EH2750 Computer Applications in Power Systems, Advanced Course.

Lecture 2
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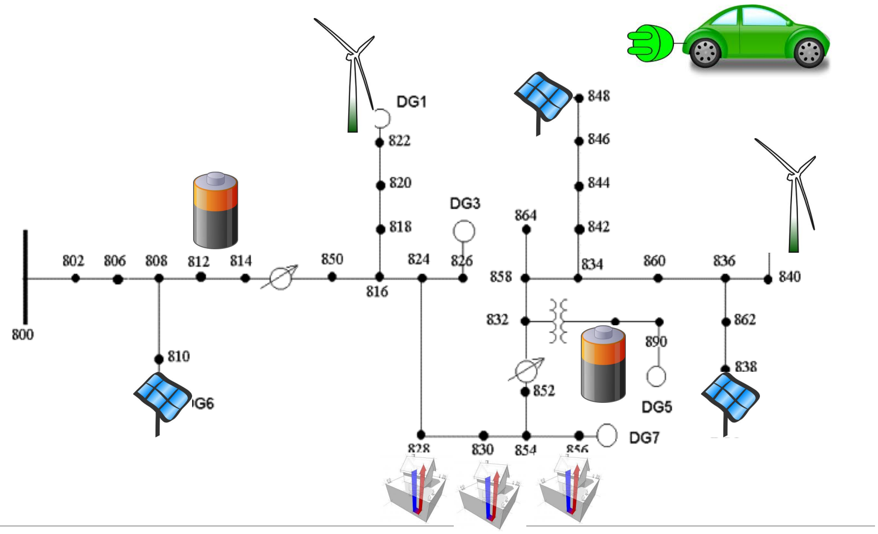
Power grids & Actors



How to know what to build?

”Who” controls what in a distribution system?
Voltage?
Frequency?
Is there a price for storage?
Can production be curtailed?
Can the system supply itself?
Can the DSO shift load in time?

Is the ICT architecture secure?
Is the performance sufficient?
Are the measurements of high quality?
Can all the systems communicate?

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Tools to manage this!?!

- A reference Architecture
  - What are the systems that will beinteracting?
  - What are their interfaces?
  - How does the power system interface the ICT system?
- Use Cases
  - Who are the actors that will use the systems?
  - What will they use it for?
  - Which systems will they interact with?
- Security and reliability
  - How do we maintain reliability
  - Security must not be compromised.
- Standards
  - How can systems be standardised?

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Mandate 490
Task to European SDO

- The EU has issued a mandate (M/490) for the standardization of Smart grid functionalities to CEN, CENELEC and ETSI.
- The expected framework will consist of the following deliverables:
  - A technical reference architecture, which will represent the functional information data flows between the main domains and integrate many systems and subsystems architectures.
  - A set of consistent standards, which will support the information exchange (communication protocols and data models) and the integration of all users into the electric system operation.
  - Sustainable standardization processes and collaborative tools to enable stakeholder interactions, to improve the two above and adapt them to new requirements based on gap analysis, while ensuring the fit to high level system constraints such as interoperability, security, and privacy, etc.

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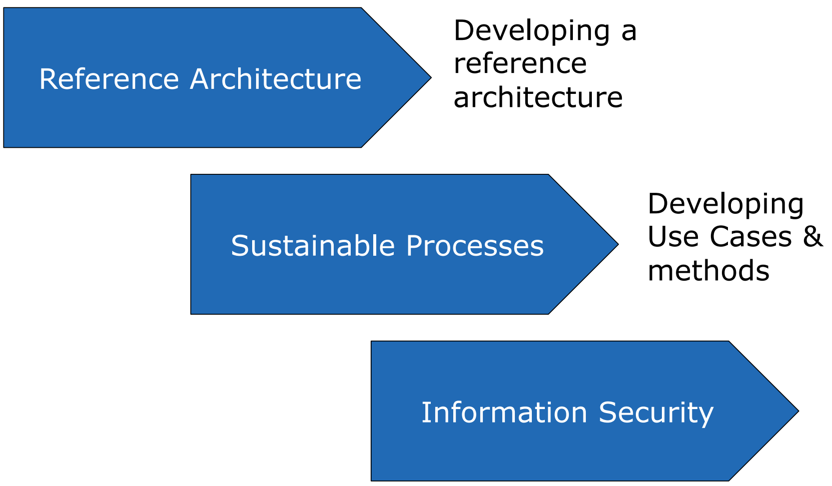
Three main working groups



