SmartGrid is greater than smart grid

News from Research Labs

Valeriy Vyatkin
University of Auckland, New Zealand

Presented at the International Energy Conference
«Technological Basis for Creation of Russia's New Energy»
Skolkovo, November 26, 2010

Contacts: v.vyatkin@auckland.ac.nz
http://www.ece.auckland.ac.nz/~vyatkin/

University of Auckland, NZ

energex

ISaGRAF

FREEDM systems center

NSF

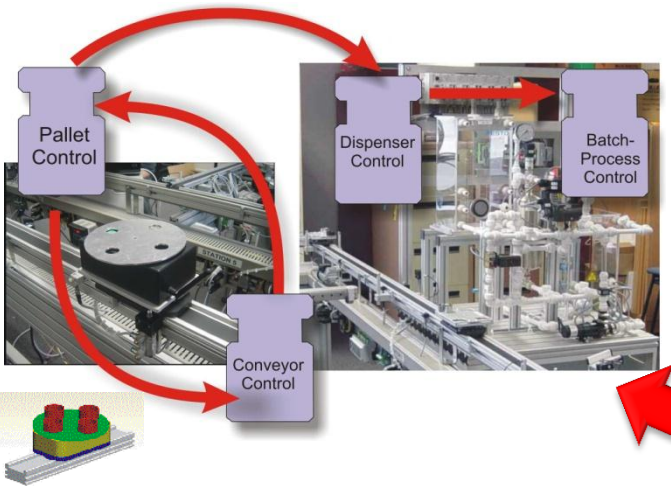
EATON
Powering Business Worldwide

NXT Control

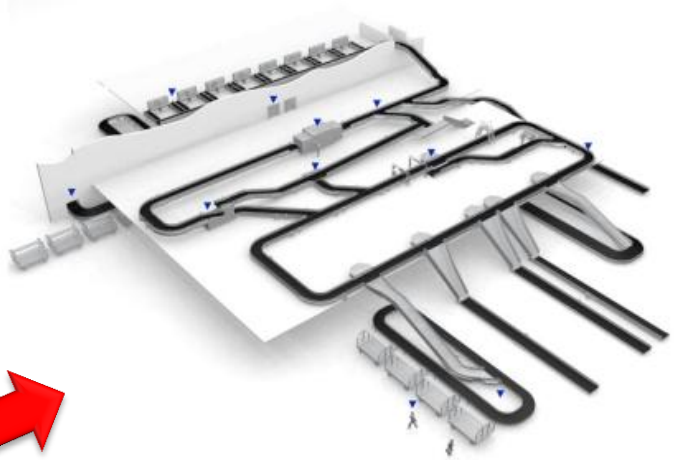
Vector

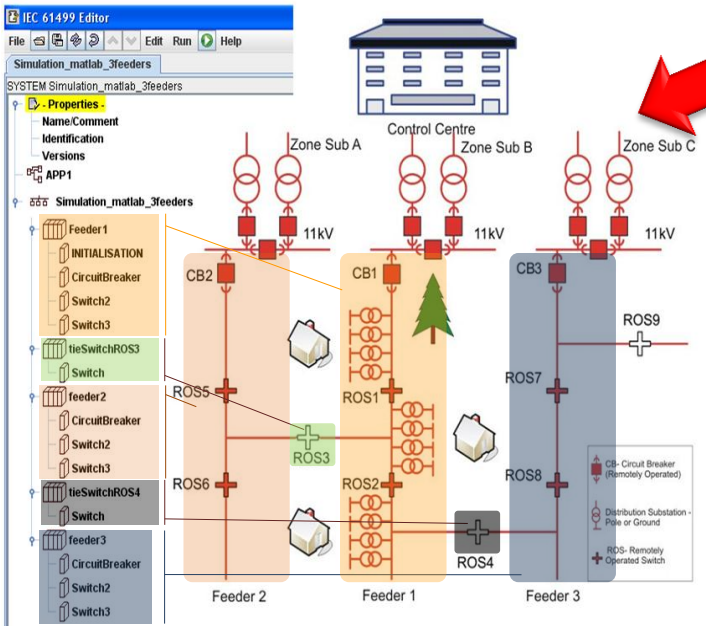
iMonitor

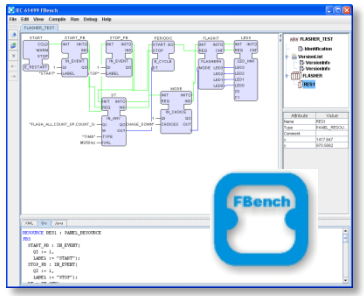
Intelligent Agents in Industrial Environment



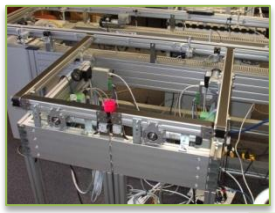
Enabler: powerful networked embedded controllers



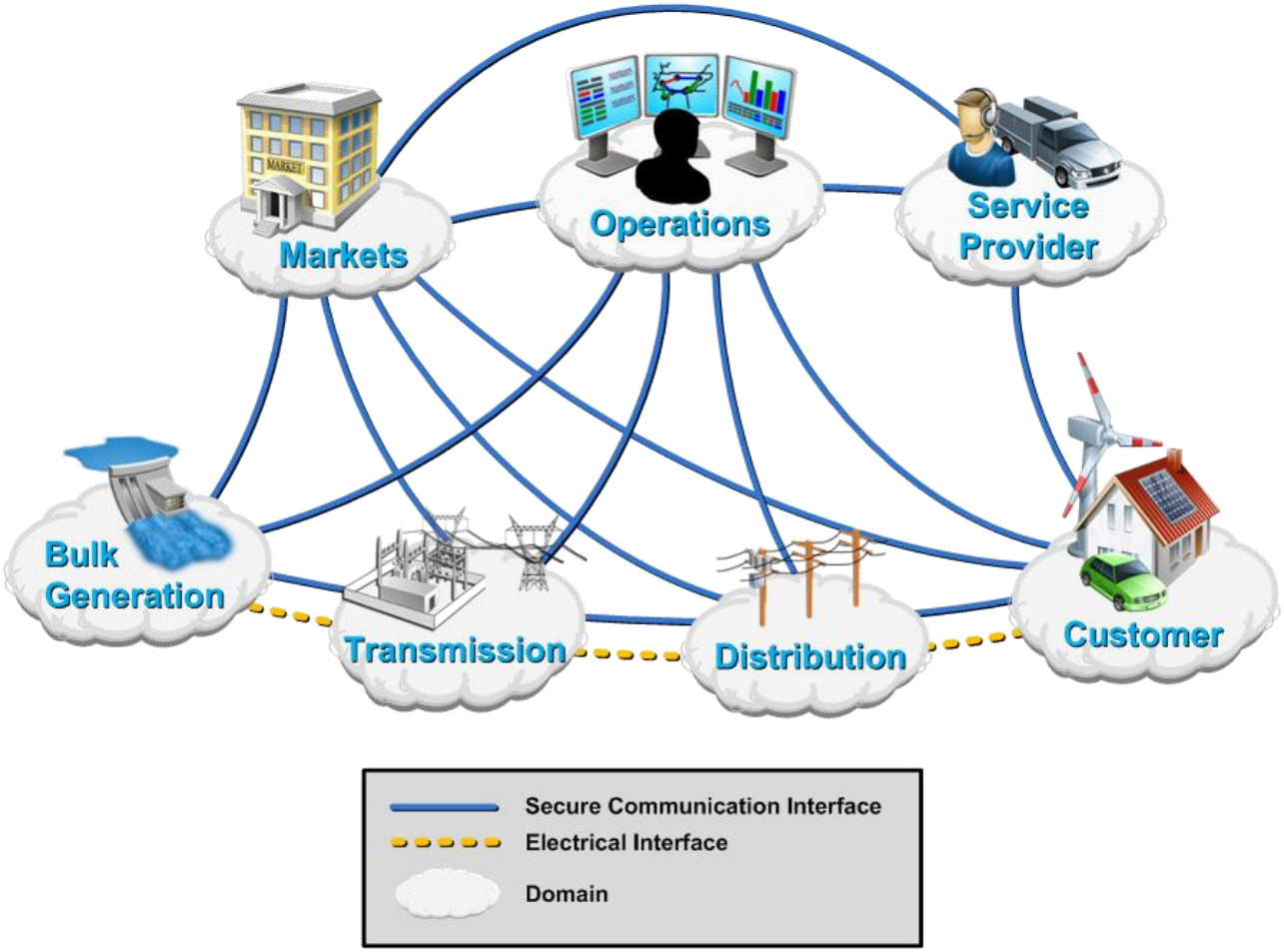




Enabler: Open Source Tool for function block programming



SmartGrid Definition (NIST)

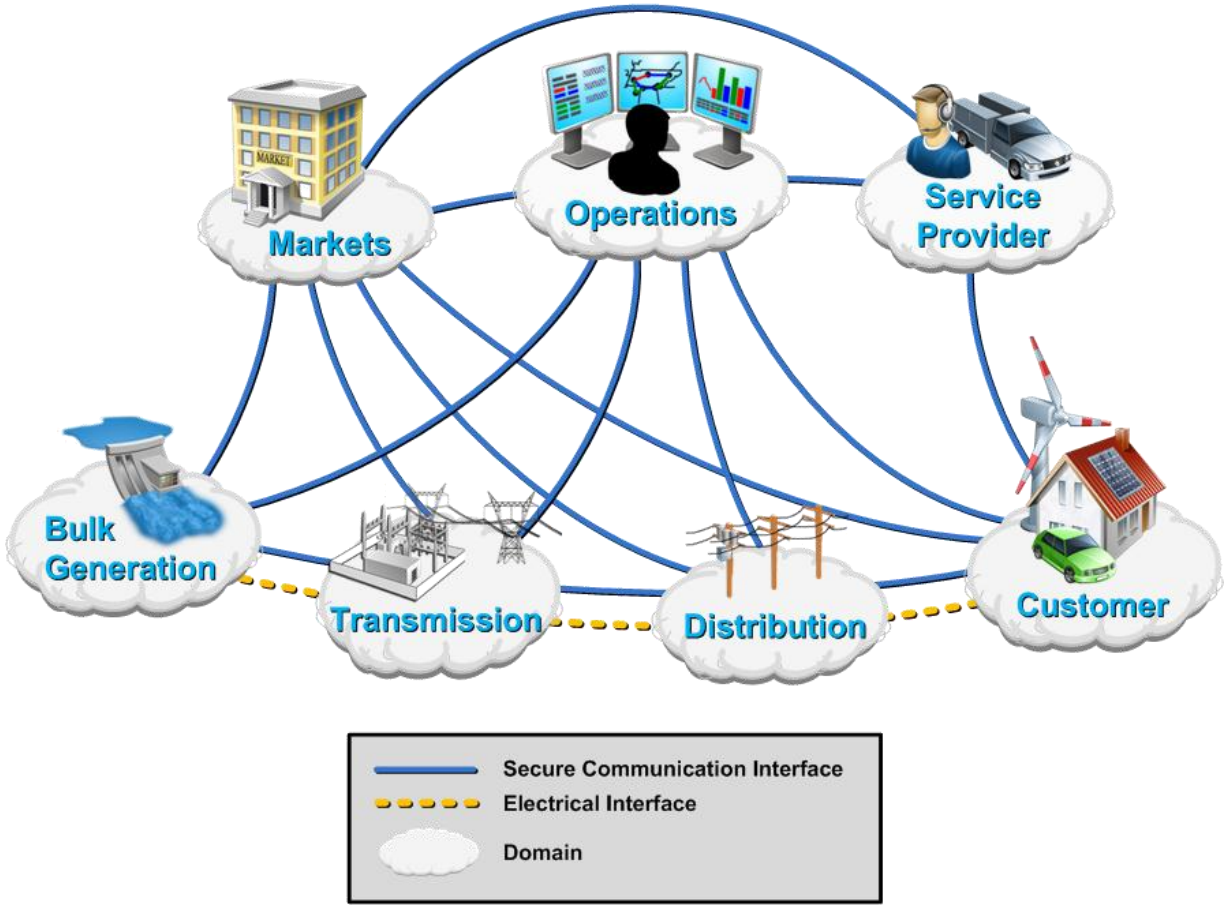


The power distribution grid is already smart enough
But, the potential of making it **smarter** is enormous!

