

AIT Austrian Institute of Technology

IEC 61499 in the Context of Smart Grids Applications

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Industry Day

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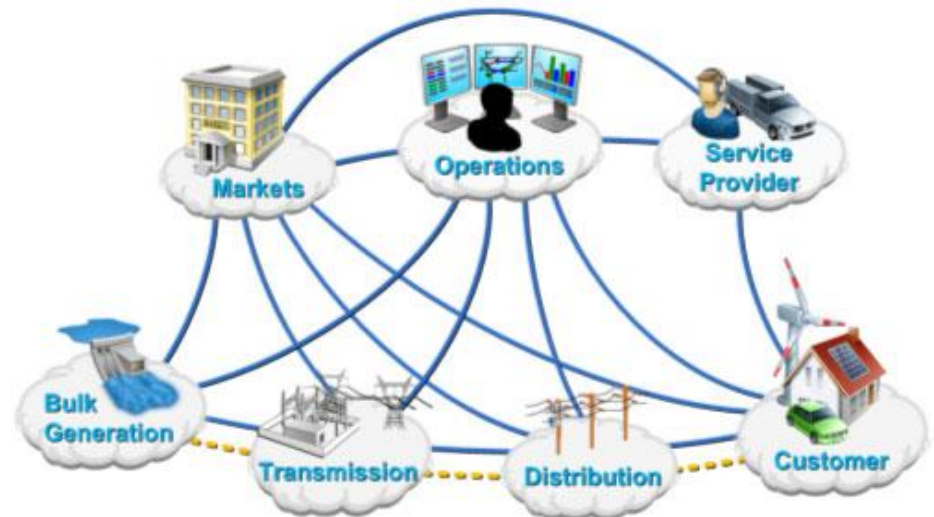
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- Standardization Activities in the Domain of Smart Grids
- Smart Grids Standards and IEC 61499
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Introduction / Motivation

What are Smart Grids?

- High efforts are spent to modernize the electrical grids
 - ▶ Transformation into “Smart Grids”
- IEC Strategic Group 3 (SG3) definition
 - It is the concept of modernizing the electric grid
 - It comprises everything related to the electric system (i.e. Integrates the electrical and information technologies) in between any point of generation and any point of consumption
 - It also includes the coupling effects with other forms of energy (e.g. thermal and electro-chemical storage, etc.)



Smart Grid conceptual model – adding intelligence to various parts of the network (Source: IEC Strategic Group 3 (SG3))

Introduction / Motivation

What are Smart Grids?

- Typical smart grids applications are
 - Power Distribution Management (DM)
(e.g. integration of distributed and renewable energy resources and electric vehicles)
 - Distribution Automation (DA)
 - Outage Management (OM)
 - Demand Response (DR) / Demand Side Management (DSM)
 - Advanced Metering Infrastructure (AMI) and Meter Data Management (MDM)
 - Asset Management (AM), etc.
- Different applications and various components have to work together in a networked system of systems
 - Interoperability, scalability and flexibility are crucial points
 - (International) standards are very important (IEC, IEEE, ISO, etc.)

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

- Requirements
 - Common semantic (data model)
 - Common syntax (protocol)
 - Common network concept
- Different models for different tasks on different levels
 - Interoperability
 - Communication
 - Data exchange, etc.
- Usage of different existing (IEC) standards (mainly from TC 57)
 - e.g. IEC 62357 Reference Architecture addressing communication requirements

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

- Core standards are

IEC 62357

- Reference Architecture – SOA
- Energy Management Systems, Distribution Management Systems

