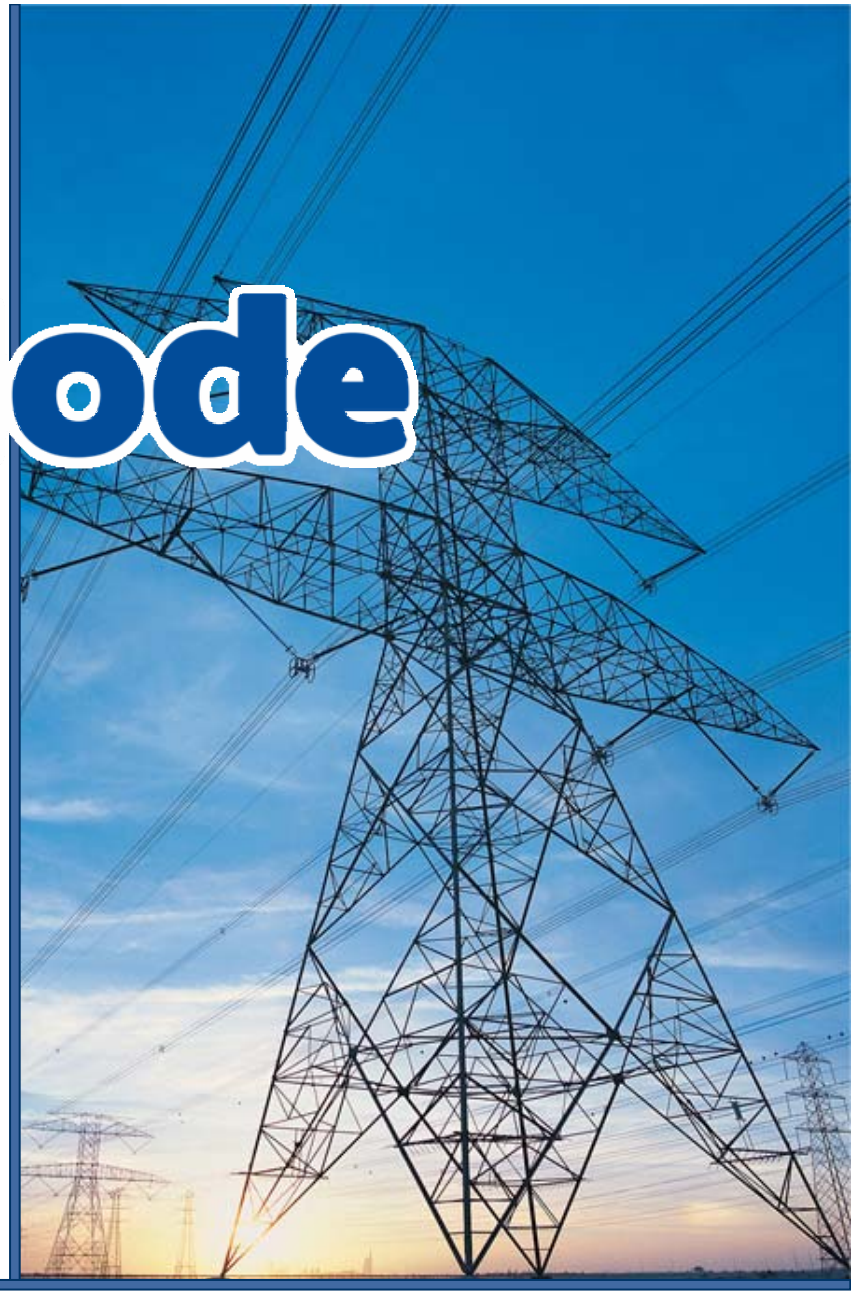
OpenNode

Open Architecture for Secondary Nodes of the Electricity SmartGrid



Darmstadt Symposion

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Atos Origin
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SEVENTH FRAMEWORK PROGRAMME

European Commission
Information Society and Media

Table of content

Motivation

- European energy industry is facing three major challenges at the same time:
  - increased integration of fluctuating power resources
  - increased “smartness” especially in the electrical distribution grid
  - stakeholder diversification: grid operation, power provisioning, metering services, …
- These challenges have to be considered jointly when developing components for the upcoming Smartgrid

- This is the case of smart Secondary Substation Nodes (SSN) as substantial component to monitor and control the distribution grid status

Project objectives

- OpenNode project focuses on the electrical distribution grid operation and explore answers on the challenges introduced:
  a. How can we improve the distribution grid monitoring to cope with volatile states in the grid?
  b. How can we control the distribution grid devices to ensure proper operation of the distribution network in both normal and excess situations?
  c. How can we integrate the “smart” substation automation devices (e.g. IEDs and attached sensors and actors) to increase the efficiency of the distribution grid?
  d. How can we interoperate with the different roles e.g. operation of the smart meters, power and grid operation?

Project objectives

- OpenNode focuses on research and development of:
  1. an open secondary substation node which is seen as an essential control component of the future smart distribution grid
  2. a Middleware to couple the SSN operation with the Utilities systems for grid and utility operation and
  3. a modular communication architecture based on standardised communication protocols to grant the flexibility required by the stakeholder diversification and to cope with massively distributed embedded systems in the distribution grid

