Developing Adaptive Intelligent Protection Scheme using RTDS

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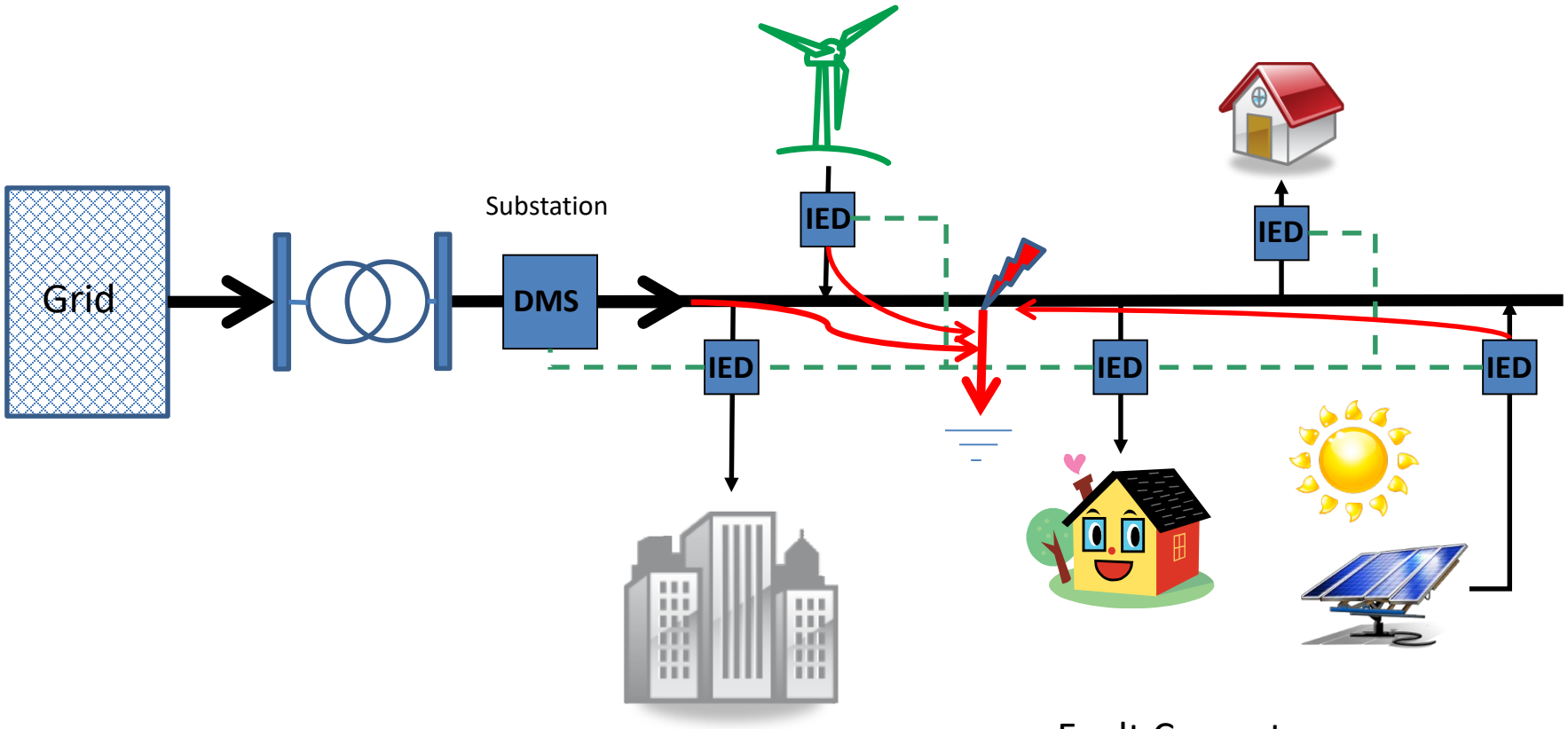
Overview

- Background
- Protection Challenges/Agent Technology
- Smart Grid Architecture/Simulation
- Testbed Development
- Outcomes

Interconnected Distribution Networks



Distribution Management System (DMS)

