The role of the "Data Model" to achieve interoperability (*)

The IEC «Common Information Model» case

(*) Activity developed by RSE on behalf of “Energy@home” association

Summary

- Energy@home & RSE profile
- Interoperability
- The contribute of the "Model Data" to achieve systems interoperability
- The SG-CG approach for the implementation of interoperable systems
- The «Common Information Model» (“CIM”) Data Model
- Application's context related to «CIM» Data Model
  - Standardized representation of electrical networks
  - Management of Energy Market
  - System integration at Utility level
  - Active customers management
- «CIM» Data Model perspective
- Conclusions

Energy@home Association

- Non-profit Association founded on July ‘12
- 21 members
- **Scope**: demand side management & home energy efficiency, not limited to the italian market
- **Goal**: create a market for new Value Added Services based upon device-to-device communication and demand side management
- **Approach**: Open and International Standard, value networking through industries, trials

Founding Members

Electrolux

Enel Distribuzione

Indesit company

Telecom Italia

Ordinary Members

Edison

Vodafone

Whirlpool EMEA

Ariston Thermo Group

Aggregate Members

FlexGrid

ST life.augmented

Eurotherm

NNAC

i-EM Intelligence in Energy Management

freescale

intecs

ISMB Istituto Superiore Mario Boella

Gemino

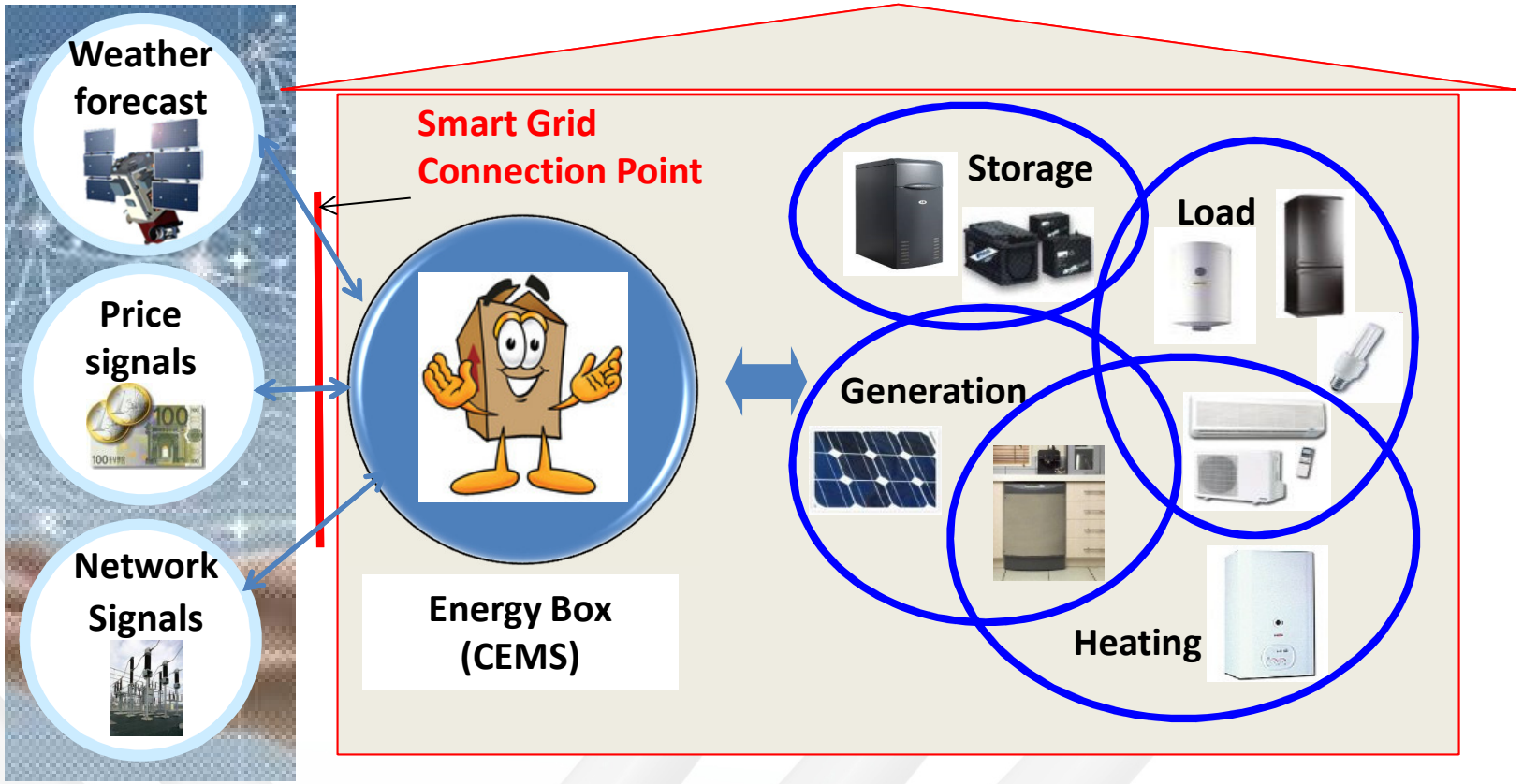
Power-One Renewable Energy Solutions

ALTRAN

RENESAS

URMET GROUP

Energy@home vision:
an Energy Box to increase efficiency and to provide Value Added Services



The Smart Grid requires a Smart Home able to increase efficiency through:

> making users aware of their consumptions

> driving users towards efficient behaviours

> supporting users to exploit ToU Pricing

> making flexibility a service from the house to the grid

Communication is the main enabler of these scenarios (Device2Device in the HAN, Grid2CEMS, …)

History and Mission

- Established at the end of 2005 as a separate company, currently owned by GSE (Gestore Servizi Energetici)
- From ENEL R&D Division, through CESI (strong liaison with Enel, Terna, electric power utilities), today RSE (Ricerca sul Sistema Energetico)
- The mission is to take over national and international funded research programs and contracts on electroenergy sectors

http://www.rse-web.it

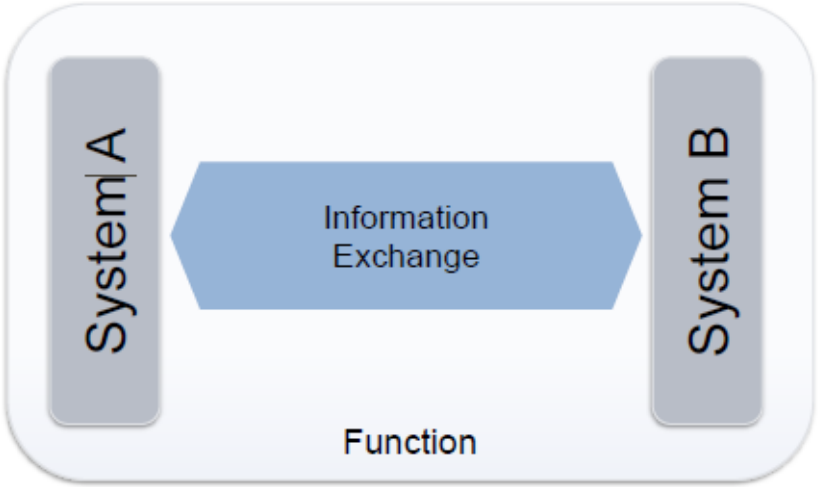
Research focus

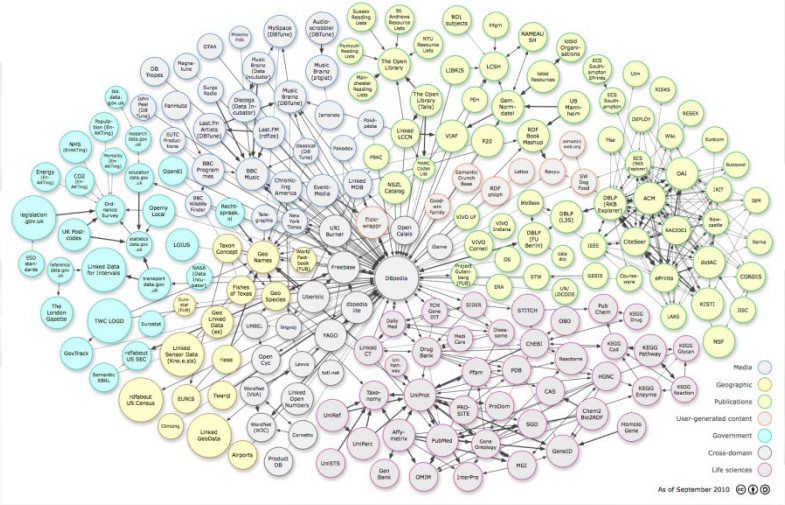
- RSE develops research activities of public interest in the electroenergetic sector, with emphasis on experimental pilot applications
- Comprehensive and system-based approach with valorisation of multi-disciplinary competences
- Oriented to benefit national electrical system users and industrial operators
- Wide-spread dissemination of public domain research results and technology transfer

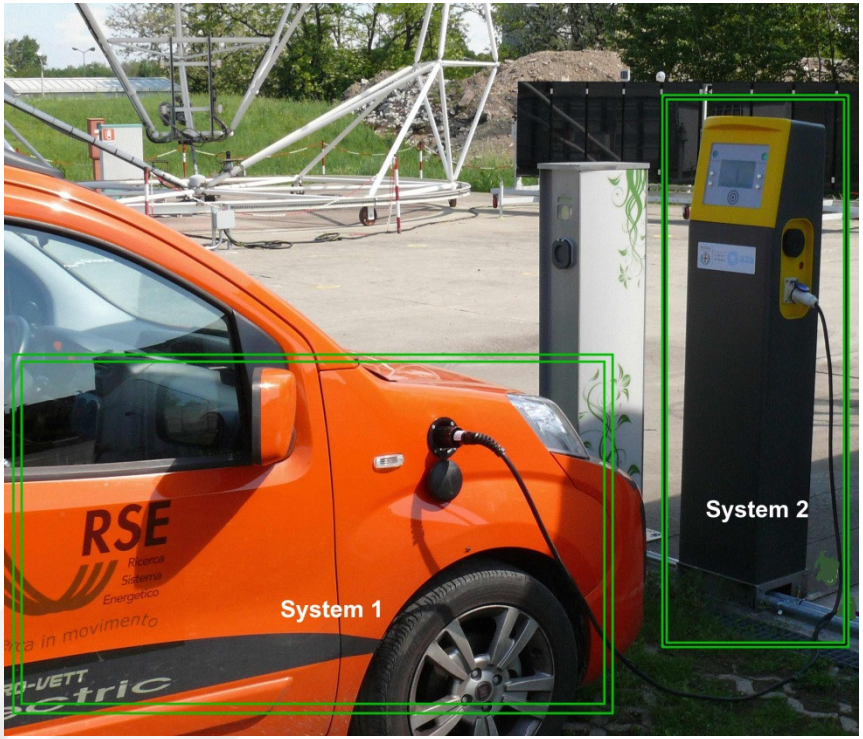
Interoperability

What is «interoperability» ?

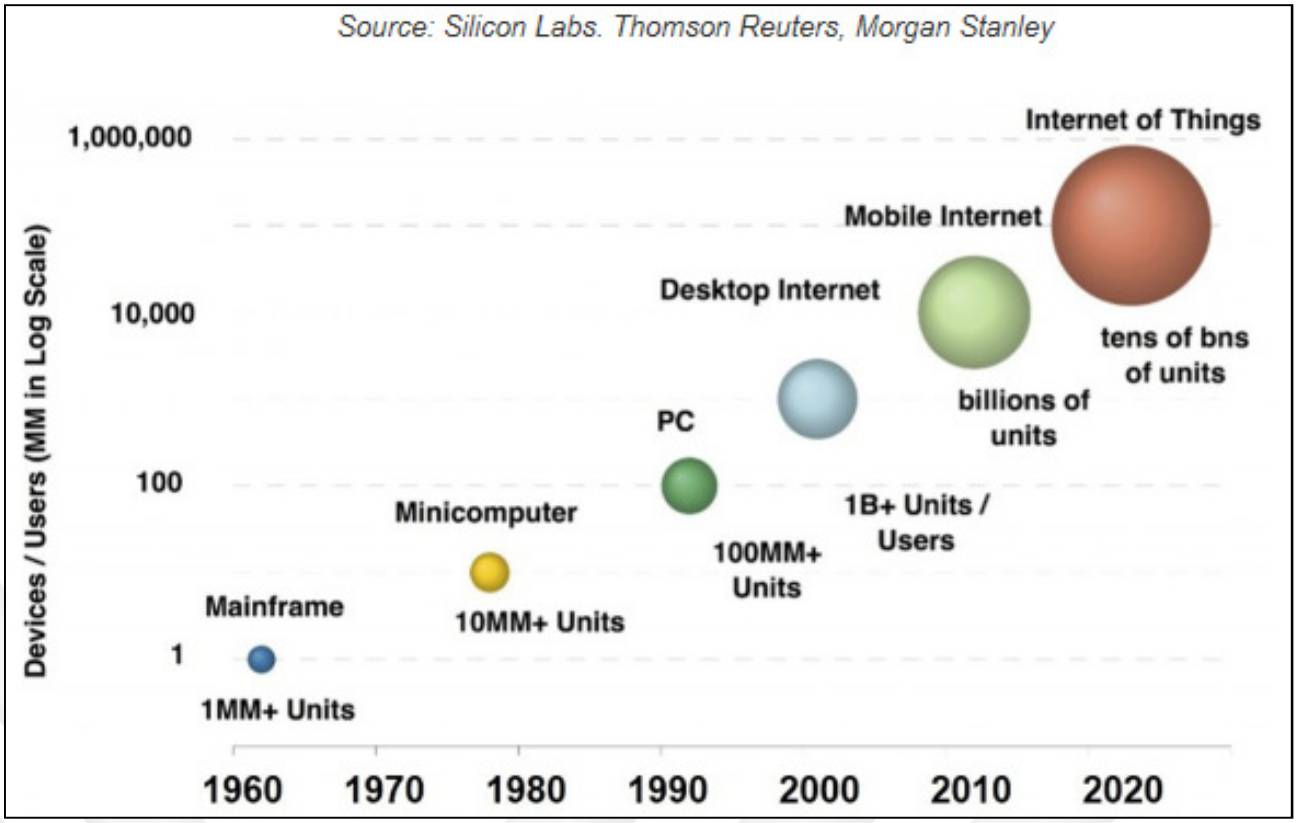
It is the ability that systems have to exchange informations and use them in order to perform required functions







The waves of networking



LAN Applications

Computer networks

- 1980 - email
- 1990 - web
- 2000 - social
- network

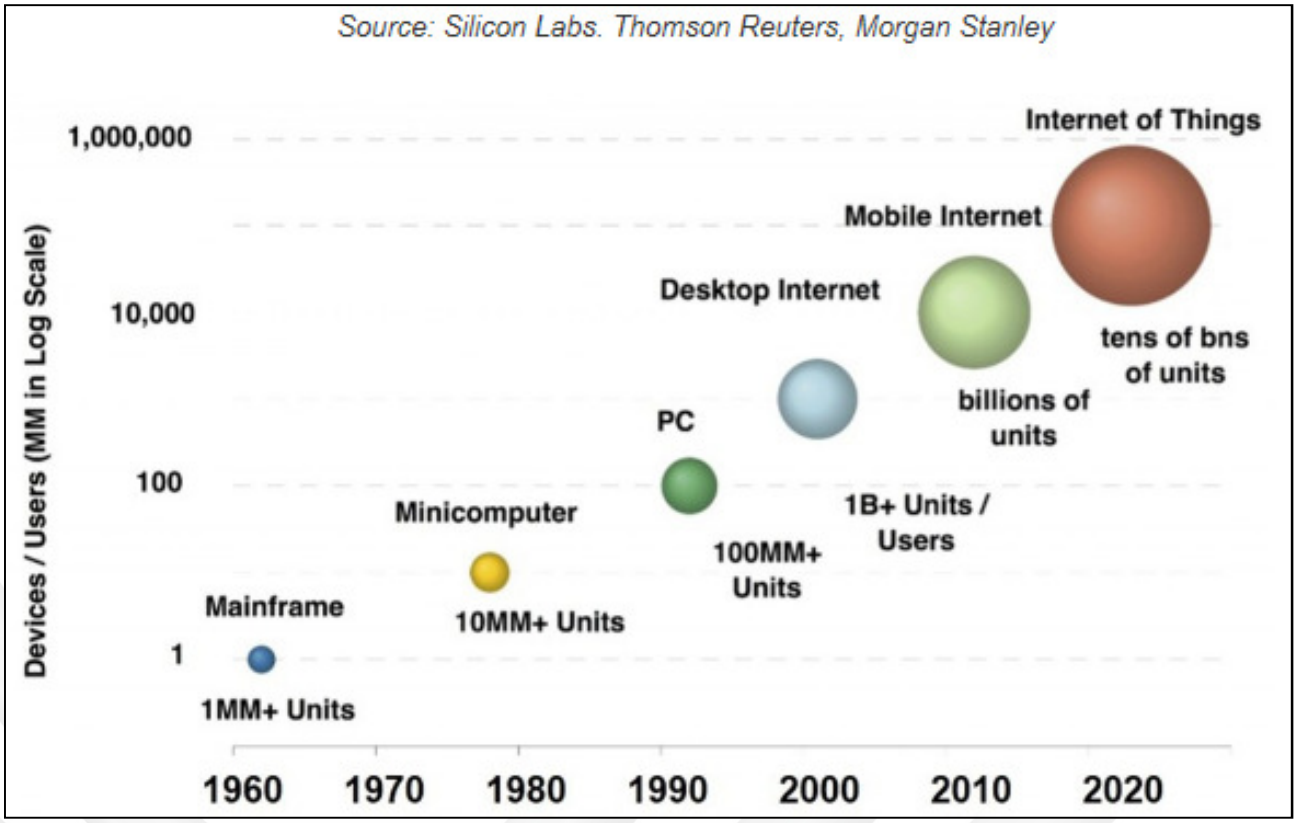
People networks

2005 – alarm, thermostat, white goods, navigator

Internet of things

Interoperability as a key success factor

The roles of Standards to achieve interoperability



TCP/IP Standard

Computer networks

W3C Standard (es. http, html)

People networks

It will be enough a new ICT standard ?