Roadmaps on SmartGrid

1. The European Electricity Grid Initiative (EEGI), Roadmap 2010-18 and Detailed Implementation Plan 2010-12
2. IEC Standardization Management Board (SMB), Smart Grid Strategic Group (SG3), “IEC Smart Grid Standardization Roadmap”, June 2010.
3. Report to NIST on the Smart Grid Interoperability Standards Roadmap," Electric Power Research Institute (EPRI)August 10 2009
4. The German roadmap E-energy / smart grid, DKE German Commission for Electrical, Electronic & Information Technologies of DIN and VDE, VDE Association for electrical, Electronic & information technologies.

SmartGrid Functions



Some features:

- Demand-response
- Distributed generation with renewables
- Electric vehicles
- Self-healing grid

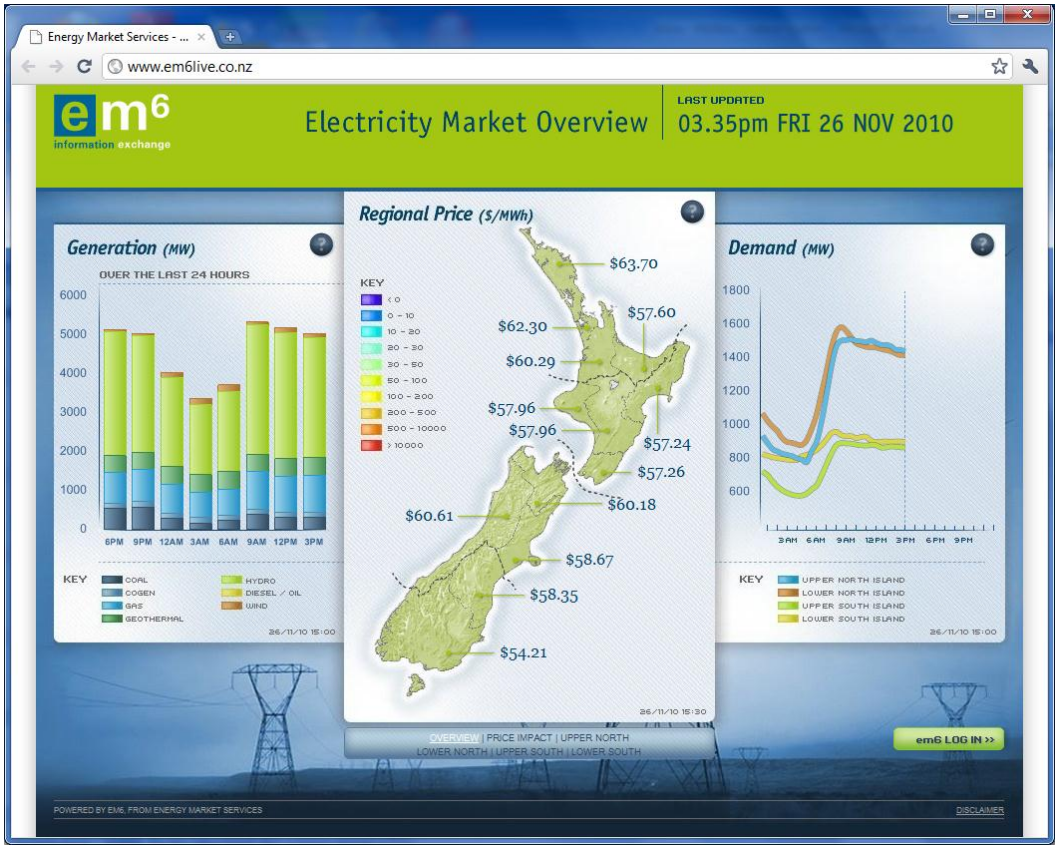
Demand-Response

Buzzwords:

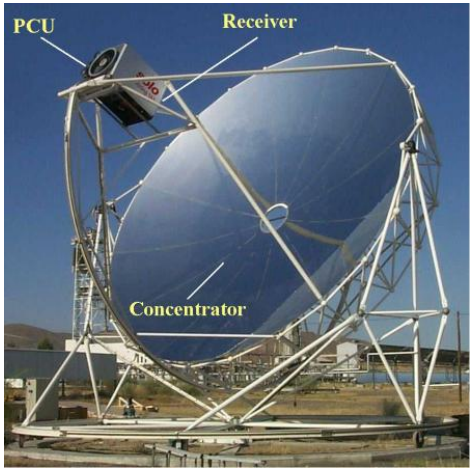
- Floating prices
- Spot Market
- Peak shaving
- Price signals
- **Smart metering**
  - **-itemized bill**
  - **-control**

<u>Technology:</u>

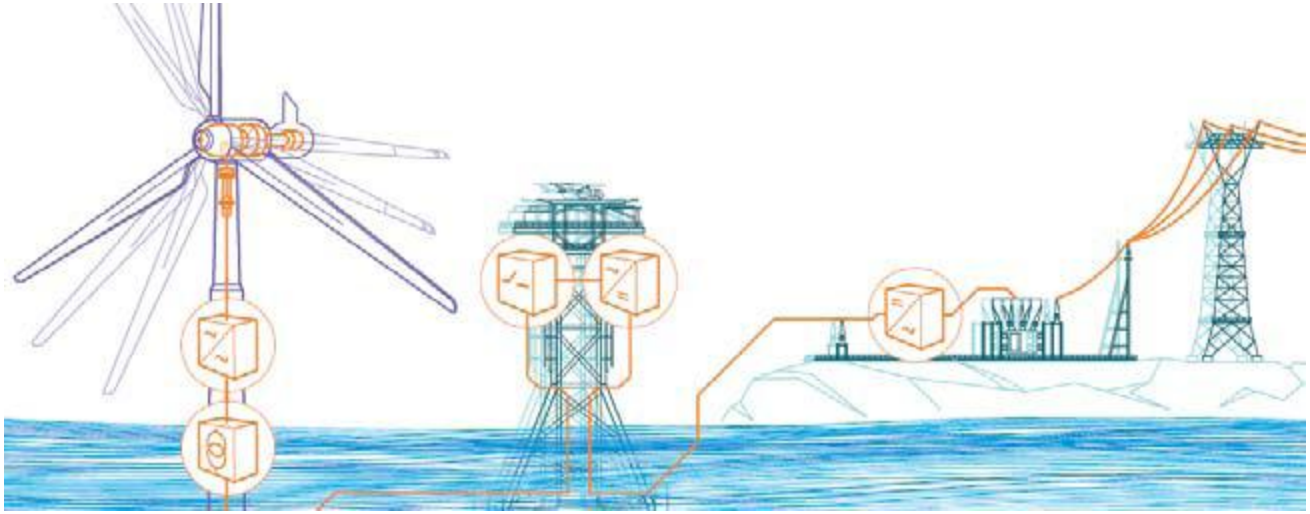
Internet, embedded electronics



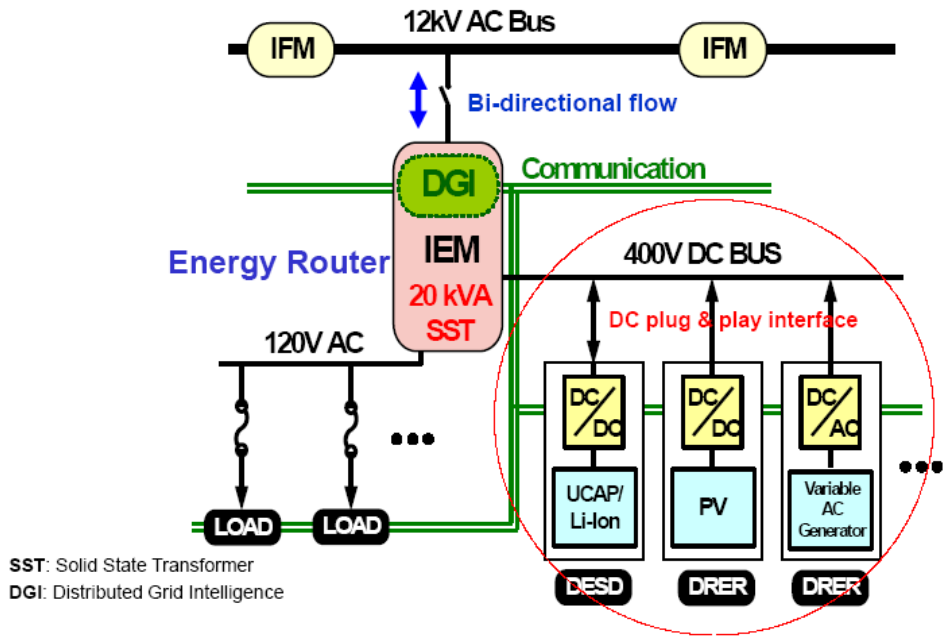
Renewables



Technology: sophisticated power electronics

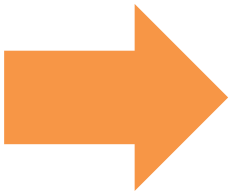


Renewables: Plug and Play

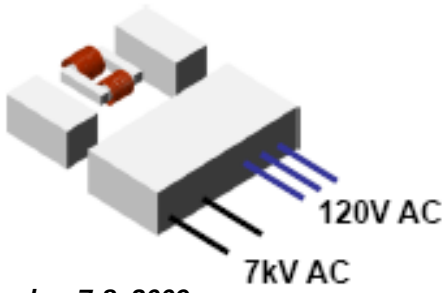


Enabling Technology: potentially a much smarter

Distribution transformer



Solid State Transformer (SST)