OpenNode approach

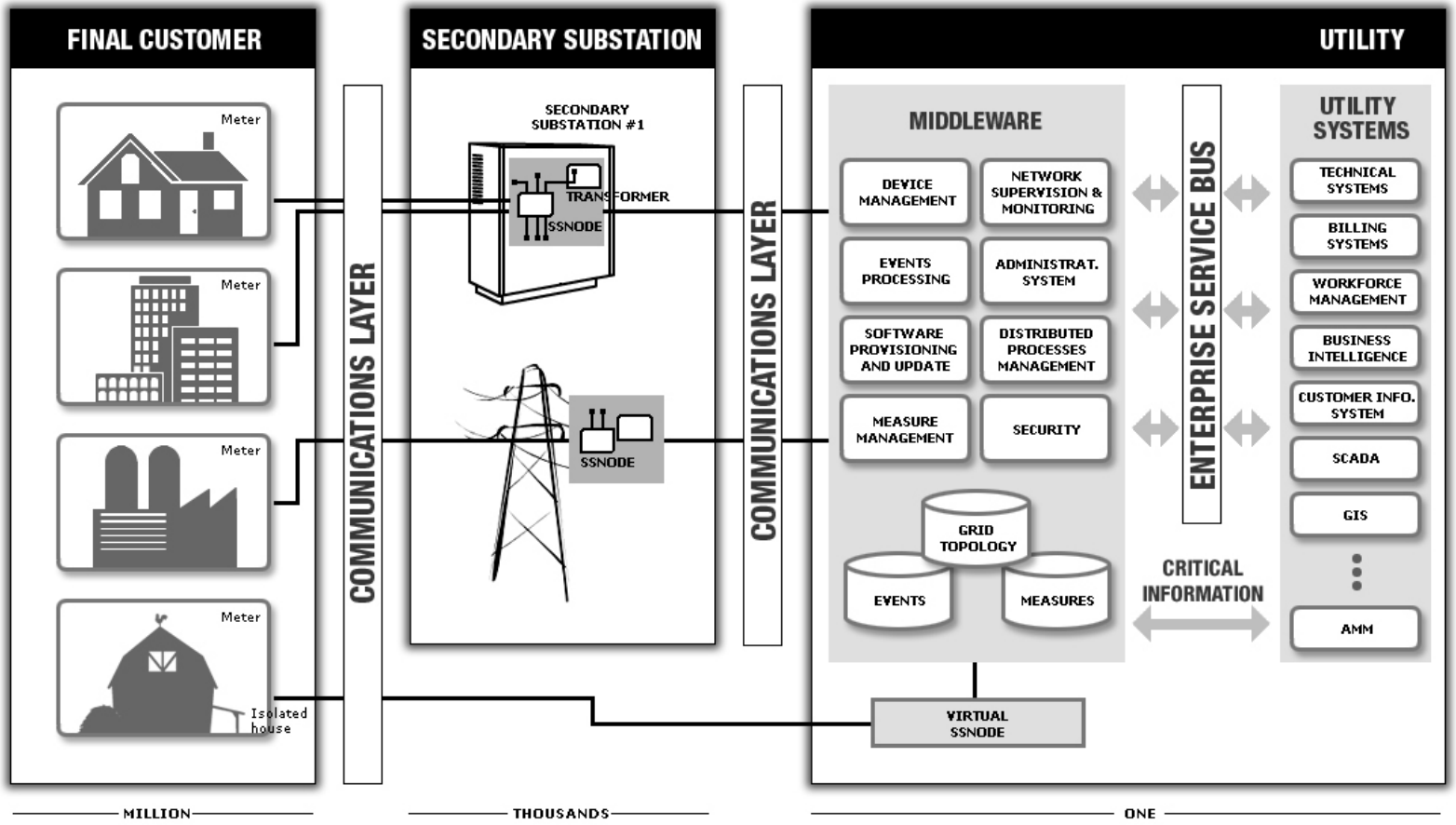
- To accomplish the objectives, a consortium has been established composed by 9 partners from 6 different European Countries, including European ICT leaders, European Consulting standard leaders and some of the greatest Utilities in Europe

- OpenNode takes into account the results of two other projects from the European Community 7th Framework Program:
  - OPEN meter (www.openmeter.com), which main objective is to specify a set of open and public standards for AMI
  - ADDRESS (www.addressfp7.org), whose target is to enable active demand as the active participation of small and commercial consumers in power system markets

Consortium

1. Atos Origin Sociedad Anónima Española (ATOS ORIGIN) - Spain
2. IBERDROLA DISTRIBUCION ELECTRICA, S.A. (IBD) - Spain
3. EDP Inovação SA (EDP) - Portugal
4. ELECTRICITE DE FRANCE S.A. (EDF) - France
5. SIEMENS AG (SIEMENS) - Germany
6. Nucleo de Comunicaciones y Control, SL (NUCLEO) - Spain
7. KEMA NEDERLAND BV (KEMA) - Netherlands
8. Instituto de Tecnología Eléctrica (ITE) - Spain
9. SIEMENS AG Österreich (SIA) - Austria

Overall System Architecture



All components in the overall OpenNode Architecture

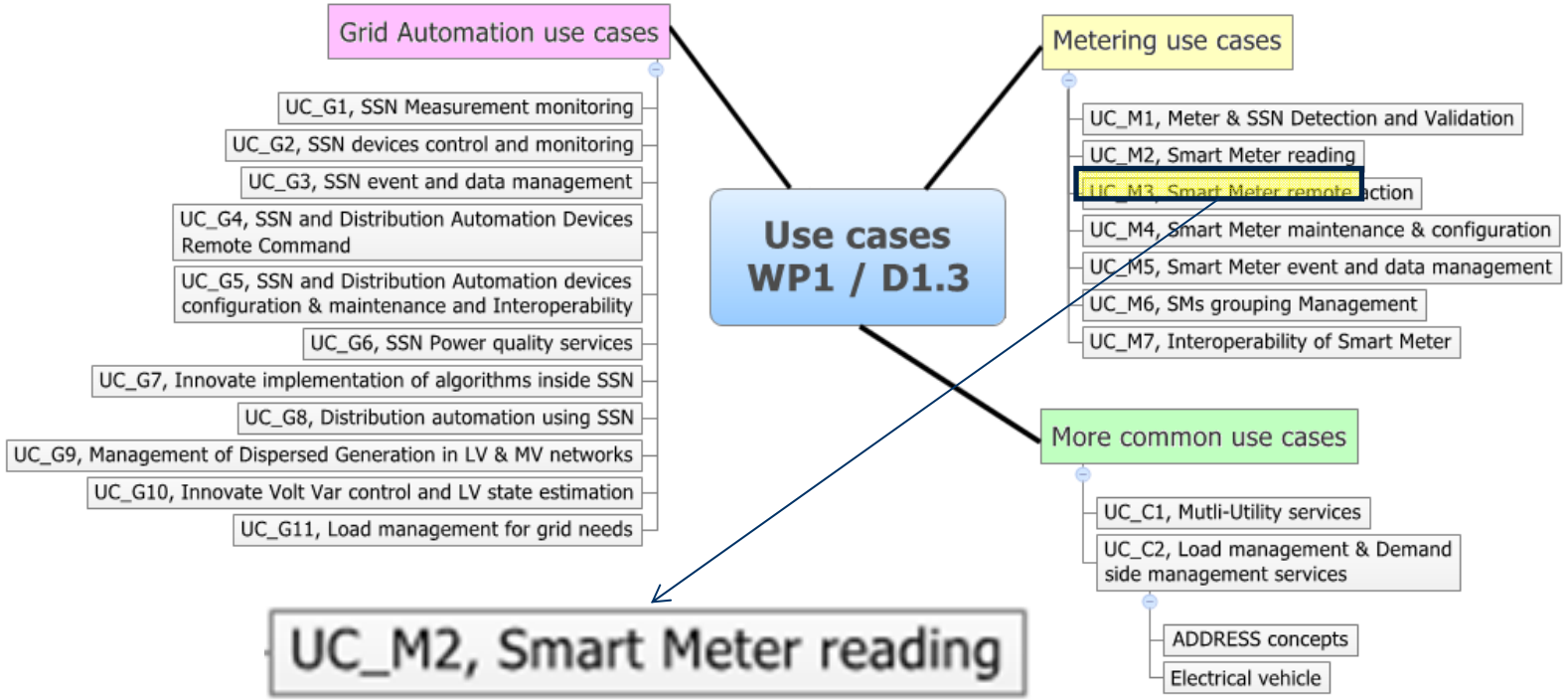
- General Overview of the OpenNode System
  - Architecture
  - Internal components
  - External boundary components
- Classification of functional requirements according to:
  - Functional importance/Priority (Basic, Optional, Advanced).
  - Time performance criticality (QoS1, QoS2, QoS3)
  - Type of function (metering, supervision or control related)
  - Allocation (distributed, local)
- General functionality expected for the main components of the System:
  - SSN
  - Middleware
  - Communications