Internet of things

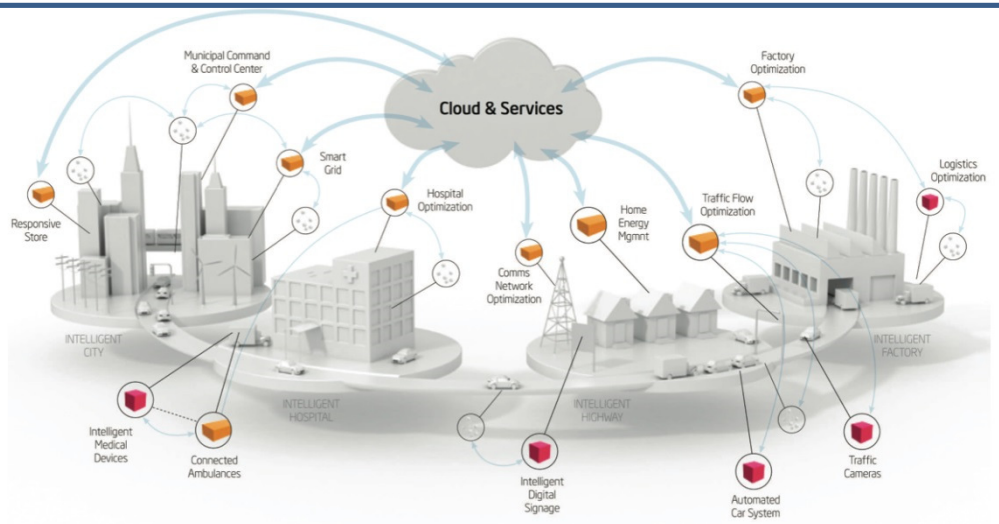
Internet of things

From the management of "things" to the provision of “services”

Today “Internet of things” is often conceived as a remote control/monitoring of "things."
(e.g., turn on the home heating)

Tomorrow “Internet of things” will use heterogeneous informations, with the purpose of providing services.

(e.g. management of home comfort , considering weather forecast , costs, habits, …)



The contribute of the "Model Data" for the systems interoperability

The integration of systems

- The prerequisites for the realisation of complex systems like «Smart City» and «Smart Grid», is the integration of a lot of systems
- The integration of systems needs the adoption of standard solutions that can guarantee interoperability
- In front of complex context like this, it’s not enough to manage big data and/or specify new communication protocols
- A global approach is needed, by increasing the value of “data” through a description of their meaning
- In this way simple data become "information" that means «knowledge» of a context/domain

Data, information, knowledge

- **Data**
  It is a well-known element (e.g. number, word) which does not need relations with others elements to exist, but taken by itself does not communicate anything
  (e.g. the term «ground» is a word, of which we do not know the specific meaning)

- **Information**
  It is an element or a datum permitting to know something, because it is inserted in a context
  (e.g. «ground» in the context of an electrical circuit)

- **Knowledge**
  A set of experiences and contextual information which provide a model to evaluate and include new experiences and informations
  (e.g. «ground» in an electric circuit has relations with «phase» and «neutral» …)

How modeling the knowledge of a domain?

- To express the knowledge of a domain (e.g. electrical domain) it is firstly necessary to define the **semantic**, which means give a meaning to information
  (specifying what it means «ground» in the electric context)

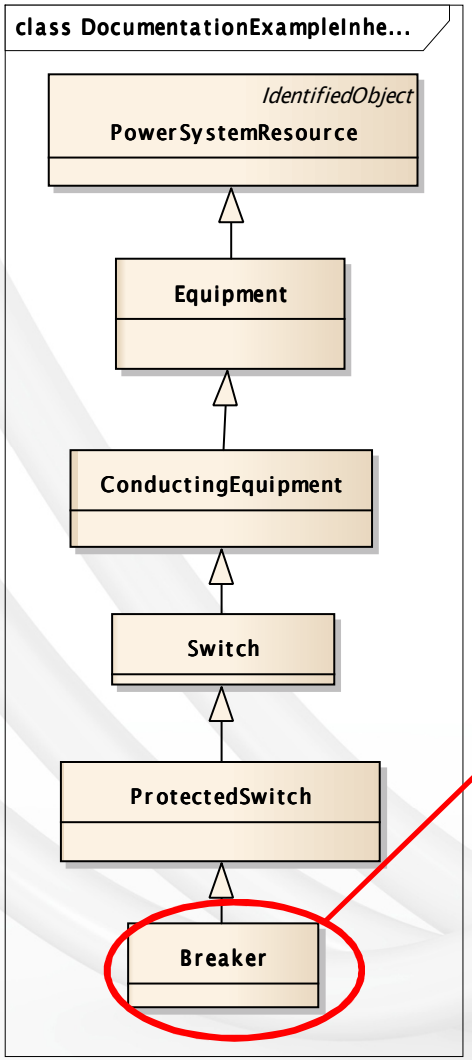
- It is also necessary define the **relations** between information
  («ground» has relations with «neutral» and «phase», it is a specialization of the «conductor» concept …)

- The semantic definition of the information and its relationship with other informations, represents the **knowledge** base of a domain
  (knowledge of electrical domain)

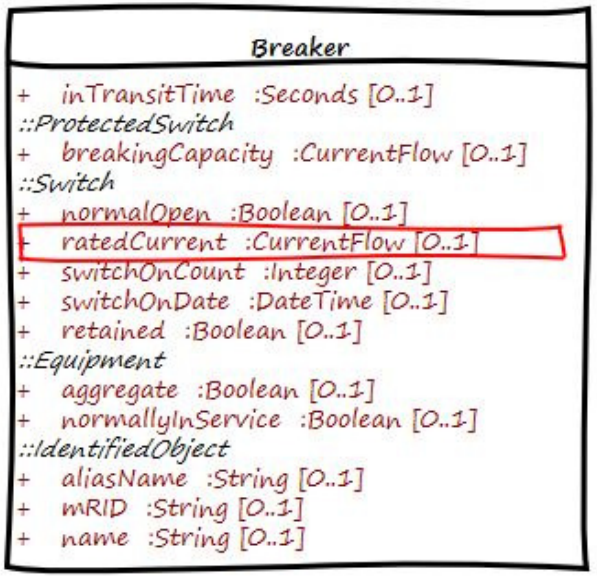
- This «knowledge» could be described in a formal way by «Data Models» or «Ontology»

- The sharing of a common «Data Model» provides a basis for understanding information exchanged between systems, enabling in this way their smart use

Example of a common semantic shared by different systems



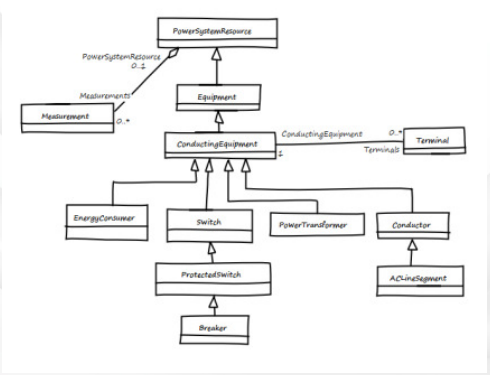
The name and the meaning of a Class and its Properties are defined unambiguously



E.g.:
The property «ratedCurrrent» of the Class «Breaker» will be interpreted with the meanings of «Nominal Current» of a «Breaker» **by all systems**

Languages to represent knowledge

- A Data model can be represented as a «class diagram» using UML.
  This graphic representation is easy to understand for humans
- The ontology languages like RDF/RDFS and OWL are instead more convenient for computers
- RDF provides simple features describing a domain.
  Being very efficient it is useful to manage big quantity of informations
- OWL is more expressive then RDF, but less efficient
- The «Common Information Model» uses UML to design «Data models»
  and, in specific context, RDF to represent concrete instances.

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      <cim:WireType.ratedCurrent>133</cim:WireType.ratedCurrent>
    </cim:WireType>
  - <cim:Line rdf:ID="_103f6571a69343f08e852510c3c54881">
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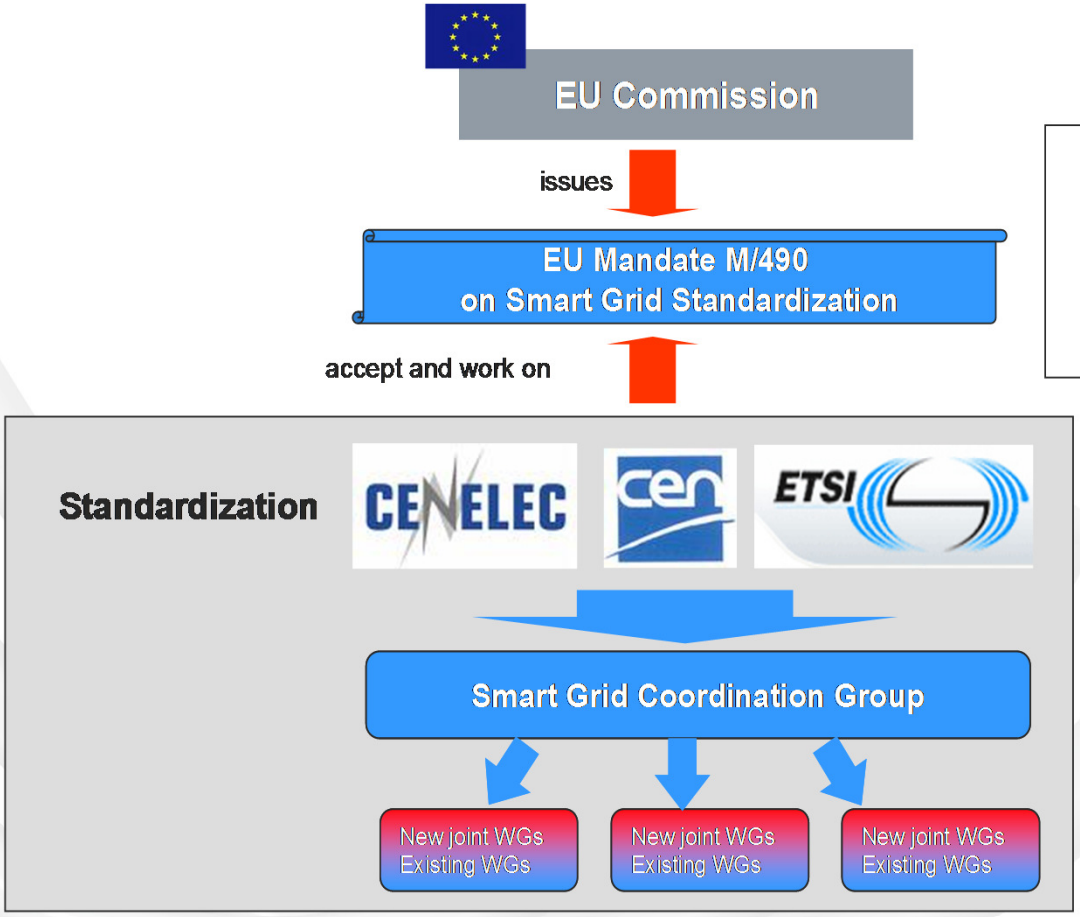
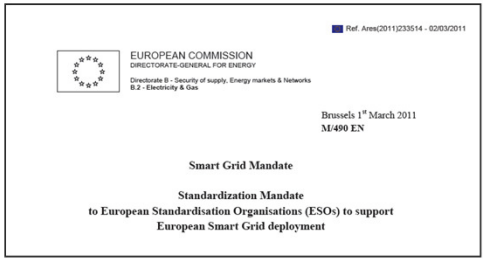
The SG-CG approach to achieve systems interoperability

European Commission M/490 mandate on Smart Grid standardization

CEN/CENELEC/ETSI answer to M/490, establishing the «Smart Grid Coordination Group» (SG-CG)





Ref. Ares(2011)233514 - 02/03/2011

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

Directorate B - Security of supply, Energy markets & Networks
B.2 - Electricity & Gas