***IEC 61970/
IEC 61968***

- CIM (Common Information Model)
- EMS, DMS, DA, SA, DER, AMI, DR, E-Storage

IEC 61850

- Substation Automation, Power Utility Automation
- EMS, DMS, DA, SA, DER, AMI

IEC 62351

- Security

IEC 62056

- Data exchange for meter reading, tariff and load control

IEC 61508

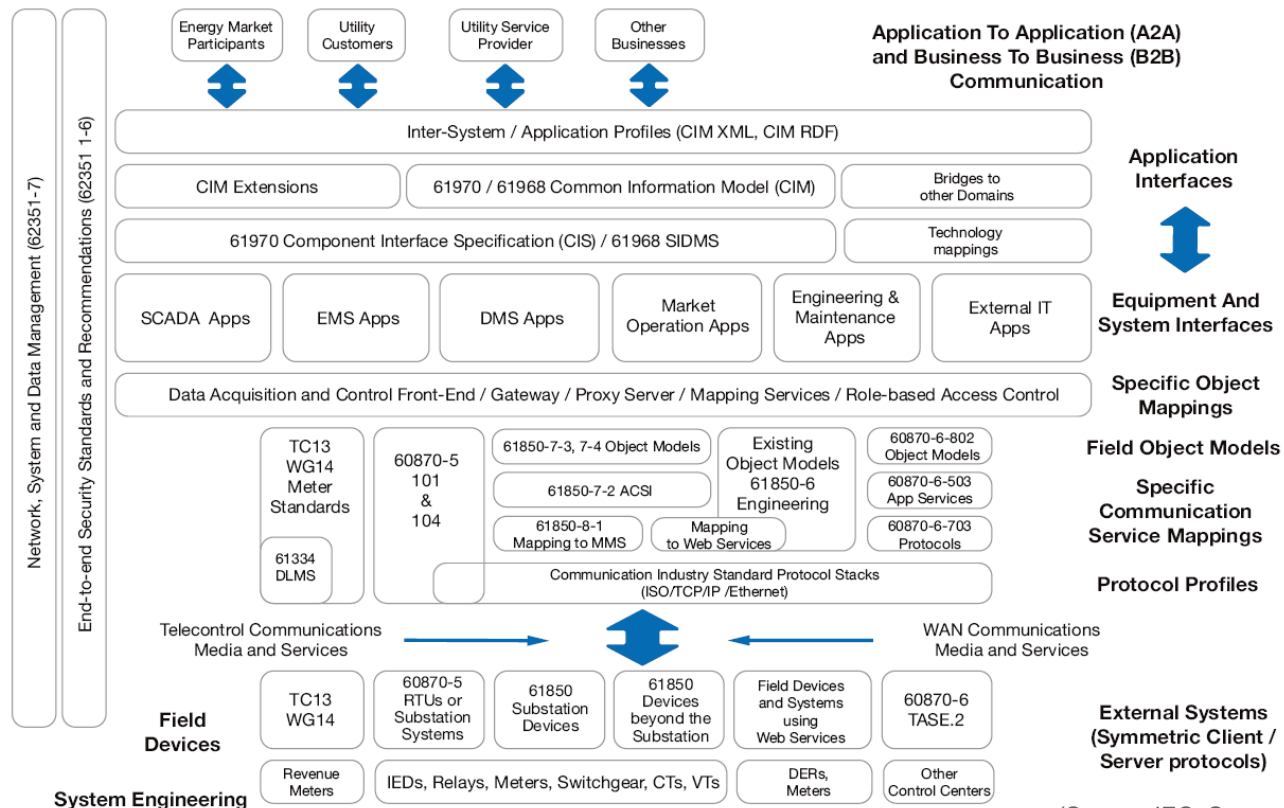
- Functional safety of electrical/electronic/programmable electronic safety-related systems

- In addition the German DKE Standardization Roadmap (E-Energy / Smart Grid) list the IEC 61499 standard as promising approach for the implementation of control algorithms

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

- Overview IEC Smart Grids standardization roadmap



(Source: IEC, Strategic Group 3 (SG3))

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

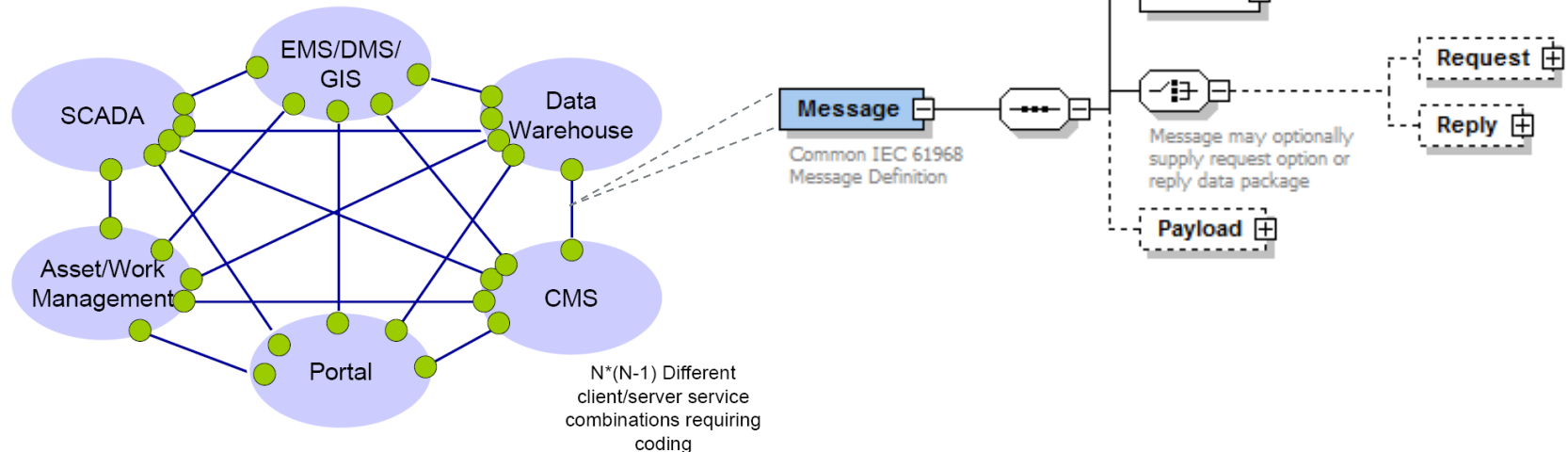
- IEC 61970/IEC 61968 – Common Information Model (CIM)
 - IEC 61970-301 is a semantic model that describes the components of a power system at an electrical system and their relationship
 - IEC 61968-11 extends with other aspects of power system information exchange such as asset tracking, work schedule and customer billing
- ▶ ***Exchange power system network model data (RDF) and messages (XML) between companies, between applications and access complex data structures***
 - Information model / canonical model – UML class diagrams
 - Contextual profiles – subset for a specific context
 - Implementation models
 - RDF – Schema for power system model exchange
 - XML – Schema for message payloads