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The EH750 Variant

Reference Architecture — Developing a reference architecture -SGAM

Sustainable Processes — IEC PAS 62559

Information Security

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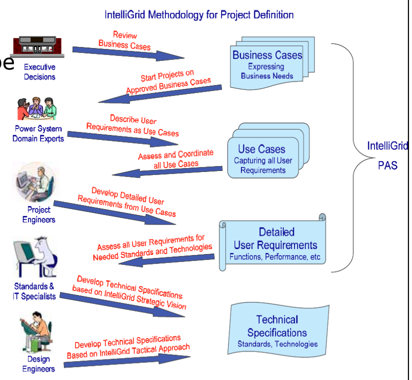
A structured approach is needed

- The IEC Publically Available Specification 62559
  - Developed initially by the EPRI in the US as part of the Intelligrid project
  - Adopted by the IEC as a PAS in 2008
- The 62559 is not a standard, it is instead a suggested way to work with developing requirements on new computer applications for power systems.

The Intelligrid method

- **Phase 1:** Executives use Business Cases to approve projects in order to meet Business
- **Phase 2:** Domain Expert Stakeholders describe their User Requirements through the formal Use Case process
- **Phase 3:** Project Engineers develop the more detailed functional and performance requirements from the Use Cases
- **Phase 4:** Project Engineers and IT Specialists assess applicability to the project of the standards, technologies, and best practices
- **Phase 5:** Design Engineers develop Technical Specifications based on Strategic Vision, Tactical Approach, & Standards



Source: IntelliGrid Methodology for Developing Requirements for Energy Systems IEC/PAS 62559

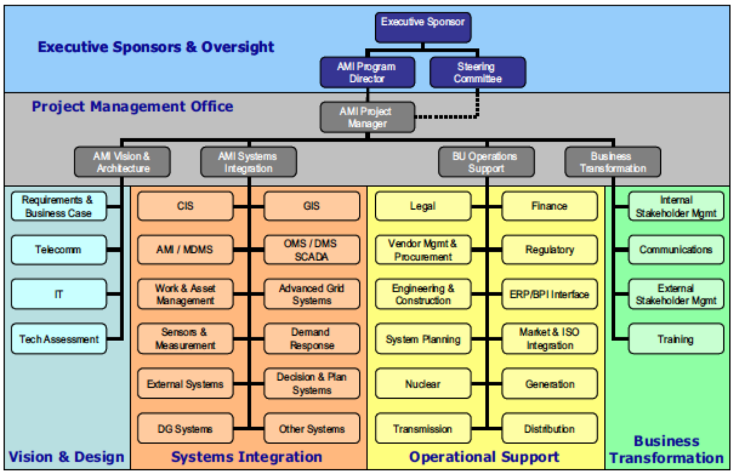
Phase 2 – A detailed look

Definition of a Use Case:
Class specification of a sequence of actions, including variants, that a system (or other entity) can perform, interacting with actors of the system IEC 62390, ed. 1.0 (2005-01)

- **Step 1:** Identification of All Potential Stakeholders
- **Step 2:** Reviewing existing Architecture Use Cases
- **Step 3:** Brainstorming List of Functions (Use Cases) with Stakeholders
- **Step 4:** Drafting Use Cases
- **Step 5:** Reviewing and Updating Use Cases

Stakeholder identification

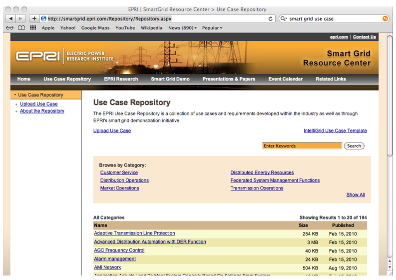
- Example from AMI project
- Stakeholders are critical for requirements capture and project acceptance



Source: IntelliGrid Methodology for Developing Requirements for Energy Systems IEC/PAS 62559

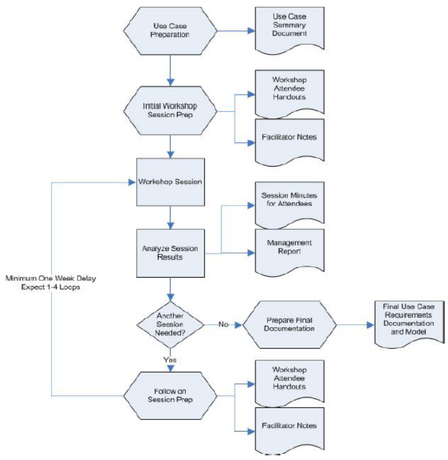
Step 2 – Review existing Use Cases

- The EPRI Use Case Repository
  - A huge collection of Use Cases exist online
  - Developed initially in the Intelligrid project in the late 1990s and continued during 2008+
  - The level of granularity & completeness very varied