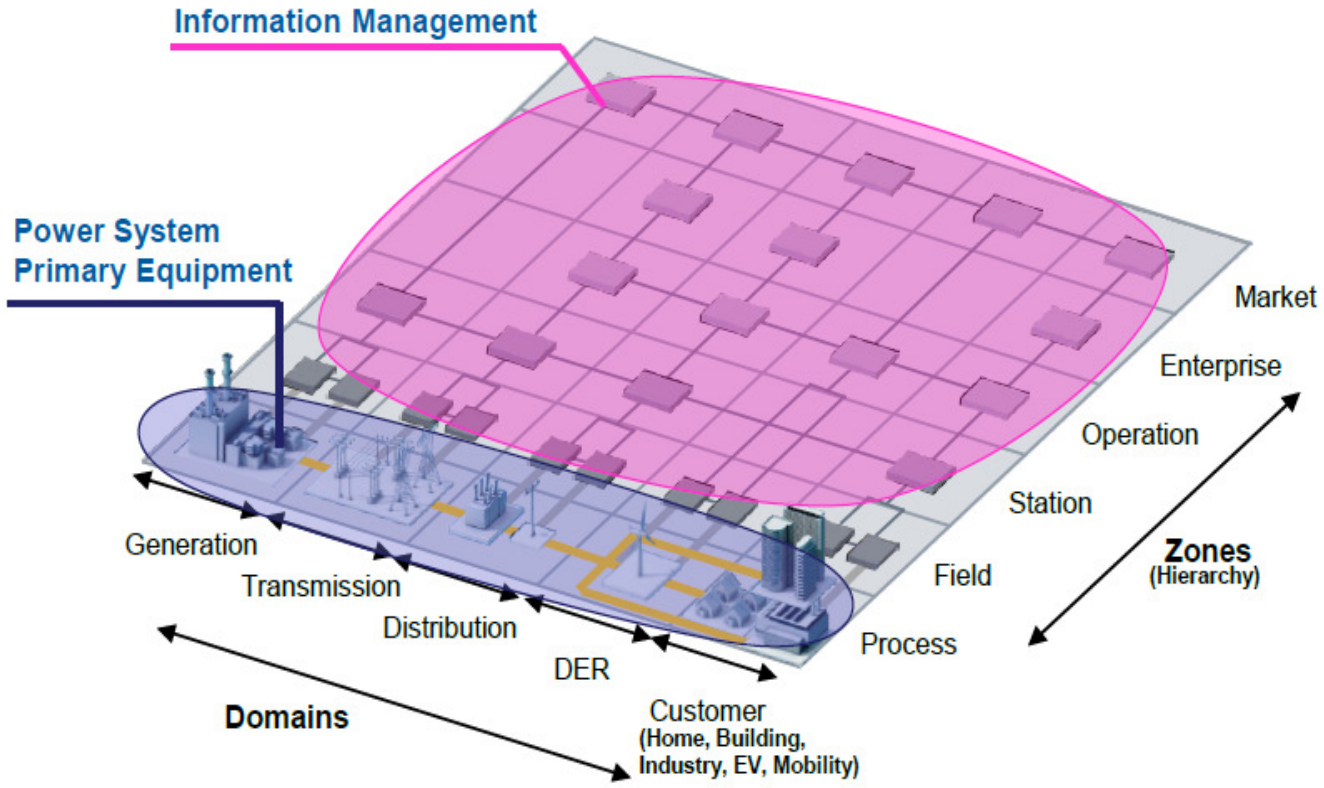
Brussels 1st March 2011
M/490 EN

Smart Grid Mandate

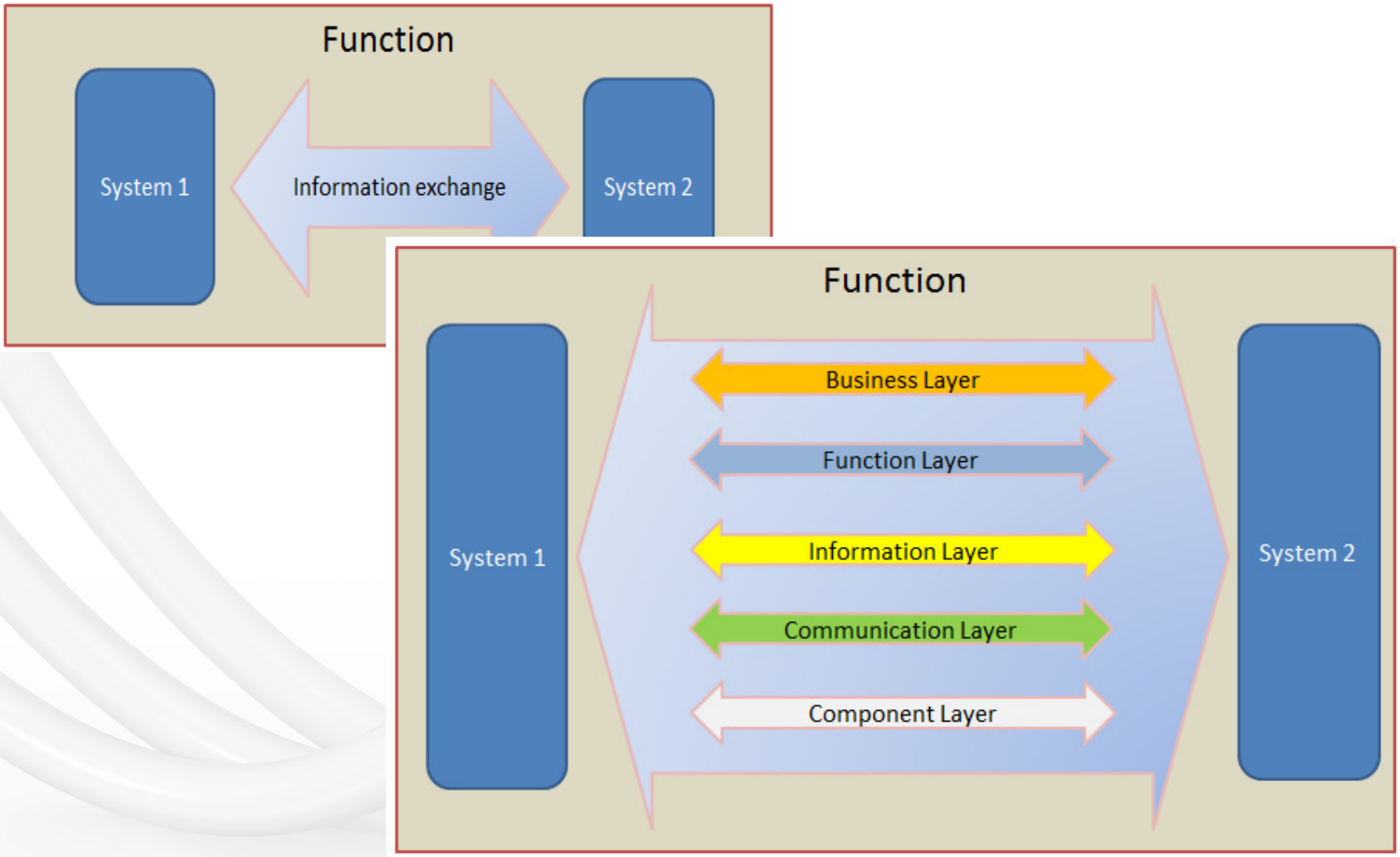
Standardization Mandate
to European Standardisation Organisations (ESOs) to support
European Smart Grid deployment

The Smart Grid Plane

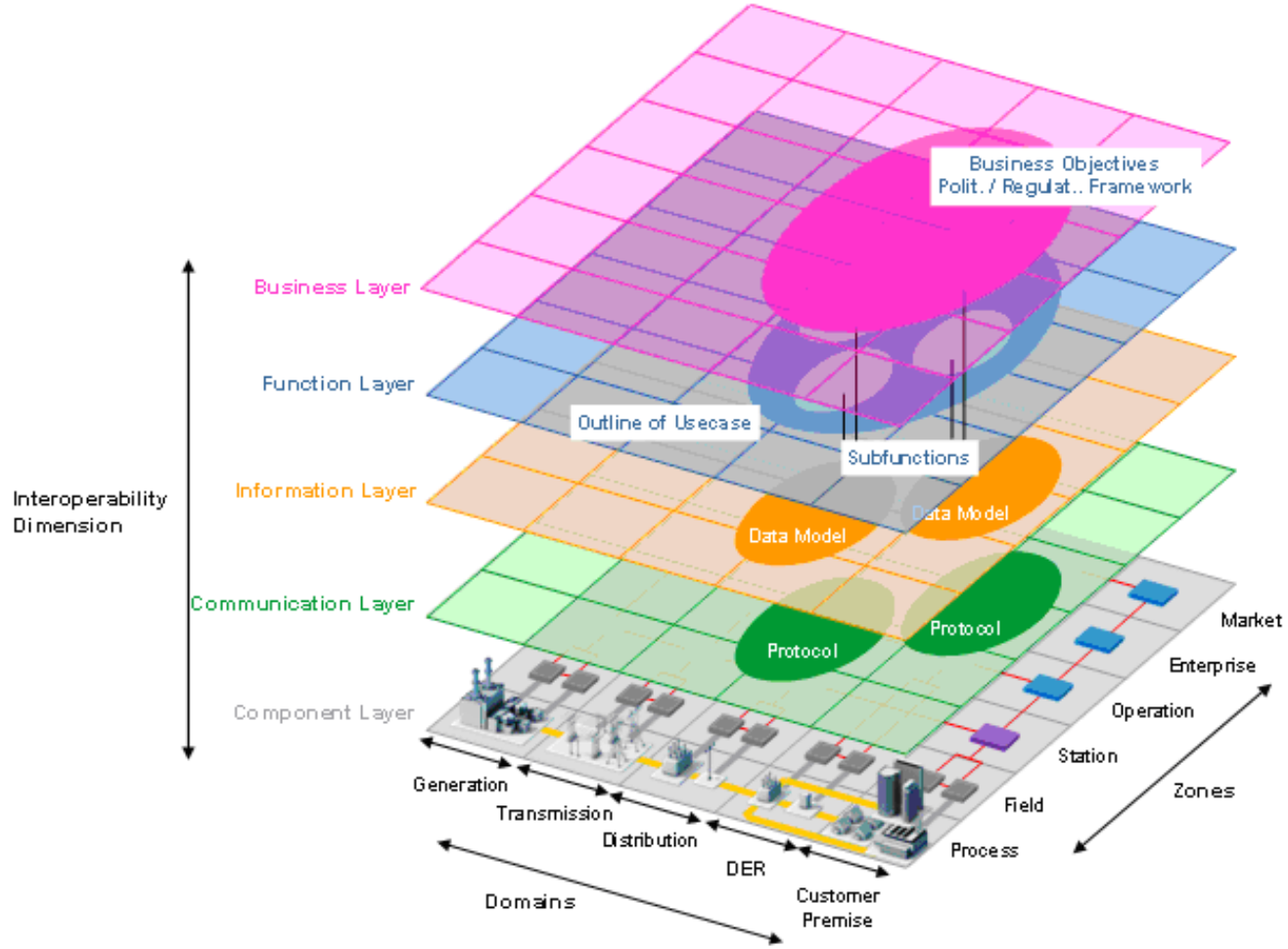
defined by SG-CG “Reference Architecture” WG



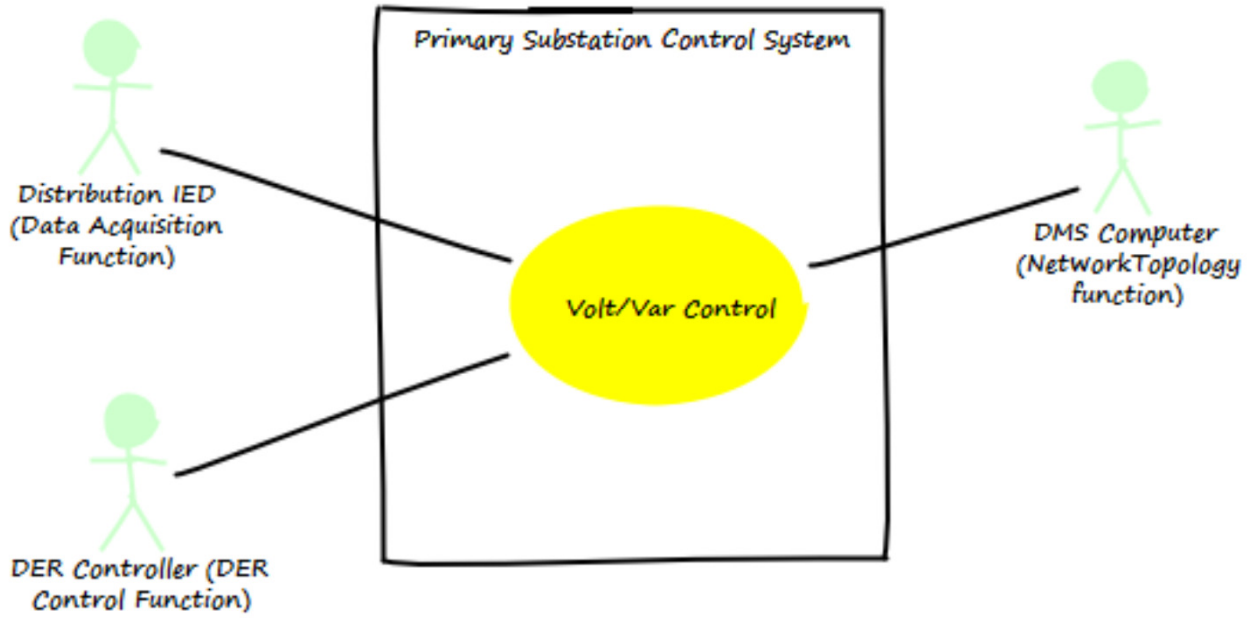
Interoperability levels



Interoperability Levels in Smart Grid Architecture Model (SGAM)

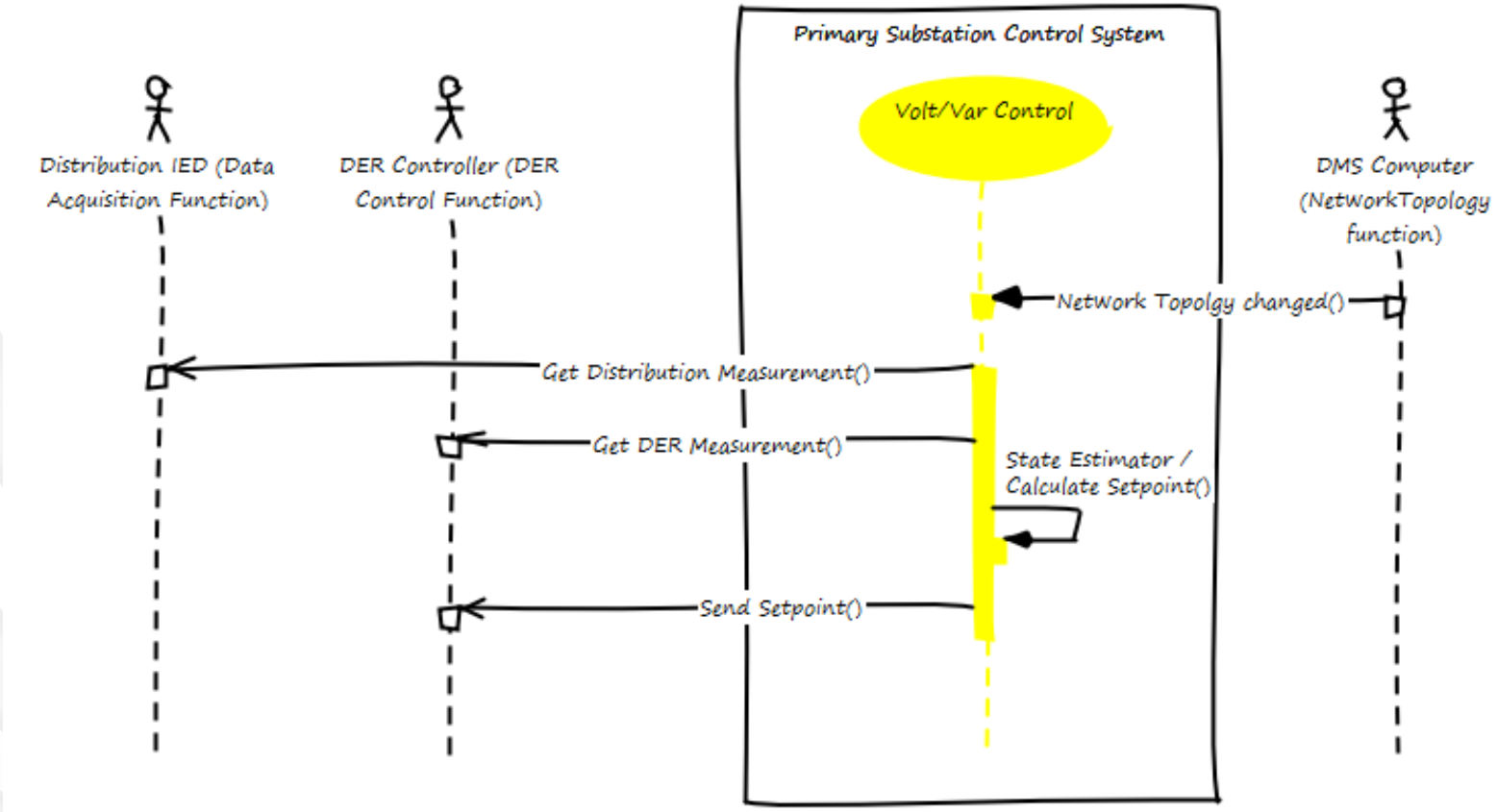


Use Case analysis
(SGAM Function layer)