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

- IEC 61970/IEC 61968 – Common Information Model (CIM)
 - Message bus concept (ESB)
 - Generic interface definition
 - 61968-1-1 ESB reference implementation supporting JMS/WebServices

Generic Web Service Integration

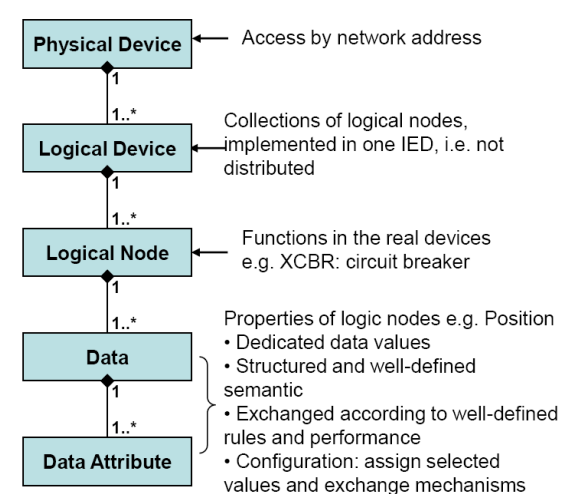
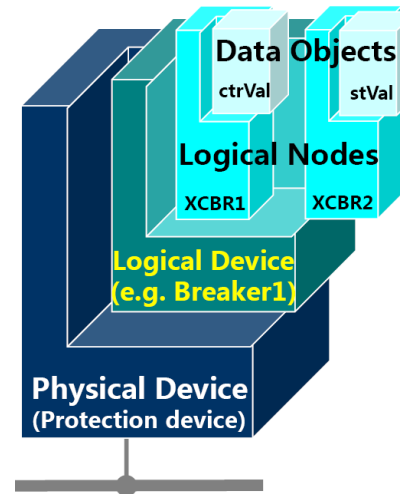


Typically no agreement on common protocols, models, services, etc.

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

- IEC 61850 – Power Utility Automation
 - Interoperability standard for communication networks and systems for power utility automation
 - Standardization of the information model and how the information should be transferred between devices
 - Covers modeling, configuration and communication
 - Object-oriented approach
 - Definition of logical devices and logical nodes
 - XML-based system configuration language (SCL)
 - Implementation of device functions not covered