Functional requirements

- BA01 - Meter Detection and Validation
- BA02 - Remote Tariff Programming
- BA03 - Electricity SMs reading (On deman
- BA04 - Electricity SMs Reading (For billing
- BA05 - Measurement and Metering Reading
- BA06 - SMs Remote Disconnection and Re
- BA07 - SMs Power Control (Demand Side M
- BA08 - SMs and SSNs Clock Synchronizat
- BA09 - SMs and SSNs Remote Firmware U
- BA10 - Alarms and Events Management
- BA11 - Illegal Manipulation Detection
- BA12 - Information Interruptions
- BA13 - SSN Automatic Detection
- BA14 - Load Profile Management
- BA15 - SS Quality Measurements and Met
- BA16 - Planned Load Shedding initiated by
- BA17 - Remote Switching of MV Lines
- BA18 - SS Monitoring Management
- BA19 - Fault Detection Management (throu
- BA20 - Maintenance Management
- BA21 - Power supply backup
- BA22 - Information Management

Id	BA17
Type of Function	CR/SR
Function / Requirement	BA17 Remote Switching of MV Lines:
Considered in any other European project?	No
Priority	Basic
Critical time classification	**QoS** 2/1
Type of Process	Distributed Process
Topic type	Grid
Demands on SSN	Execution of switching manoeuvres in those SS MV bays equipped with circuit breakers capable of being remotely operated.
Demands on Communications	Allow the flow of information/commands from the LMVRCS down to the SSNs.
Demands on Middleware	To act as a gateway.
Demands on External systems	SS MV bays equipped with circuit breakers capable of being remotely operated. Introduction of the appropriate commands in the Middleware by the LMVRCS.
Brief Explanation	The corresponding LMVRCS shall be able to perform switching operations in the circuit breakers of the SS MV bays through the Middleware and the corresponding SSN (if the cells are provided with automatic circuit breakers) in order to optimize the performance of the grid.