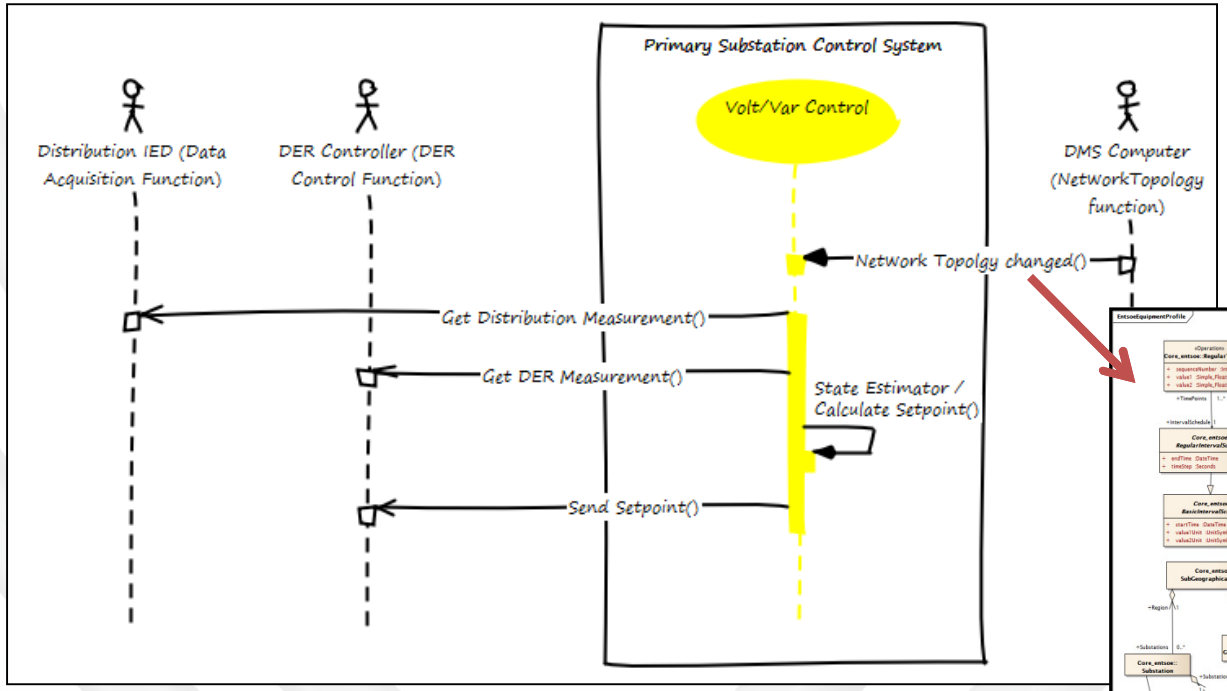
Interactions between System and Actors

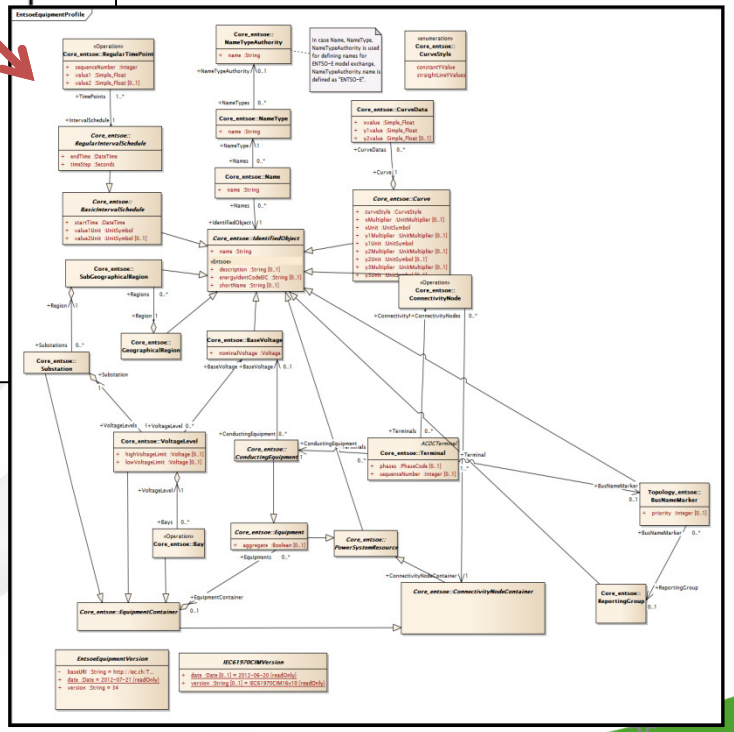
(Sequence Diagram on SGAM Function layer)



Mapping information exchange on standard Data Model

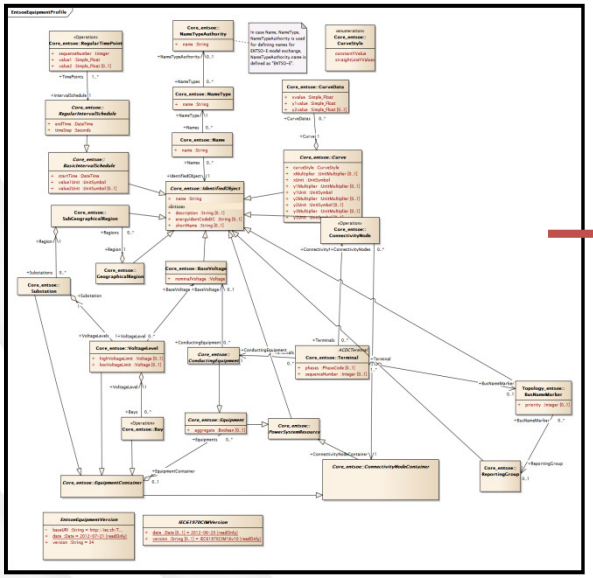
(SGAM Information layer)

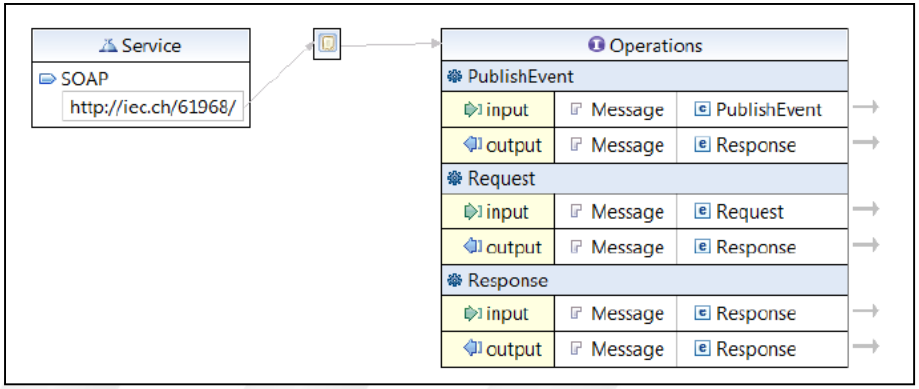




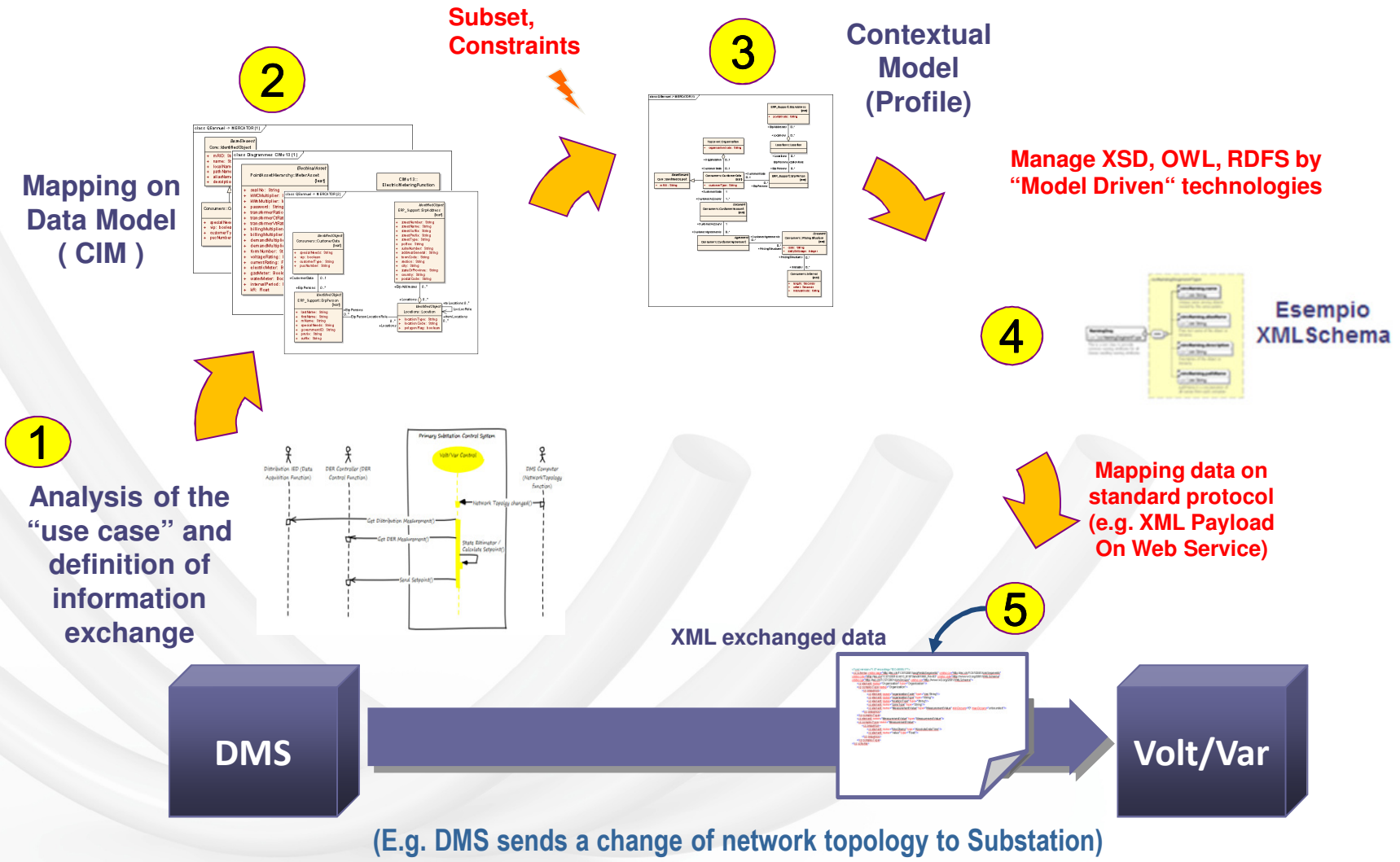
Apply a communication protocol

(SGAM Communication layer)





The process for the development of interoperable systems



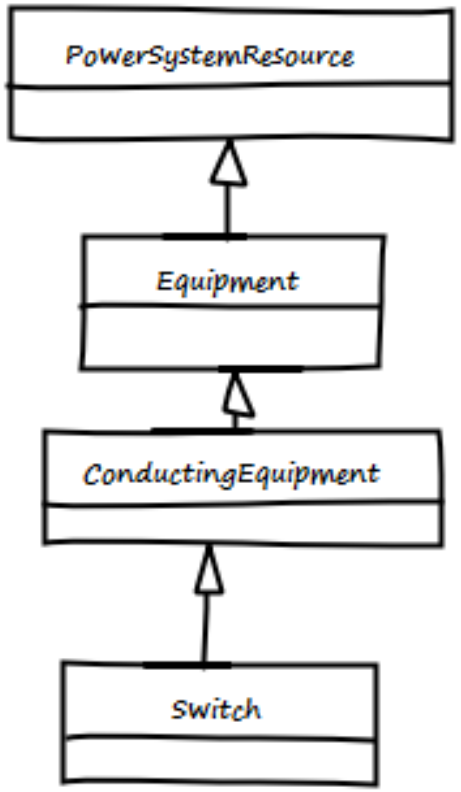
(E.g. DMS sends a change of network topology to Substation)

IEC «Common Information Model» (CIM)

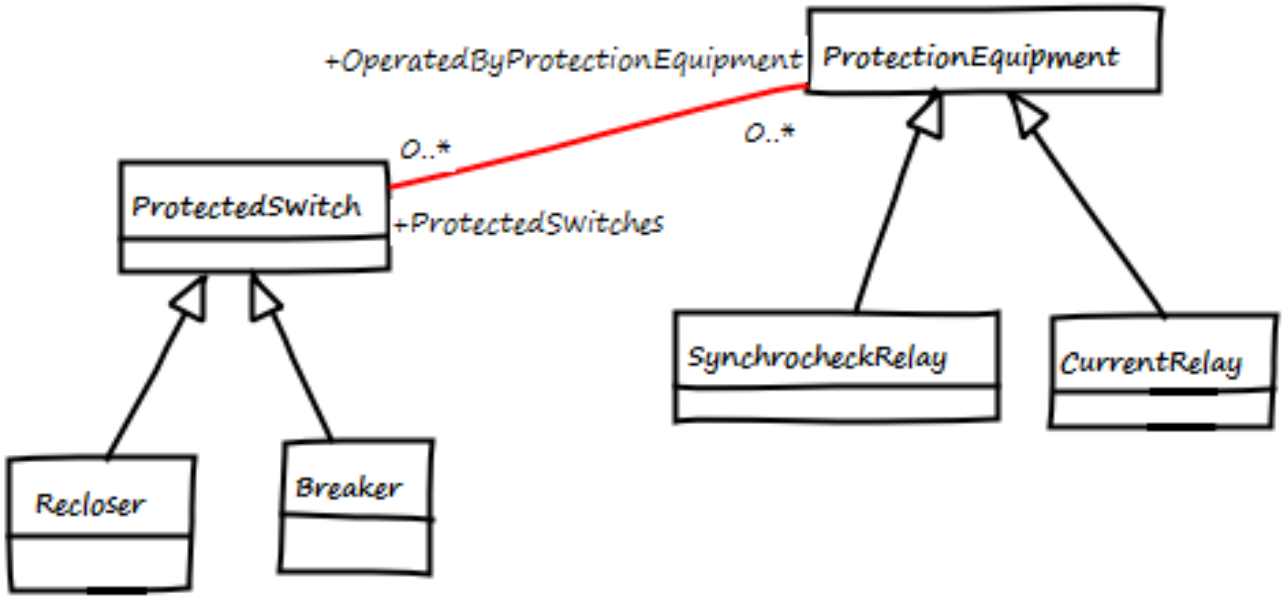
IEC “Common Information Model”

- The “Common Information Model” («**CIM»)** is a Data Model expressed by a UML Class diagram
- CIM represents the main resources and the relationship between them, for the management of the electric system
- Expressing the knowledge associated to the electrical domain, CIM represent its base ontology

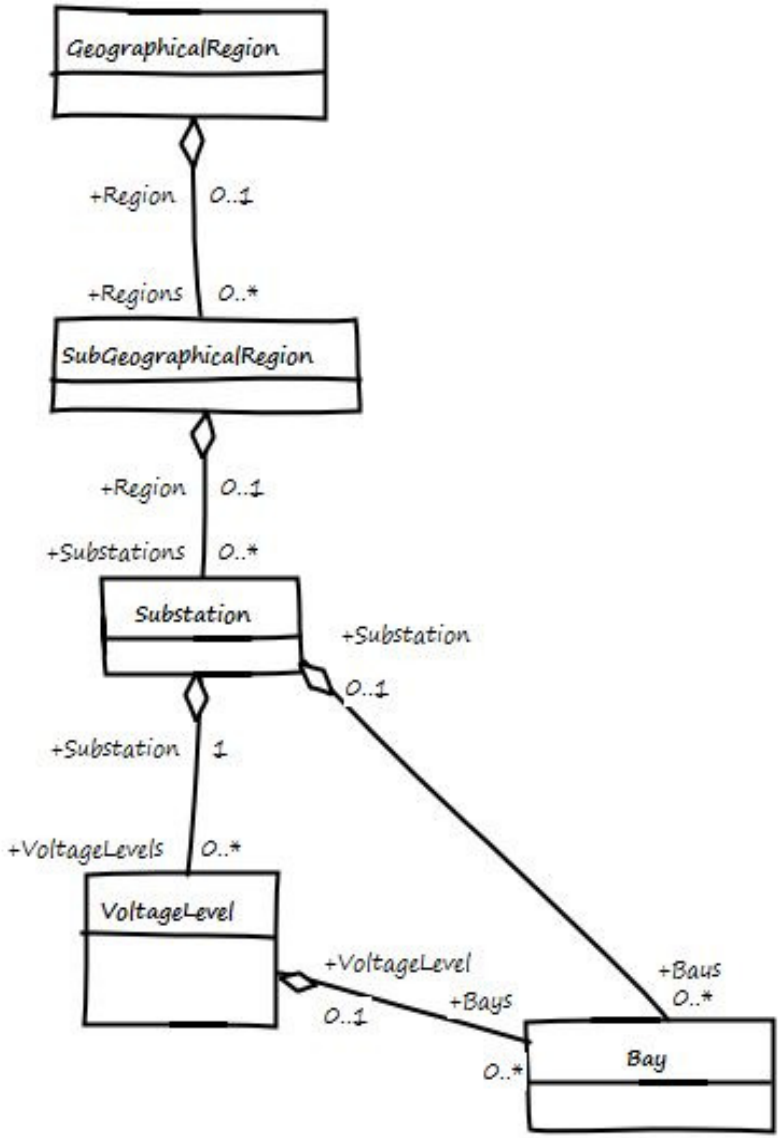
Example of classes inheritance in «CIM»