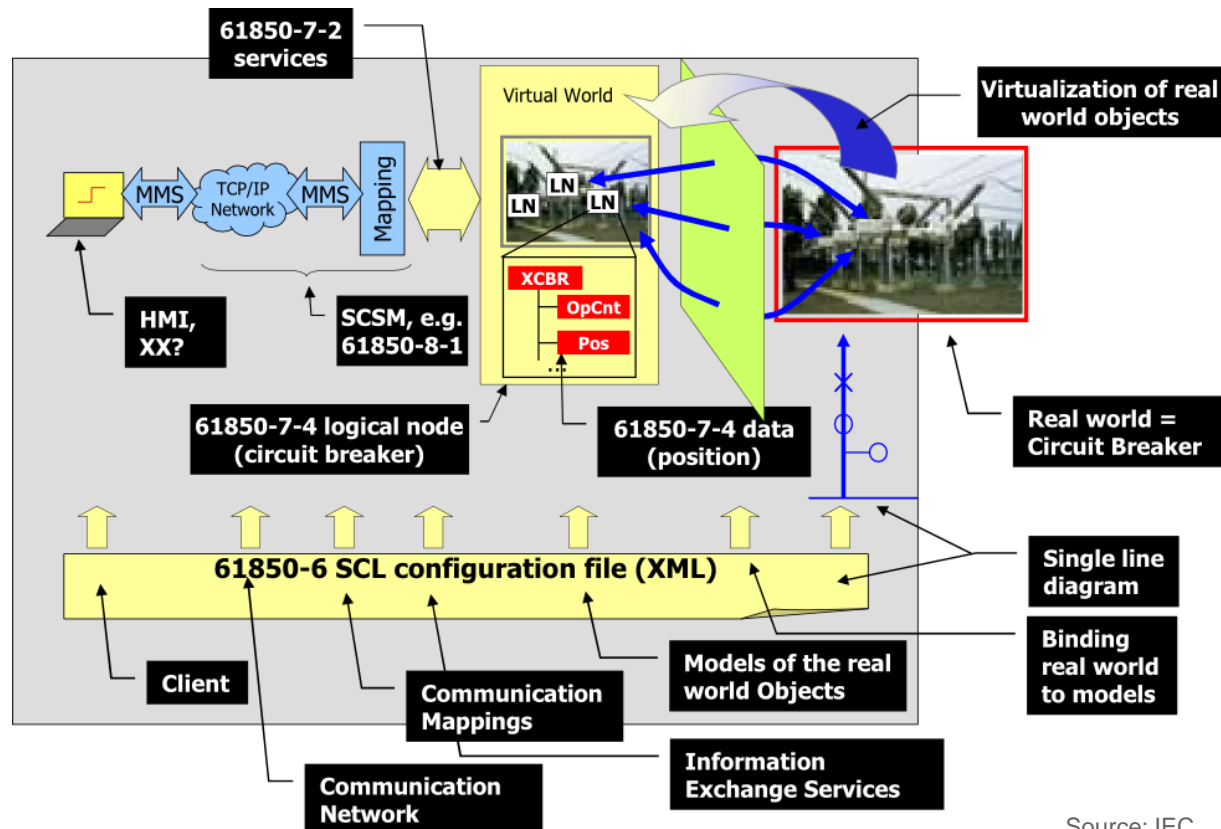


Source: IEC

Standardization Activities in the Domain of Smart Grids

IEC Strategic Group 3 (SG3) – Smart Grids Standardization Roadmap

- IEC 61850 – Power Utility Automation



Source: IEC

Smart Grids Standards and IEC 61499

Mapping of IEC 61850 Functions and Services into IEC 61499 Elements

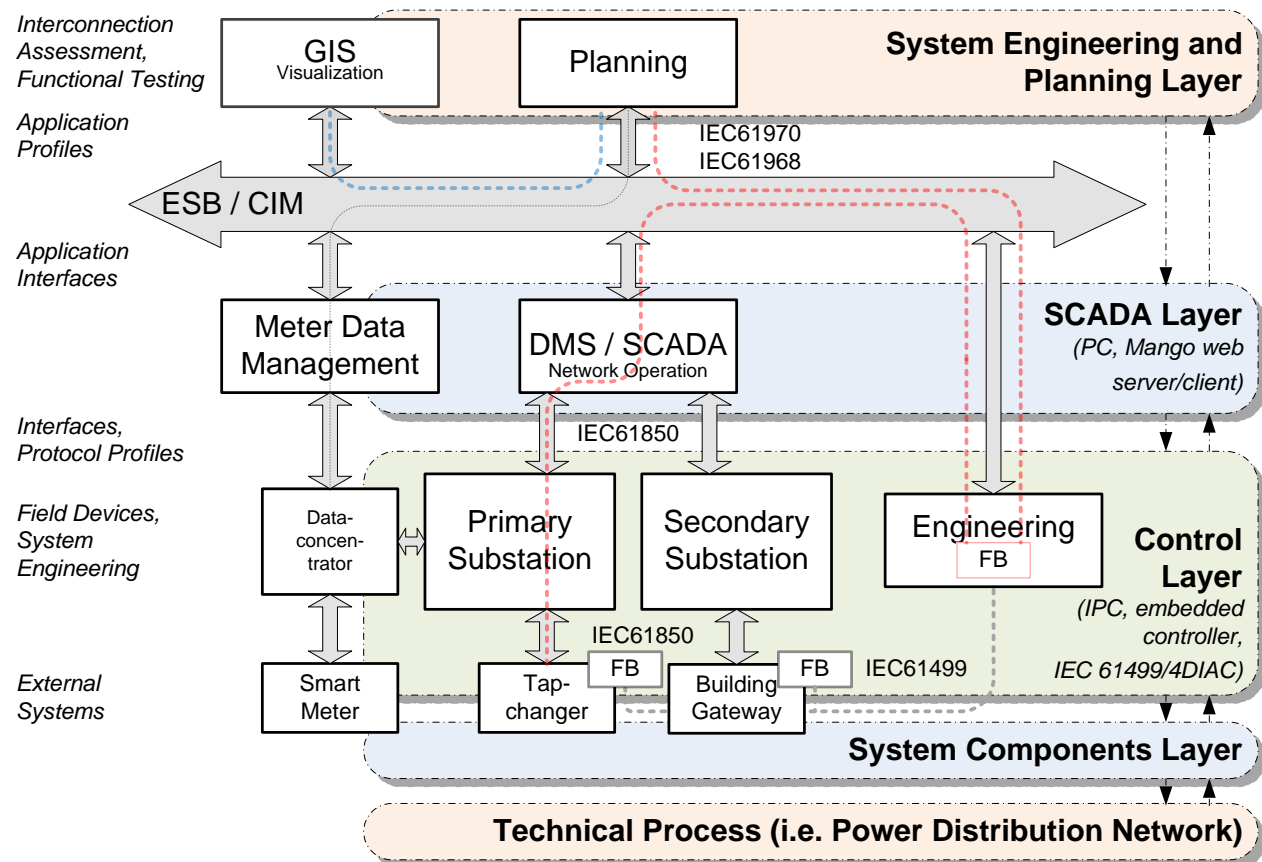
Concept	IEC 61850 Element	IEC 61499 Element
<i>Intelligent Electronic Device (IED)</i>	Physical Device	Device
<i>Logical Host</i>	Logical Device (LD)	Resource
<i>Reusable Component</i>	Logical Node (LD)	Composite Function Block / Basic Function Block
<i>Interface to Hardware (Process & Communication)</i>	Abstract Communication Service Interface (ACSI)	Service Interface Function Block
...