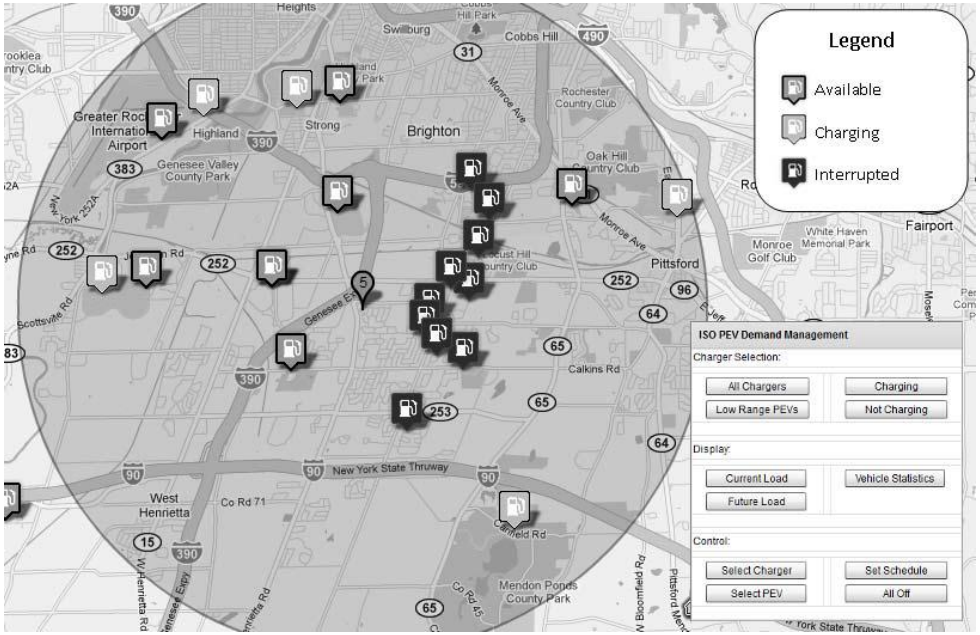
Illustrations from: A. Huang, FREEDM Systems, ***NSF-VT RESIN Workshop, Alexandria, VA, December 7-8, 2009***

Electric Vehicles

So many unknown unknowns, but lots happening!

Charging station

Web infrastructure



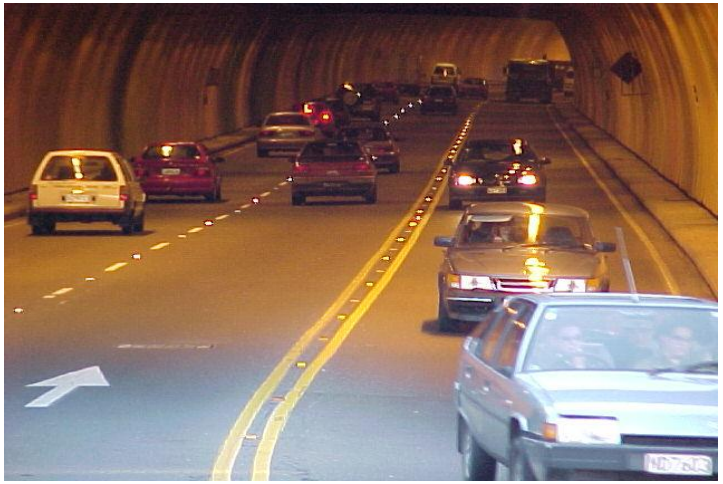
Mobile application

Technology: Automotive, Power electronics, Internet, Communication, Power transfer
Impact: Complex
Dependency: Complex

Illustrations from: Käbisch et al., “Interconnections and Communications of Electric Vehicles and Smart Grids”, IEEE SmartGrsidComm Conference, 2010

IPT Technology (University of Auckland)

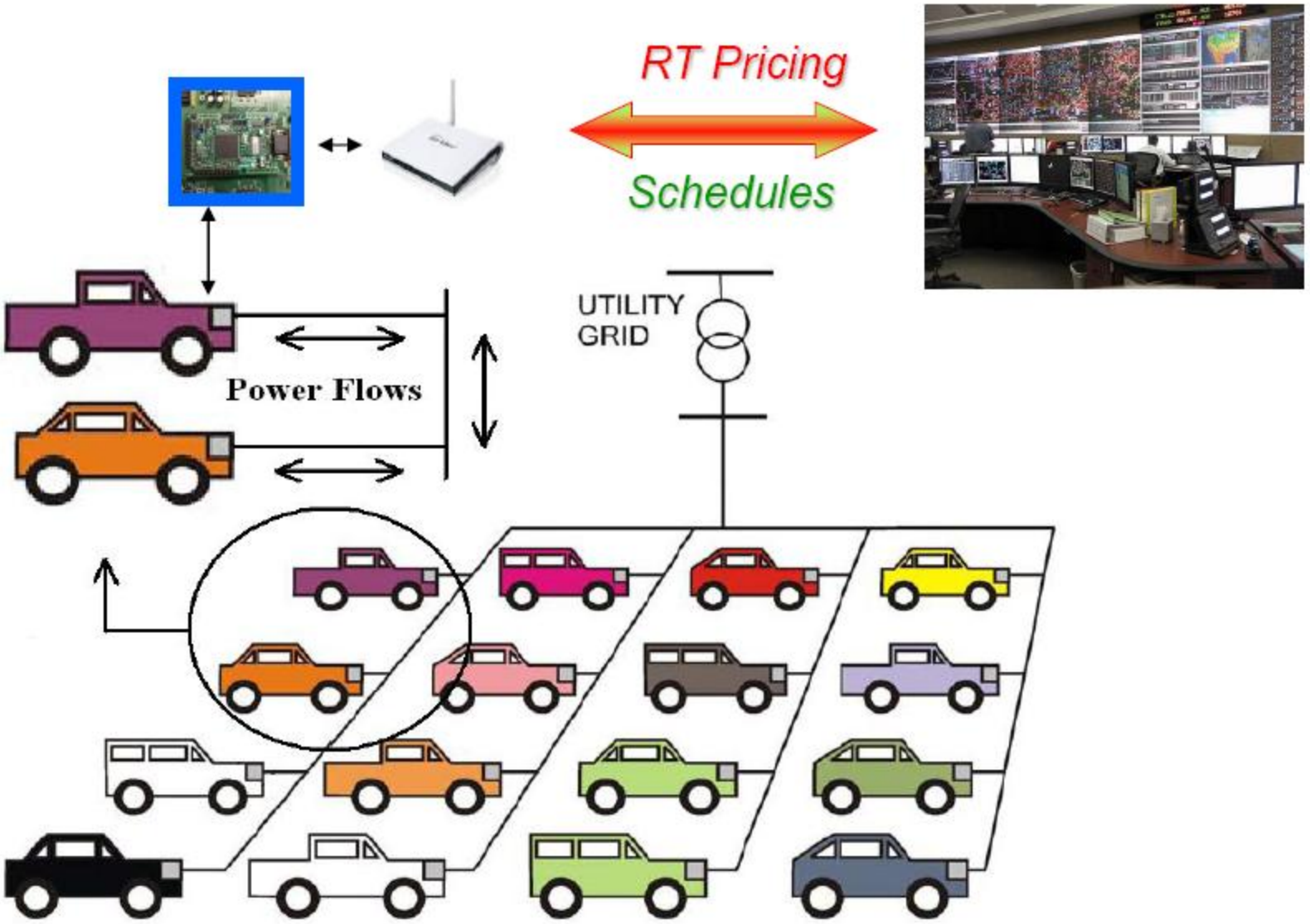
Wampfler 20kW Charge



Terrace Tunnel (Wellington, NZ)

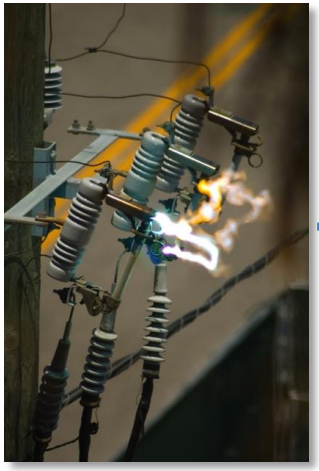
Whakarewarewa Thermal Village, NZ

EV improving the Grid



Slide from © G. K. Venayagamoorthy, NSF-VT RESIN Workshop, Alexandria, VA, December 7-8, 2009

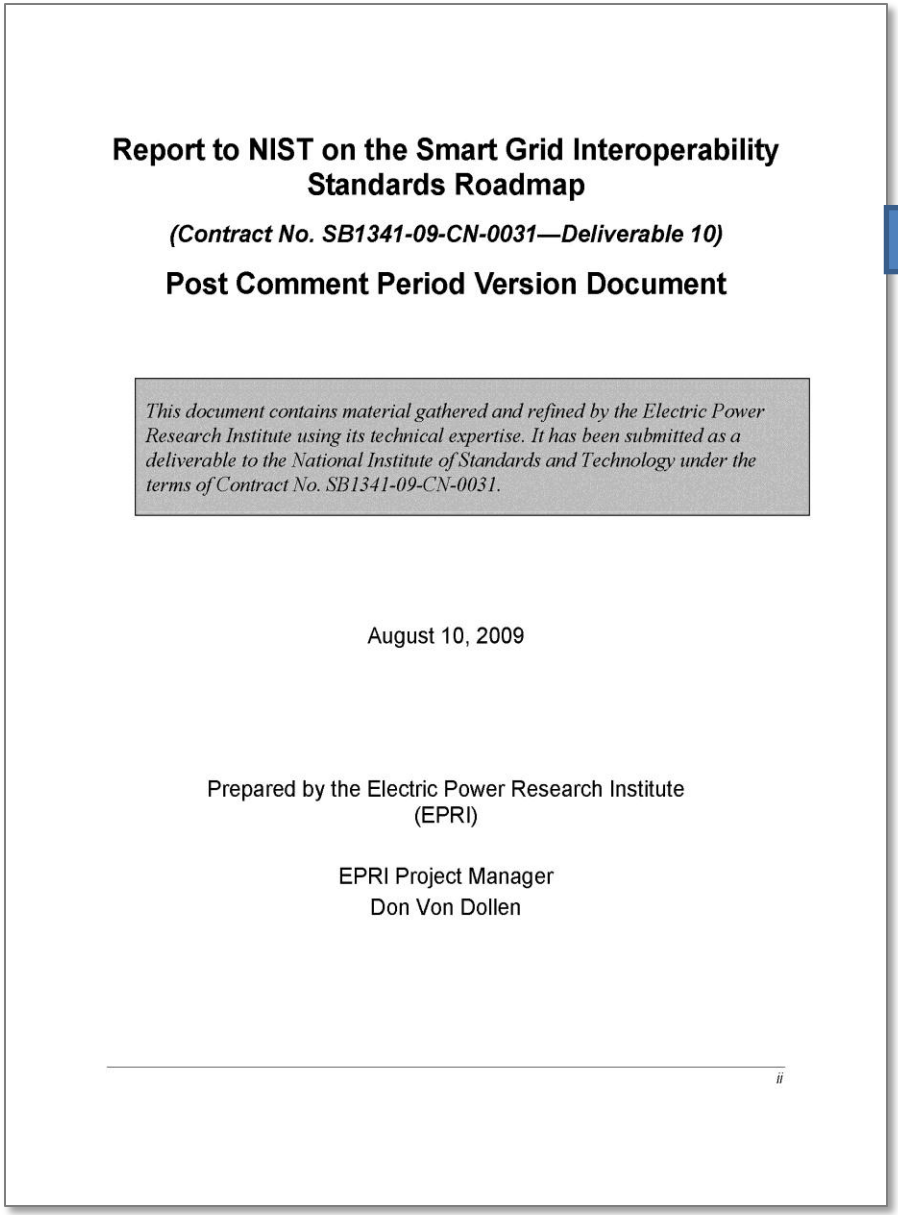
Self-healing Grid



- **Automatic** fault location, isolation and service restoration (FLISR)
- Preventing and localizing cascading failures in real time
  - Technology: Phasor Measurement Unit (PMU) + GPS – stability margins calculation