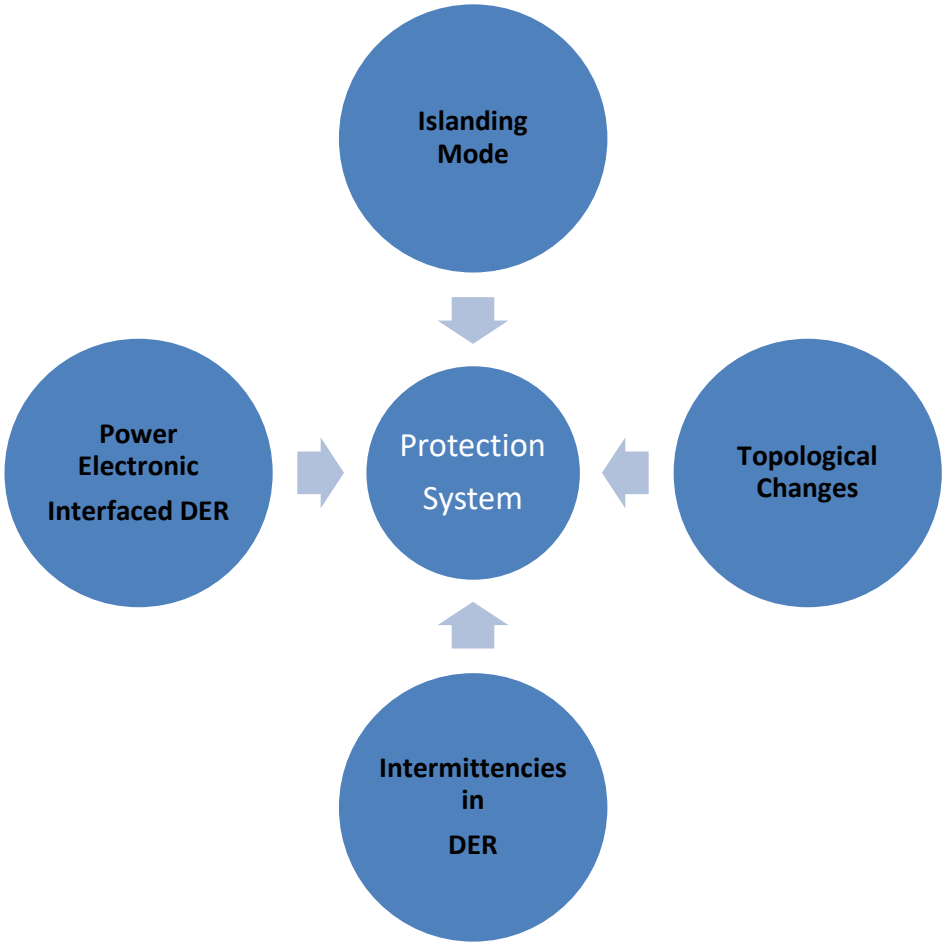
Intelligent Electrical Device (IED)