Sources: N. Higgins, et al., Distributed Power System Automation with IEC 61850, IEC 61499 and Intelligent Control, IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, 2010
 L. Zhu et al., Standard Function Blocks for Flexible IED in IEC 61850-Based Substation Automation, IEEE Transactions on Power Delivery, 2011

Projects / Activities at AIT

AIT's Standard-based Automation Architecture for Smart Grids Applications

- Key Standards
 - Integration (SOA)
 - IEC 62357
 - Planning & High-Level Operation (CIM)
 - IEC 61970
 - IEC 61968
 - Low-Level Operation
 - IEC 61850
 - IEC 61499

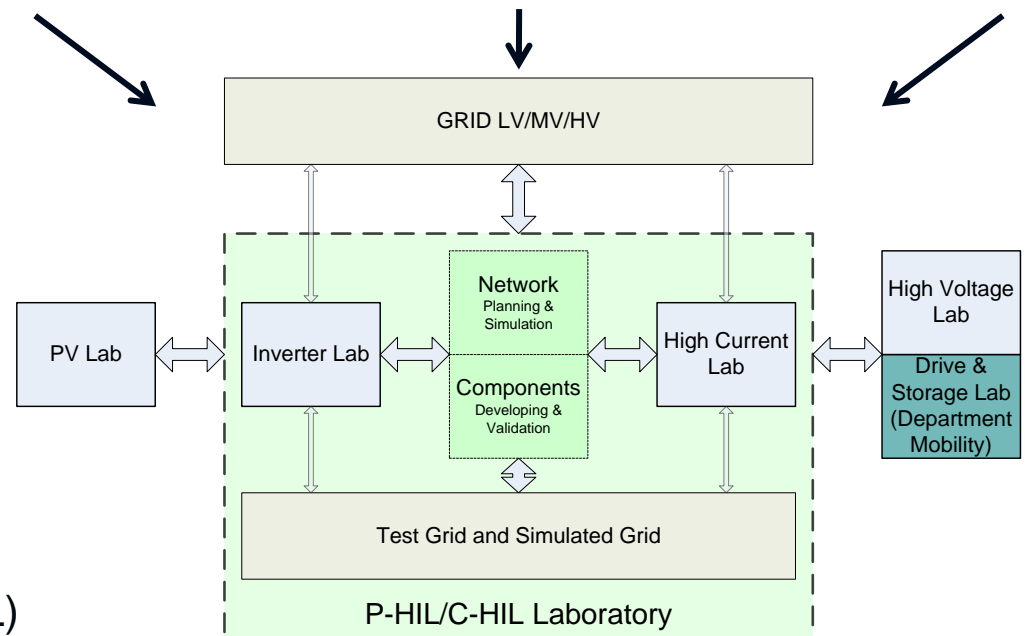


Projects / Activities at AIT

SimTech Laboratory – P-HIL/C-HIL for Electric Distribution Grids / Smart Grids

- Real-time network simulations
- Component validation and tests
- System studies
 - Interaction of components with a simulated grid (i.e. Power-Hardware-in-the Loop – P-HIL)
 - Interaction of a control or protection device on a simulated grid (i.e. Controller-Hardware-in-the-Loop – C-HIL)
 - Identification of component model for off-line simulations
- ▶ Ideal environment for interoperability studies (e.g. IEC 62357 – IEC 61970/IEC 61969 – IEC 61850 – IEC 61499 integration; test and validation environment for IEDs)

