SUBSTATION AUTOMATION SYSTEM : IEC61850 Perspective

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Substation Automation System

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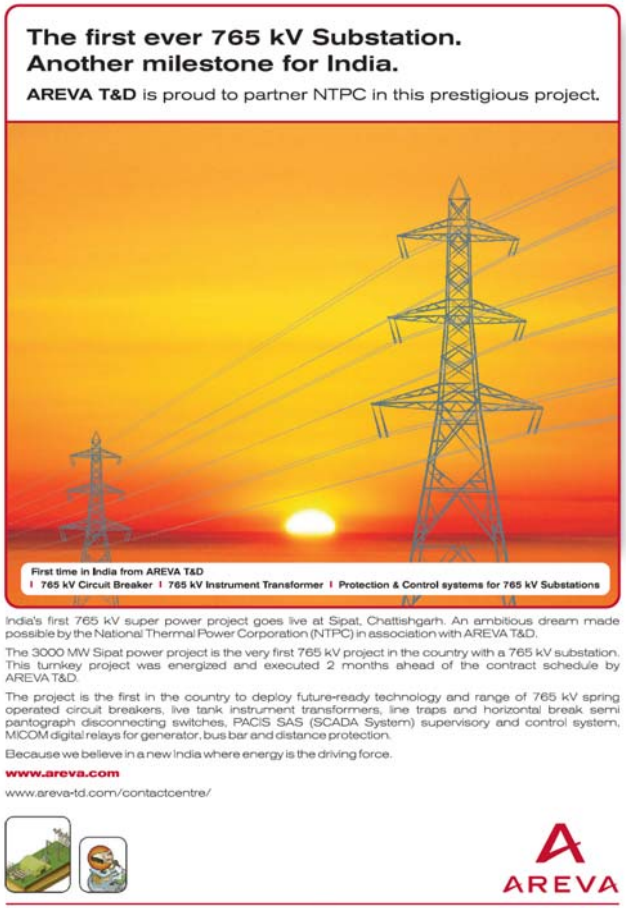
Drivers for Development

- **Regulatory Compliance**
- **Network Reliability**
- **Cost Improvement**

Introduction

- IEC 61850 has become a cornerstone technology for substation automation
  - Communication protocol voted in 2004
- Estimated >1.000 projects, >30.000 IEDs from different suppliers
  - Interoperability is proven on real projects
- This is however just the beginning of a new era
  - New applications emerging
  - Extensions of the standard and companion ones
  - Industrialization aspects

- **Currently :**
  - **>400 IEC 61850 projects at different stages of execution,**
  - **> 15.000 IEC 61850 IEDs manufactured**
- **From simple architectures (distribution substation) to more complex ones (industries and rail made of several interconnected substations by IEC 61850)**



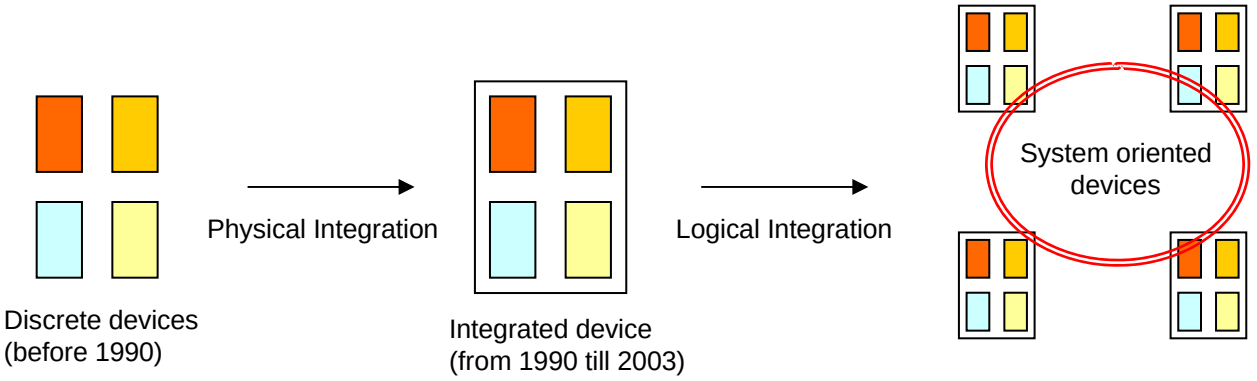
IEC 61850 in a Nutshell: A Powerful Toolbox

- **Communication services: How to exchange data**
  - **Includes the well advertised GOOSE, i.e. peer-to-peer link**
- **Data modeling: What data to exchange**
  - **A dictionary defining unambiguous names in the power area**
- **Configuration language: How to share data references**
  - **Formal exchange of XML files between engineering tools**