Fault Current

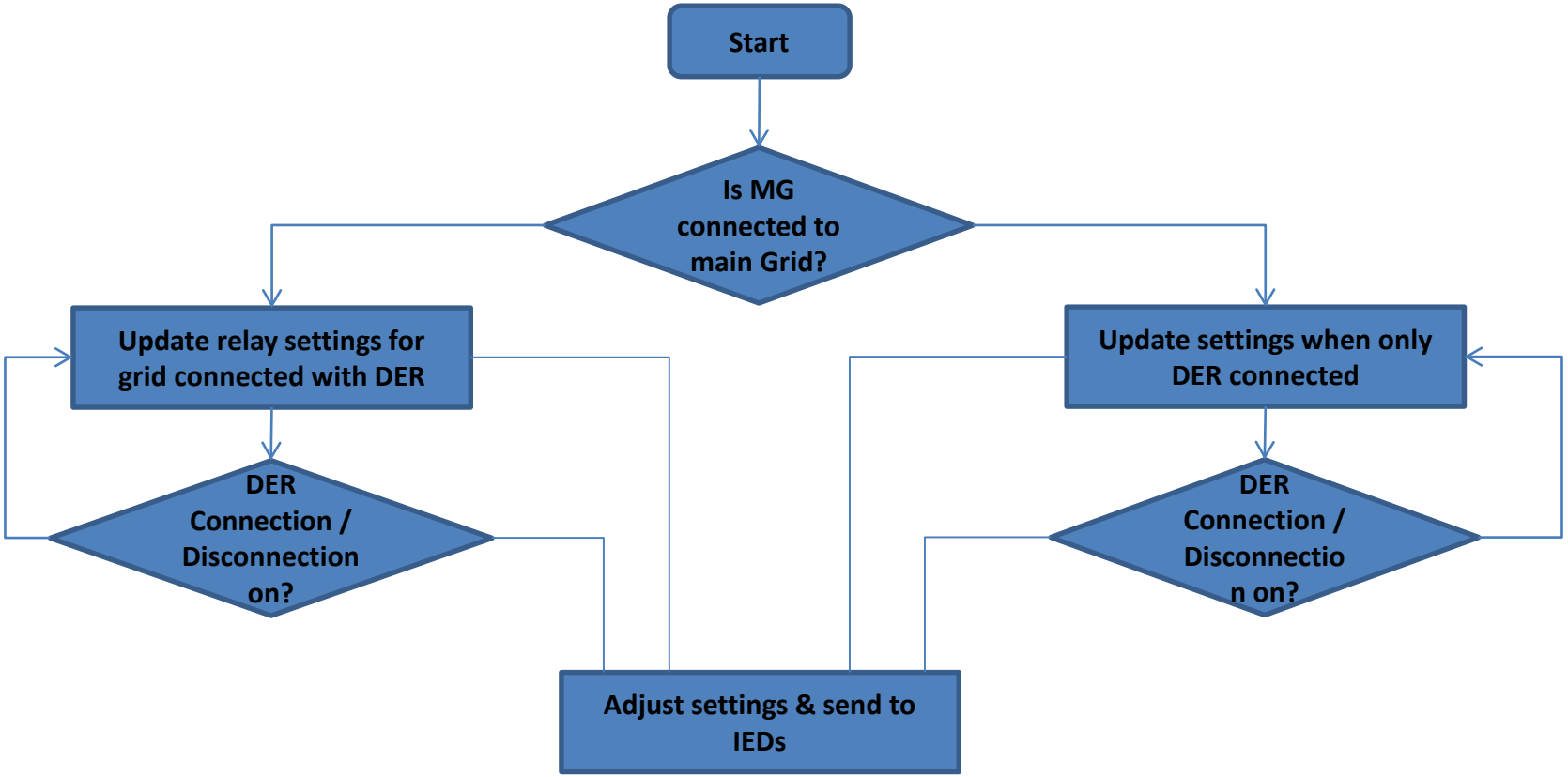
Communication link

Power Flow

Protection System for Micro-grids

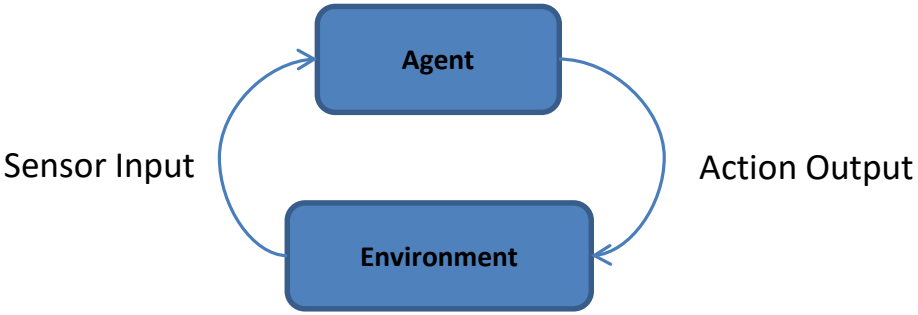


Adaptive Protection



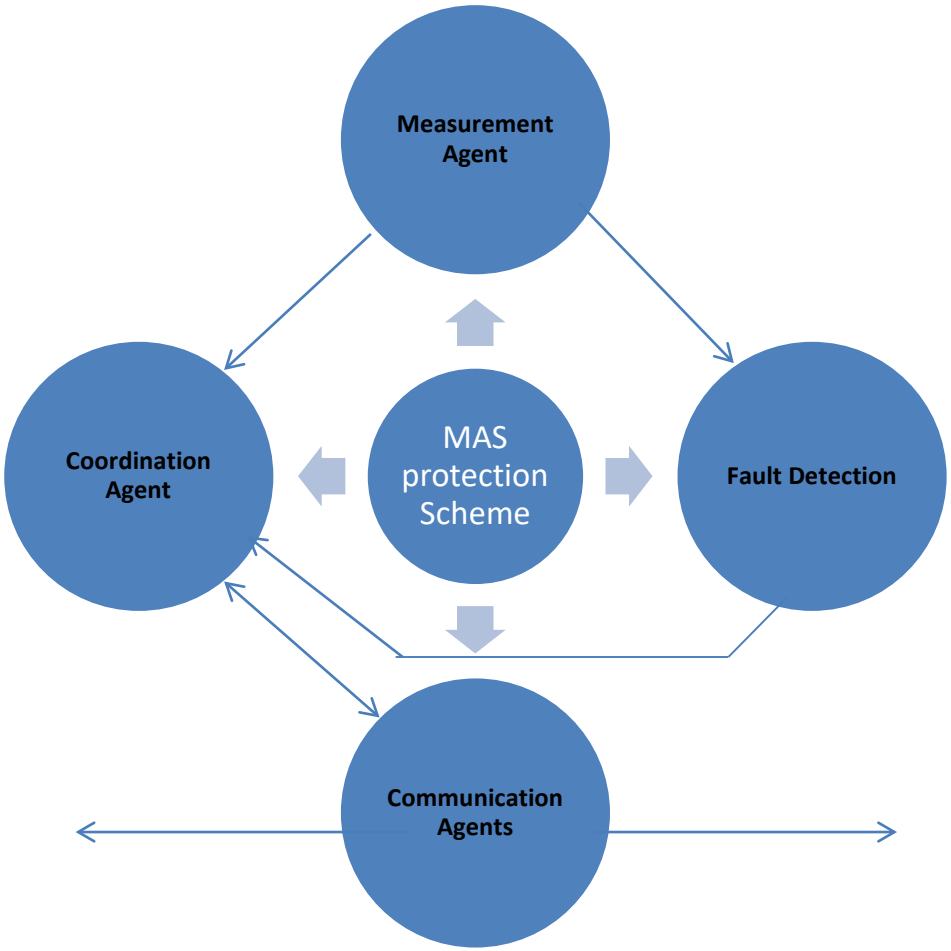
Schematic Block Diagram for Adaptive Protection in Micro-Grids