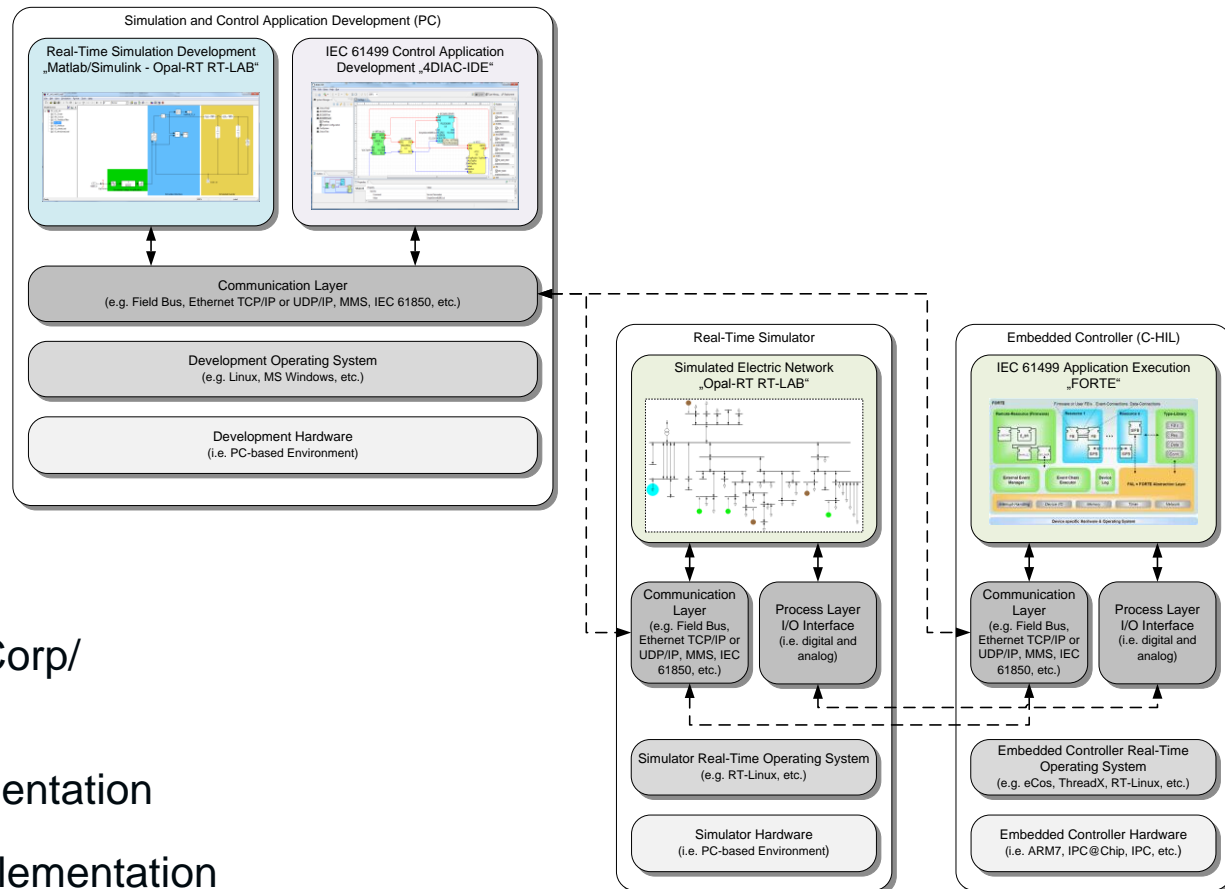
IEC 62357 – IEC 61970/IEC 61969 – IEC 61850 – IEC 61499 integration



Projects / Activities at AIT

SimTech Laboratory – P-HIL/C-HIL for Electric Distribution Grids / Smart Grids

- Real-time simulation of distribution networks
- Real-time simulator from Opal-RT (Matlab/Simulink based) for P-HIL and C-HIL experiments
- Controller and control concepts implementation based on IEC 61499 (4DIAC implementation) and IEC 61850 (SystemCorp/NettedAutomation stack)
 - Industrial PC implementation
 - Beck IPC@Chip implementation