Step 3 - Brainstorming

- Workshop format
- All stakeholders invovled
- Open discussions
- Documentation and analysis after the workshop

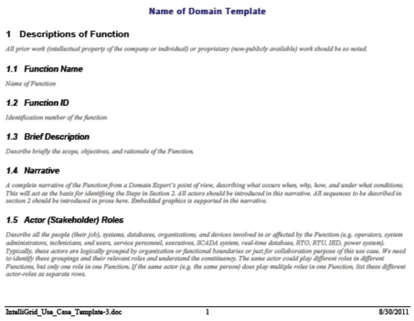


Step 4 – Drafting Use Cases

- Important contents of a Use Case
  - The **goal** of the use case, which is usually its name. e.g. "Utility remotely connects or disconnects customer".
  - The **narrative**. A short English text version of the story.
  - The **actors**. An actor is anything in the system that communicates. e.g. a "customer" or a "meter".
  - The **assumptions** that the use case is based on. These can constitute requirements in and of themselves.
  - The **contracts** and **preconditions** that exist between the actors,
  - The **triggering** event that led to the scenario taking place.
  - The **steps**. A numbered list of events that tell the story in detail.

Step4 -continued

- First draft of Use Case is documented in the Intelligrid Use Case Template



Name of Domain Template

1 Descriptions of Function

All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work should be so noted.

1.1 Function Name

Name of Function

1.2 Function ID

Identification number of the function

1.3 Brief Description

Describe briefly the scope, objectives, and rationale of the Function.

1.4 Narrative

A complete narrative of the Function from a Domain Expert's point of view, describing what occurs when, why, how, and under what conditions. This will act as the basis for identifying the Steps in Section 2. All actors should be introduced in this narrative. All sequences to be described in section 2 should be introduced in prose here. Embedded graphics is supported in the narrative.

1.5 Actor (Stakeholder) Roles

Describe all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTO, RTU, IED, power system). Typically, these actors are logically grouped by organization or functional boundaries or just for collaboration purpose of this use case. We need to identify these groupings and their relevant roles and understand the constituency. The same actor could play different roles in different Functions, but only one role in one Function. If the same actor (e.g. the same person) does play multiple roles in one Function, list these different actor-roles as separate rows.

IntelliGrid_Use_Case_Template-3.doc 1 8/30/2011

Step 5 – Reviewing & updating

- Reviewing & updating continues as more information is gained.

- In Phases 3 & 4 the non-functional requirements are further detailed.

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Items to consider for detailing

- Configuration
- Quality of Service Requirements
- Security Requirements
- Data Management Issues
- Constraints or Other Issues

The PAS provides checklists for all these areas

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The EH750 Variant

Reference Architecture

Developing a reference architecture -SGAM

Sustainable Processes

IEC PAS 62559

Information Security

What is a reference architecture?

A Reference *Architecture* describes the *structure* of a system with its element types and their structures, as well as their *interaction* types, among each other and with their environment. Describing this, a Reference Architecture defines restrictions for an instantiation (concrete architecture). Through abstraction from individual details, a Reference Architecture is universally valid within a specific domain. Further architectures with the same functional requirements can be constructed based on the reference architecture. Along with *reference* architectures comes a *recommendation*, based on experiences from existing developments as well as from a wide acceptance and recognition by its users or per definition. [ISO/IEC42010]

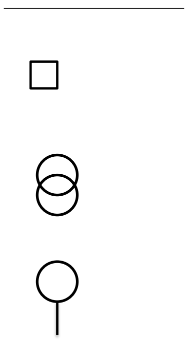
In short: it is the specification of which language you should use to describe the system you are describing.

Example:

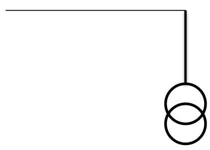
Reference architecture for for Power systems

One line diagram (just one possible form of description)