Agent Technology



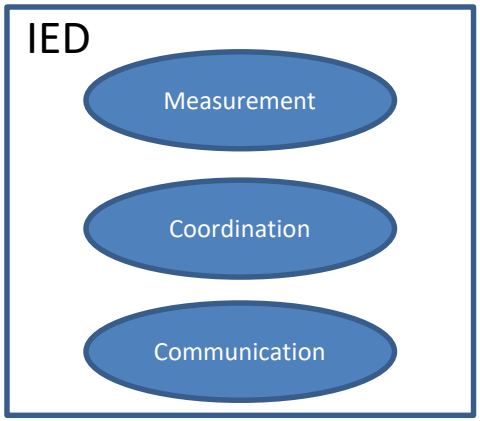
- Autonomy
- Cooperative behaviour
- Goal driven
- Scalability

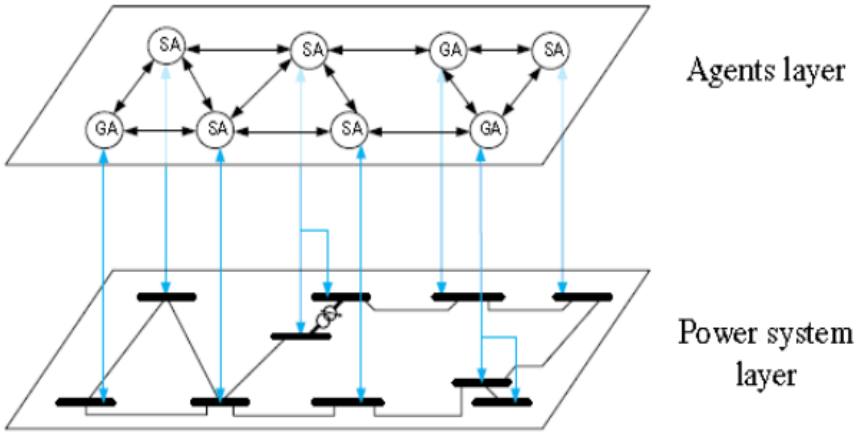
Multi-Agent Systems (MAS)



- Protection tasks divided into subtasks
- Cooperation between subtasks
- Communication between protection IEDs (Knowledge sharing)