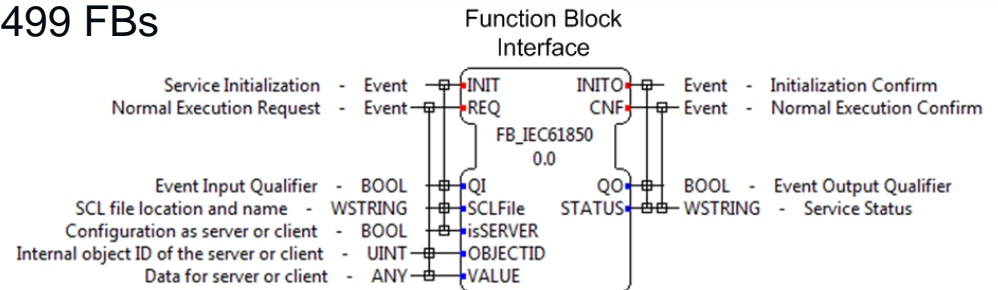


Projects / Activities at AIT

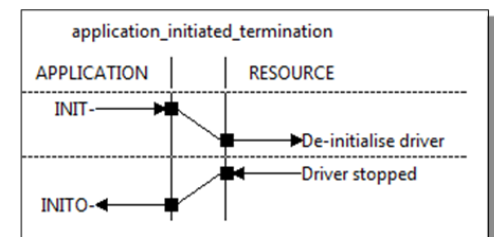
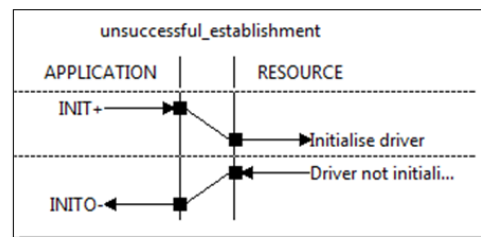
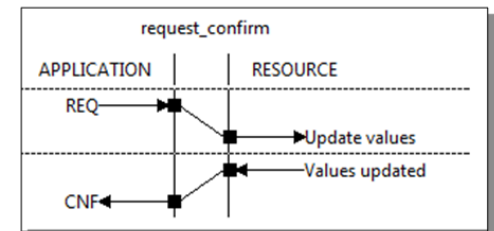
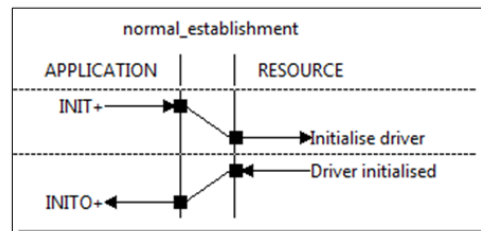
SimTech Laboratory – P-HIL/C-HIL for Electric Distribution Grids / Smart Grids

- IEC 61850 integration into IEC 61499 FBs

- Standard compliant representation of Intelligent Electronic Devices (IED)
- As IEC 61499 service interface function block
- Usage of the SystemCorp IEC 61850 stack
 - Industrial PC implementation
 - Beck IPC@Chip implementation
- Windows-based implementation (DLL)