A set of symbols

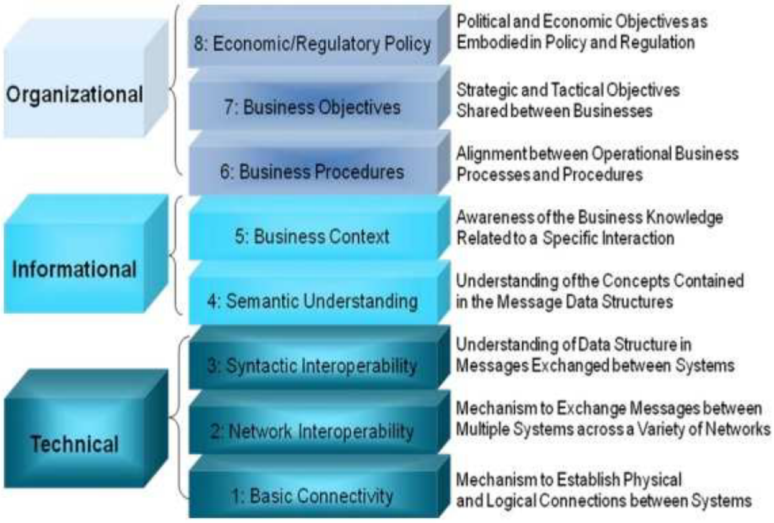


Rules on how you can combine them

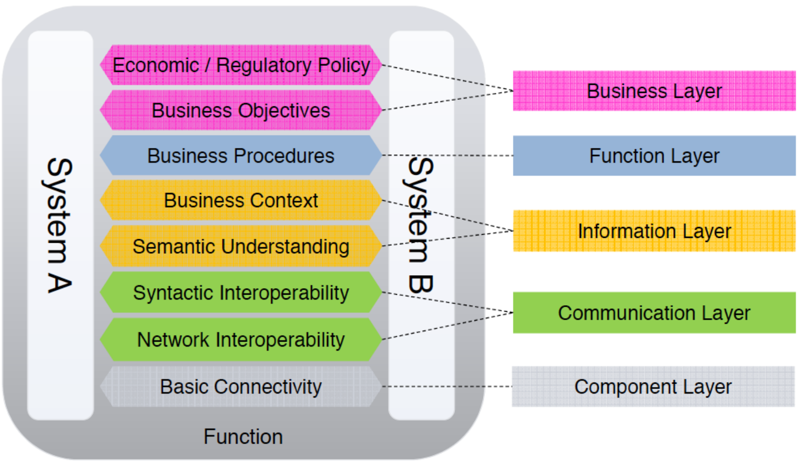


Sort of similar for ICT systems

Gridwise Interoperability framework



Condensed model in the SGAM



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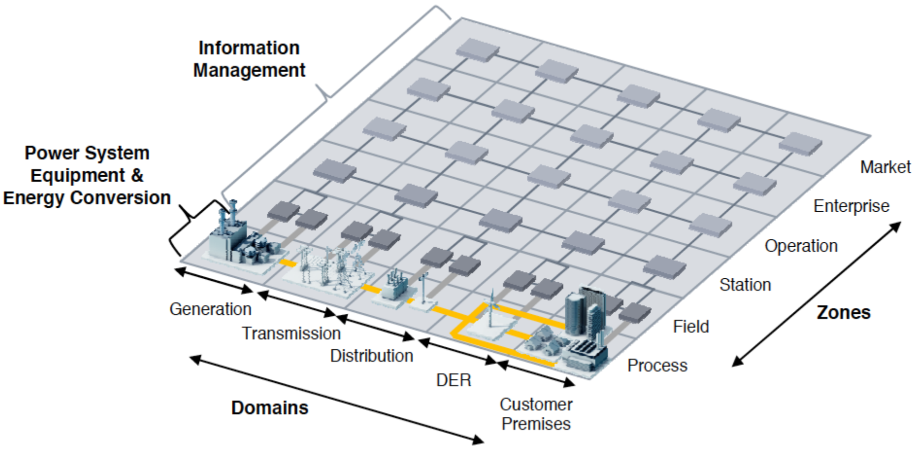
The context– the Smartgrid Plane



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Architecture Domains

Domain	Description
Bulk Generation	Representing generation of electrical energy in bulk quantities, such as by fossil, nuclear and hydro power plants, off-shore wind farms, large scale photovoltaic (PV) power– typically connected to the transmission system
Transmission	Representing the infrastructure and organization which transports electricity over long distances
Distribution	Representing the infrastructure and organization which distributes electricity to customers
DER	Representing distributed electrical resources, directly connected to the public distribution grid, applying small-scale power generation technologies (typically in the range of 3 kW to 10.000 kW). These distributed electrical resources can be directly controlled by DSO
Customer Premises	Hosting both - end users of electricity, also producers of electricity. The premises include industrial, commercial and home facilities (e.g. chemical plants, airports, harbors, shopping centers, homes). Also generation in form of e.g. photovoltaic generation, electric vehicles storage, batteries, micro turbines… are hosted

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Architecture Zones

Zone	Description
Process	Including both - primary equipment of the power system (e.g. generators, transformers, circuit breakers, overhead lines, cables, electrical loads …) - as well as physical energy conversion (electricity, solar, heat, water, wind …).
Station	Representing the aggregation level for fields, e.g. for data concentration, substation automation…
Operation	Hosting 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 commercial and organizational processes, services and infrastructures for enterprises (utilities, service providers, energy traders …), e.g. asset management, staff training, customer relation management, billing and procurement.
Market	Reflecting the market operations possible along the energy conversion chain, e.g. energy trading, mass market, retail market...