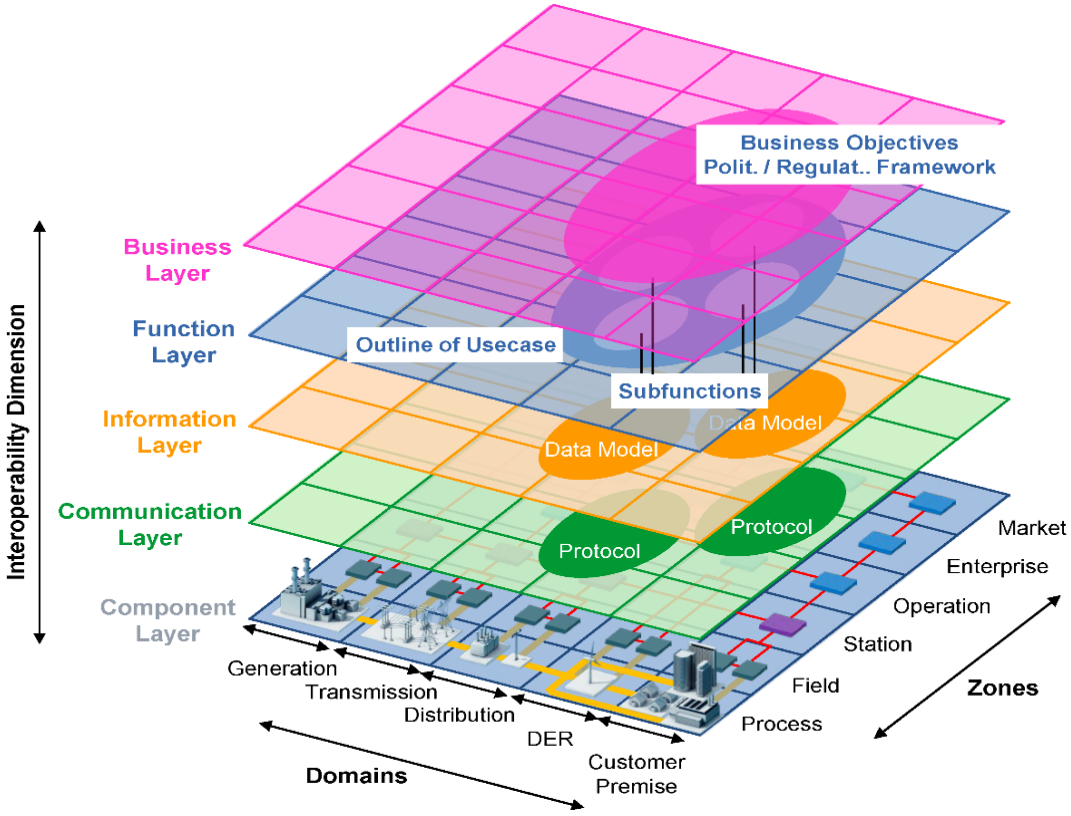
Integrating MAS into power system





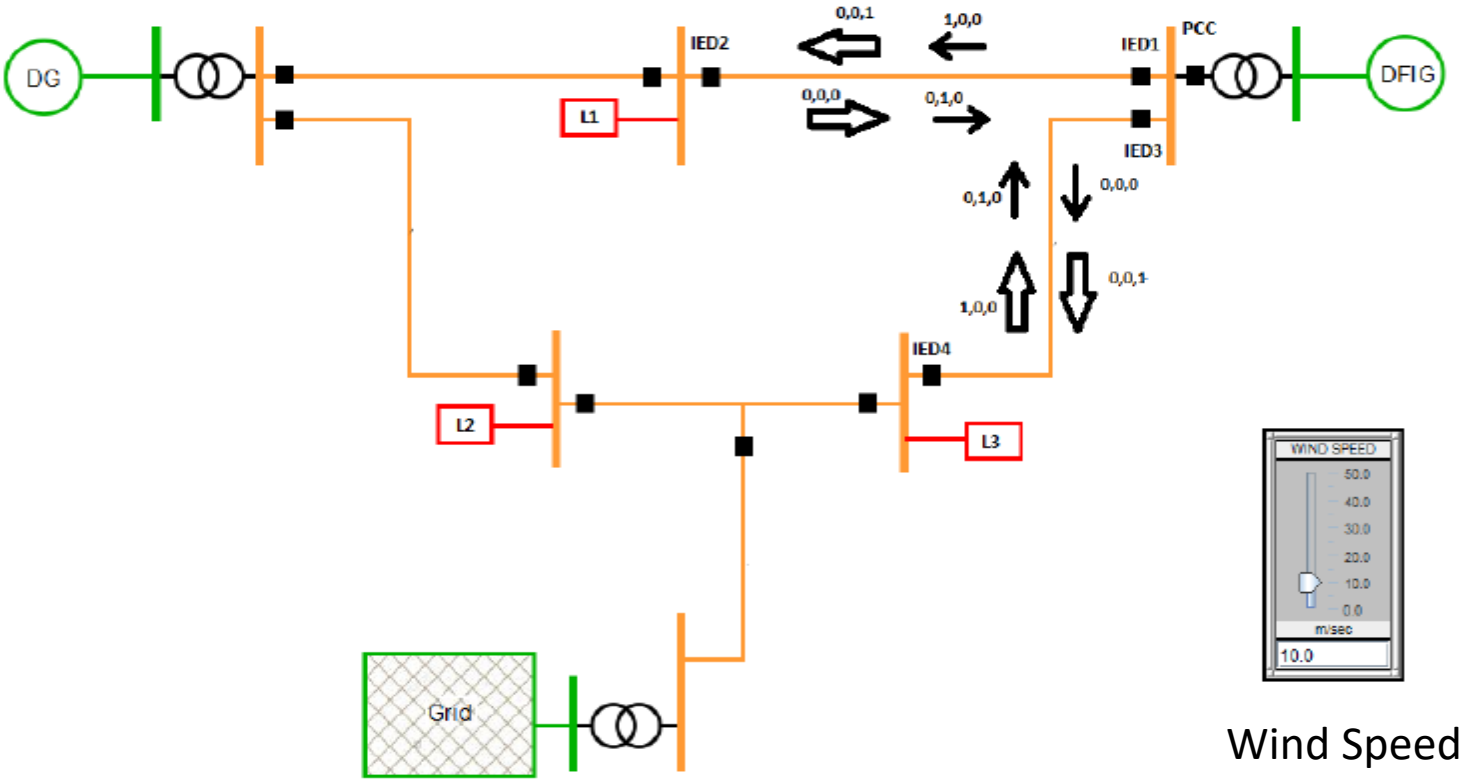
- Each IED composed of different agent types
- Two parallel layer based architecture
- Interaction between physical power system and automation layer through ICT infrastructure
- Distributed and scalable for large systems such a power system networks

Smart Grid Architecture/Simulation[Reference]



- **Domain:** Containing physical infrastructure within the energy conversion system
- **Zone:** Automation functionalities and services which are required to power system automation
- **Interoperability:** Information and communication layers which interfacing component layers to enterprise management system (EMS)