SmartGrid ICT:
New Concepts, Architectures & Standards

ICT Standardisation



Report to NIST on the Smart Grid Interoperability Standards Roadmap

(Contract No. SB1341-09-CN-0031—Deliverable 10)

Post Comment Period Version Document

This document contains material gathered and refined by the Electric Power Research Institute using its technical expertise. It has been submitted as a deliverable to the National Institute of Standards and Technology under the terms of Contract No. SB1341-09-CN-0031.

August 10, 2009

Prepared by the Electric Power Research Institute (EPRI)

EPRI Project Manager
Don Von Dollen

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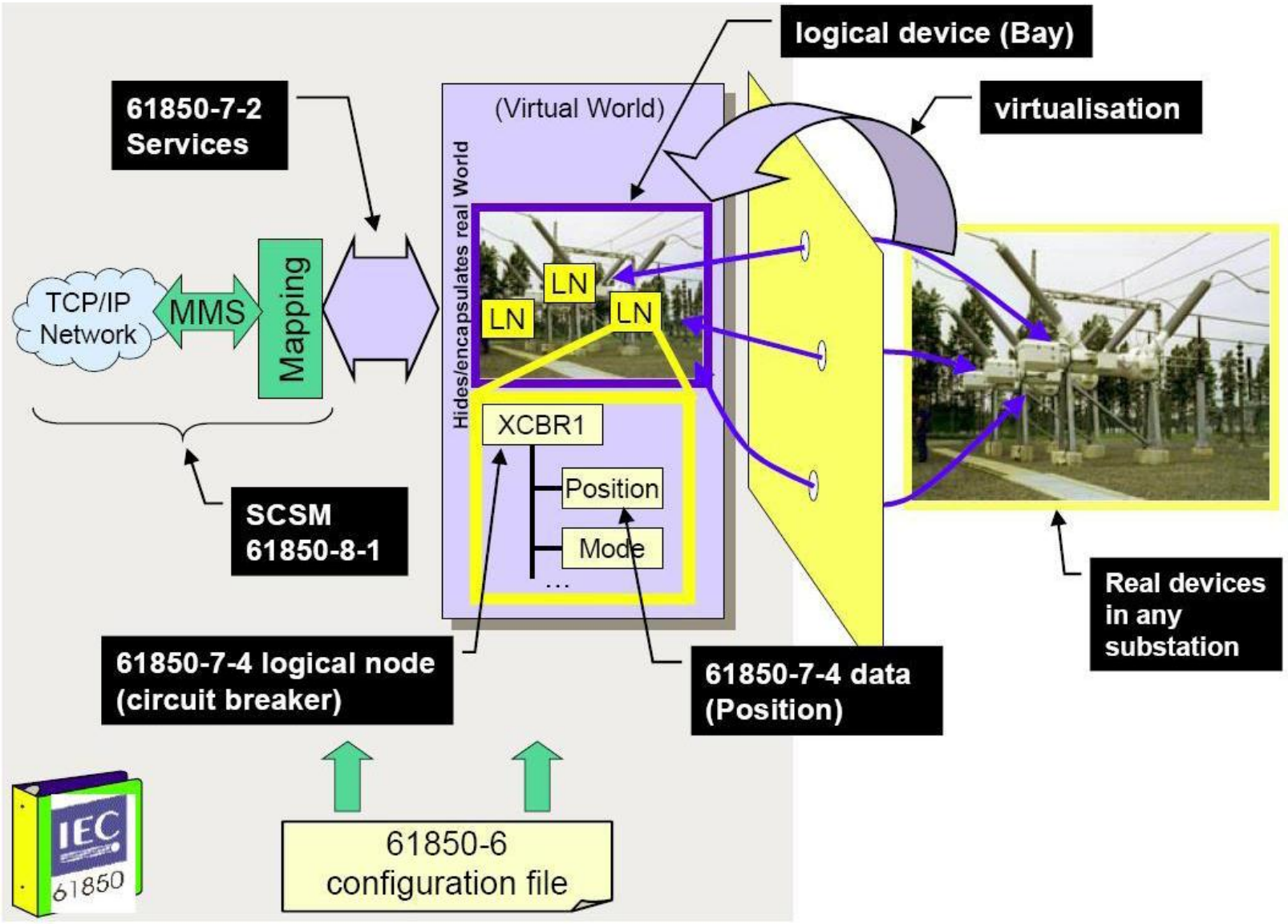
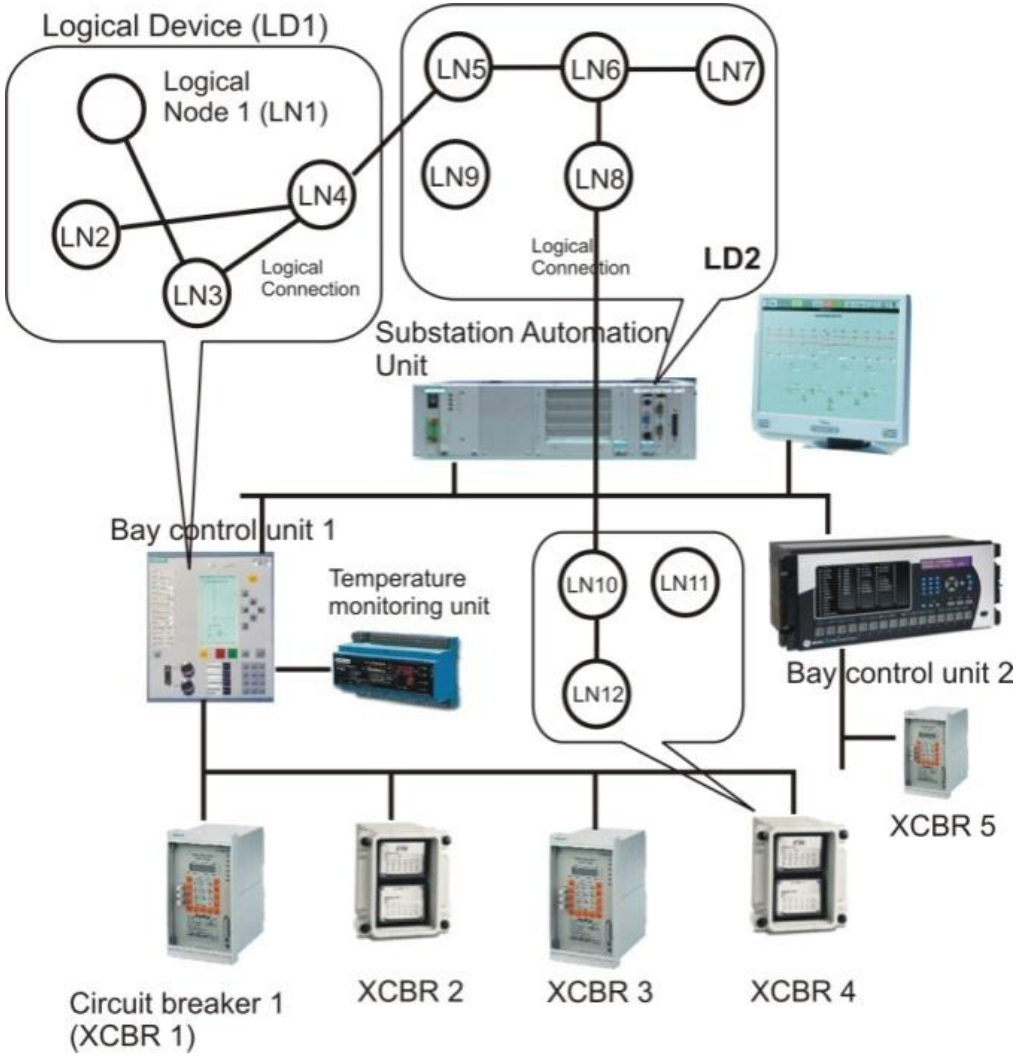
IEC 61850 - Communication networks and systems for power utility automation

IEC 61850 modeling approach



IEC 61850: Advanced State of the Art

Bottom-up data flow, top-down control chain, SCADA architecture



Substation

Bay

Physical

Benefits of IEC 61850 Standardisation

- **Eliminate Procurement Ambiguity**
- **Lower Installation Cost**
- **Lower Transducer Costs**
- **Lower Commissioning Costs**
- **Lower Equipment Migration Costs**
- **Lower Extension Costs**
- **Lower Integration Costs** with enterprise IT
- **Implement New Capabilities – enabling the future**

Advanced Architectures of the Future:

Artificial Nervous System

Distributed Agents

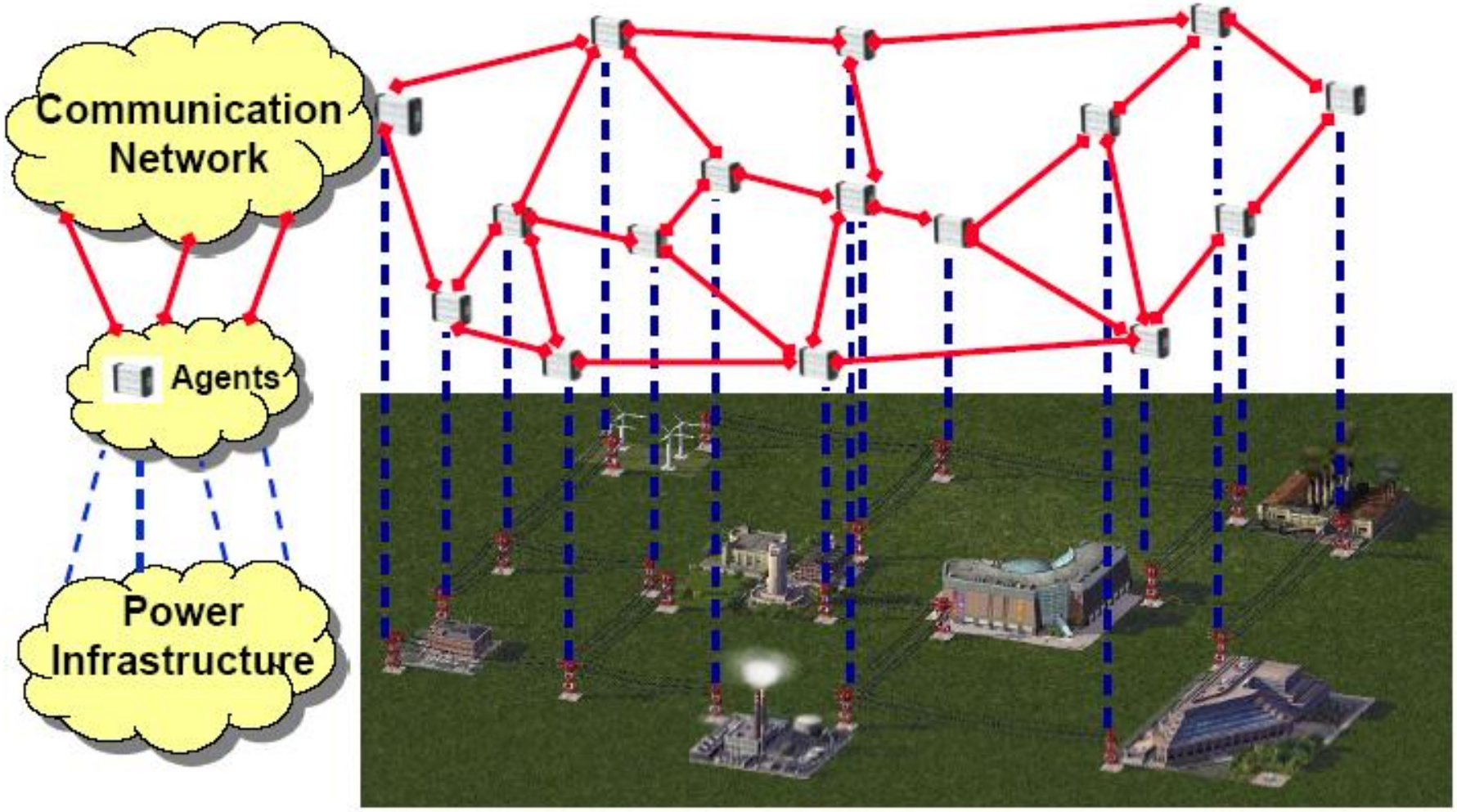
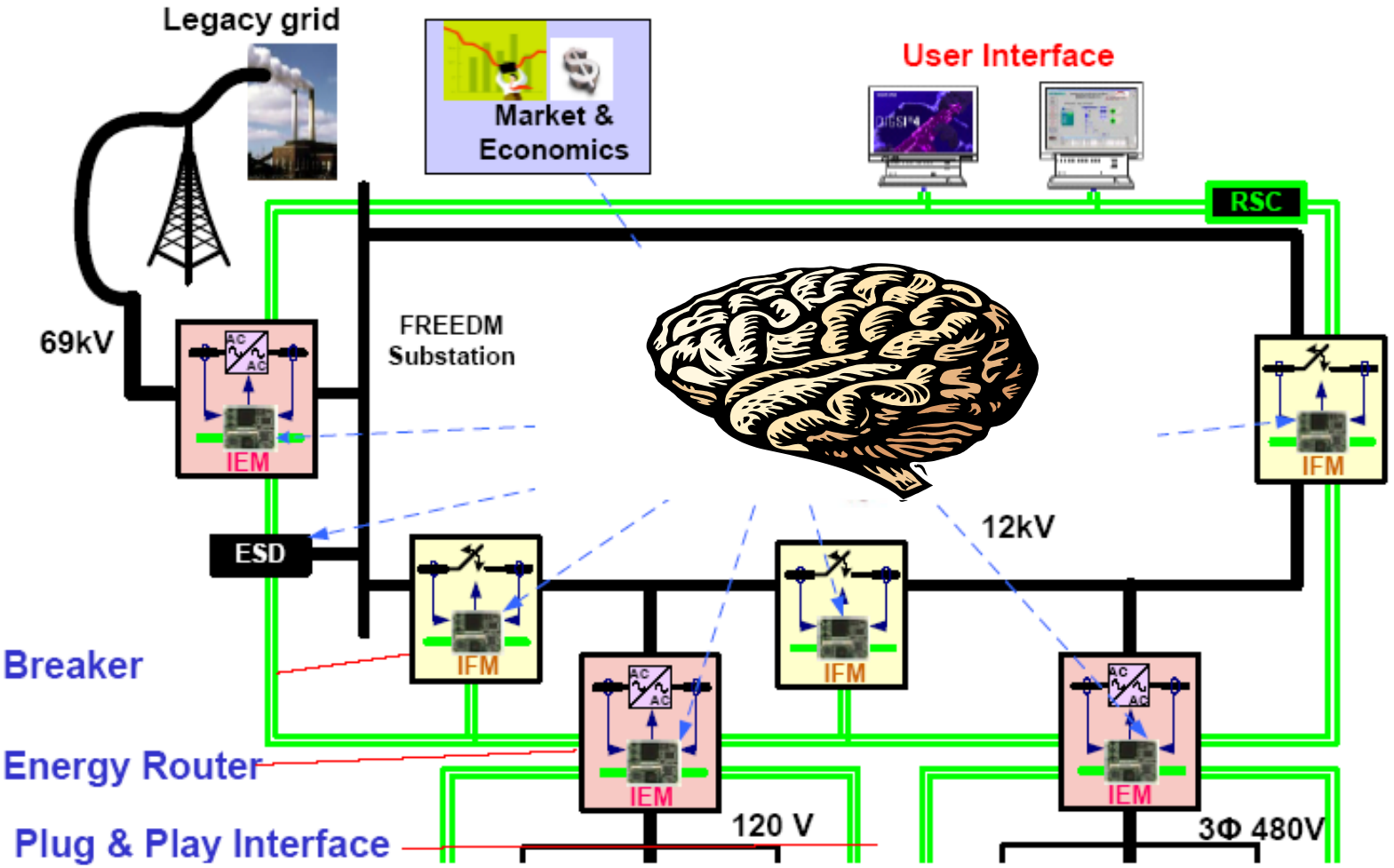


Illustration from: Resilient and Sustainable Electric Power and Communications Infrastructures L.Mili et al, PI, Virginia Tech

FREEDM NSF Project

proposed SmartGrid Architecture



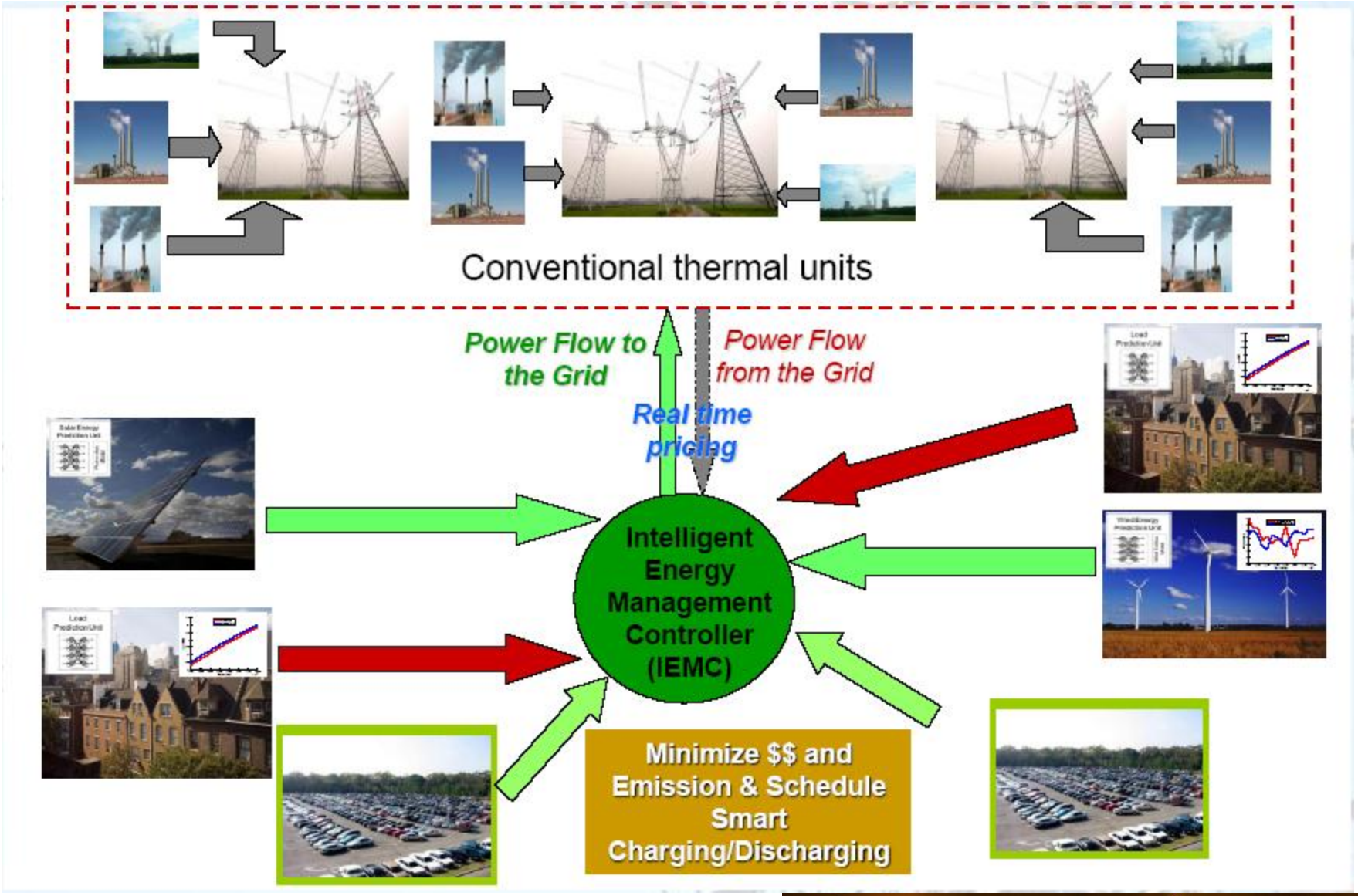
IEM: Intelligent Energy Management **IFM**: Intelligent Fault Management

