SMART GRID SCENARIO

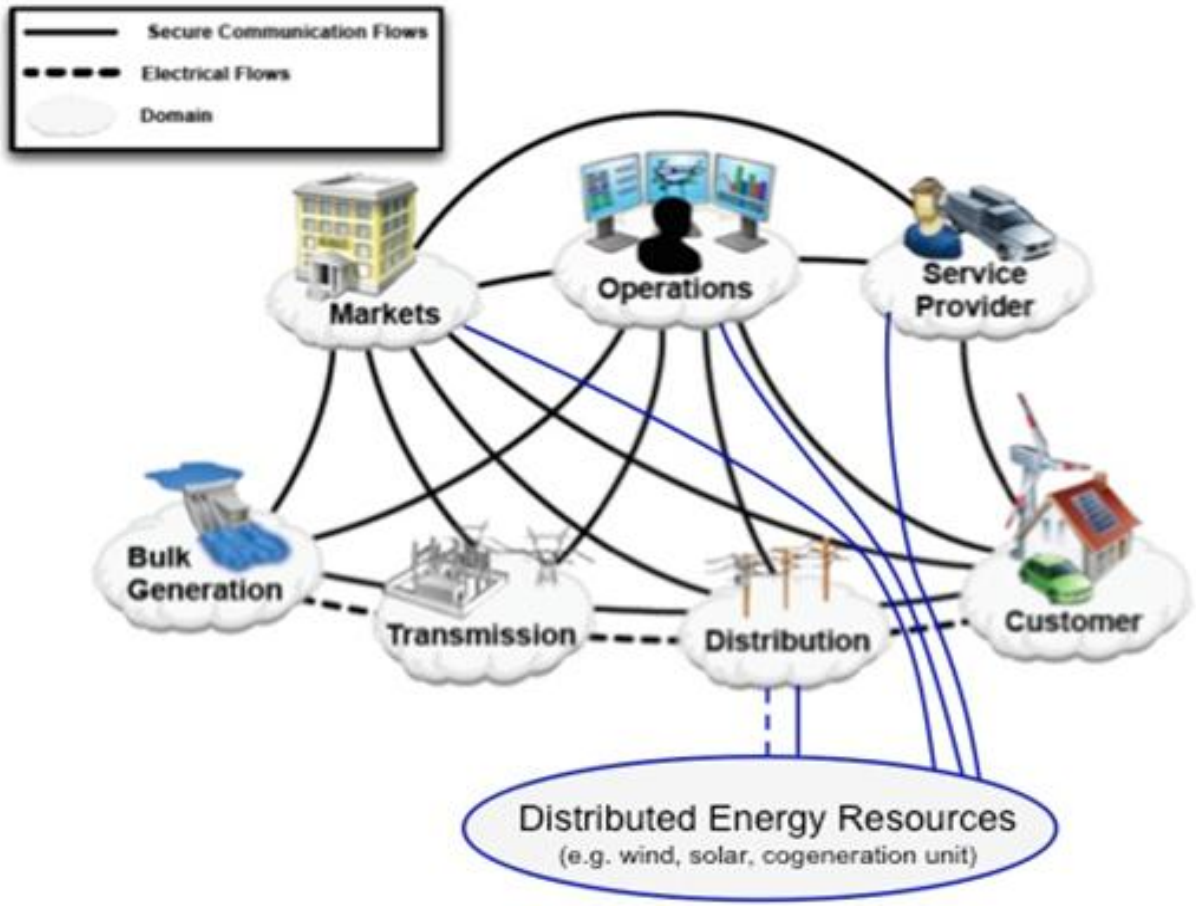
Marina Egea,
Atos

What is Smart Grid

- is an electricity network that can integrate in a cost-efficient manner the behaviour and actions of all users connected to it - generators, consumers and those that do both
- to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety

[Expert Group 1 of the EU Commission Task Force for Smart Grids, CENELEC (European Committee for Electronical Standardization)]

EU extension to the NIST conceptual model for Smart Grid



Smart Grid domains

- covers the complete electrical energy conversion chain ranging from
  - Bulk generation: generation of electrical energy in bulk quantities e.g. by fossil, nuclear and hydro power plants, off-shore wind farms, large scale photovoltaic (PV) power
  - Transmission: the infrastructure and organization which transports electricity over long distances
  - Distribution: the infrastructure and organization which distributes electricity to customers
  - DER (distributed electrical resources), applying small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW). DER can be directly controlled by DSO (distribution system operator)
  - Customer (industry, commercial, home): both - end users of electricity, also producers of electricity (e.g. PV, EV storage, electric transportation)