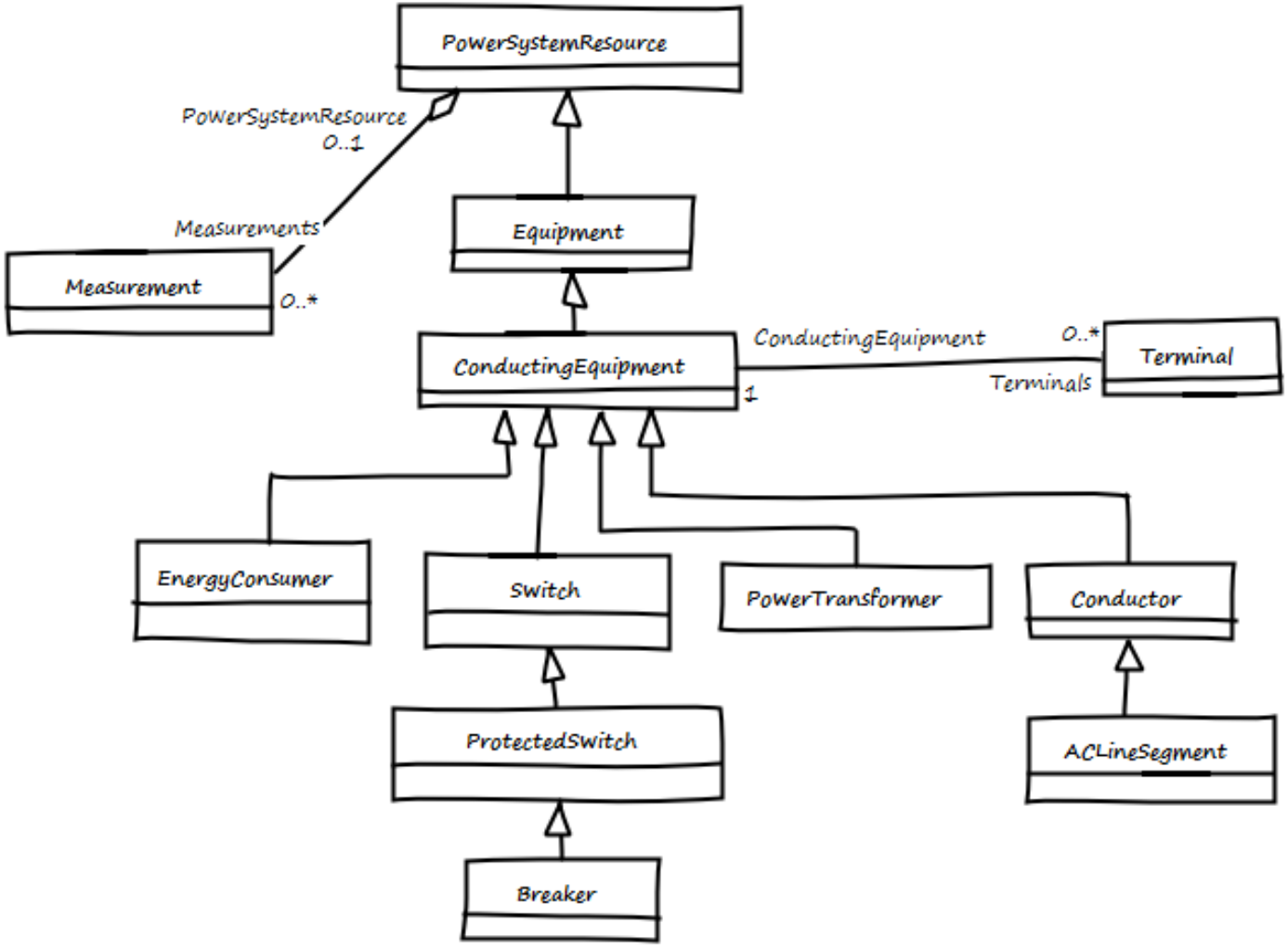
Example of association in «CIM»



Example of aggregation in «CIM»



«CIM» expresses the electric domain knowledge



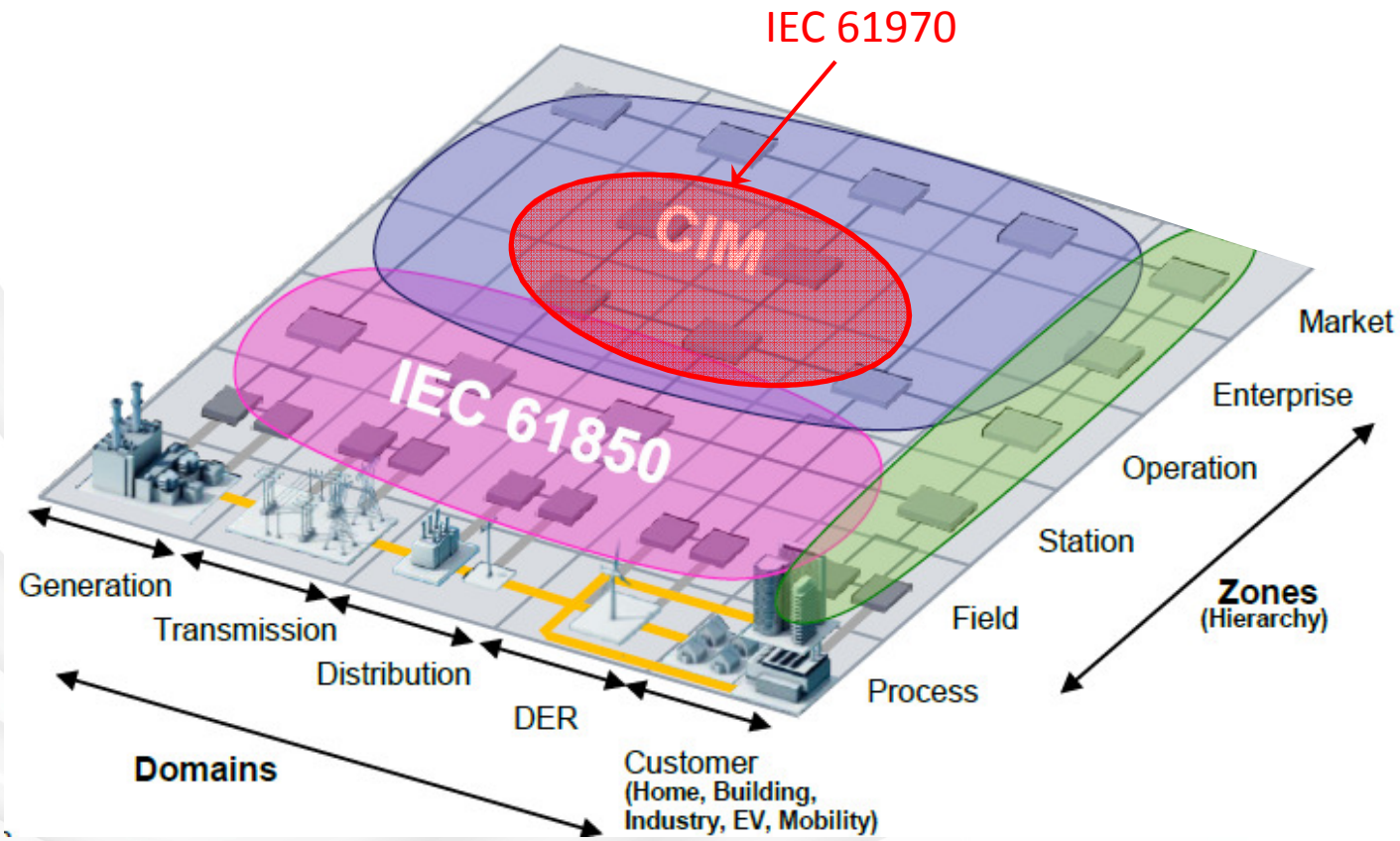
CIM – Main application contexts

Main application contexts

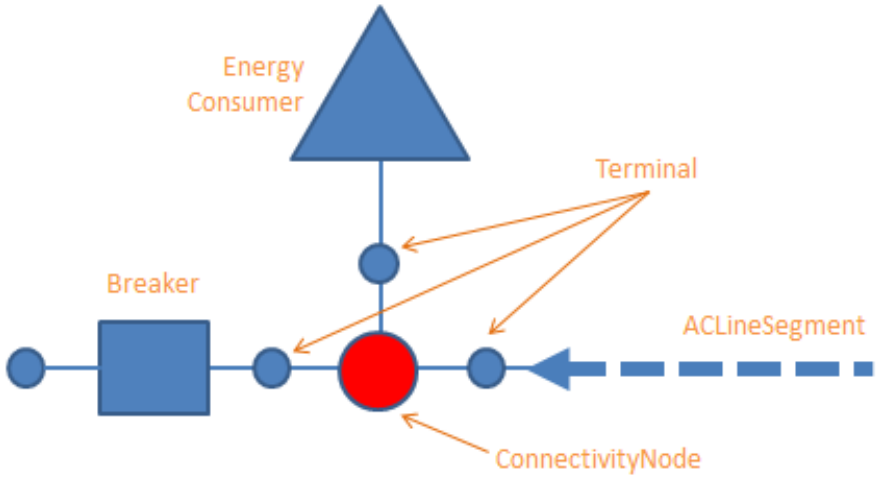
- Standardized representation of electrical networks topology
- Management of the electrical market
- System integrations at Utility level
- Management of the active customers

CIM for standard representation of electrical networks (IEC 61970)

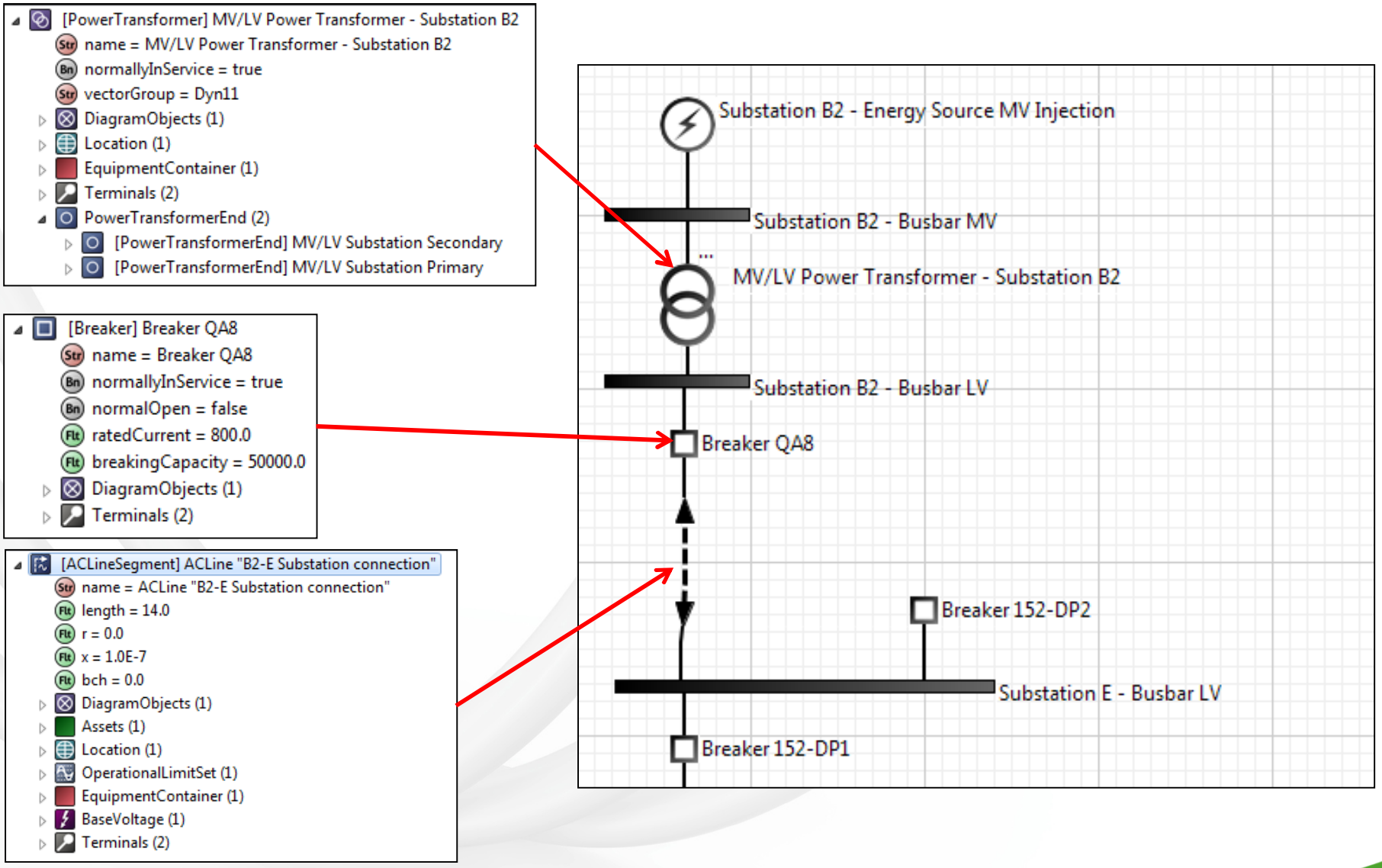
Application context associated with standard representation of electrical networks



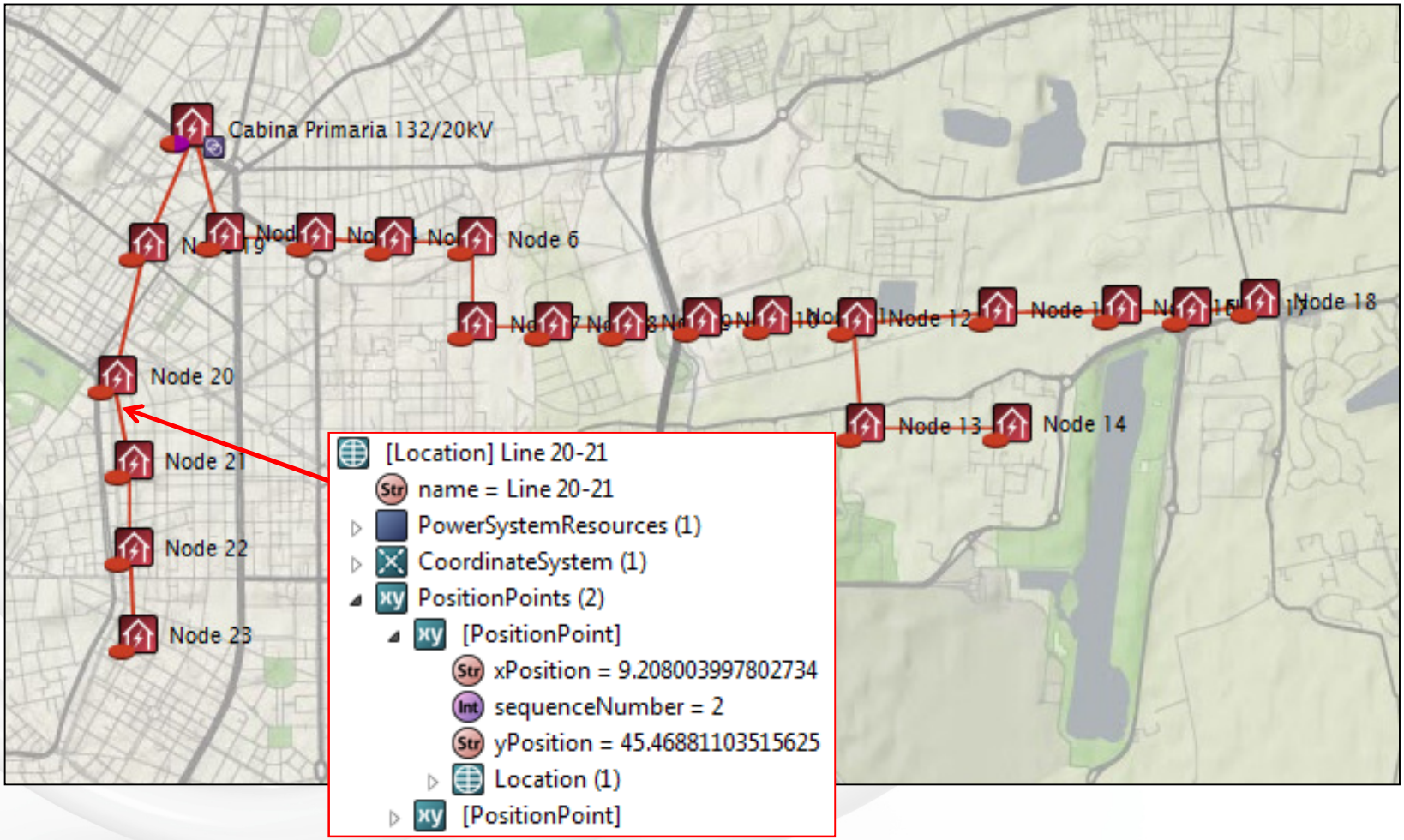
Representation of electrical components and their interconnections