Use Cases

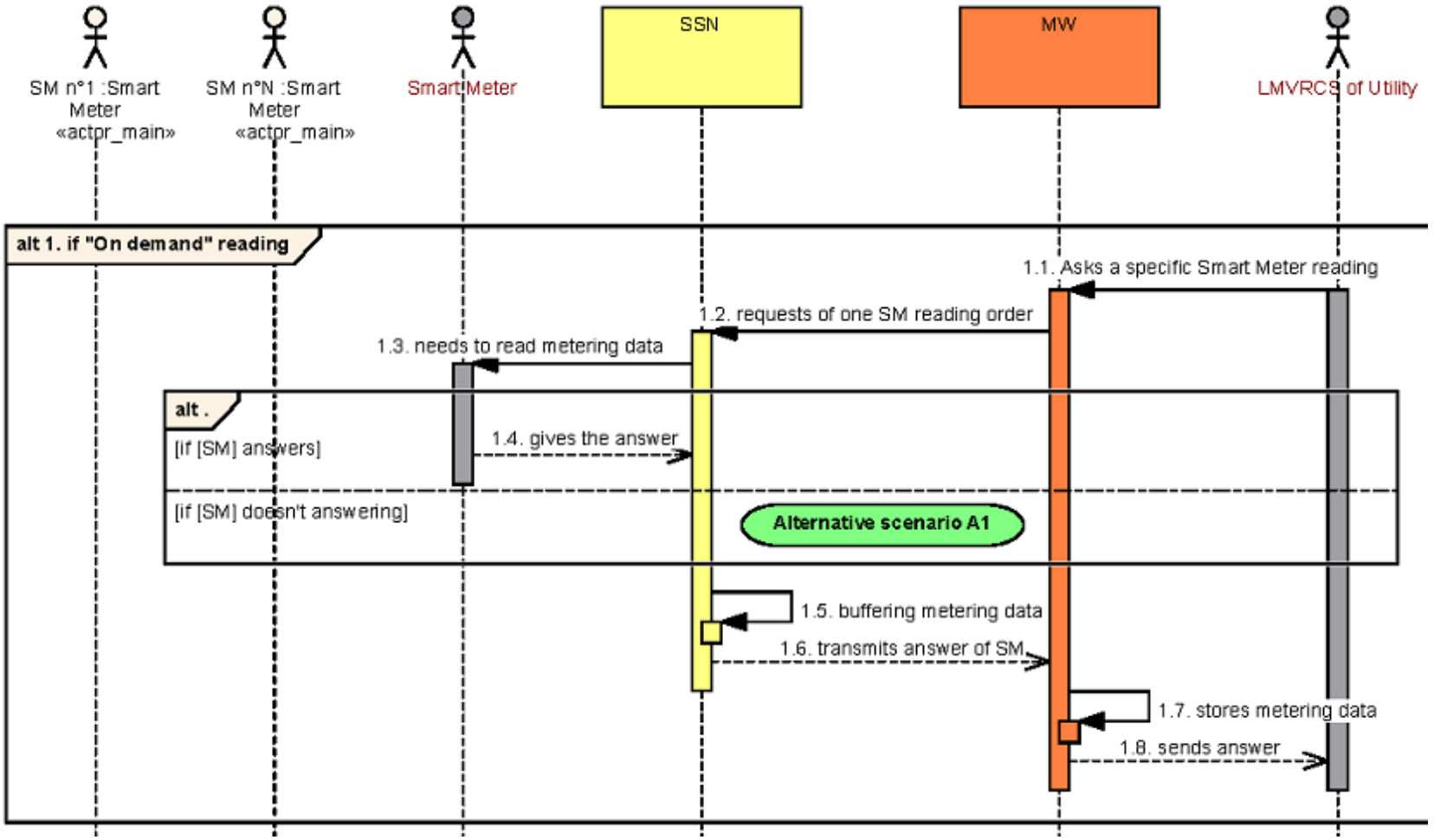


Use Case / Apply with	UC_M1	UC_M2	UC_M3	UC_M4	UC_M5	UC_M6	UC_M7	UC_G1	UC_G2	UC_G3	UC_G4	UC_G5	UC_G6	UC_G7	UC_G8	UC_G9	UC_G10	UC_G11	UC_C1	UC_C2
SSN	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Virtual SSN	✓	✓	✓	✓	✓	✓	✓									≈		✓	✓	✓