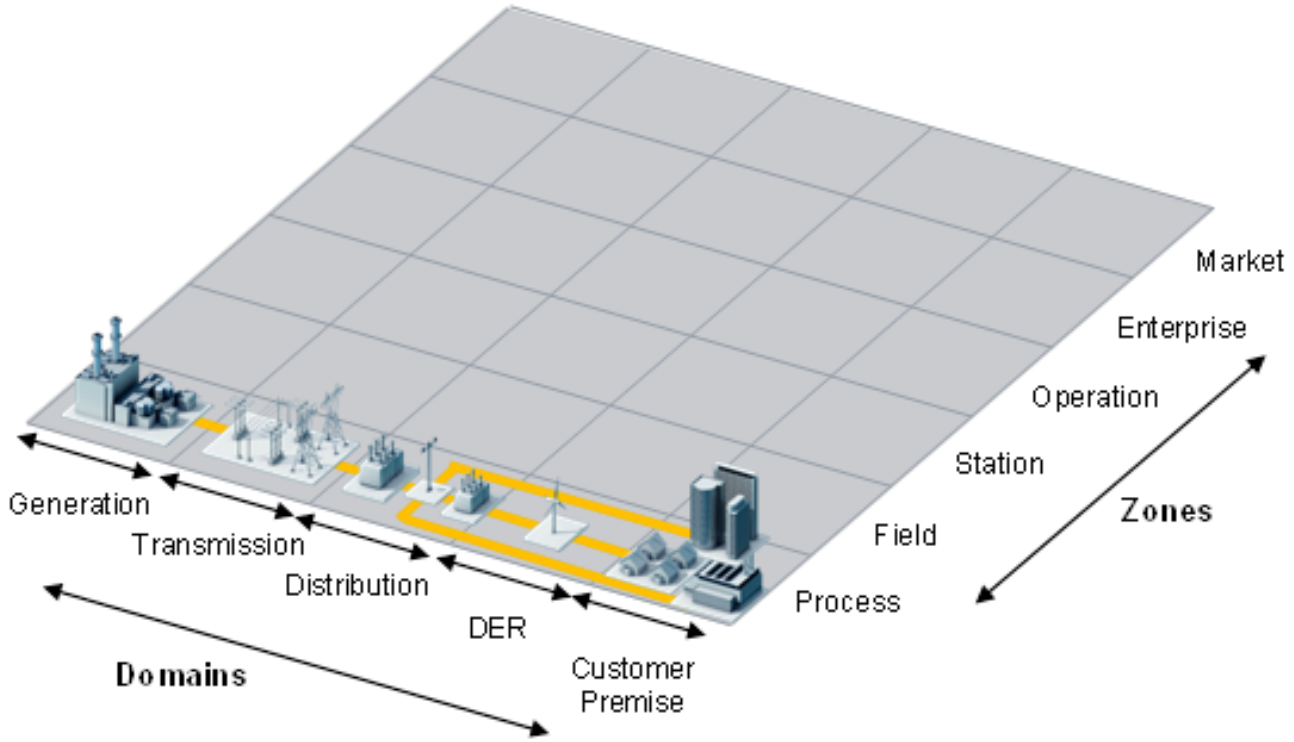
Smart Grid zones

- represent hierarchical levels of power system management [IEC62357-2011] ranging from
  - Process: includes the primary equipment of the power system, e.g. generators, transformers, circuit breakers, overhead lines, cables and electrical loads.
  - Field: includes equipment to protect, control and monitor the process of the power system, e.g. protection relays, bay controller, any kind of sensor and actor devices.
  - Station: represents the aggregation level for fields, e.g. data concentration.

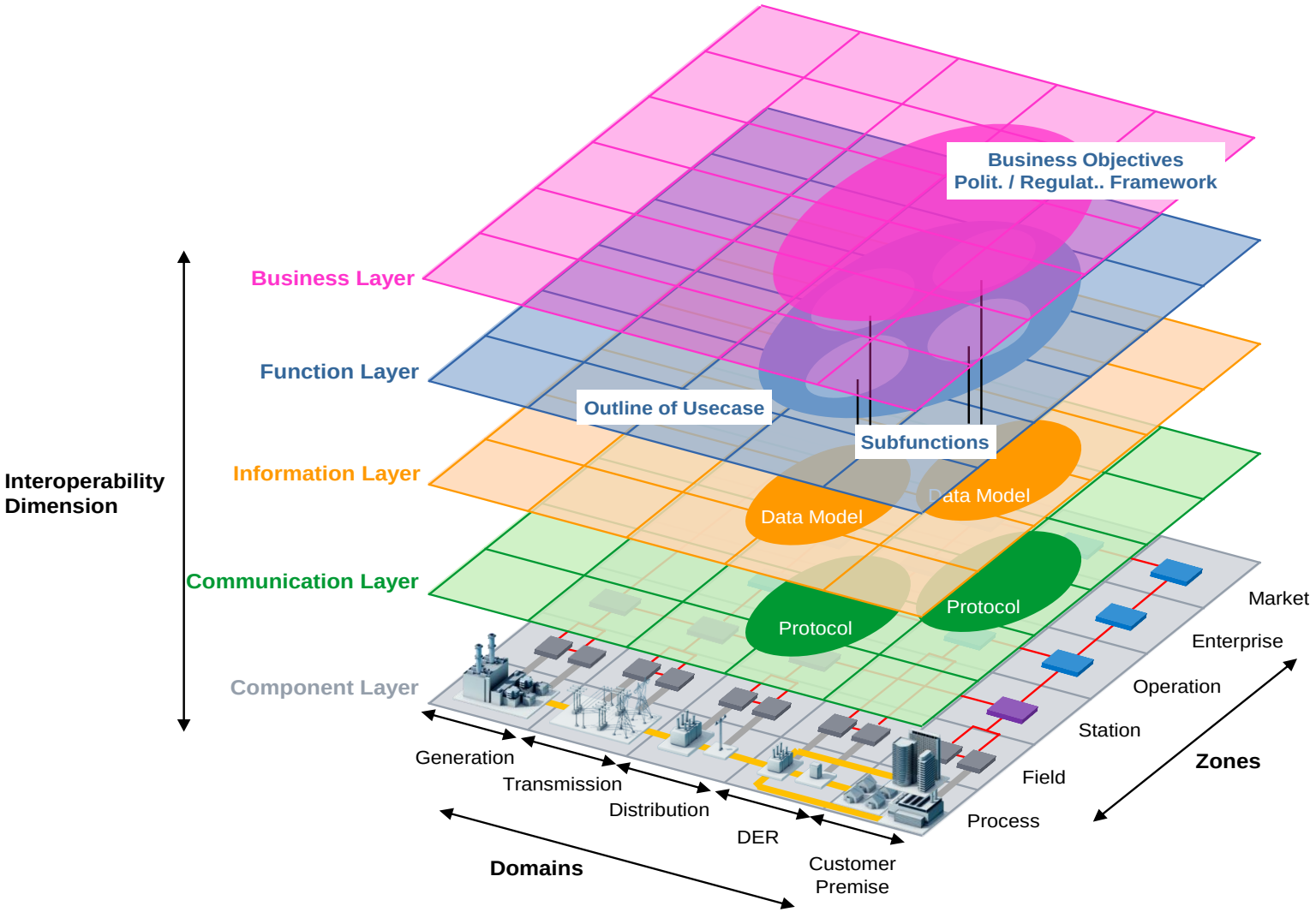
Smart Grid zones

- Operation: hosts power system control operation in the respective domain, e.g. distribution management systems (DMS), energy management systems (EMS) in generation and transmission systems, microgrid management systems, virtual power plant management systems (aggregating several DER), electric vehicle (EV) fleet charging management systems.
- Enterprise: includes processes and infrastructures for enterprises (utilities, service providers, energy traders …), e.g. asset management, staff training, customer relation management, billing and procurement.
- Market: reflects the market operations possible along the energy conversion chain, e.g. energy trading, mass market, retail market, ...