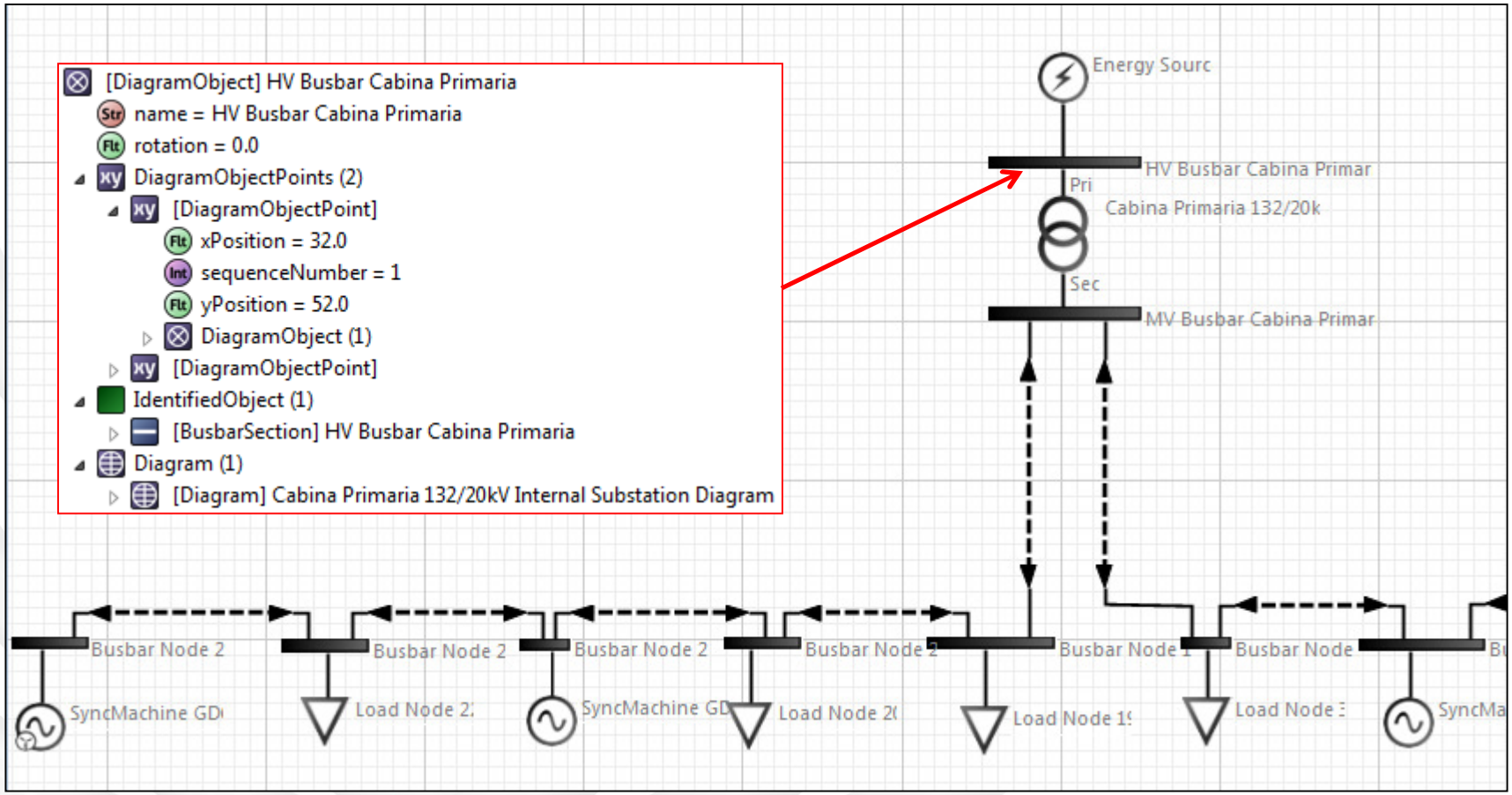
Example of a representation of a distribution grid



Geographical representation of grid



CIM for graphical representation of electrical circuits



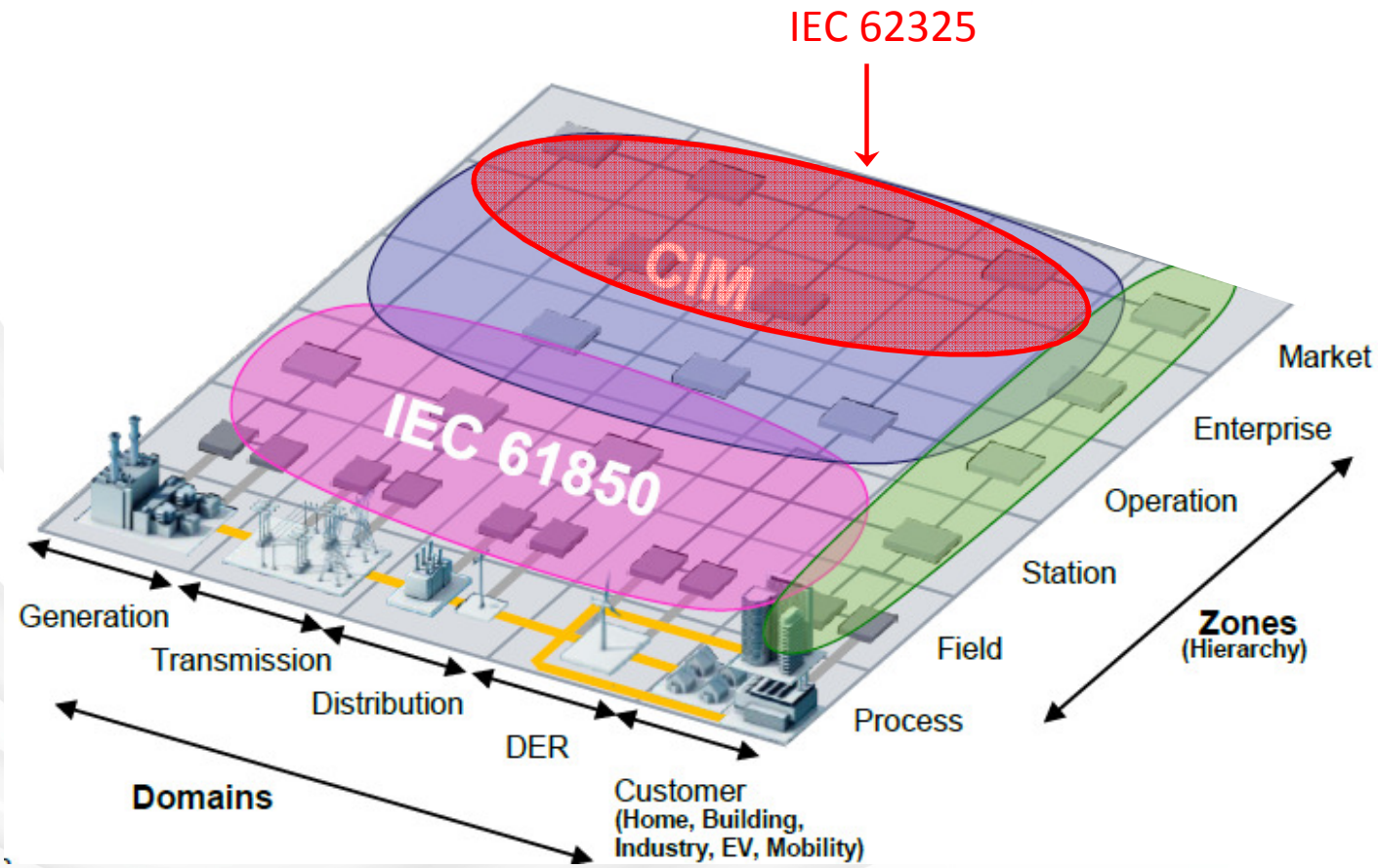
Current use and perspectives of CIM for electrical networks representation

- Today “CIM” is used by European Network of Transmission System Operators for Electricity “ENTSO-E” to exchange information at European level. (https://www.entsoe.eu/major-projects/common-information-model-cim/)

- In the future this approach could be applied for information exchange between transmission and distribution system operators

CIM for the management of the energy market (IEC 62325)

Application context associated with the management of the energy market



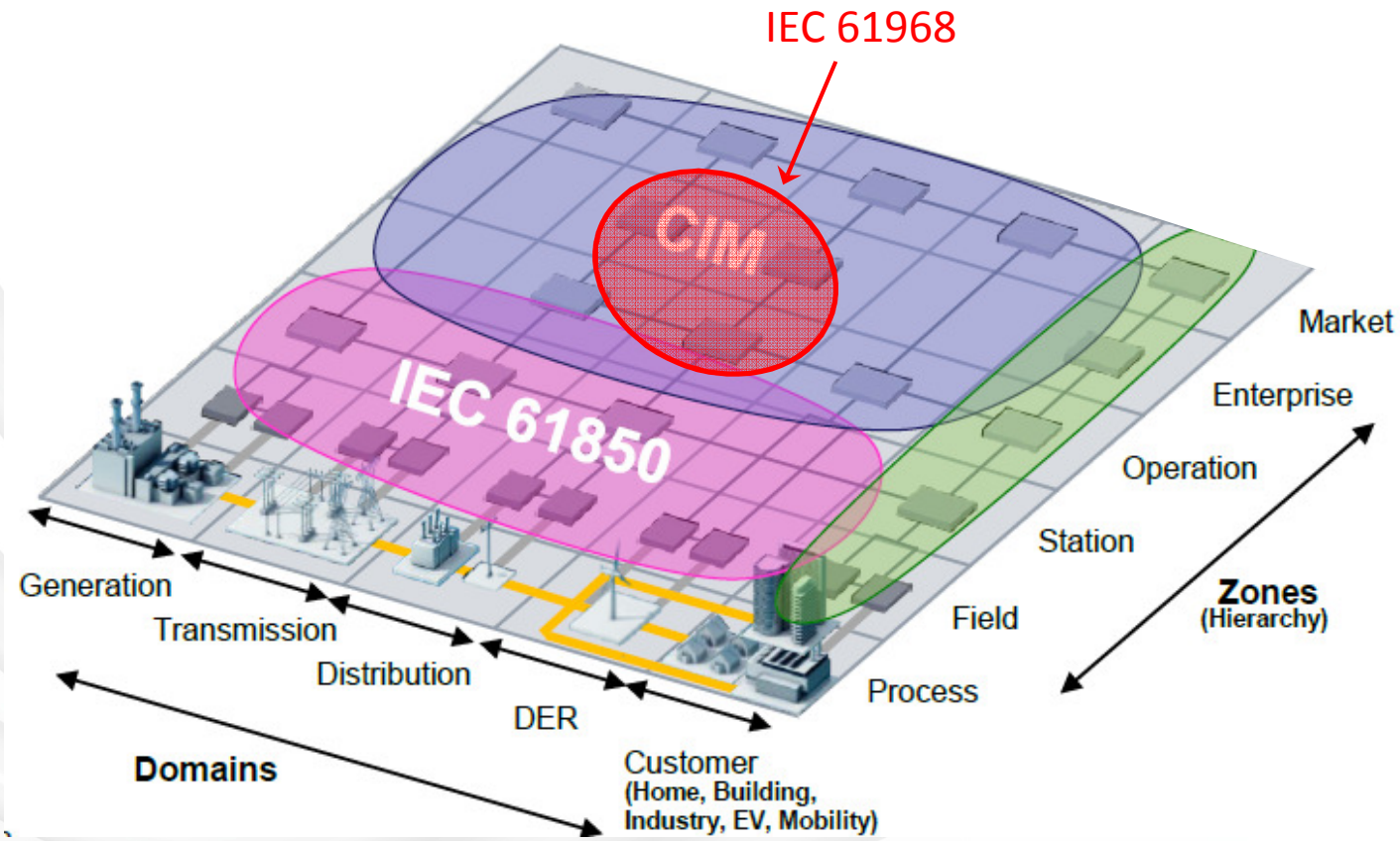
Extension of the CIM Model for the management of the energy market

- The native CIM Model, specified by IEC61970-301 and IEC61968-11, was extended using the definition of classes necessary to implement the energy market management.
- This extension, which is specified by IEC62325-301, is composed by three classes set, or packages:

MarketCommon	(Stakeholders involved in the electrical exchange)
MarketManagement	(European Market Model)
MarketOperations	(US market Model)

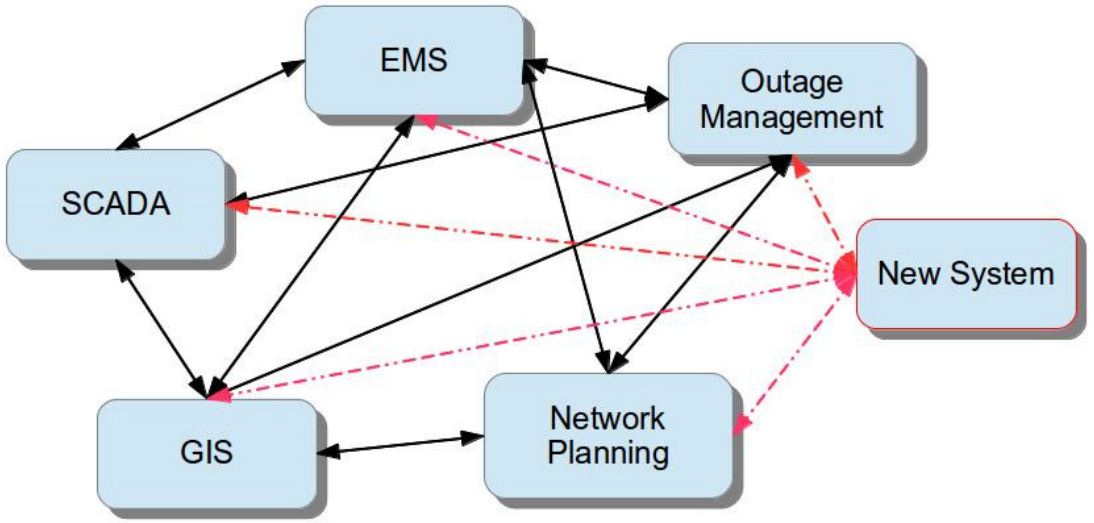
CIM for system integrations at Utility level (IEC 61968)