Function Block Service Sequences

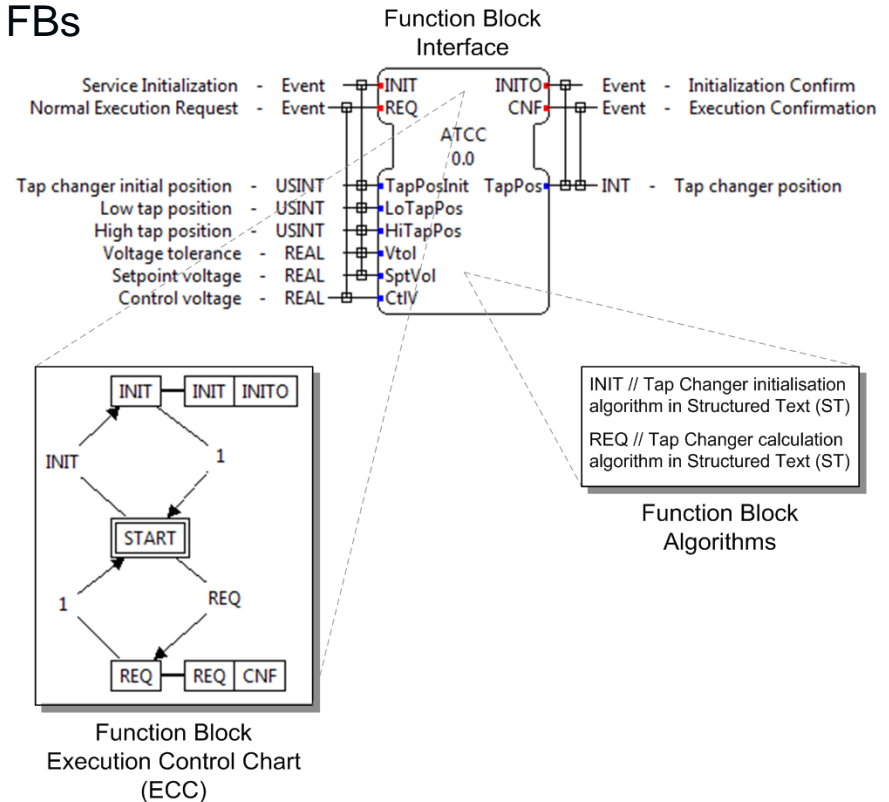


Projects / Activities at AIT

SimTech Laboratory – P-HIL/C-HIL for Electric Distribution Grids / Smart Grids

- IEC 61850 integration into IEC 61499 FBs

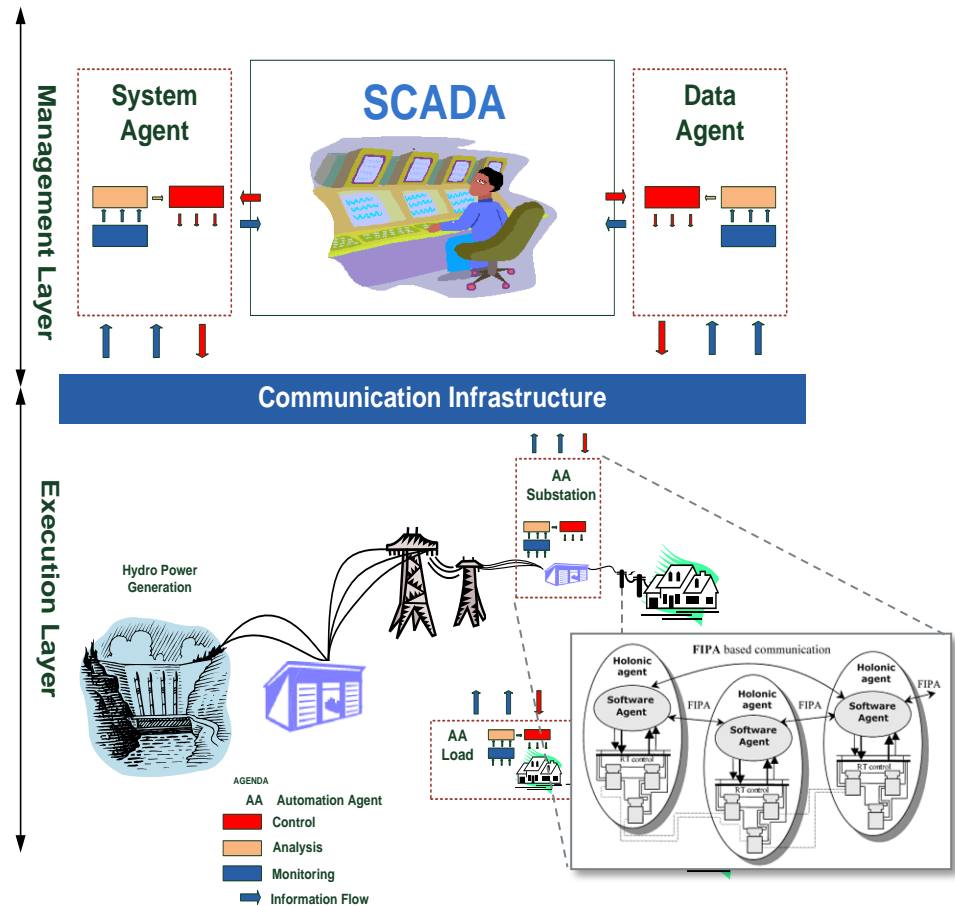
- Automatic Tap Changer Controller (ATCC) Implementation
- As IEC 61499 basic function block
- Algorithm implemented in Structured Text (ST)



Future Activities

MASGrid – Multi-Agent System for Self-Optimizing Power Distribution Grids

- Austrian research project
- Partners
 - Vienna University of Technology Automation and Control Institute
 - AIT Austrian Institute of Technology – Energy Department
- Vision/goal
 - Self-optimizing power distribution grids
 - Usage of agent-technology for High-Level Control (HLC)
 - Usage of IEC 61499 for Low-Level Control (LLC)



Future Activities

IEEE IES Technical Committees Work

- IEEE IES Technical Committee on Smart Grids and Standards
 - Harmonization of IEC 61499 (distributed control) and IEC 61850 (power systems automation) for Smart Grids applications
 - Addressing interoperability and communication issues in Smart Grids
 - Development of standardized simulation and testing procedures for Smart Grids applications (i.e. PHIL and CHIL experiments)
 - Establishment of advanced simulation methods and technologies in Smart Grids
 - Establishment of virtual test facilities for Smart Grids applications and components
- IEEE IES Technical Committee on Industrial Agents
 - Promotion of open source approaches for industrial automation (e.g. for application areas manufacturing, energy, logistics, etc.)
 - Promotion of Multi-Agent Systems (MAS) based approaches for Smart Grids

Summary and Conclusions

Actual and future activities

- Test and validation approach of standard-based implementation of IEDs in Smart Grids
- CHIL-simulation of power systems and network components together with distributed control is performed
- Approach is based on the IEC 61499 standard for distributed automation and the IEC 61850 for power system automation
- Various laboratory tests (incl. performance tests, etc.) are planned for the future
- Development of an open source IEC 61499 FB library of IEC 61850 services is planned for the future
- Coupling of the IEC 61499/4DIAC-based control approach with a Multi-Agent Control system for reconfigurable power distribution networks
- Active involvement in the IEEE IES Technical Committees for Industrial Agents, Smart Grids and Standards

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Announcement – Invitation 4DIAC Workshop

W3 Second 4DIAC User's Workshop (4DIAC)

- In conjunction with ETFA'2011
- Presentation about ongoing work of the IEC 61499 open source project

Framework for Distributed Industrial Automation and Control (4DIAC)

September 9, 2011, 9:00 – 12:30

- Session Application Modeling
 - Details on: IEC 61499 and 4DIAC for smart grids applications

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your ingenious partner

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