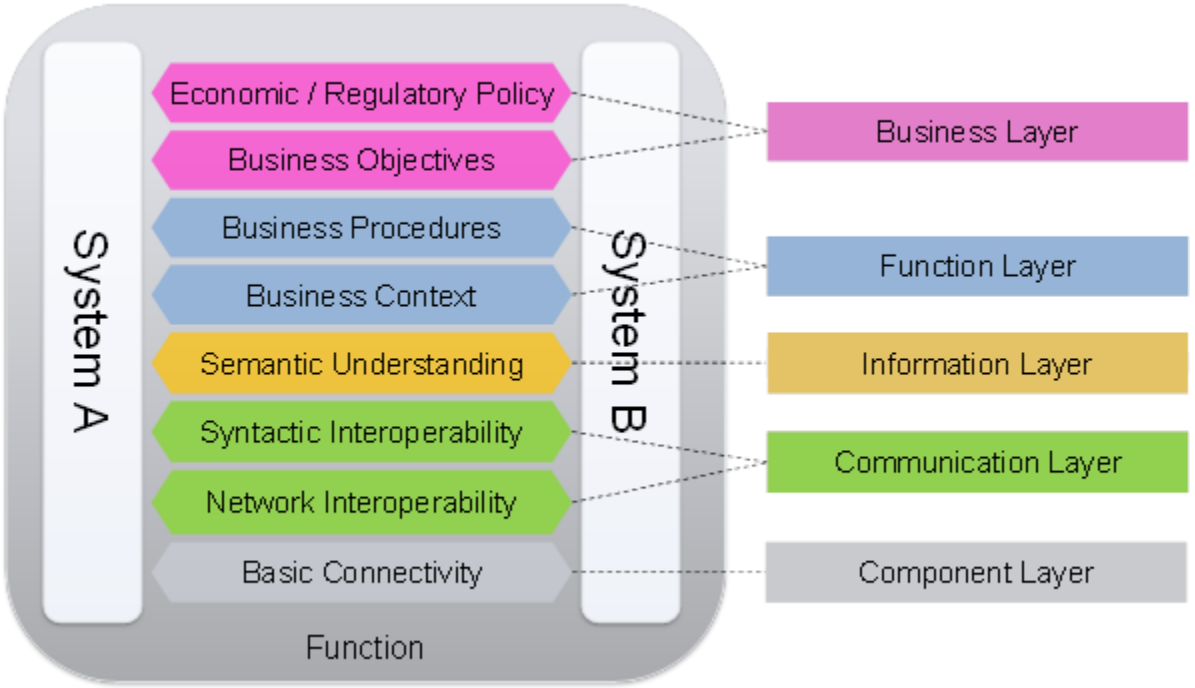
Smart Grid plane



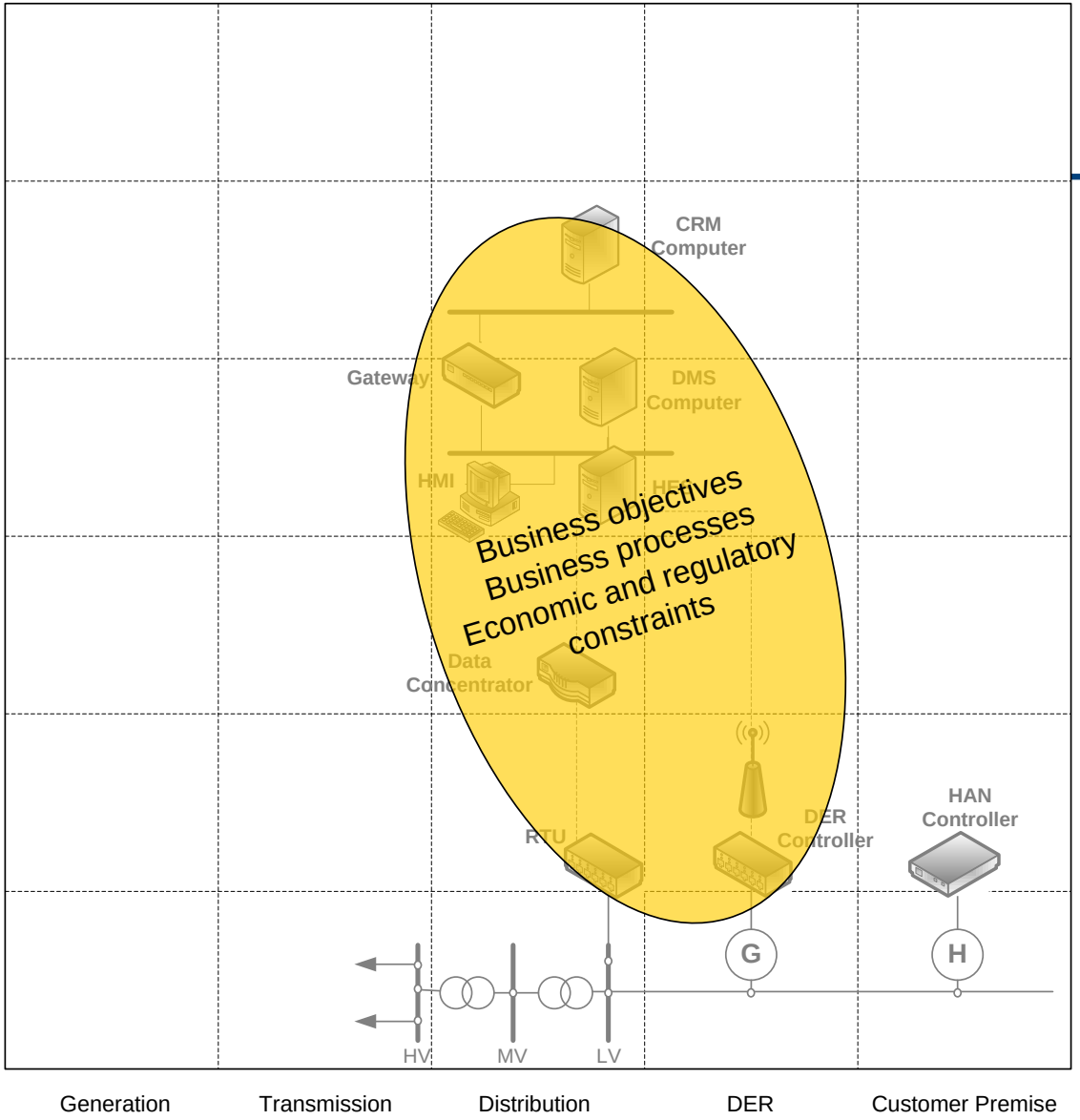
Smart Grid Reference Architecture

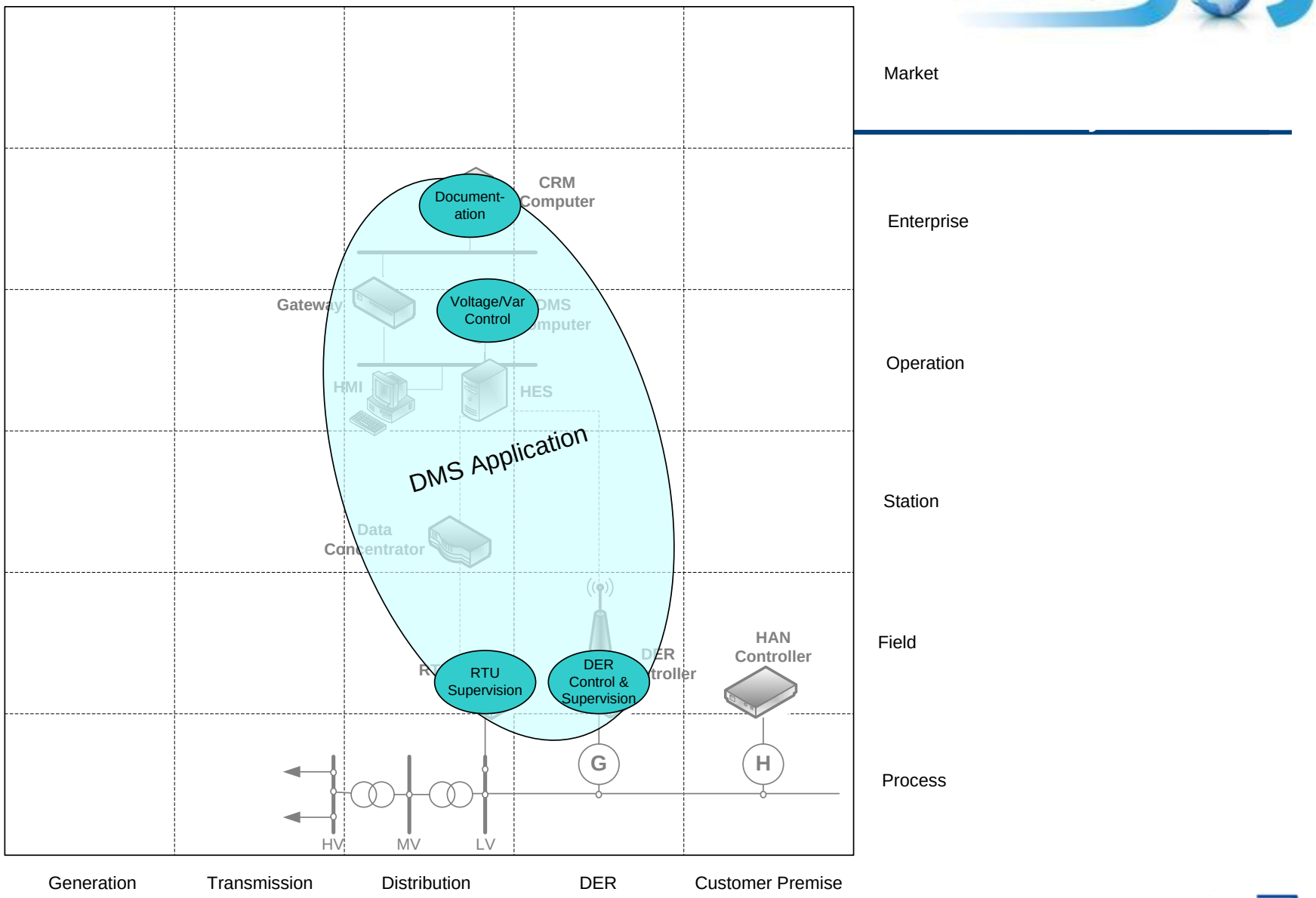


Interoperability Layers