Table 2: Use case achieved by SSN and virtual SSN

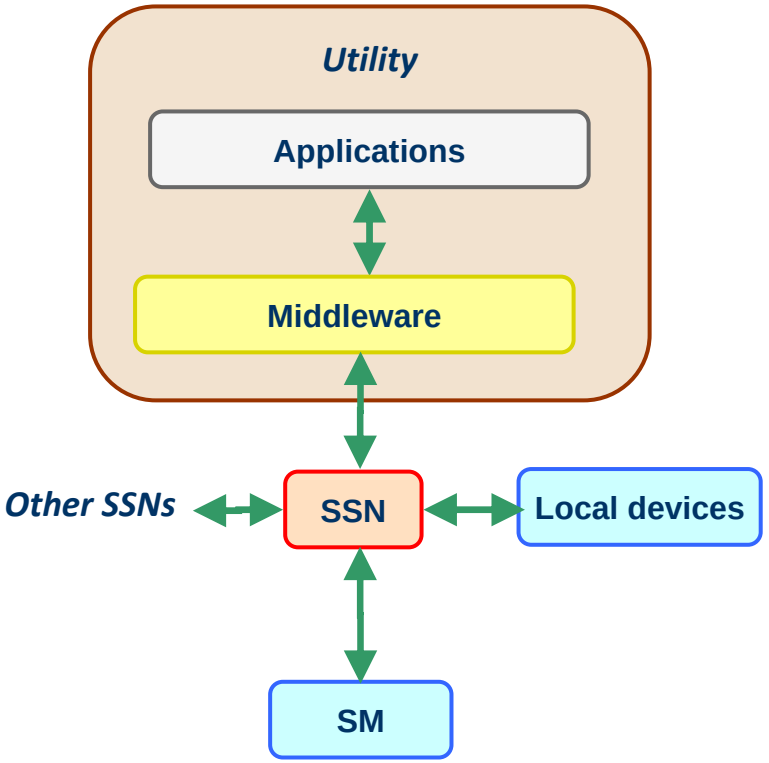
Use Cases

One example



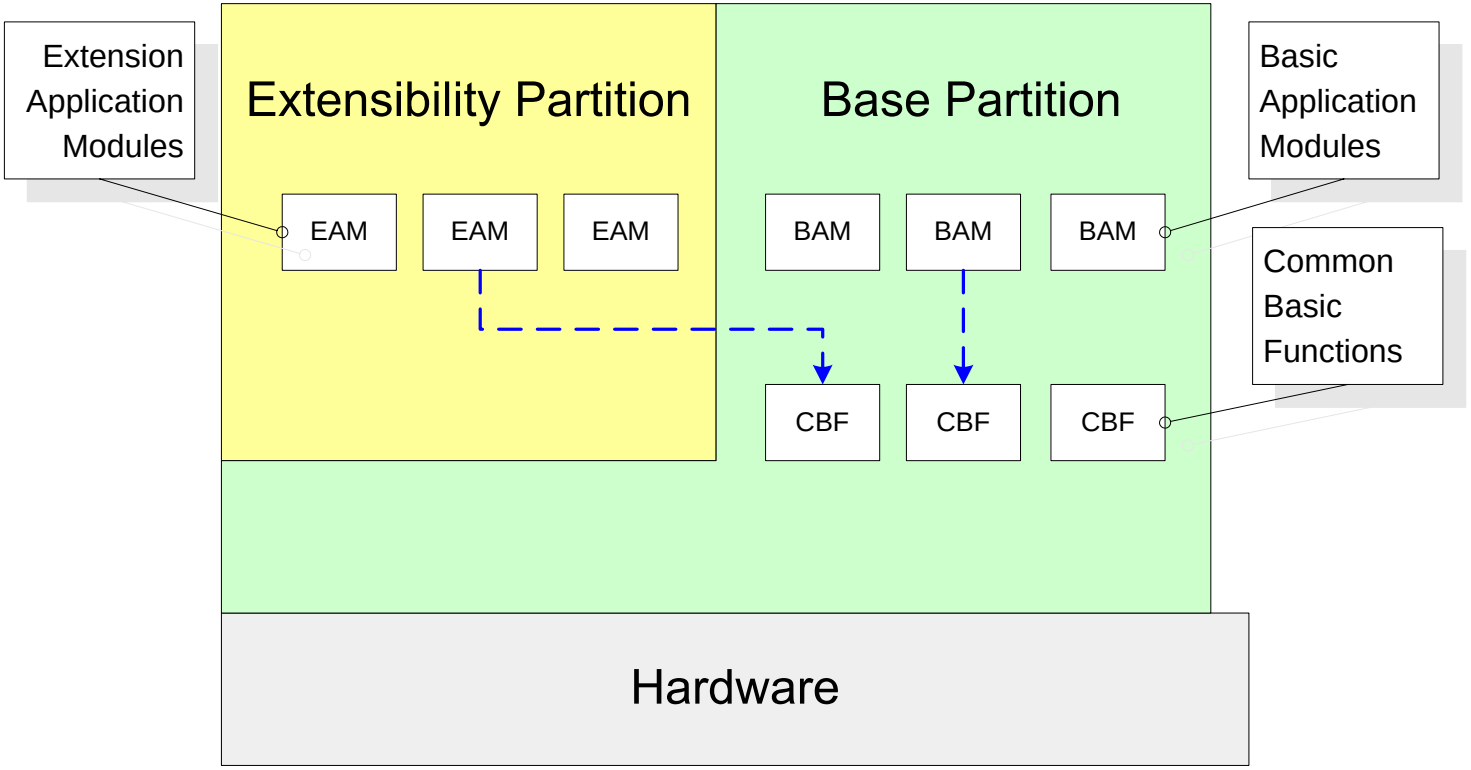
The SSN in the future Smart Grid

- The SSN is the essential component of the future smart distribution grid
- It is the link between the Metering Devices and the control system / the Middleware
- Provides the integration of the metering infrastructure with other activities at the Utilities and third parties
- Performs functions of Grid Automation, can be remotely controlled and is even able to take decisions by itself
- The limit of the SSN smartness is how much are we willing to pay for it

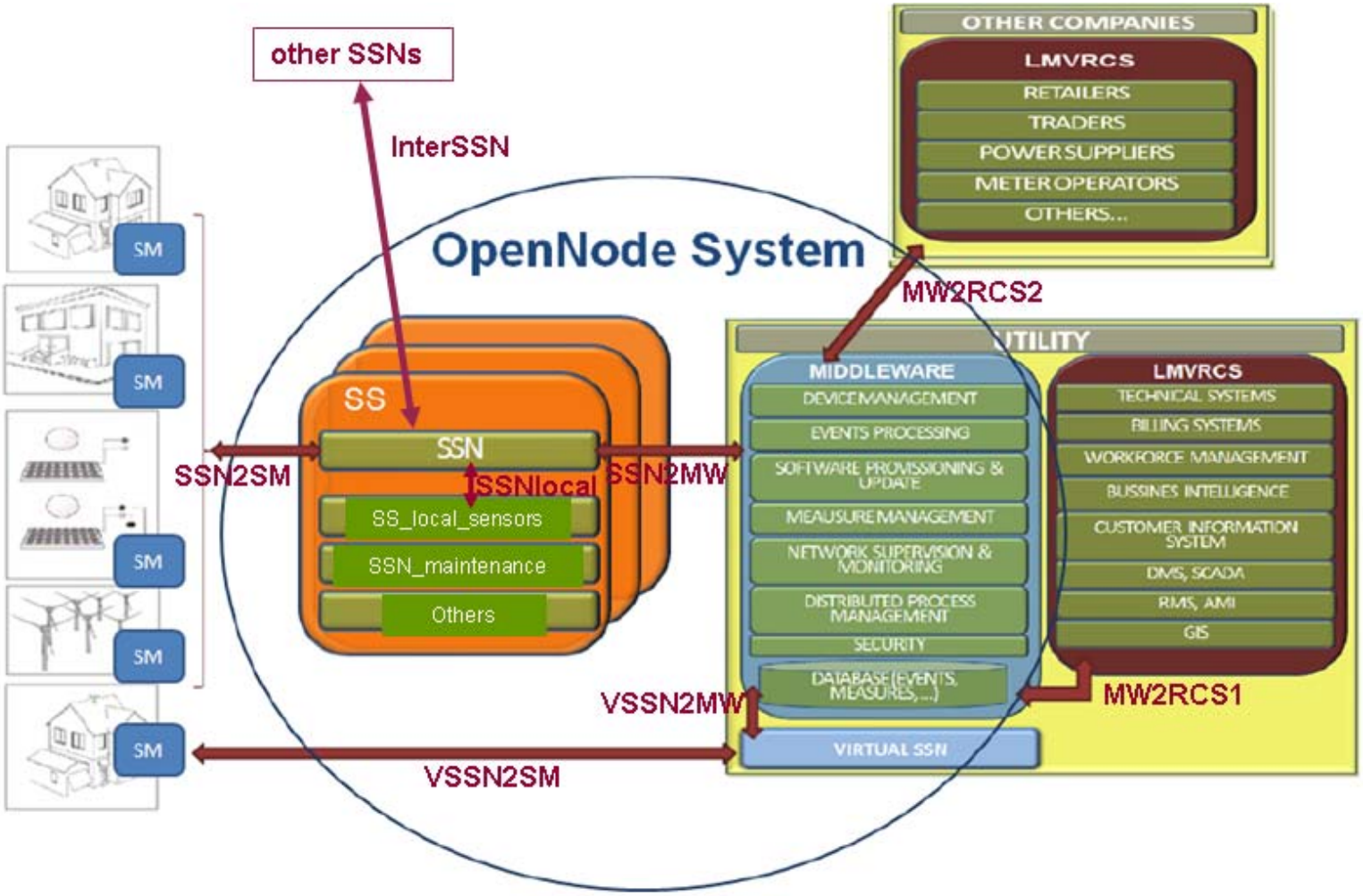


SW Reference Architecture

- Software architecture with two partitions
  - Base partition: manufacturer specific
  - Extensibility partition: for third-party developments