DRER: Distributed Renewable Energy Resource **DESD**: Distributed Energy Storage Device

This slide is courtesy of A. Huang

FREEDM Systems Center

Brain2Grid NSF Project



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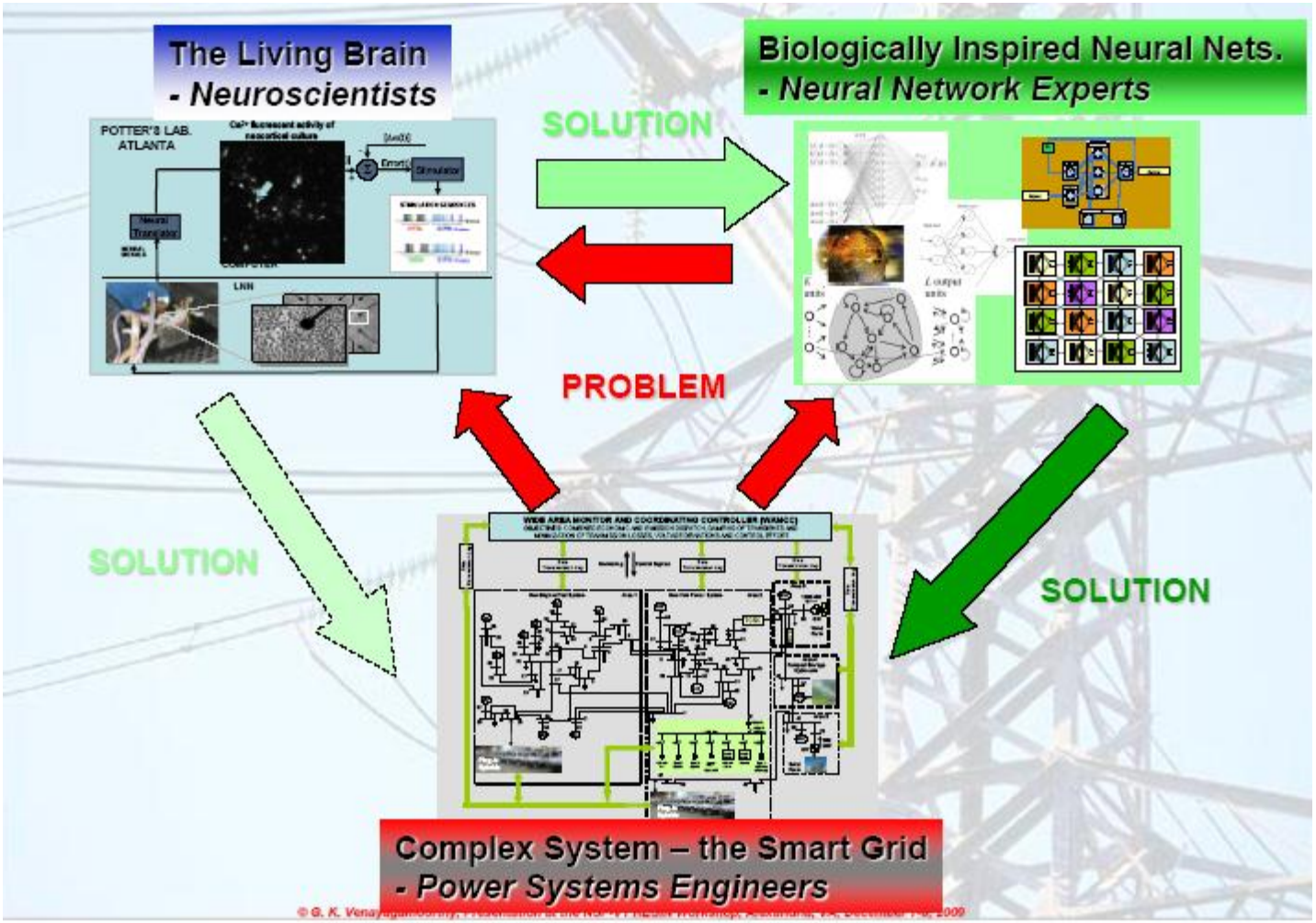
Brain2Grid NSF Project

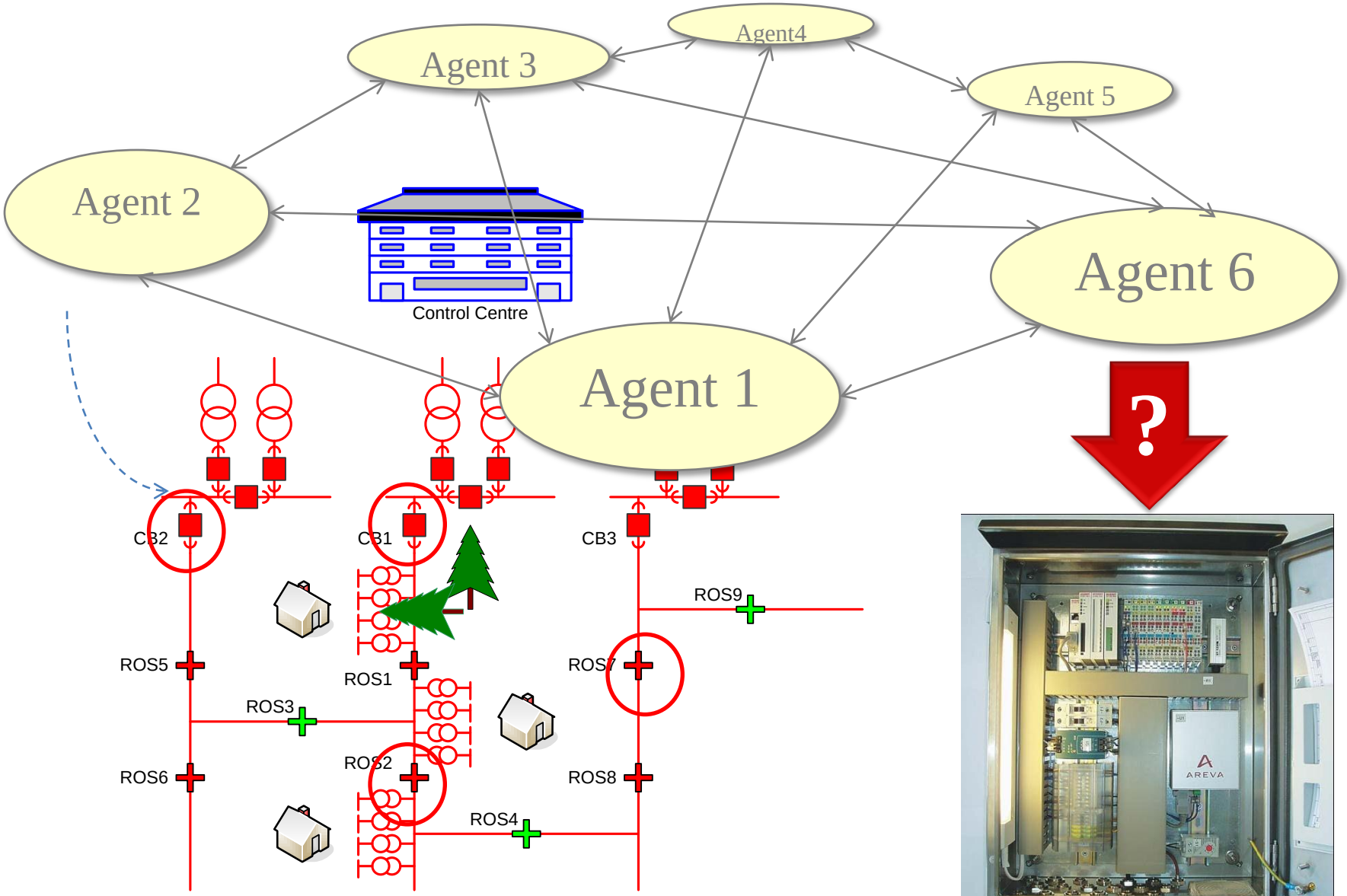


MISSOURI S&T University of Science & Technology

Georgia Tech

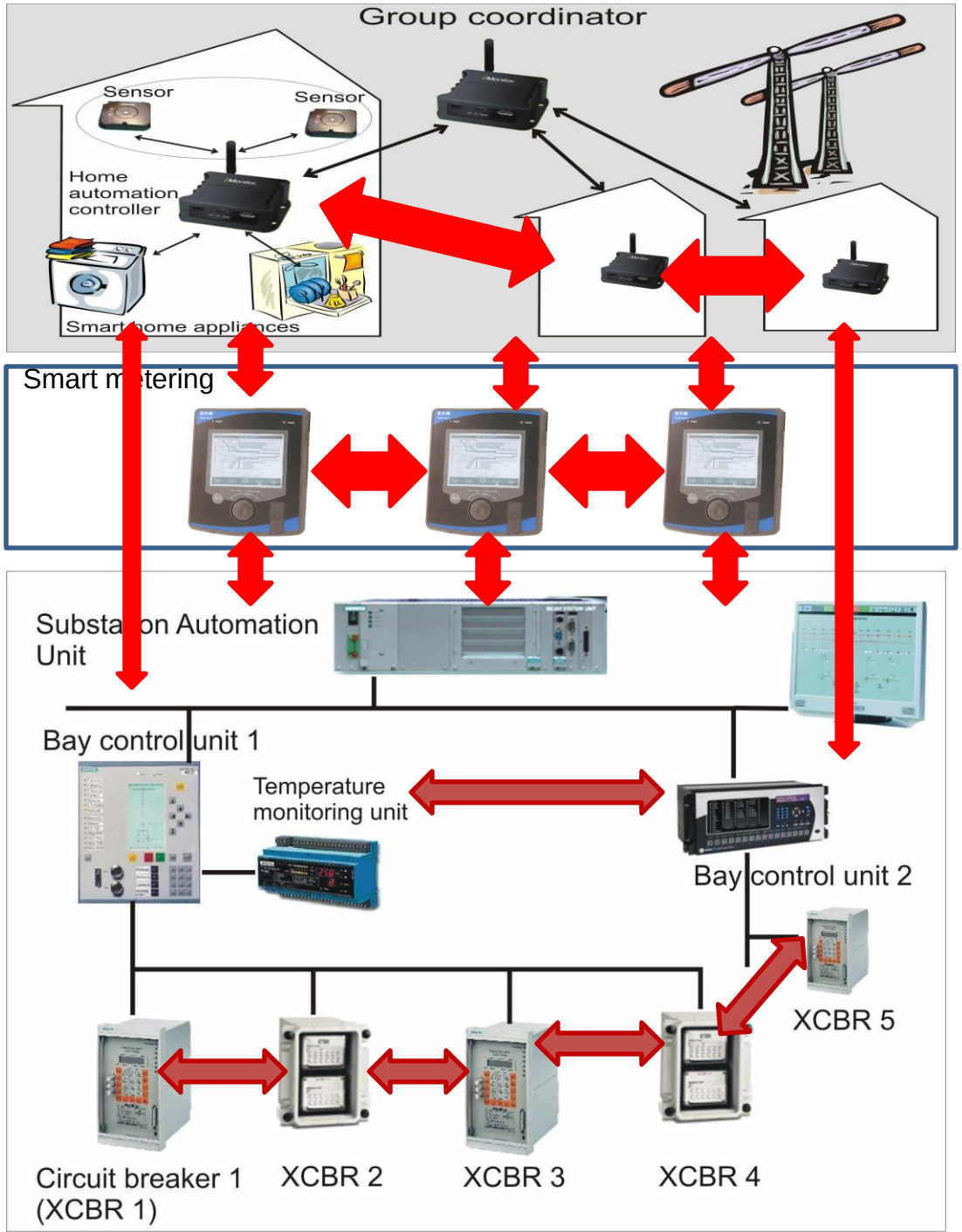
Slide from © G. K. Venayagamoorthy, NSF-VT RESIN Workshop, Alexandria, VA, December 7-8, 2009