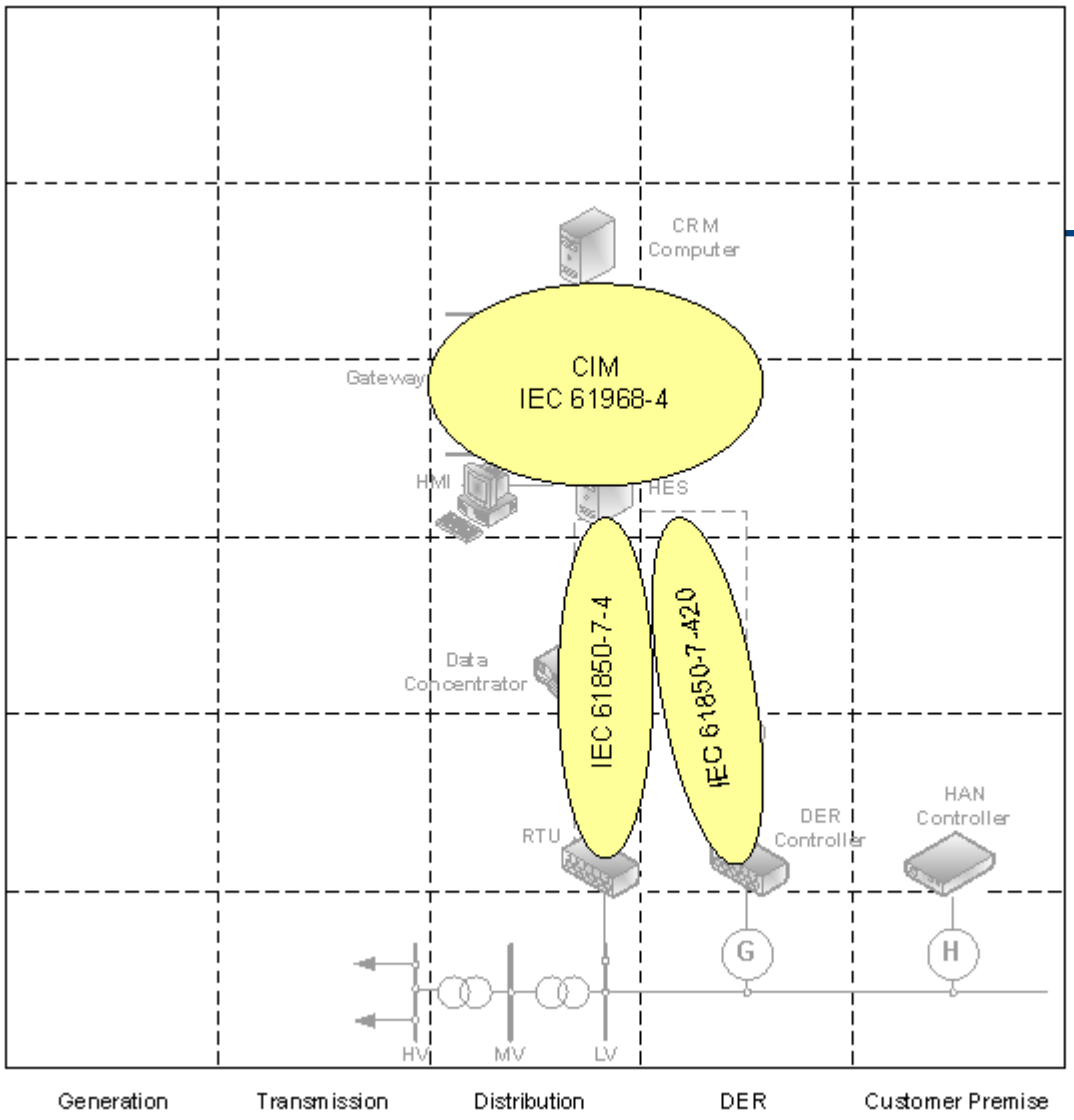


Business Layer

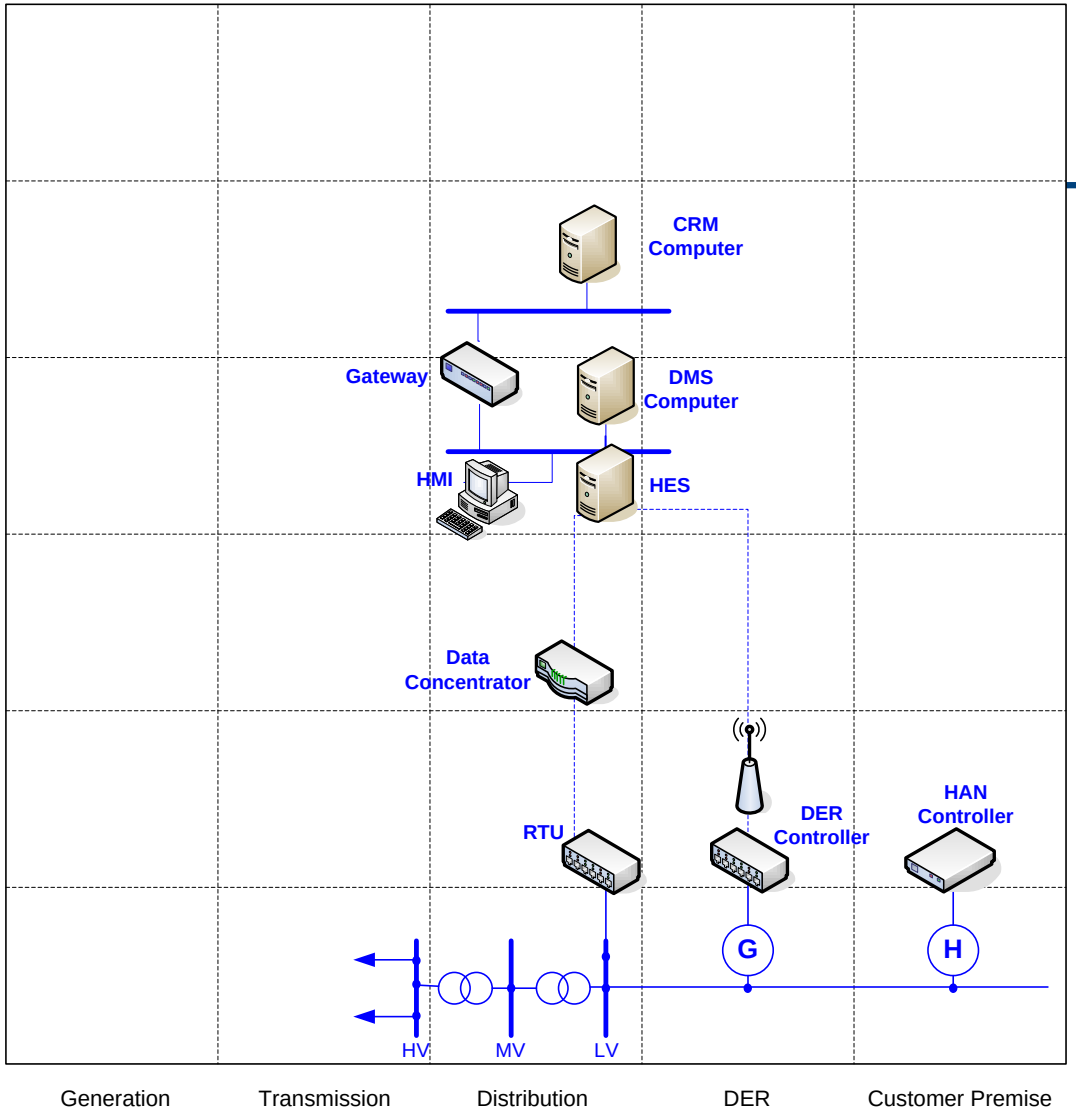



Market
Enterprise
Operation
Station
Field
Process
Document-ation
CRM Computer
Gateway
Voltage/Var Control
HMI
HES
DMS Application
Data Concentrator
RTU Supervision
DER Control & Supervision
HAN Controller
G
H
HV
MV
LV
Generation
Transmission
Distribution
DER
Customer Premise