Communication Interfaces



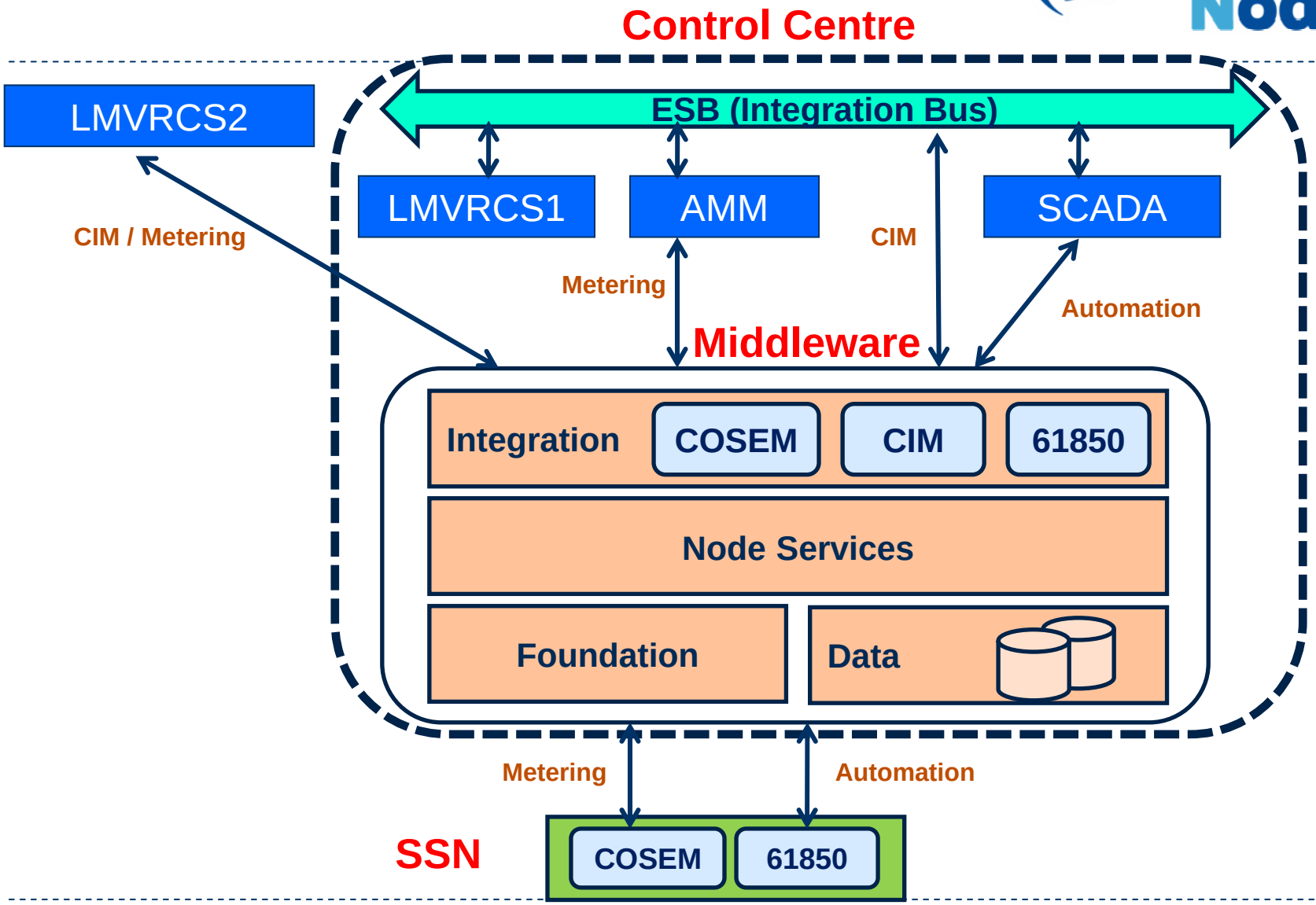
Middleware Objectives

- The Middleware is a central software that runs in the Control Centre of the Utility who owns the distribution power grid
- Is the gate of the SSNs to the Utilities systems: transferring and integrating data in both ways
- Manages the technical data and the storage of events and readings of the assets considered at OpenNode: SSN, SM and other devices
- Sits in a privileged position, because is the first system that is aware of all the grid information, so:
  - Must supervise the LV/MV grid status from the data and events that arrive at the MW
  - May perform some autonomous actions

Middleware Components

- Module decomposition: composed of four layers. Each layer is responsible of managing a specific concern:
  - Integration: includes the modules and infrastructure needed to realize the LMVRCS (control centre) integration
  - Node services: contains the modules that provide the core services needed by the SSN network and any other grid device
  - Foundation: provides cross-cutting services like security, administration and configuration
  - Data: hosts the data repositories that the Middleware manages: grid topology, measurements and events

Middleware Components



Communication Architecture

- Definition of a communication architecture for SSN communication interfaces, to the utility applications at the central site (e.g. control centre system) and to the meters
  - consideration of all layers including application data models, communication protocols and transport technologies
  - communication via different transport technologies and standard communication protocols
  - inclusion of IT security architecture

- Integration of the SSN prototype implementations with the meter, the middleware and the control center

Communication Architecture

Important Communication Requirements

- Standardized Solutions (ISO/IEC, IEEE, IETF, W3C)
- IT Security, Confidentiality and Integrity
- Flexibility and self-healing capability
  - Redirection of IT traffic (resilience and high reliability)
  - Fault detection and fault elimination in electrical grid as well as in controlling IT network
- Auto-Configuration and Auto-Detection of Devices
  - Automatic Recognition and Configuration of SSNs and Meters
- Modularity
  - Exchangeability and adaptability of communication modules
- Service quality
  - Latency / response times / delays (>= 1 sec. sufficient)
  - Required data rates (bandwidth)
  - Synchronous data transmission for events and notifications