Multi-Agent Control on the Device-level

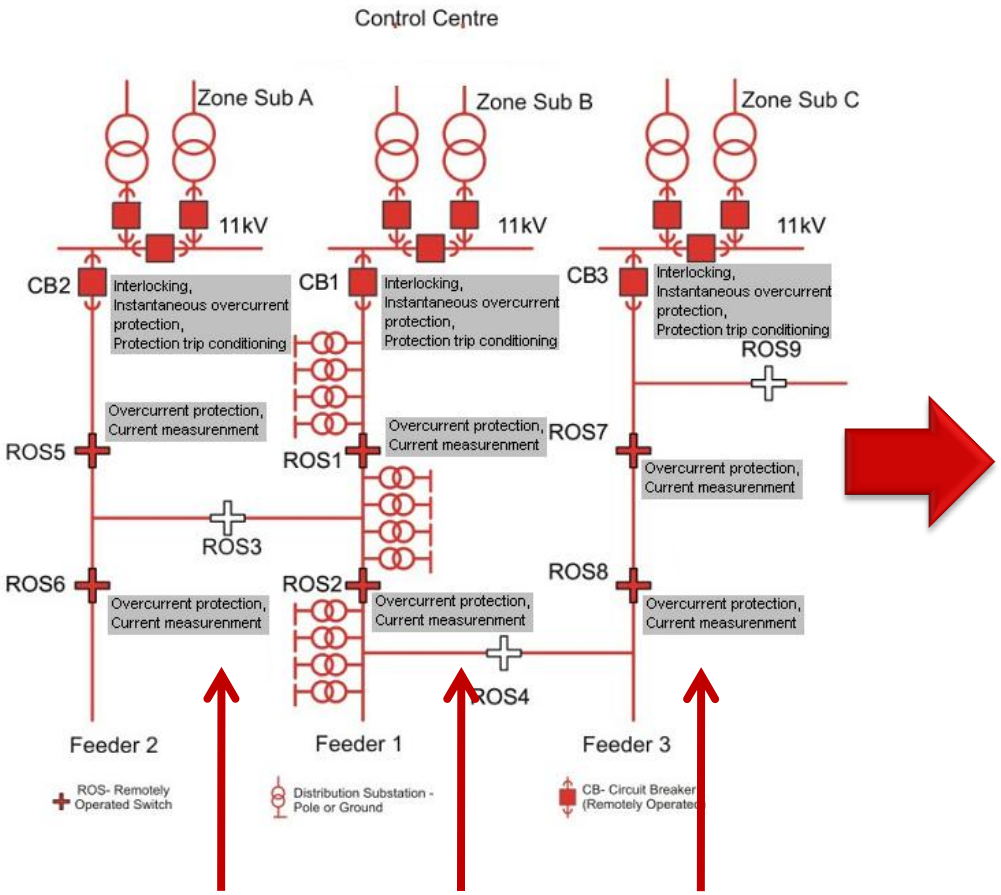


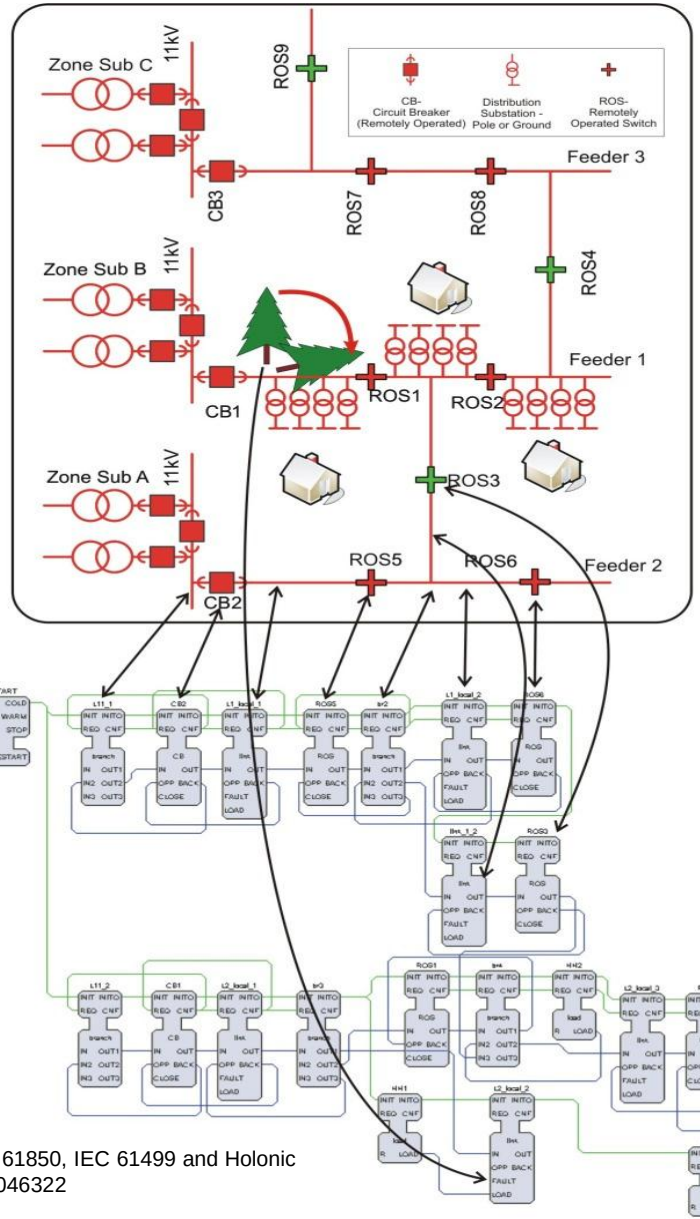
"The Smart Grid ... incorporates into the grid the benefits of distributed computing and communications to deliver real-time information and enable the near-instantaneous balance of supply and demand **at the device level**."

NIST Roadmap, 2010



Intelligent Logical Nodes with IEC 61499 Function Blocks



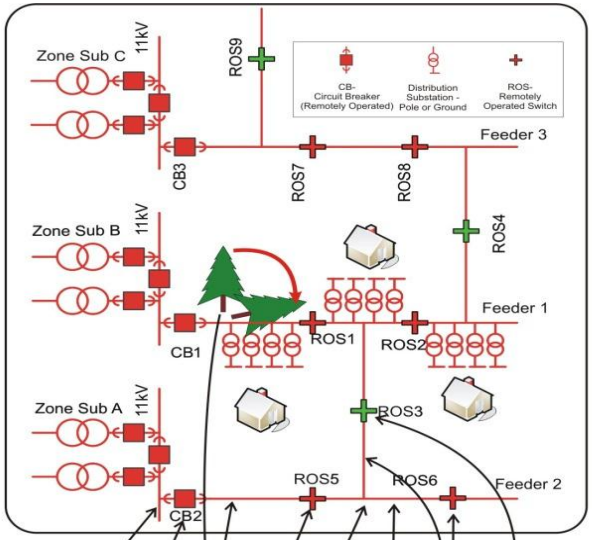


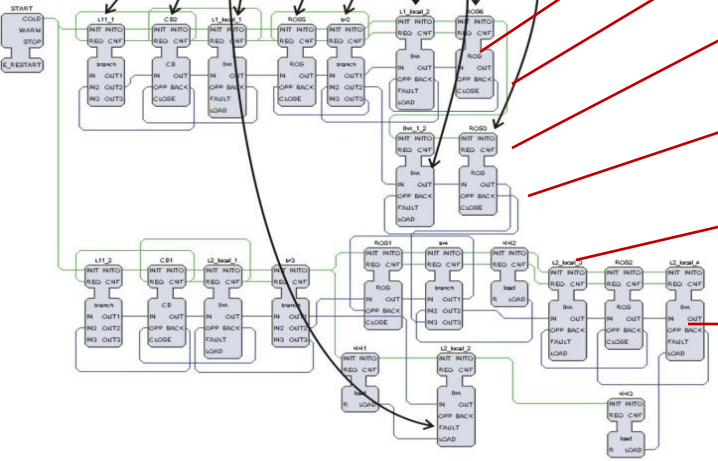
IEC 61850 ILNs FB Library

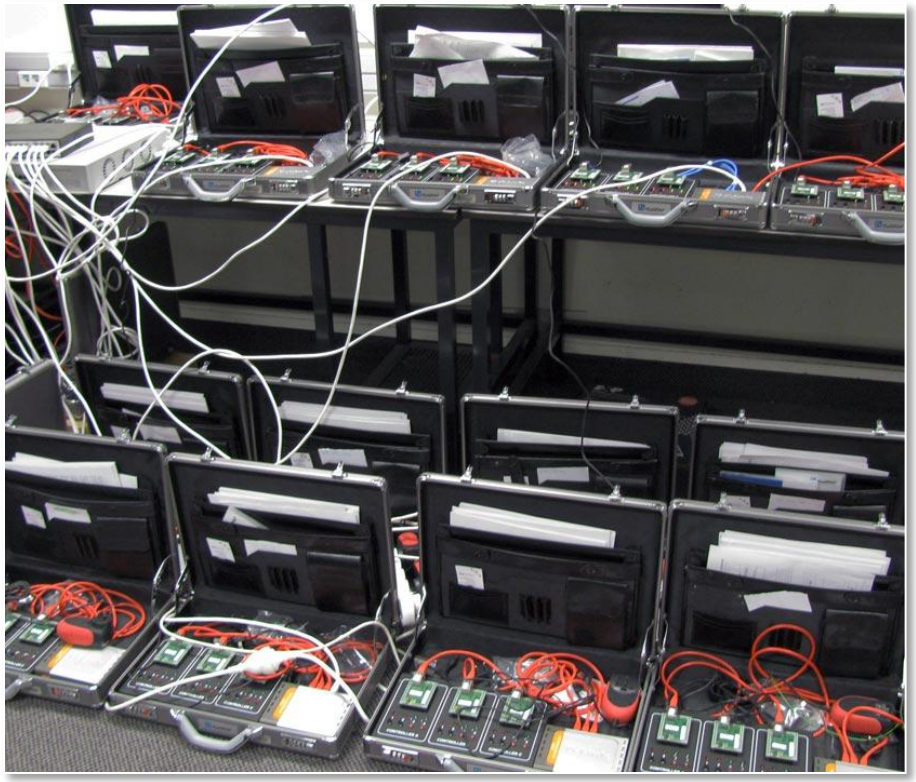
IEC 61499

N. Higgins, V. Vyatkin, N. Nair and K. Schwarz, "Intelligent Decentralised Power Distribution Automation with IEC 61850, IEC 61499 and Holonic Control",IEEE Transactions on Systems, Machine and Cybernetics, Part C, 40(3), 2010, 10.1109/TSMCC.2010.2046322