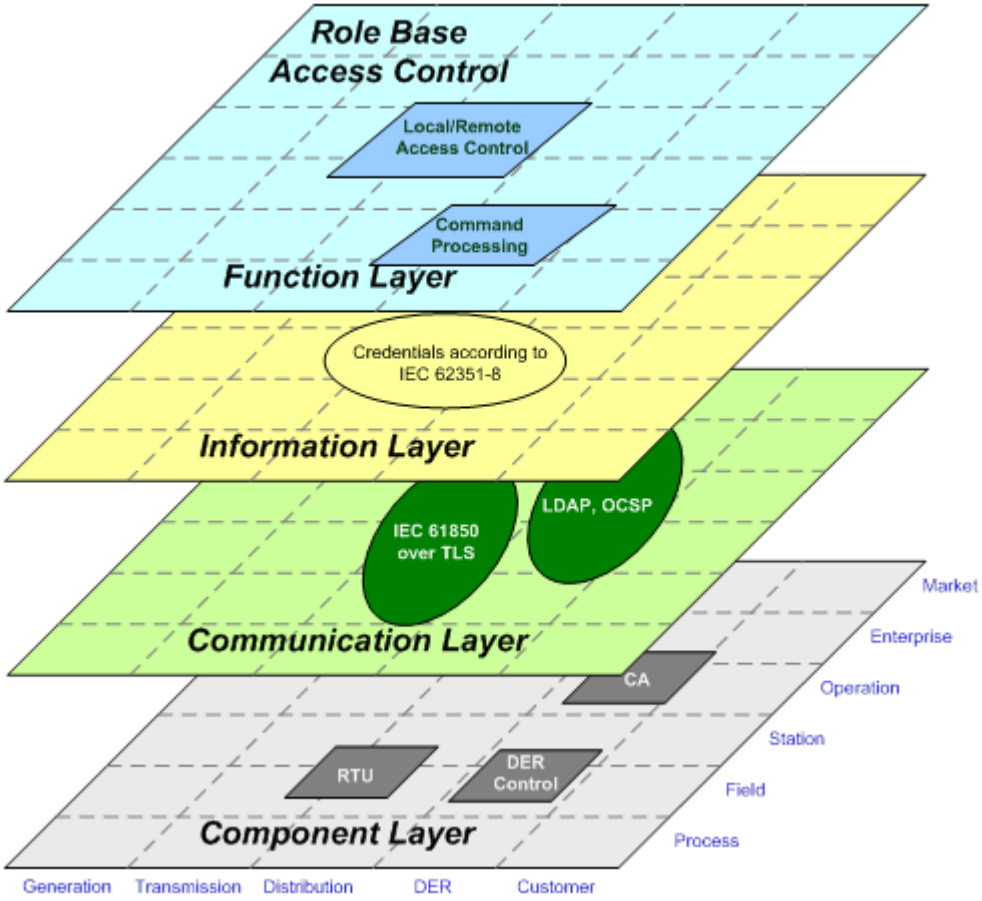
Information Layer



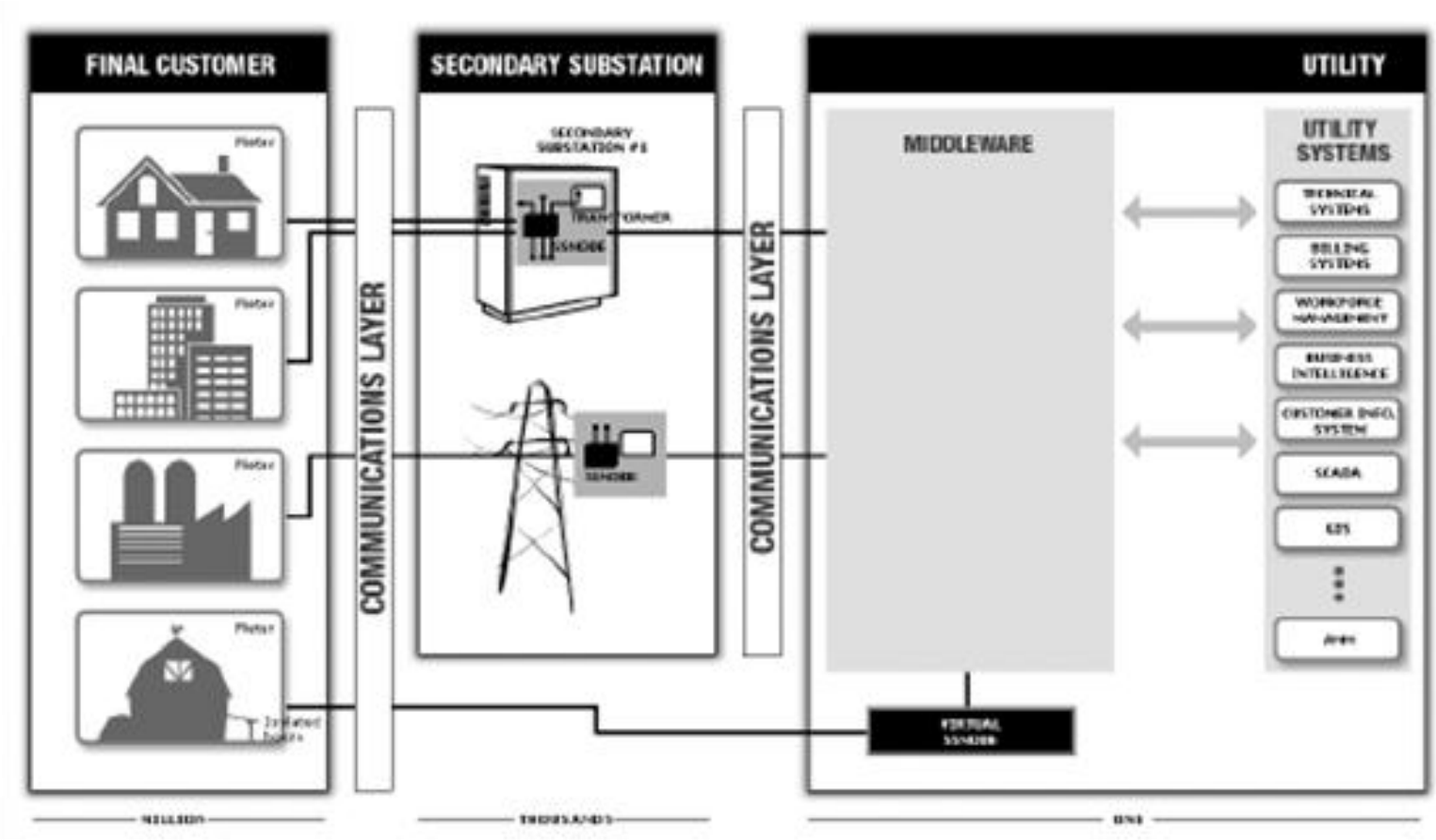
Component Layer



Regarding Security: RBAC influences all layers



Use case: Overall scenario– OpenNode



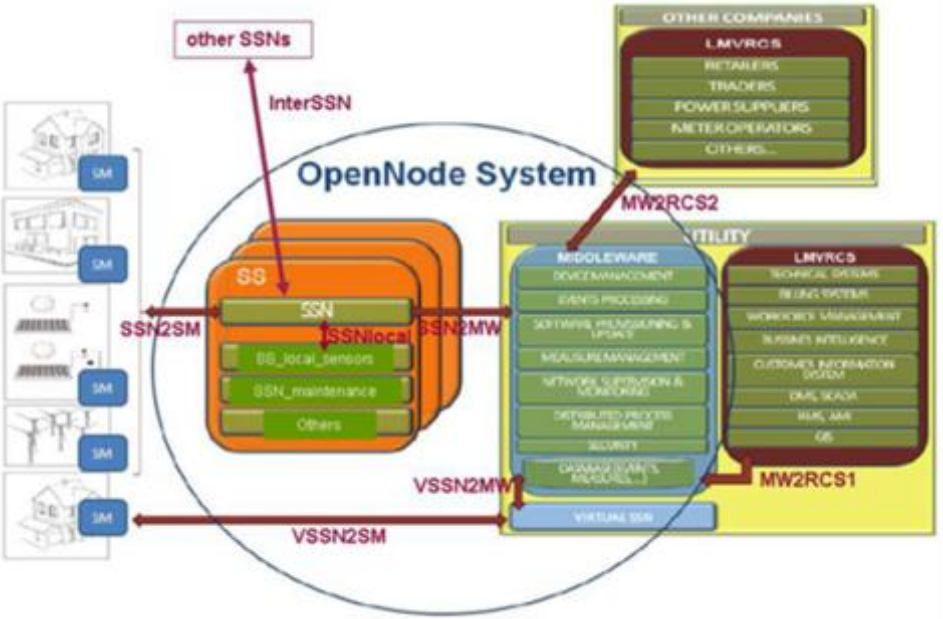
Use case: Overall scenario– OpenNode

- how all the information from / to the SMs (Smart Meters) is communicated and how is responsible for giving or receiving the information.
- new functionalities that allow a more efficient and automatic way of operating.
- Many of these functions related with info gathered in the SS (Secondary Substations).