Micro-grid



Wind Speed Control

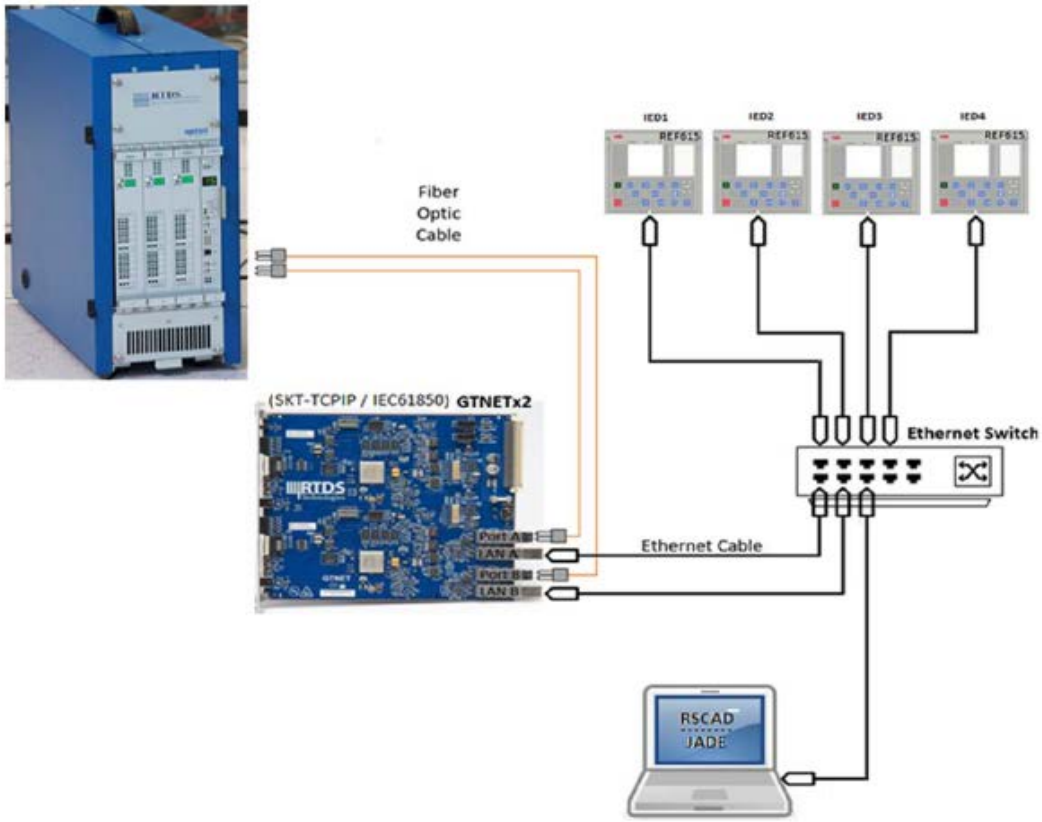
Typical micro-grid interconnected to DFIG system

Protection Setting Adjustment

	IED1			IED2			IED3			IED4		
Operation/Settings	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
0.9<Slip<1.1 (synchronous)	1	0	0	1	0	0	0	0	0	0	0	0
Slip>1.1 (super-synch)	0	0	1	0	0	1	0	0	0	0	0	0
0.6<Slip<=0.9 (sub-synch)	0	1	0	0	1	0	0	0	0	0	0	0
Parked (disconnected)	1	0	0	1	0	0	0	1	0	0	1	0