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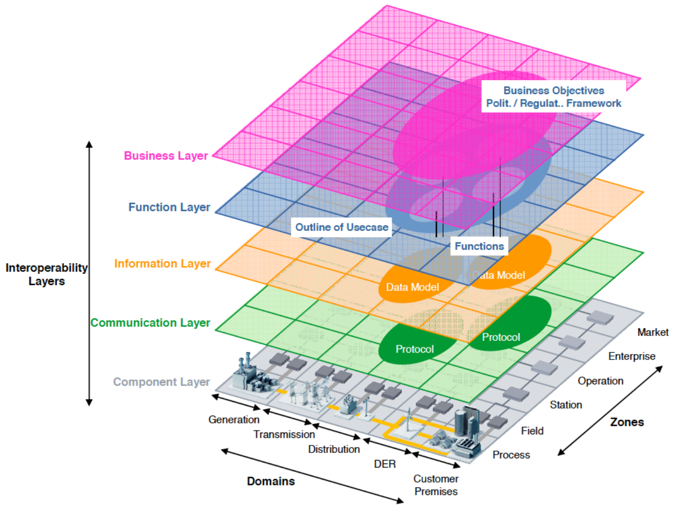
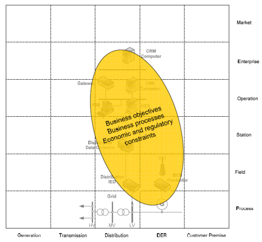
Complete Reference architecture



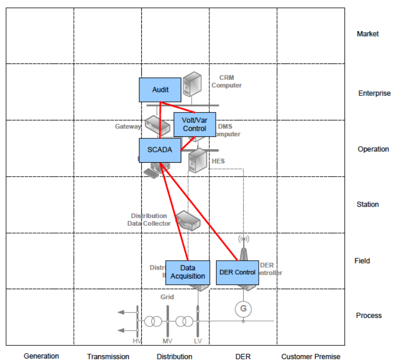
Business Layer

The business layer represents the business view on the information exchange related to smart grids. SGAM can be used to map regulatory and economic (market) structures and policies, business models, business portfolios (products & services) of market parties involved. Also business capabilities and business processes can be represented in this layer. In this way it supports business executives in decision making related to (new) business models and specific business projects (business case) as well as regulators in defining new market models. The Business layer is addressed in more detail in paragraph 6.1.



Function layer

The function layer describes functions and services including their relationships from an architectural viewpoint. The functions are represented independent from actors and physical implementations in applications, systems and components. The functions are derived by extracting the use case functionality which is independent from actors.



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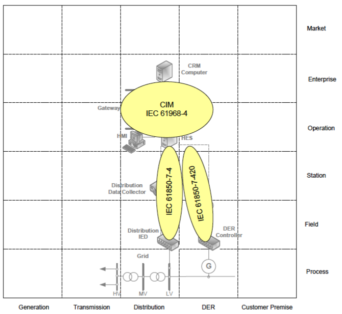
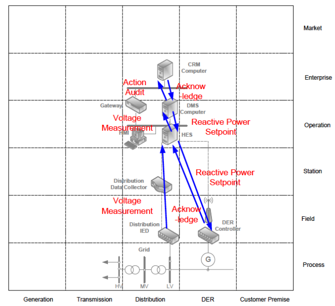
Information Layer

The information layer describes the information that is being used and exchanged between functions, services and components. It contains information objects and the underlying canonical data models. These information objects and canonical data models represent the common semantics for functions and services in order to allow an interoperable information exchange via communication means.





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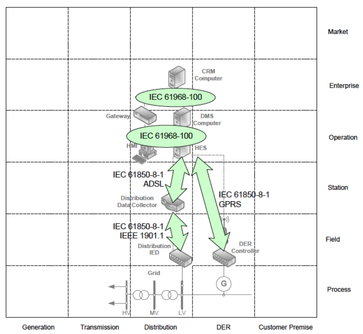
Communication Layer

The emphasis of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service and related information objects or data models.