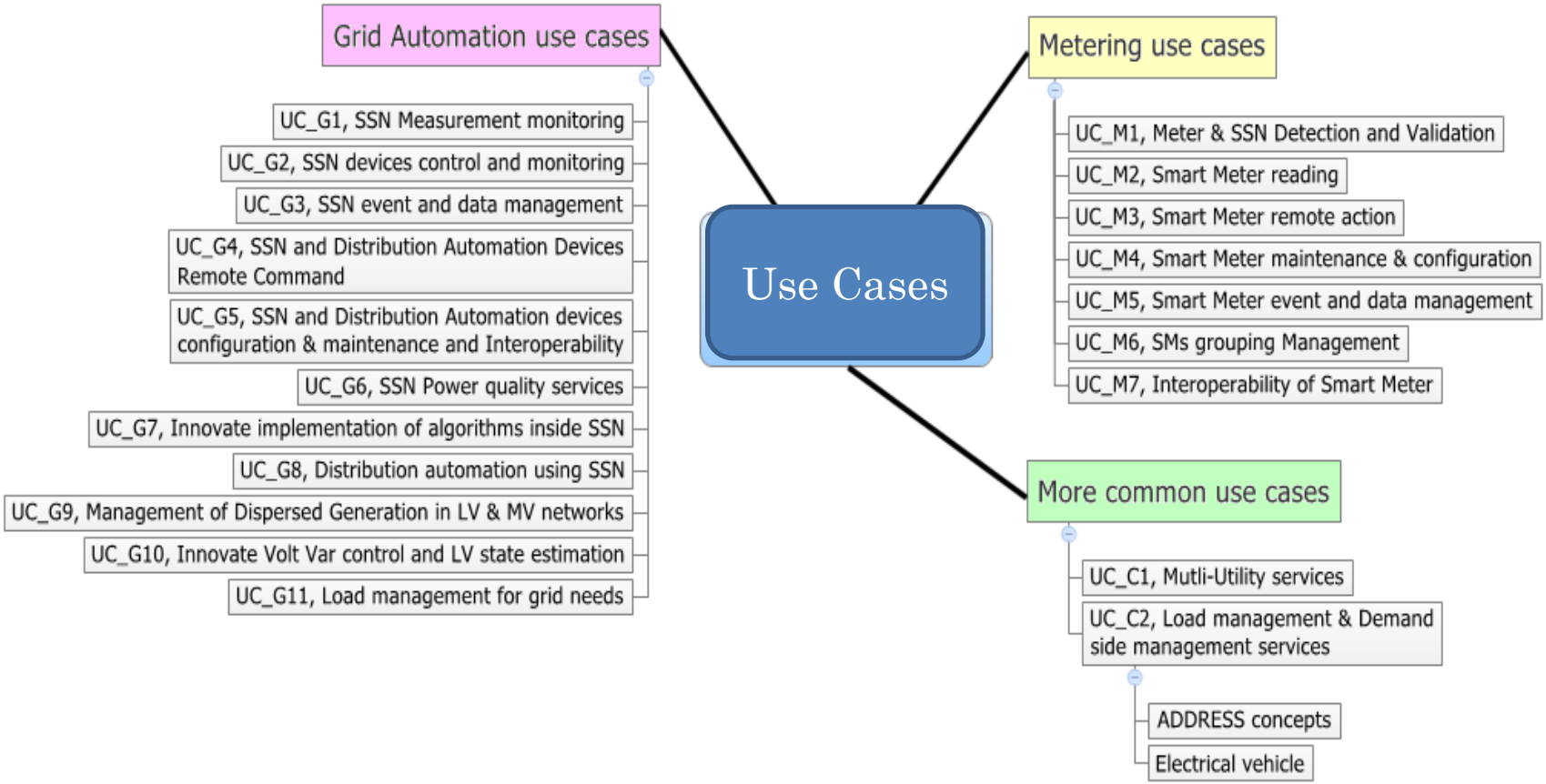
- LMVRCS (Low / Medium Voltage Related Company System, which may refer to a SCADA system
  - DMS (Distribution Management System),
  - Control System, RMS (Remote Metering System),
  - Maintenance System,
  - GIS (Graphical Interface Sys-tem),
  - Legacy Systems,

Open Node idea

- with no active participation of the customer, the Open Node System shall improve their power quality and availability
- From the stakeholder´s point of view, it shall bring advantages
  - the utilities shall benefit from a controllable LV/MV grid which status is known at any time, information enough to handle a loaded inventory database of devices; the meter operator shall benefit from a remote management of the meters…



Open Node Use Cases



Actors

- **SSN:** intelligent unit to be installed in every SS (secondary substation)
- **Middleware (MW):** central software in charge of receiving the information from the SSNs, storing it, and providing it to the LMVRCS. For some local functions, they shall be able
  - evaluate the information,
  - to take decisions,
  - to store relevant information and to provide it to the LMVRCS
- **Smart meter:** an electrical meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes.
  - enable two-way communication between the meter and the central system.
  - Unlike home energy monitors, smart meters can gather data for remote reporting.

Use Case: Electricity SMs reading (For billing)

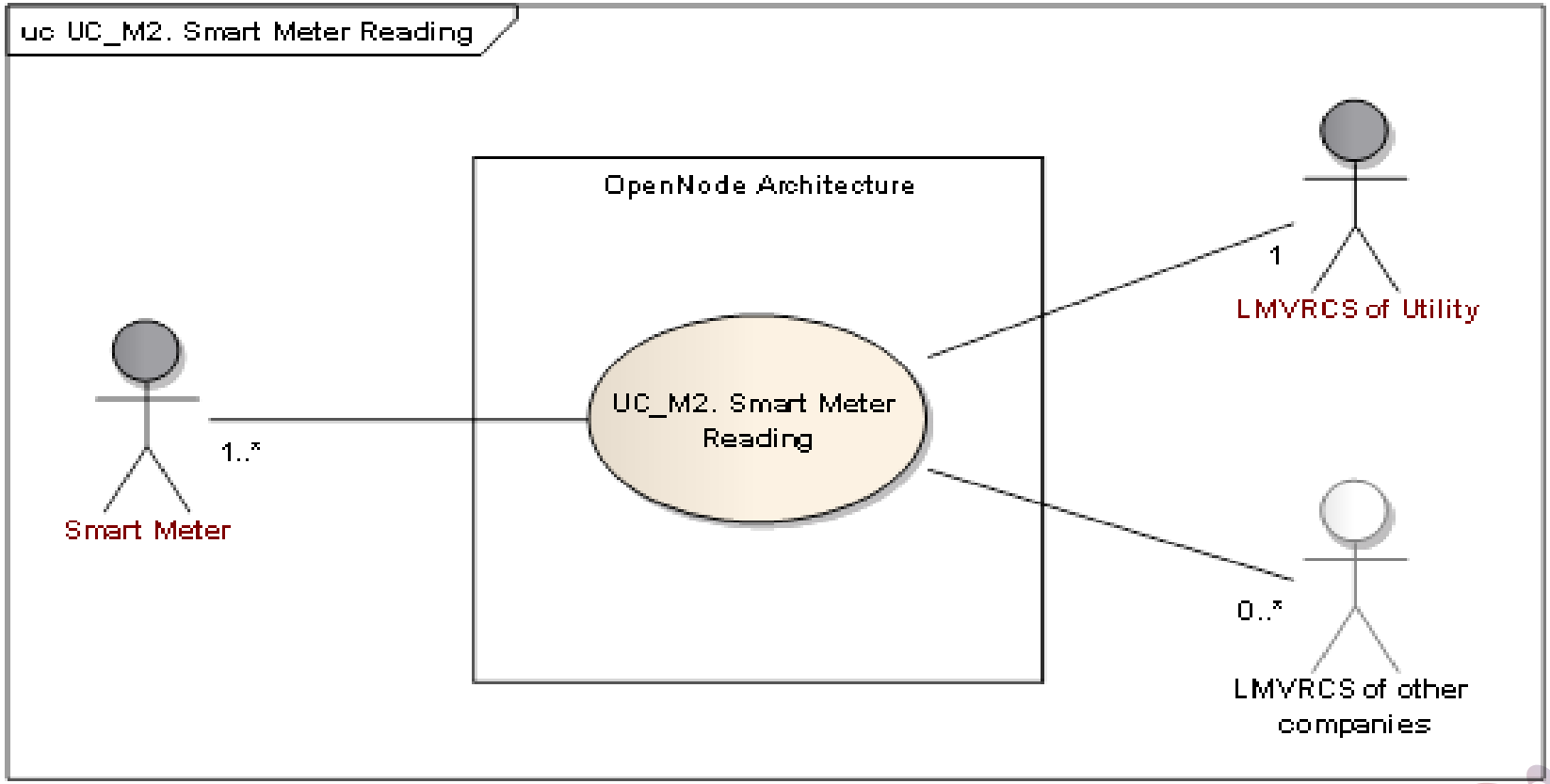
- describes the SM data acquisition process for billing purposes.
- The SSN will periodically gather metering information for billing from the SMs connected to it according to a configurable time period.
  - It will store this information in its internal DB
  - it will periodically report this information up to the MW on a configurable time period
  - The information will be stored in the Middleware DB
  - this information will be periodically sent by the MW the corresponding LMVRCSs that need the information.
- in some countries, a direct SM information access is necessary for some LMVRCSs.