Group Settings for IEDs under different operating slip for DFIG

Testbed Development

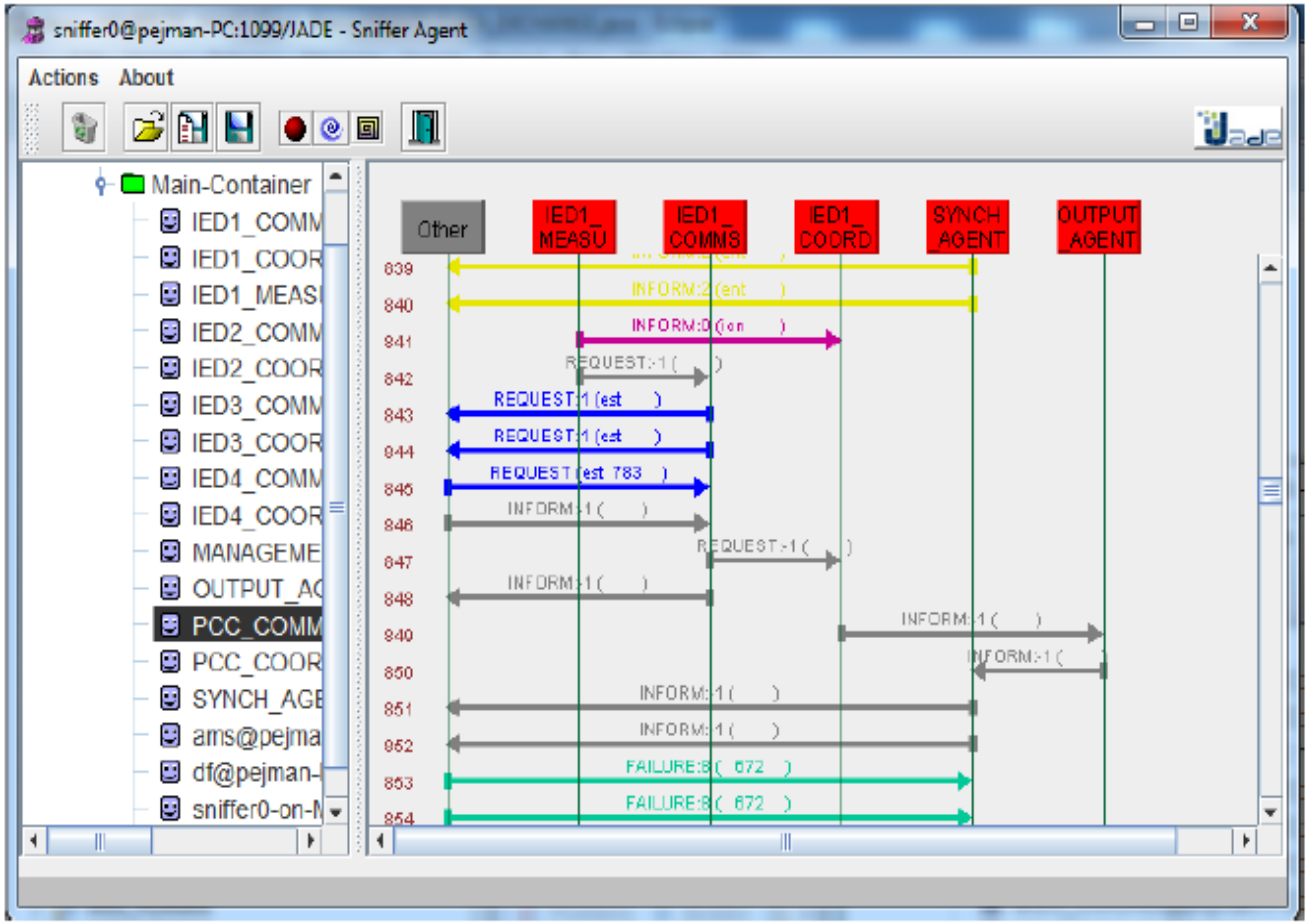


Hardware components constituting proposed co-simulation Platform

Co-simulation platform

- RTDS rack
- GTNET (IEC61850 protocol)
- IEDs
- Communication network/Ethernet switch
- JAVA Agent Development Environment (JADE)/Agent Platform

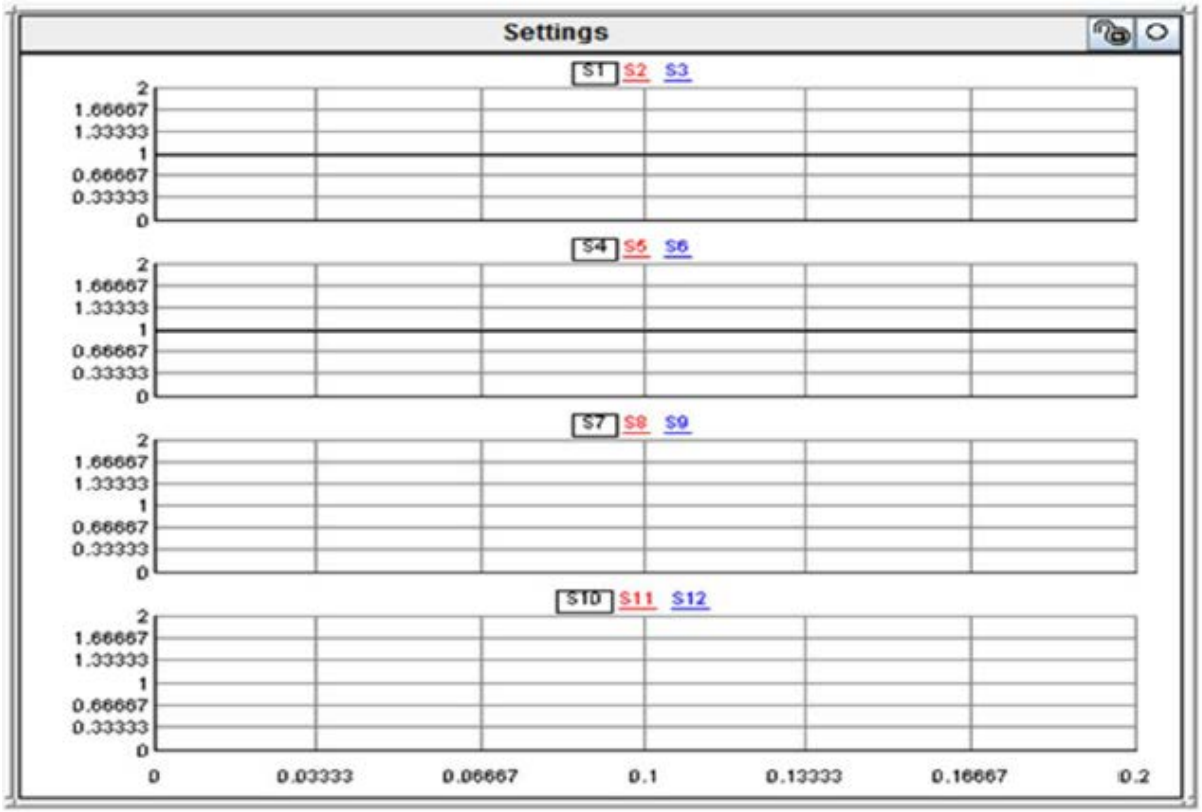
Agent Communication



Communication Message Exchange between different agents and IED in MAPS

IED Group Settings

(synchronous slip)