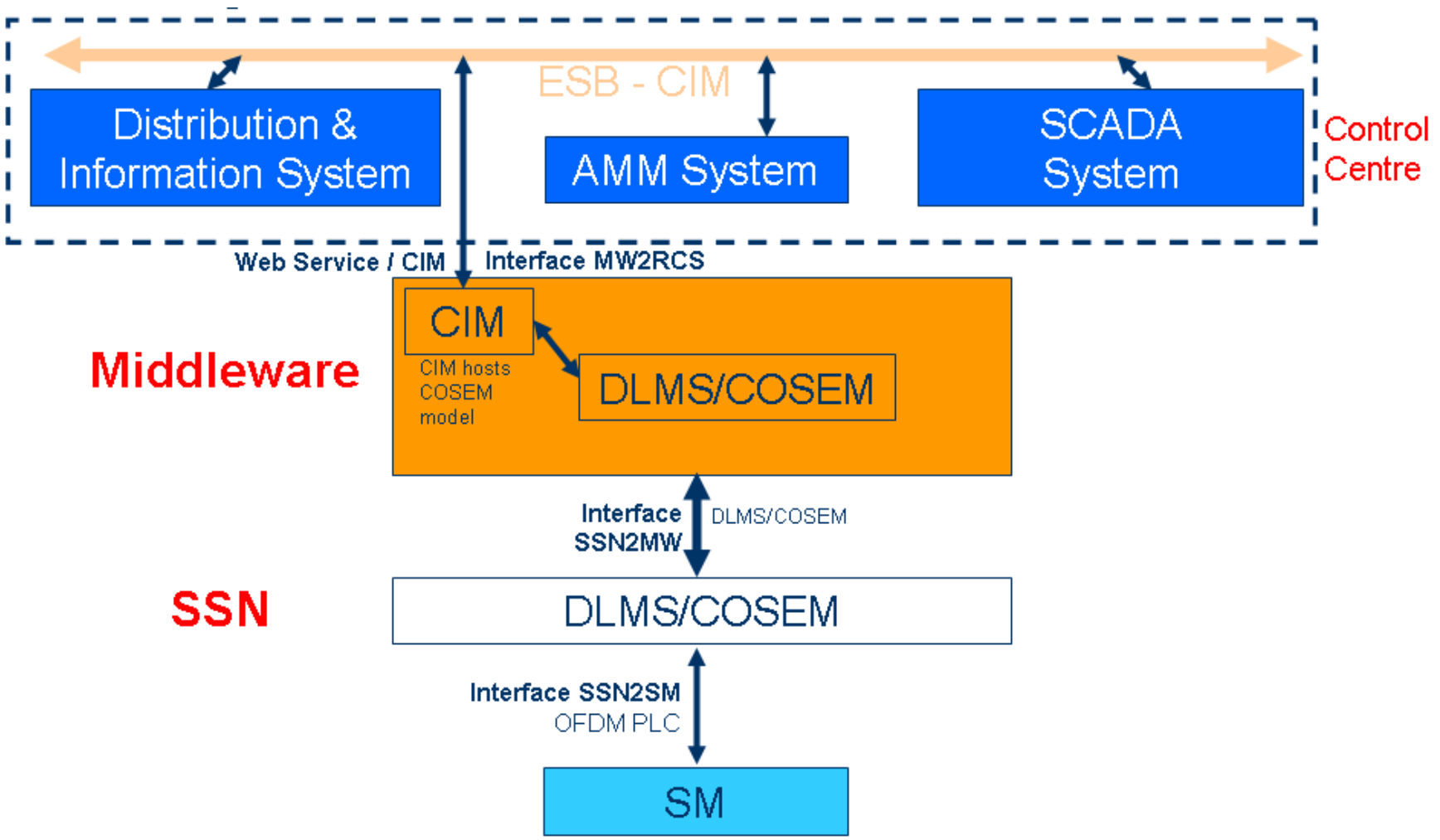
Communication Architecture

Data Models & Upper Layers Communication Solutions

- IEC 61850 “Communication Networks and Systems in Substations”
  - Comprehensive IEC Standard for Data Modelling and Transmission
  - Data transmission based on other Protocol Standards like MMS, IEC 60870-5-104, Web Services (W3C standard)
- DLMS (Device Language Message Specification) / COSEM (Companion Specification for Energy Metering)
  - Focus on data exchange with energy meters
- IEC 60870-5
  - General open communication standard for industrial automation
  - IEC 60870-5-104 is a transmission protocol to enable network access using an open TCP/IP interface to the network
- IEC 61970/61968
  - CIM (Common Information Model) standards for operational purposes