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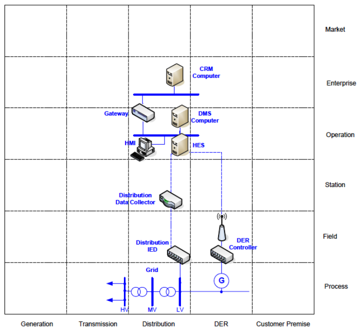
Component Layer

The emphasis of the component layer is the physical distribution of all participating components in the smart grid context. This includes actors, applications, power system equipment (typically located at process and field level), protection and tele-control devices, network infrastructure (wired / wireless communication connections, routers, switches, servers) and any kind of computers.



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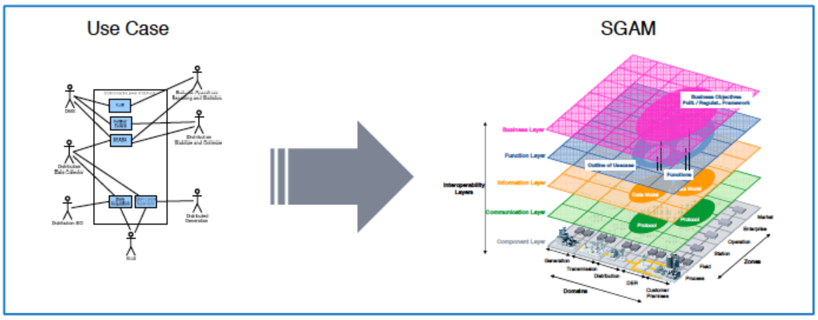
Putting it all together

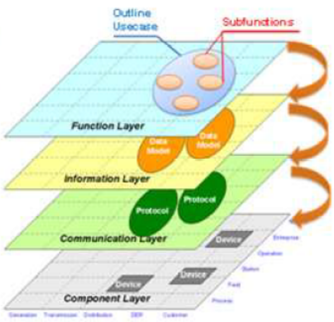


Putting it all together

Mapping of use case

For a given use case, the following steps are recommended to map it to the *SGAM*:

1. Begin at Function Layer
2. Identify those domains and zones, which are affected by the use case
3. Outline the coverage of the use case in the smart grid plane
4. Distribute the sub-functions or services of the use case to appropriate location in the smart grid plane
5. Continue with next layers
6. Drill down to components, communication and information layers.
7. Verify that
   a. all layers are consistent and there are no gaps
   b. all entities are connected



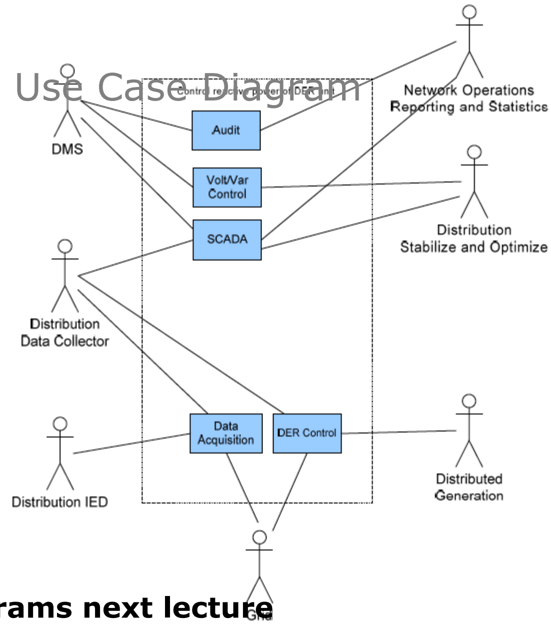
Step 1 – Use Case Analysis

- Identify Name Scope and Objective of the Use Case
- Which actors are involved –actor list?
- Is there a Use Case Diagram available?'

Example: reactive power control of DER unit

Scope and Objectives of Use Case	
Related business case	Operation of distribution grid
Scope	Monitor voltage level in distribution grid, control reactive power of DER unit, volt/var control of distribution grid,
Objective	Monitor and control voltage level of distribution grid in tolerated limits