Application context associated with systems integration



CIM for Utility system integrations

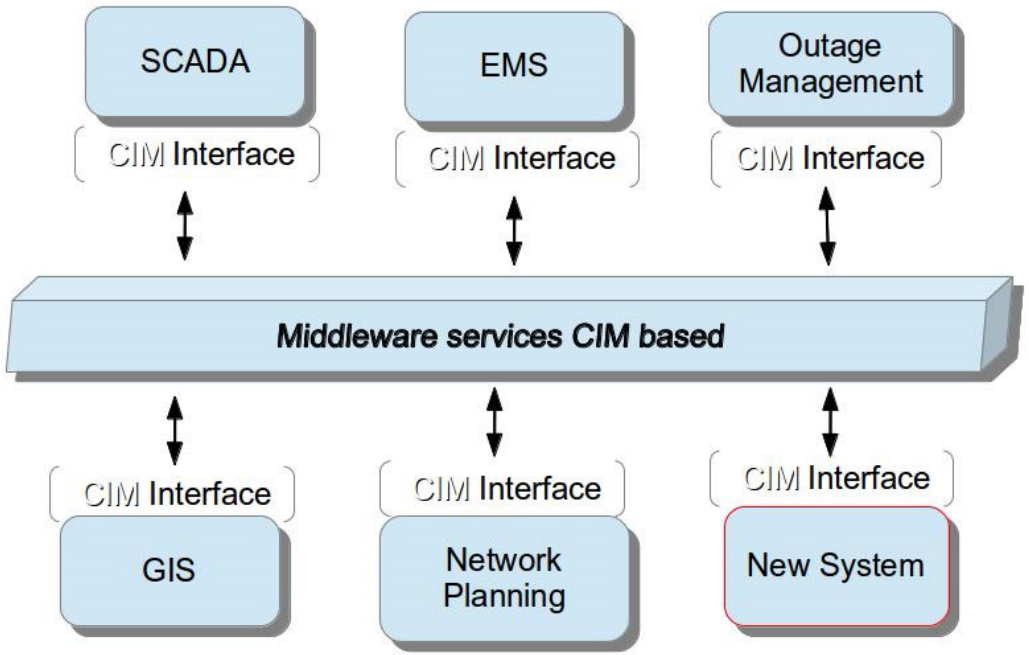
Different software applications use the same informations



Every new application/system has to develop (n-1) interfaces

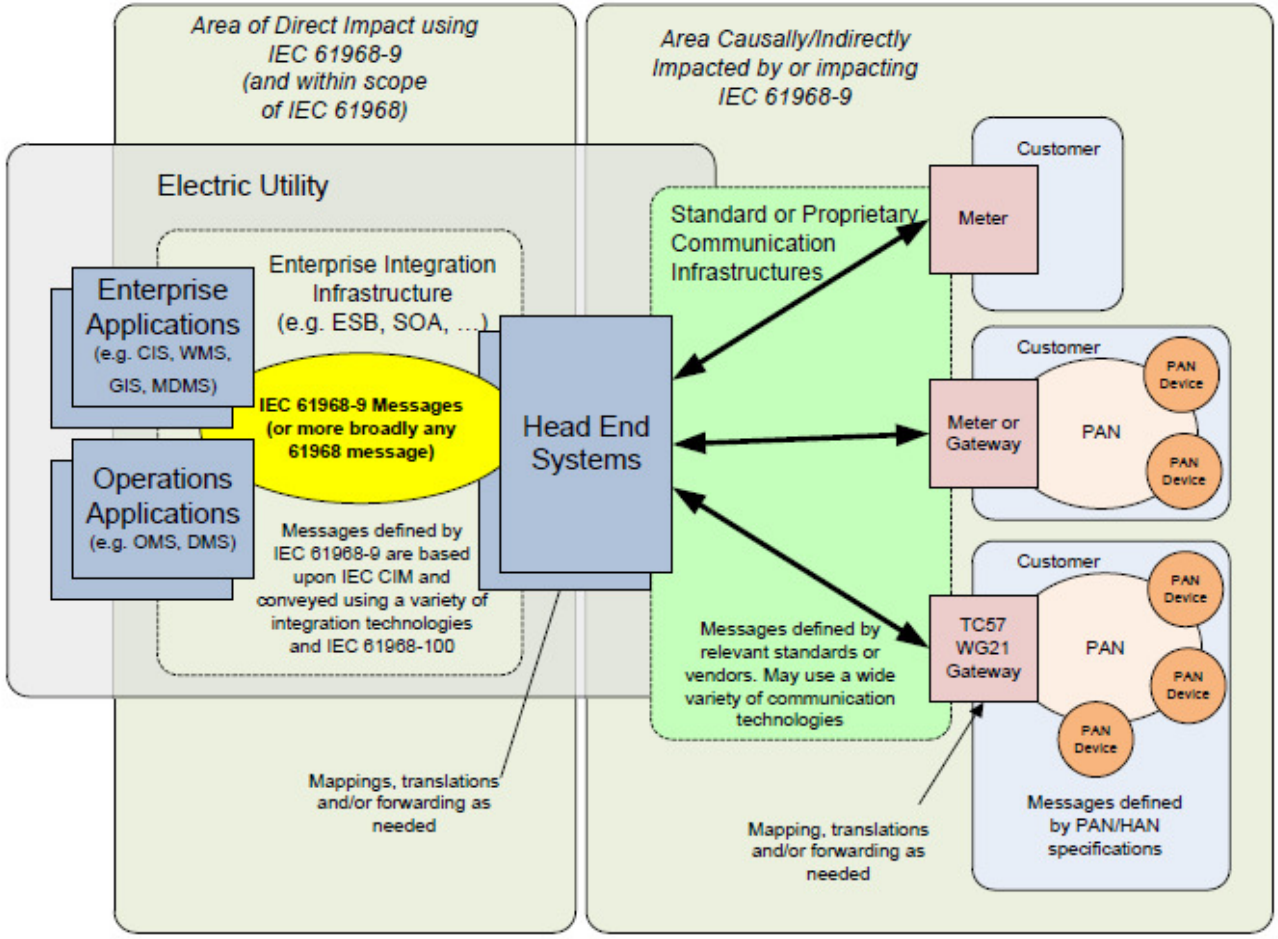
CIM for Utility system integrations

CIM represents the common semantic reference model for different applications



Every new application has to develop only one standard interface

IEC 61968-9 standard for metering
Direct and indirect scope

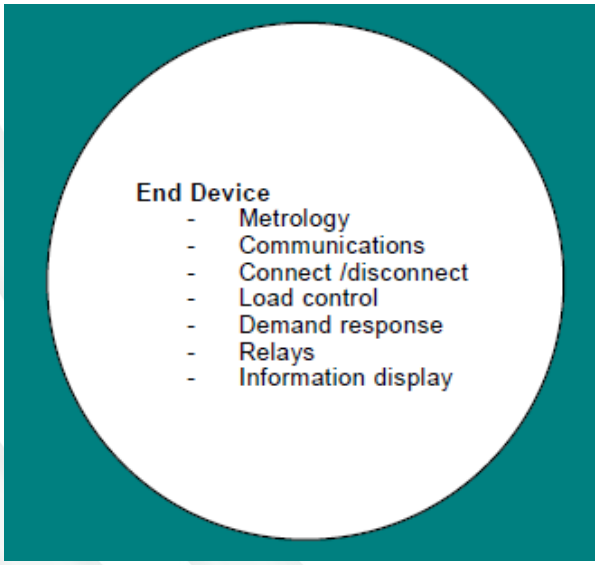


IEC 61968-9 standard for metering

The central role of the “End device” and “EndDeviceControl” classes

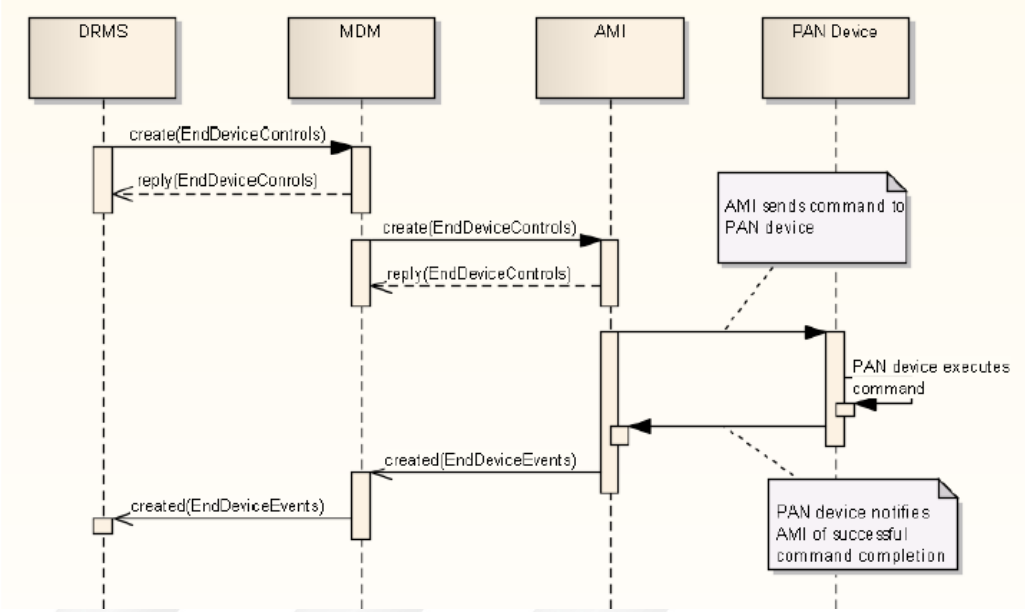
EndDevice

(Asset container that performs one or more end device functions)



EndDeviceControl

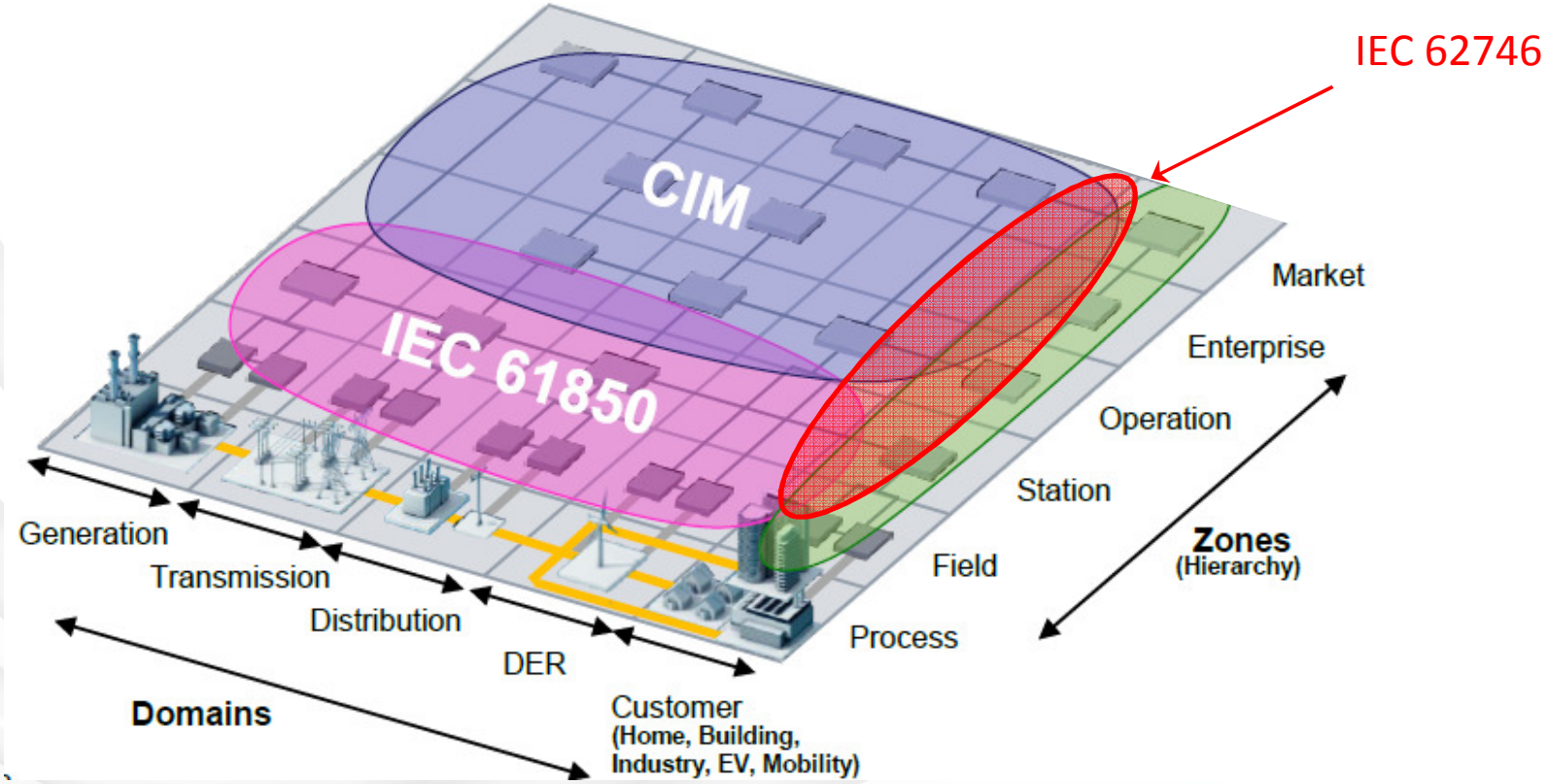
(Instructs an end device to perform a specified action)



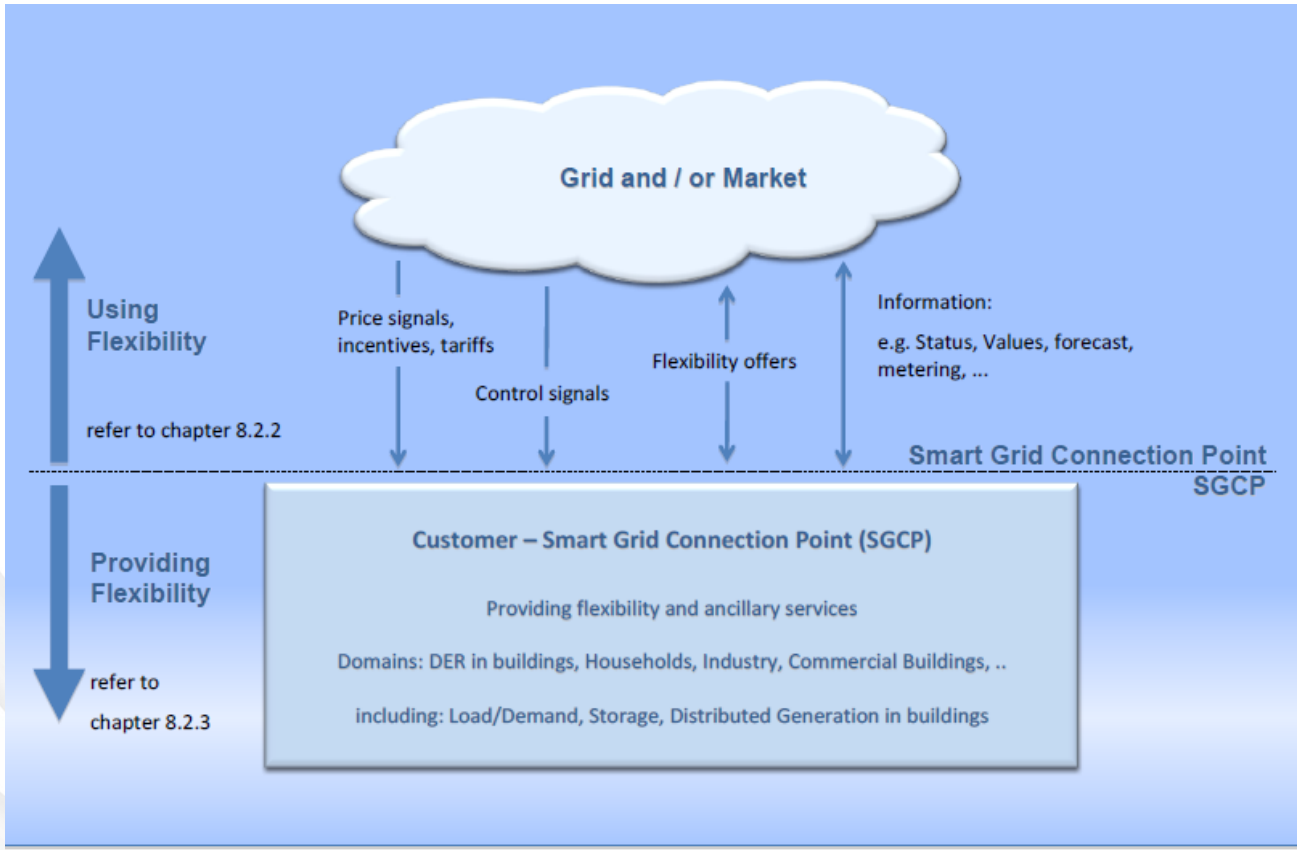
Event or Control Description	EndDeviceControl Type	Expected Events	EndDevice Domain	EndDevice SubDomain	EndDevice EventOrAction
Load control initiate, port 0	*.15.0.54	*.15.17.242 *.15.17.217	LoadControl	n/a	Start
Load control stop/terminate, port 1	*.15.0.55	*.15.17.216 *.15.17.218	LoadControl	n/a	Stop

