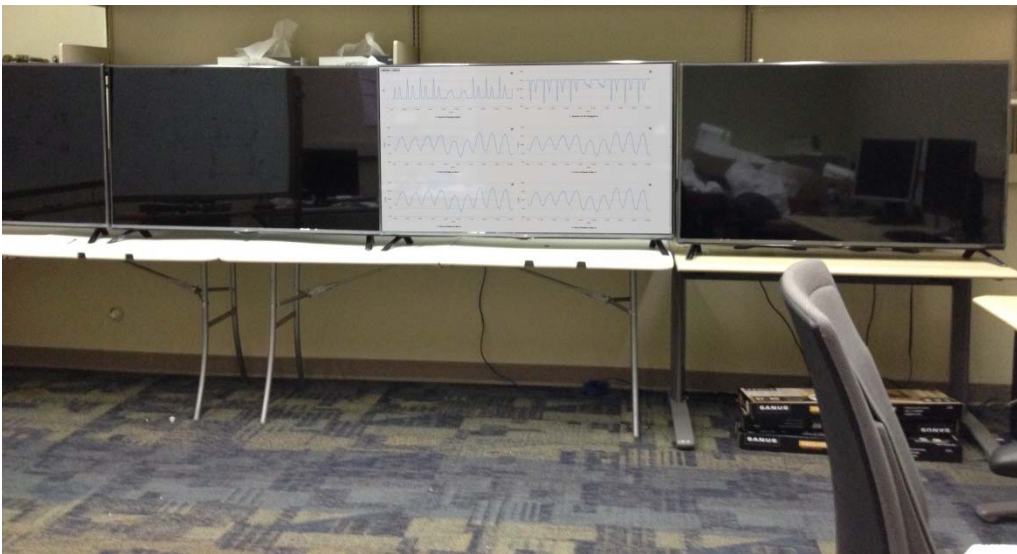
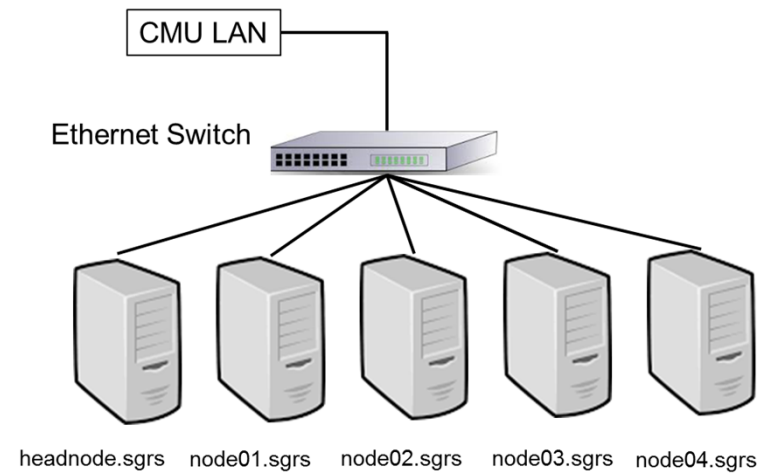
Cloud Computing

Connect to Grid

Wagner, Ilic, Franchetti



SGRS - Infrastructure



Wagner, Ilic, Franchetti



Questions