Step 1- Use Case Diagram



More on UML Diagrams next lecture

Step 1- Actor list

Actors			
Grouping (Community)		*Group Description*	
Actor Name see Actor List	*Actor Type* see Actor List	*Actor Description* see Actor List	*Further information specific to this Use Case*
Grid	System	Power Distribution system	
Distribution-IED	Device	Intelligent Electric Device (IED) is a communications-enabled controller to monitor and control automated devices in distribution which communicates with Distribution SCADA or other monitoring/control applications, as well as distributed capabilities for automatic operations in a localized area based on local information and on data exchange between members of the group. Operations such as such as tripping circuit breakers if they sense voltage, current, or frequency anomalies.	
Distributed Generation	Device	Distributed Generation, also called Distributed Energy Resources (DER), includes small-scale generation or storage of whatever form. This is in contrast to centralized or bulk generation and/or storage of electricity. These generation facilities are part of Demand/Reponse programs and may be dispatchable	

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Step 1- Pre-conditions & assumptions

Use Case Conditions			
Actor/System/Information/Contract	**Triggering Event**	**Pre-conditions**	**Assumption**
Distribution Management System		• The Grid is continuously monitored • The Grid topology is known and reflects the real topology • The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches)	
Distribution-IED		The device is up and running	
Distributed Generation		The DER is connected to the grid and injects active and reactive power	
Distribution Data Collector		The device is up and running	
Distribution Stabilize and Optimize		The application is up and running	
Distribution Management System		The application is up and running	
Network Operations Reporting and Statistics		The application is up and running	

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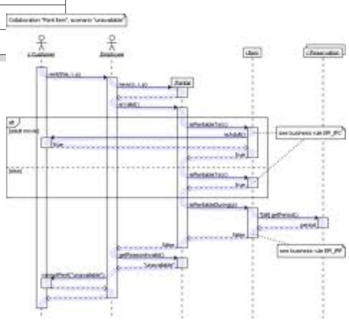
Step 1 – Use Case step by step analysis

- Step by step descriptions & Sequence Diagrams

Step #	Triggering Event	Actor What actor, either primary or secondary is responsible for the activity in this step?	Description of the activity Describe the actions that take place in this step including the information to be exchanged. The step should be described in active, present tense	Information producer	Information Receiver	Information exchanged	Additional Notes Elaborate on any additional description or value of the step to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column
Data Acquisition"							
1a	Periodically	Distribution IED	Distribution IED acquires analogue voltage measurement	Grid	Distribution IED	Analogue Voltage Measurement	
2	Periodically	Distribution IED	Distribution IED transmits voltage measurement	Distribution IED	Distribution Data Collector	Voltage Measurement	
3	Periodically	Distribution Data Collector	Distribution Data Collector transmits voltage measurement to DMS system.	Distribution Data Collector	DMS	Voltage Measurement	
Scada							



More on UML Diagrams next lecture

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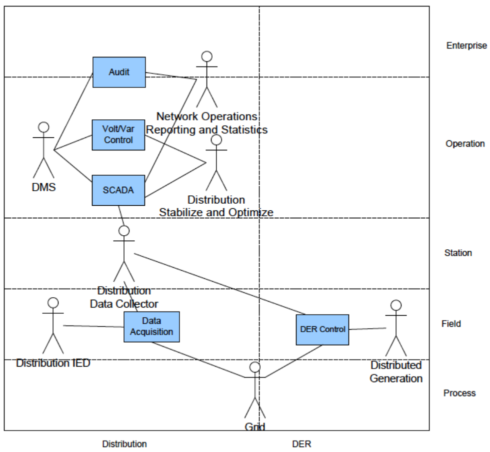
Step 2 – Develop the Component layer



Map the Use Case diagram to a SGAM Domain – Zone diagram

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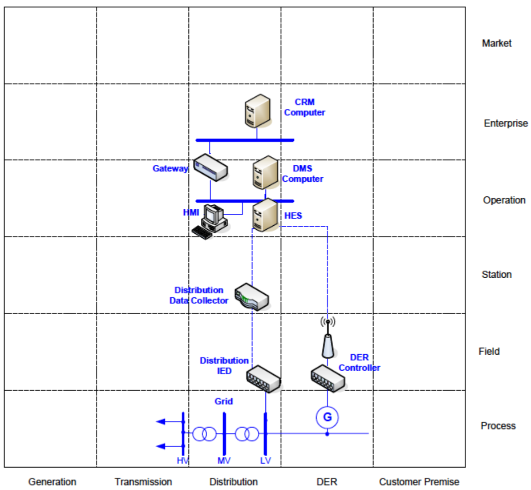
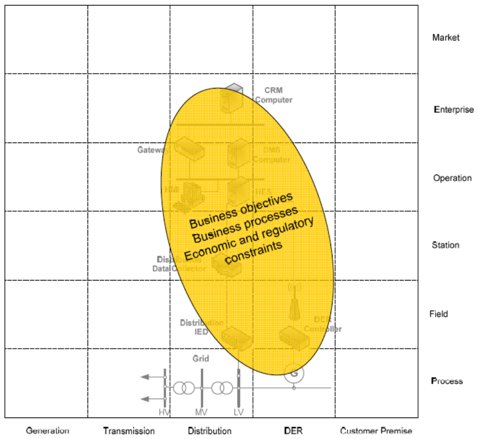
Step 2 – Develop Physical setup