CIM for the management of the active customers (IEC 62746)

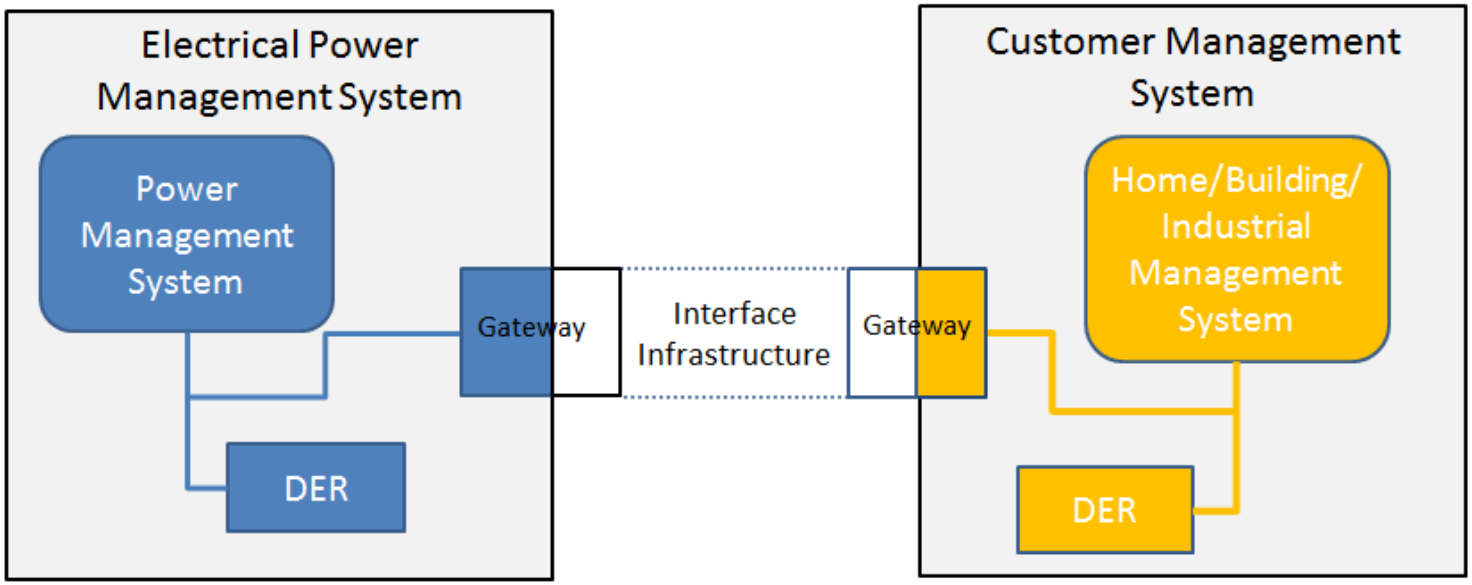
Applicative context associated with the management of active consumers



Management of the flexibility associated with active customers

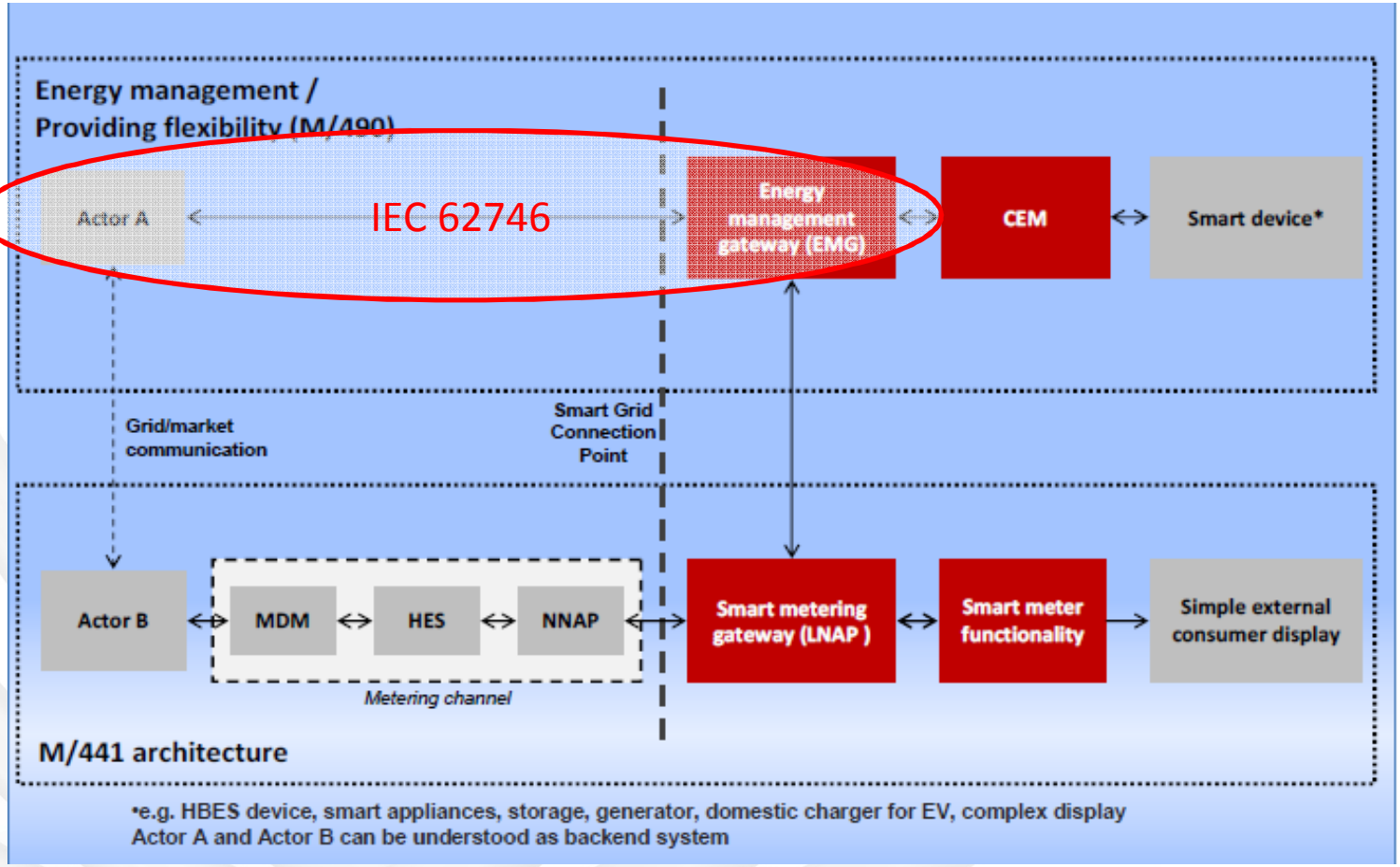


«Grid» – «Active customer» interface architecture



Functional architecture for management of active customers

IEC 62746 appplication context



Source: CEN-CENELEC-ETSI Smart Grid Coordination Group – Sustainable Processes Report

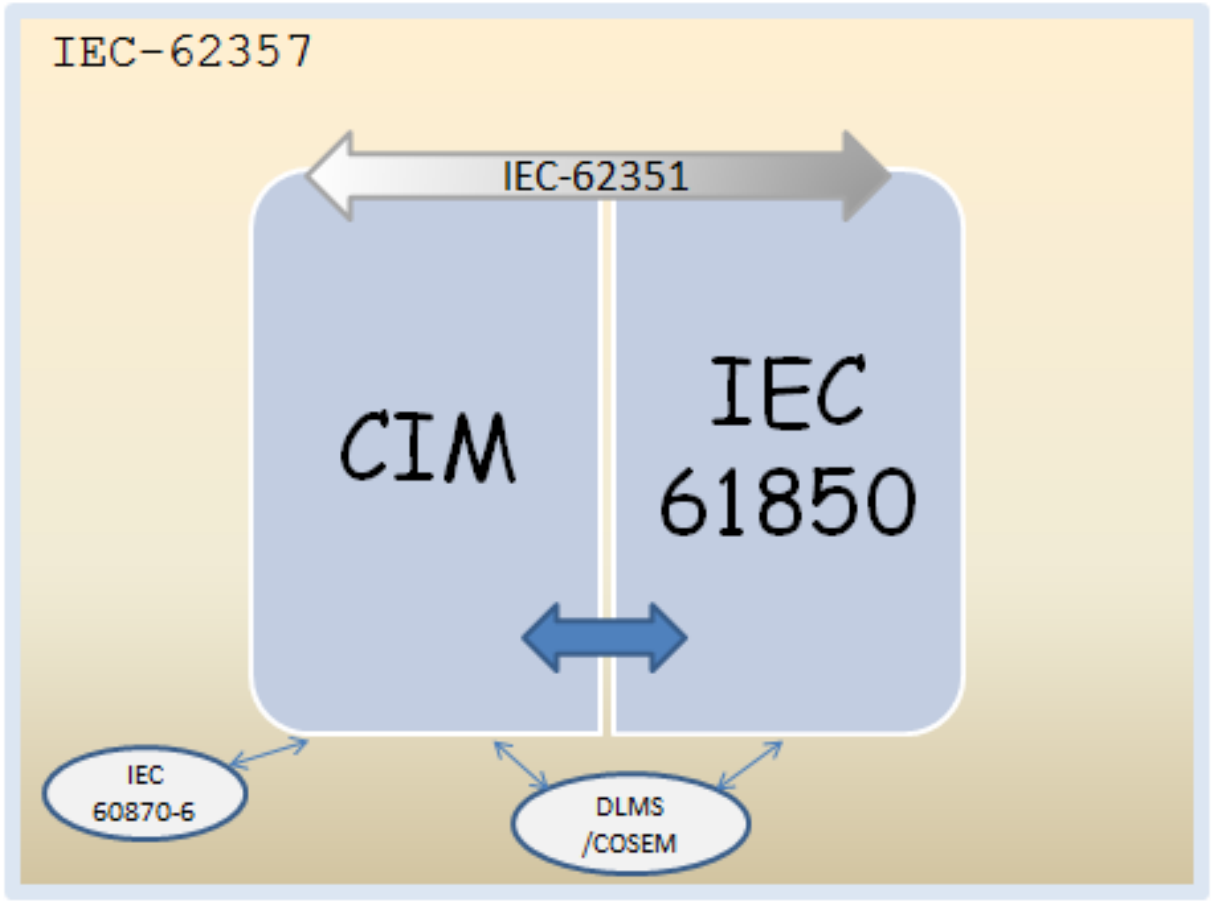
Development process of IEC 62746 standard

- The IEC 62746 standard for interface between Grid and Active Customers will be based on current OpenADR 2 specifications (*)
- Contemporary , the current CIM Model will be extended based on Use Cases associated with the Grid-Active Customer interface
- The final solution will use a new version of OpenADR, based on this extended CIM Model

(*) http://www.openadr.org/

CIM – Future expectation

Main IEC standard for the electrical system management



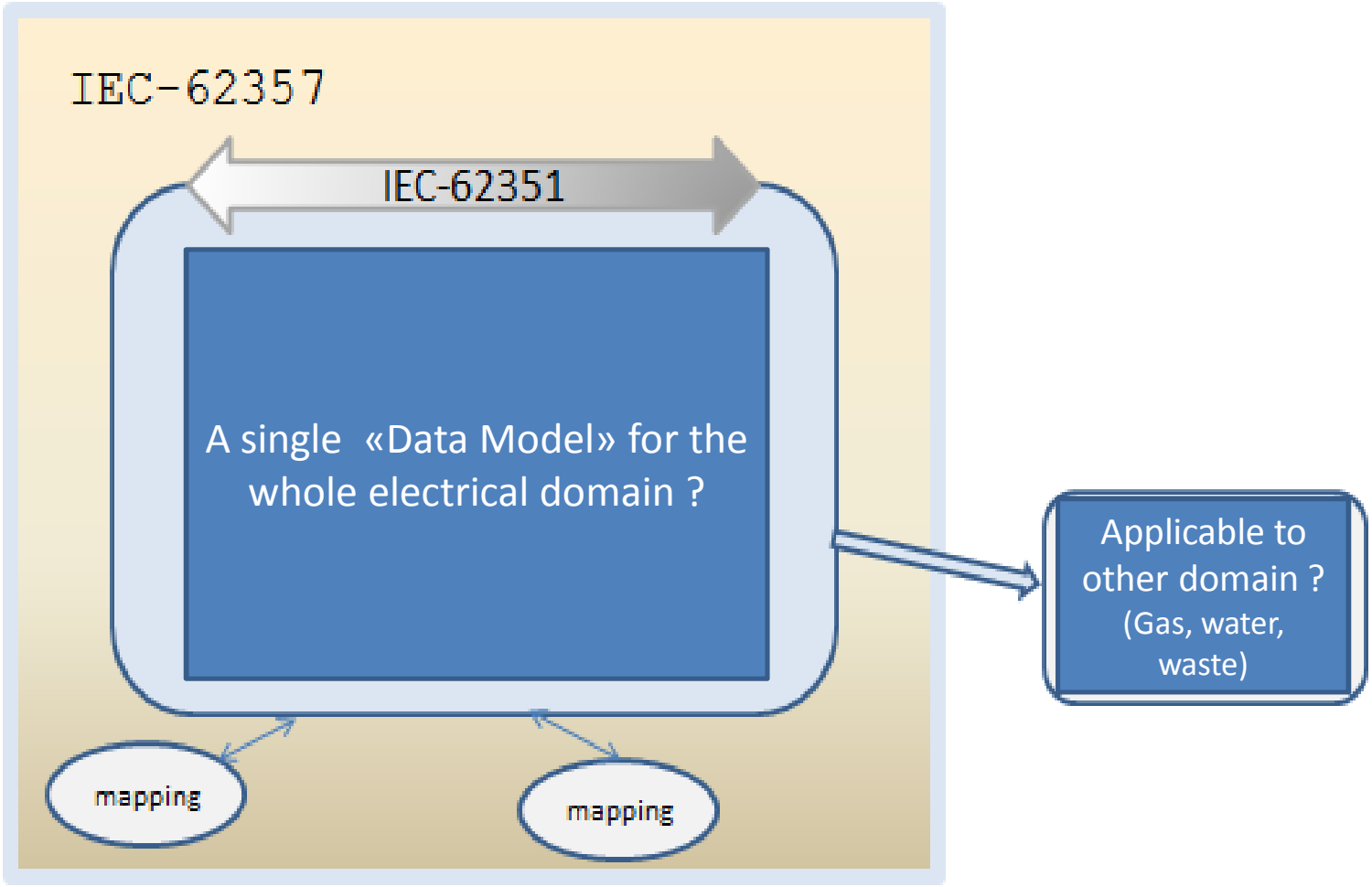
Preparatory activities to extend the «CIM» approach on others context of the management of the electrical system

- Harmonization between CIM and IEC 61850
(TC57 - WG19)

- Harmonization between CIM e DLMS/COSEM
(IEC/TS 62056-6-9)

- Representation of IEC 61850 in UML
(TC57-WG10, WG17,WG18 – TC88 JWG25)

Prospective of definition of a single Data Model for the whole electrical domain



Conclusions

- The development of the Smart Grid needs the integration of many heterogeneous systems
- This process will be based on the “interoperability” concept
- The interoperability, both a semantic level and syntactic level, will be facilitated by the use of “Data Models” (Ontologies)
- “CIM” is currently used in many electrical business context.
  It represents the most mature Ontology for the electrical domain
- CIM should be considered for any new ICT solution for the management of the electrical domain

For more info on this topics, please refers to: http://www.rse-web.it/documenti/documento/315346

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