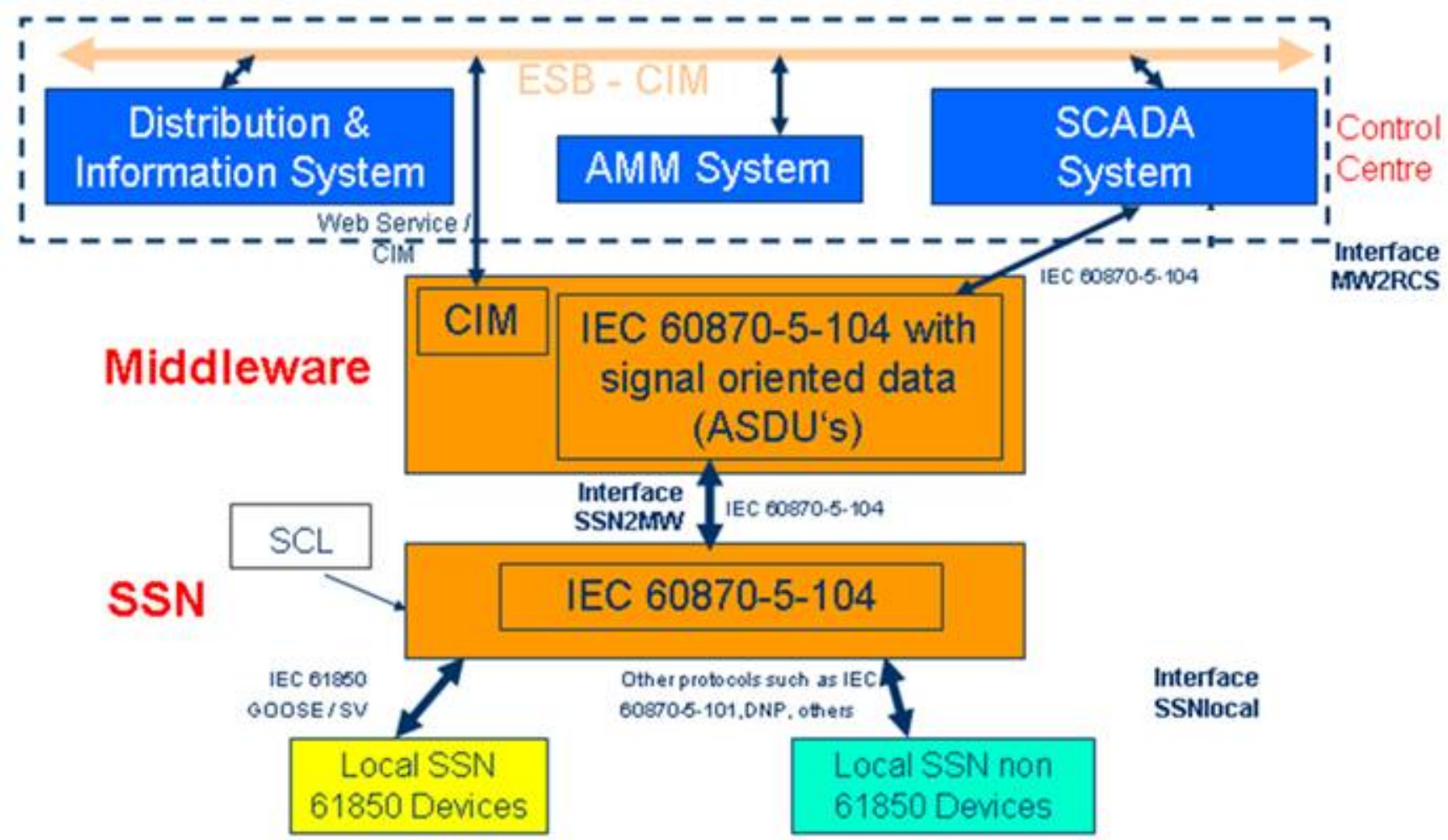
Communication Architecture

Metering Data Transmission



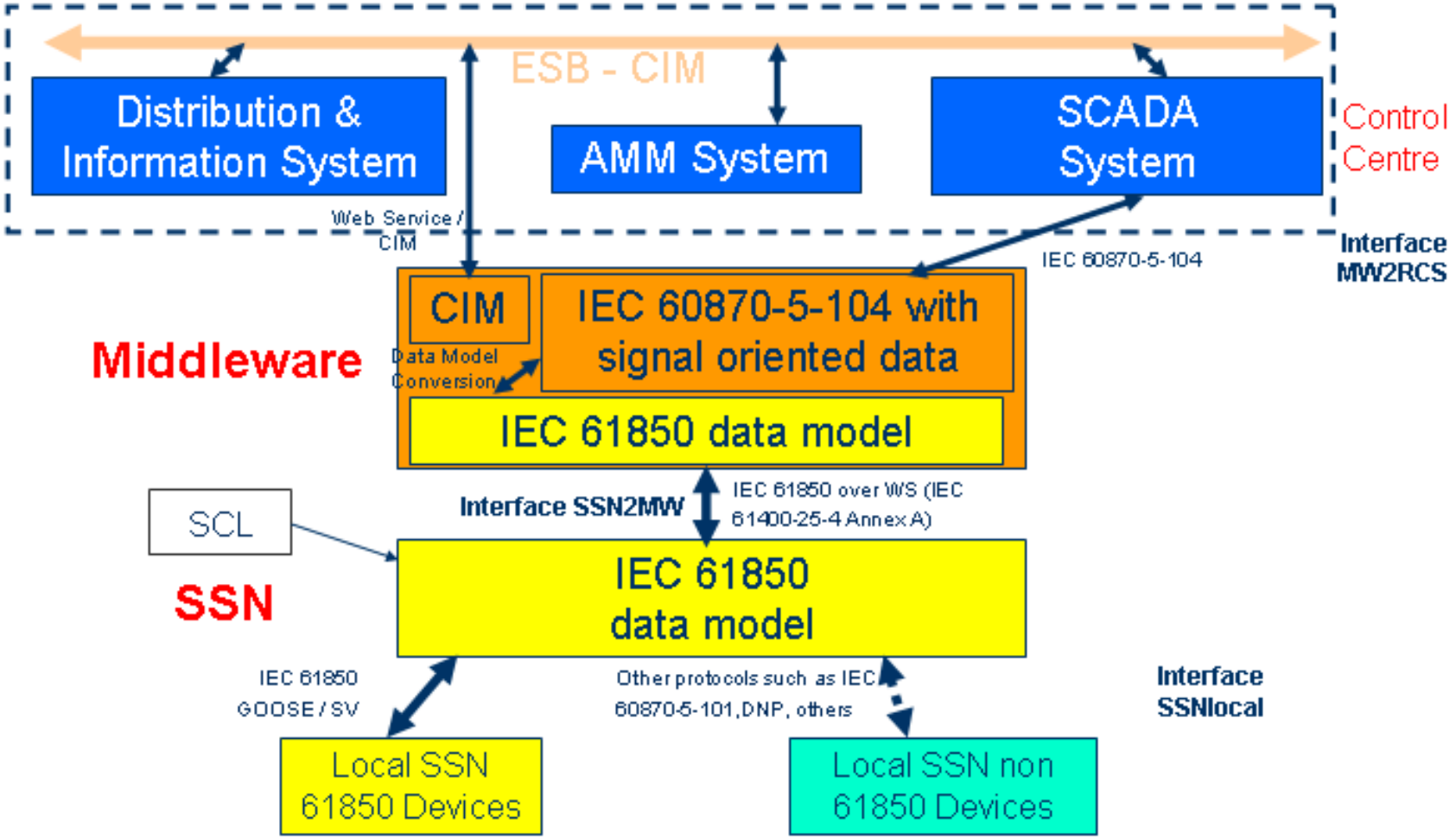
Communication Architecture

Grid Automation Data Transmission (Fast Prototype)



Communication Architecture

Grid Automation Data Transmission (Enhanced Prototype)



Current Status. Conclusions

- OpenNode's general requirements and use cases are completed as well as the Middleware and SSN specification and detailed design
- Communication architecture is defined including the evaluation and selection of standards
- Currently the development of both the SSNs and the MW are on an early stage and the data models, protocols and interfaces definition is about to be completed
- First prototypes of the SSNs and the Middleware reference implementation are expected to be completed by the end of 2011
- OpenNode has the ability to successfully integrate and give support to the requirements and technologies involved and needed for the development of the now present Smart Grid

Thank you for your attention

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Evaluation for Data Models and Upper Layer Protocols

	Advantages	Disadvantages	Eval. Result
IEC 61850 & MMS	- support of RT transfer - part of 61850 (61850-8-1) - synchronous transfer support	- MMS is complex standard, not easy to handle	suitable for interface SSN2MW, enabling synchronous comm.
IEC 61850 & IEC 60870-5-104	- support of RT transfer - broad dissemination - synchronous transfer support	- matching 61850 and 104 only partially (only for CDC) - 104 will be outdated in future	„fallback solution“ for interface SSN2MW
IEC 61850 & Web Services	- WS very wide-spread and easily extendable (flexibility) - future-oriented solution	- mapping to 61850 only by 61400 (wind turbines) - high data volume with XML - synchronous transfer difficult	suitable for interface SSN2MW, push services difficult
GOOSE / SV	- support of RT transfer - part of 61850 (61850-8-1, 9) - synchronous transfer support	- only for local data exchange (Ethernet)	suitable for local interface SSNlocal
DLMS / COSEM	- support of RT transfer - synchronous transfer support - well adapted for meters	- specialized on meters	suitable for SSN2SM interface
IEC 60870-5-104	- support of RT transfer - broad dissemination - synchronous transfer support	- 104 will be outdated in the future in smart grids	suitable for interface MW2RCS
CIM (IEC 61968 / 61970)	- support of RT transfer - synchronous transfer support - adapted to Control Centre	- specialized on operations & maintenance environment	suitable for the control centre communication