IED1 [1,0,0]

IED2 [1,0,0]

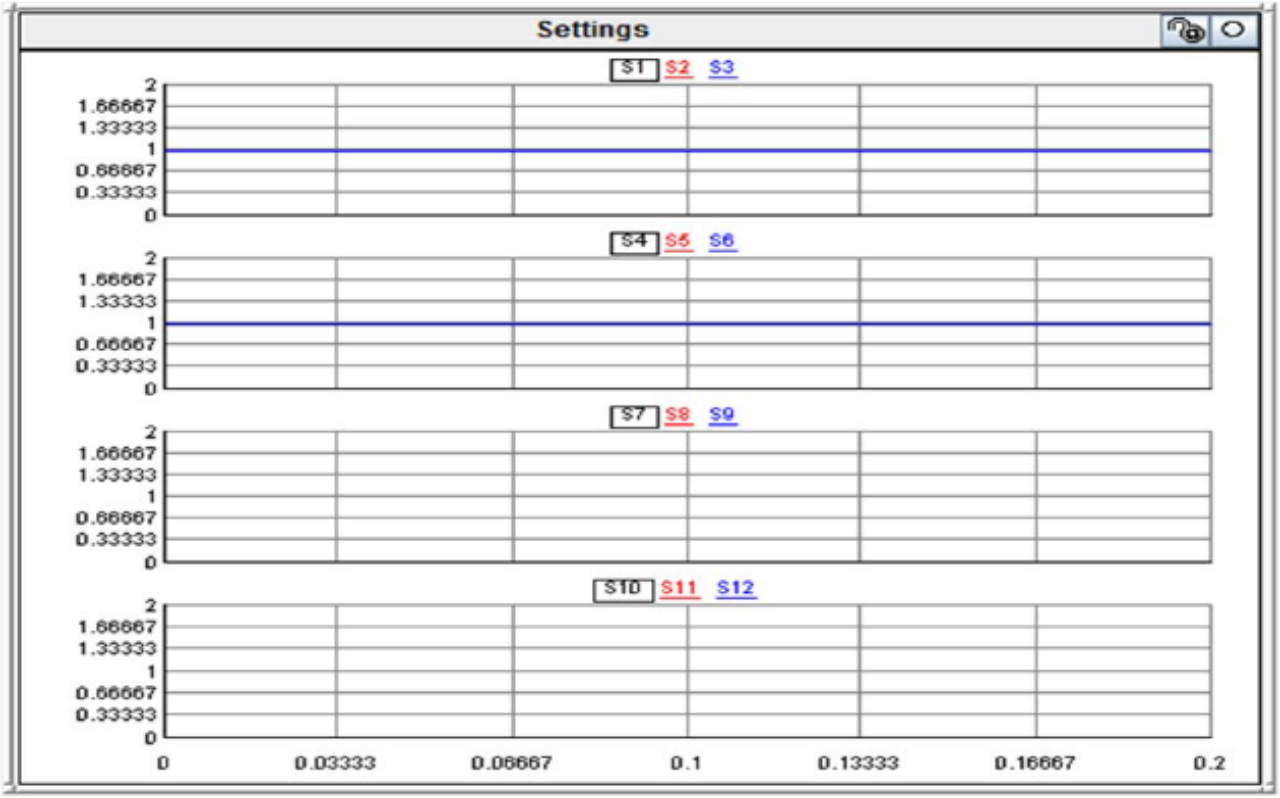
IED3 [0,0,0]

IED4 [0,0,0]

Protection Group Settings for IEDs in Synchronous operating slip of DFIG system

IED Group Settings

(super-synchronous slip)



IED1 [0,0,1]

IED2 [0,0,1]

IED3 [0,0,0]

IED4 [0,0,0]

Protection Group Settings for IEDs in Super-Synchronous operating slip of DFIG system

Outcomes

- Integration of AI into system protection within smart grid paradigm.
- Multi-domain simulation platform /essential for R&D smart grid.
- Capability to address wide range of research platform from energy market to power electronic interfaced DERs.
- Simulation of the Real world scenario for testing interoperability between different automation levels for smart grid.

Reference

- **Smart Grid website at the National Institute of Standards and Technology (NIST)**

https://www.nist.gov/engineering-laboratory/smart-grid