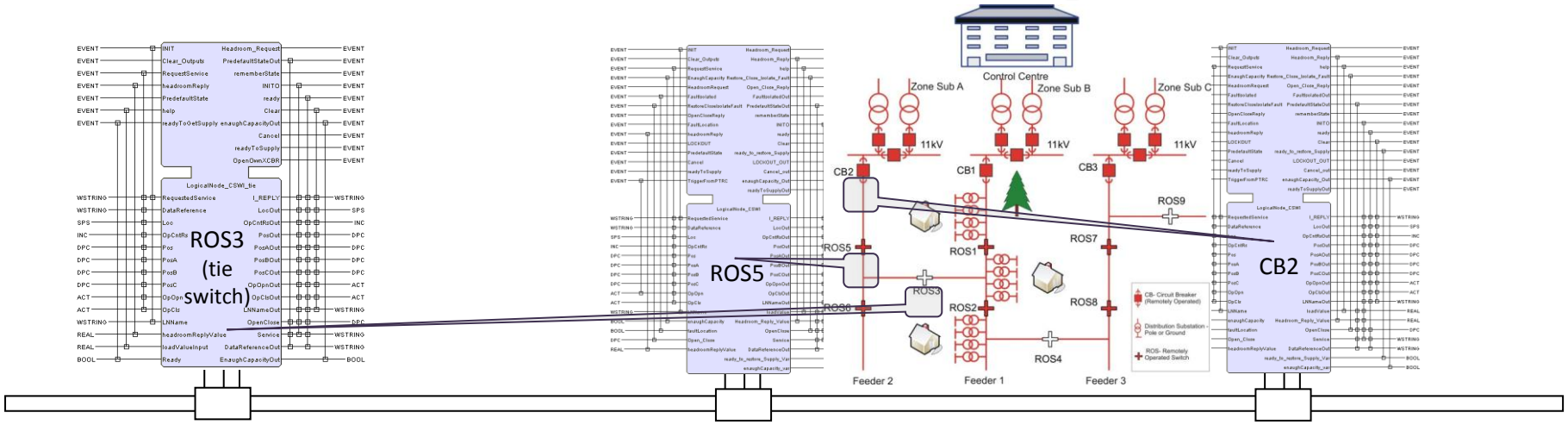
50 Networking Controllers Testbed (University of Auckland, NZ)

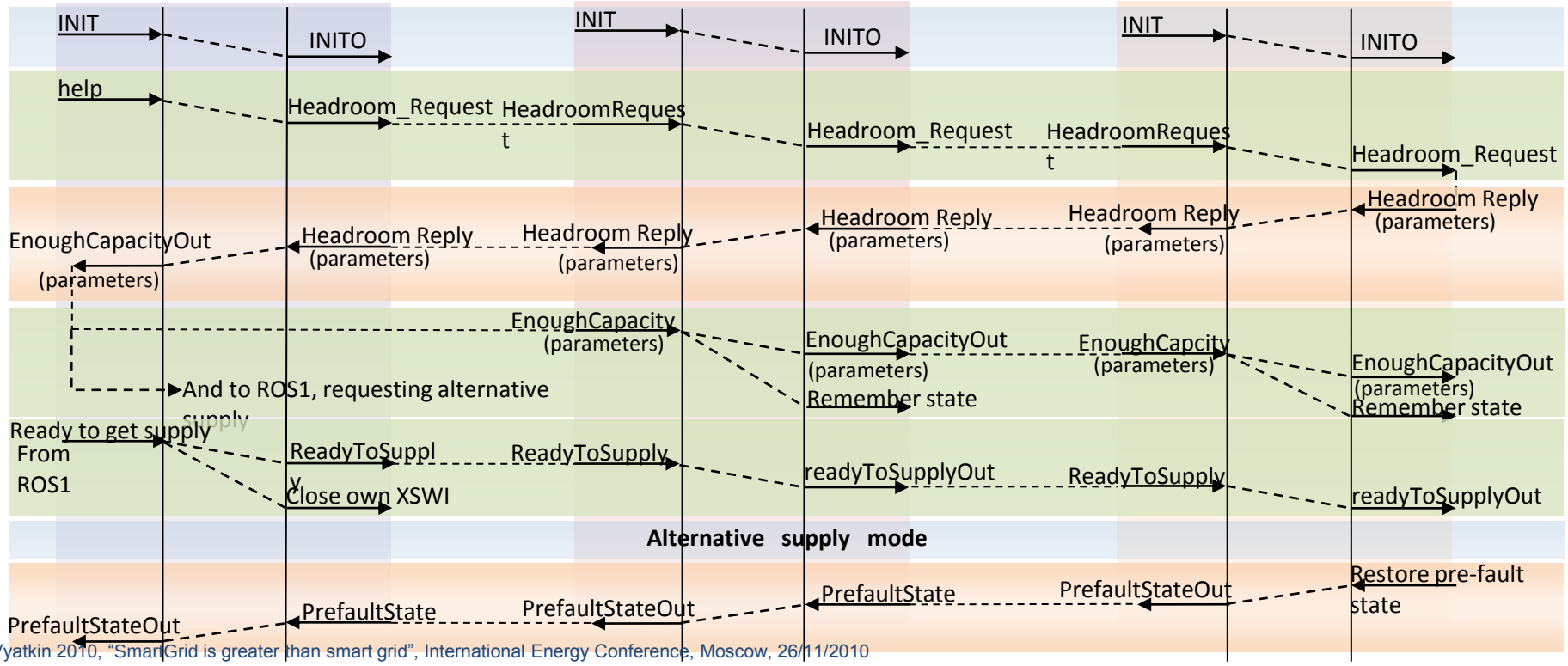






FLISR achieved by negotiation between switches w/out central supervisor





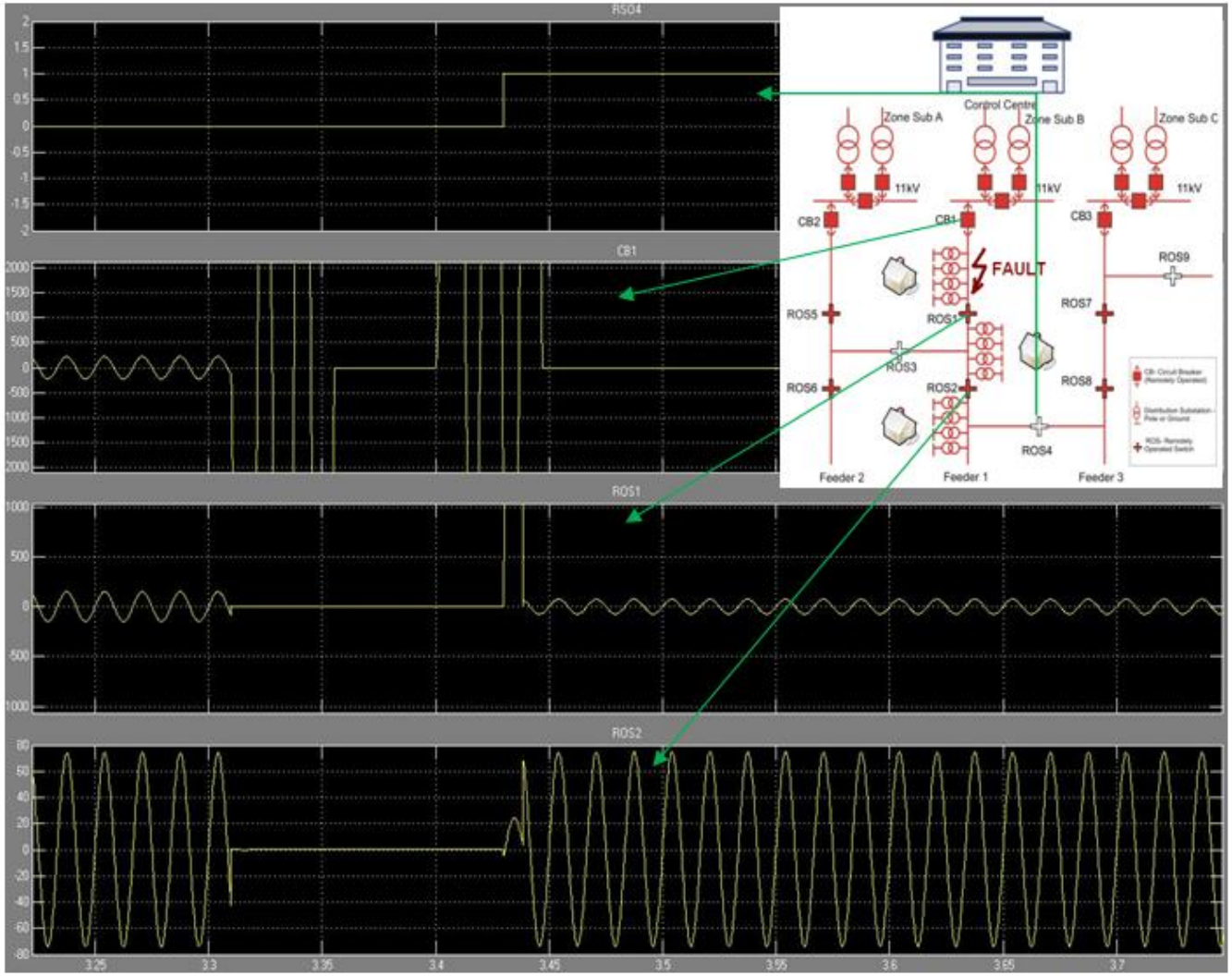
Simulation Results

ROS4

CB1

ROS1

ROS2



FLISR scenario: fault is on CB1 section, supply restored on ROS1 and ROS2 sections

Conclusion

- Lots happening in the research domain !
- Open Standards
- Beware the word “intelligence”
- Disruptive technologies can appear and change the landscape