Describe the components from the Use Case Diagram as tangible objects



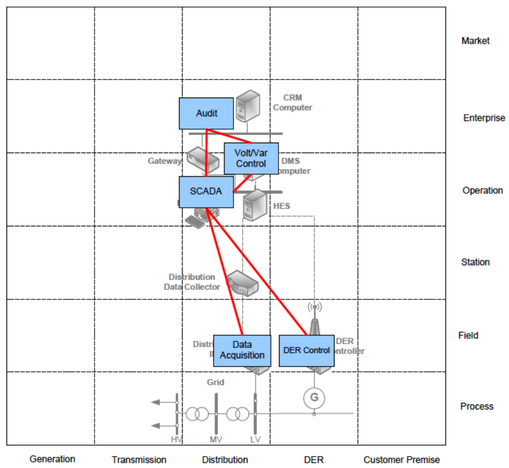
Step 3 – Develop Business layer

Useful to de-lineate the scop of the use case



Step 4 – Develop the functional layer

Assign the functions to the components. Not necessarily one-to-one.



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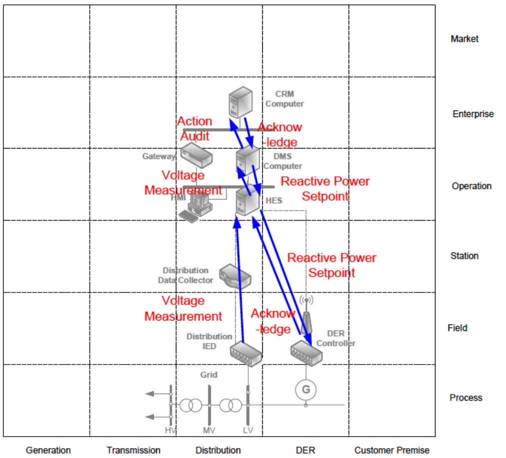
Step 5 – Develop the Information layer

Identify (from the Use case description) which data is to be exchanged between which components & function.



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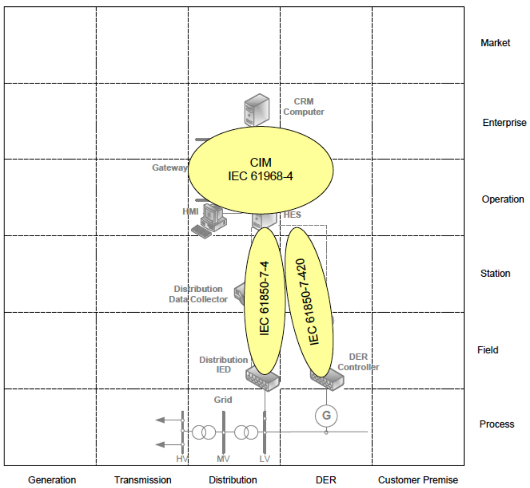
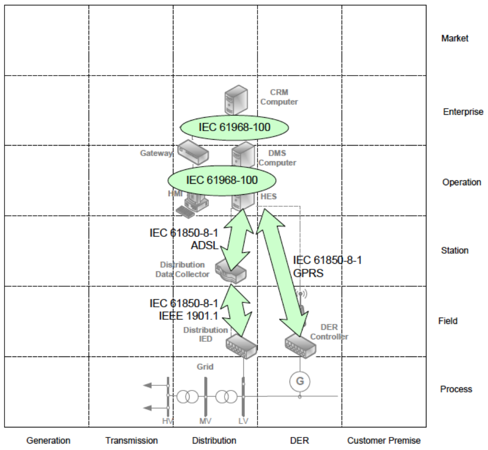
Step 5 – determine datamodels to use

Based on type of information exchanged, determine suitable standardised datamodel



Step 6 – Determine communication protocols to use.

Define standard for communication protocol, including physical and link layer protocols to use



The end

- After following the process we should have:

  1. A detailed description of a Use Case including its scope, actors, step by step breakdown etc.
  2. A total of 5 architecture ”drawings” that present different views of the Use case

Why all this?

It hopefully provides good information to make it possible for others to review, find faults and then finally design the actual systems