Use Case: Electricity SMs reading (For billing purposes)

The data acquisition process is:

1. A LMVRCS might ask the MW for the current metering readings in one or several SMs.
2. The MW will request this information to the SSN.
3. The SSN will request the information to the corresponding SM.
4. The SM will provide the metering information with time stamp and an identification name to the SSN, the SSN to the MW, and the MW to the LMVRCS

Use Case: On demand Electricity SMs reading



Use Case: On demand Electricity SMs reading

- The SSN and the MW store the last SM readings requested in their internal database,
  - If information is requested and the communication with the SM fails, the last readings stored with time-stamps will be available
  - If SM readings cannot be accessed the SSN will send the last information stored in its database.
  - The MW will send its last if the communication with the SSN is unavailable.
- Among the possible metering readings that may be requested are:
  - Power and energy values in all four quadrants,
  - Voltage, Current power factor
  - Energy load profiles, Quality parameters (meter status, connection status, error reports, etc.)

Use case: Alarm and Event Management

- process of checking constantly for errors in each SM and in those SS meters and devices associated to each SSN, and the process of managing the event reports created in those different devices.
  1. The SSN must check periodically the correct functioning of each connected device (SMs, local SS meters, relays and sensors) and its own status. If any problem is detected, the SSN must report it to the MW immediately.
  2. The SSN will give the correct priority to both the alarm and event reports in order to avoid possible negative delays.
  3. The MW shall check this information, store it in its DB, and act accordingly: it may take a corrective decision by itself or it may decide to warn the corresponding LMVRCSs.
- The MW shall request the last alarm and event reports stored in any SM or SSN. It shall have all those reports available for sending if they are requested by any authorized LMVRCS.

Use case: Alarm and Event Management

Each LMVRCS shall decide the priority of the events and if they may be considered alarms. Some possible events / alarms to be reported could be:

- Critical malfunctions triggered by the SMs or the SSN
- Critical deviations of the clock,
- Indication of modification of critical parameters in the meter;
- Software and firmware version.
- Changes from Presence to absence of voltage.
- Unauthorized access attempts/ any possible violation attempt.
- Power control as threshold programming.
- Switch-off of the disconnection element
- Outage / planned interruptions.

High level Security Requirements

Availability: The system, all of its components (SMs, SSNs, Local Devices, MW), and its information assets must be sufficiently available (SLA) to authorized parties. The system and its components must function properly, reliably and robustly.

Confidentiality, non-repudiation:

- confidentiality and integrity of the transmitted information must be ensured against outsiders and secure authentication of the communication parties.
- Facts/data may not be falsely repudiated after having been issued / generated by the involved parties or components.

Authentication and authorization:

- Reliable authentication and authorization of communication partners (including administrators interacting with the system

High level security Requirements

Reliability, integrity, secrecy

- The system shall provide reliable time stamps and update the internal clocks of the various components regularly.
- It shall protect its security functions against malfunctions and tampering. E.g. SMs, Devices and SSNs shall only collect and buffer minimal data, and safely delete any information that is no longer required.

Privacy

- billing relevant consumption data must remain access restricted for administrators, unless actually indispensable for the required task. Legally adequate privacy protection of personal identifiable information.

Smart Meter data structure (simplified, partial)

Some of the typical records stored in the internal DB of the SM are:

- Current date, time in sync with a clock in terms of year, month, day, hour, minute
- Time and date of last sync
- Initial date, time when SM started to measure (initial value)
- Status of meter reading: Import, import and export, export, disabled
- Power limit, Power tariff, Customer name
- User id number, Type of contract
- Flag of disconnectivity
- Start, end date.
- Time bands per day: weekly tariff (Monday to Friday), Saturday and Sunday tariff
- Power available to be supplied in each tariff (there can be 3 different types of tariffs: flat, daylight, night).
- Voltage interruptions during the last billing period (period of time expressed in intervals of 15 minutes).

Smart Meter data structure (simplified, partial)

- Save threshold for voltage interruption and cumulative totalizer of voltage interruptions.
- Counter of voltage interruptions in seconds during the current and the previous billing period.
- Same parameters to store meter power fails.
- Duration of time intervals in which meter has to calculate the average of voltage values to evaluate the voltage variations in day period.
- Time period in days in which voltage variations have to be observed.
- Upper/Lower threshold for voltage.
- Instantaneous value of voltage measured.
- Minimum/max voltage in current and previous period.
- Number of failed authentication attempts.

- Alarms: meter without correct date and time info, alarm on communication if it is unable to connect, clock is not in sync, etc.

Access to SM information

- Users can access information from billing company by a web service
  - the information contained in their profile (RW),
  - billing information (RO): tariff information, power consumption, power excess (for which a special tariff is exceed) when the user crossed the upper voltage limit.
  - The bill will depend on the type of contract agreed: day, night or flat rate.
- Billing company can update tariffs and type of contract.
- DMS can update voltage and power limits and access any incidency that has to do with voltage interruption and failed authentication attemps.
- SSN may access different SM to check that the obtained information is correct by checking confirmation by redundancy checks from different SMs.

Access to SM information

- SCADA system
  - can configure parameters to update, read and store meter power fails, duration of time intervals in which meter has to calculate the average of voltage values to evaluate the voltage variations in day period, time period in days in which voltage variations have to be observed,
  - Upper/Lower threshold for voltage, Lower threshold for voltage.

- Alarms are managed by the SCADA system although DMS has also access to the information.
- The SCADA system should report to billing company any problem that may affect customer(s)' bills.