Enabling unprecedented innovations

But ONLY a toolbox

IEC 61850: From physical to logical integration

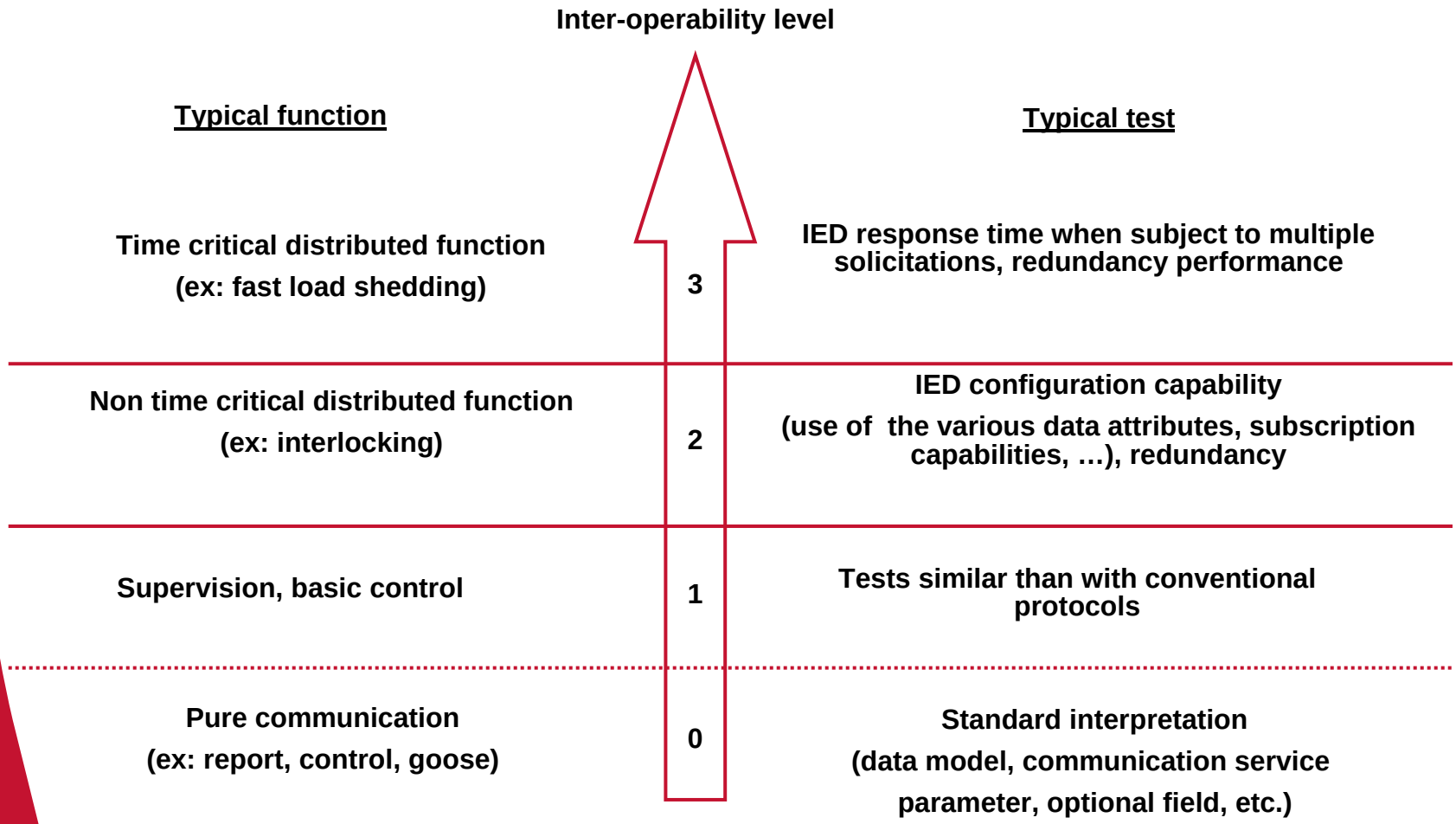


- **Physical integration has be the way to optimize cost since the venue of digital relays, i.e. 15-20 years ago**
- **The logical integration is still a very untapped domain, for automation and asset management, at substation/regional/grid levels**
- **Current IED might just be IEC 61850 enabled or designed to be fully integrated into a distributed system**

Interoperability possible issues

- **Ethernet**
  - **Configuration**
- **IEC 61850**
  - **Standard bugs/interpretations**
  - **PICS/MICS consistency between devices**
  - **Number of client/goose accepted**
- **Distributed function**
  - **Capability to configure the relevant processing: semantic (for instance dynamic topology detection), downgraded case, etc.**
  - **Specification and test coverage: nominal, downgraded, performance, endurance**
  - **Performance: competition between processing resources**
  - **Version consistency**

Inter-operability: Different Levels



Inter-operability
Need for an efficient process

CIGRE B5.32

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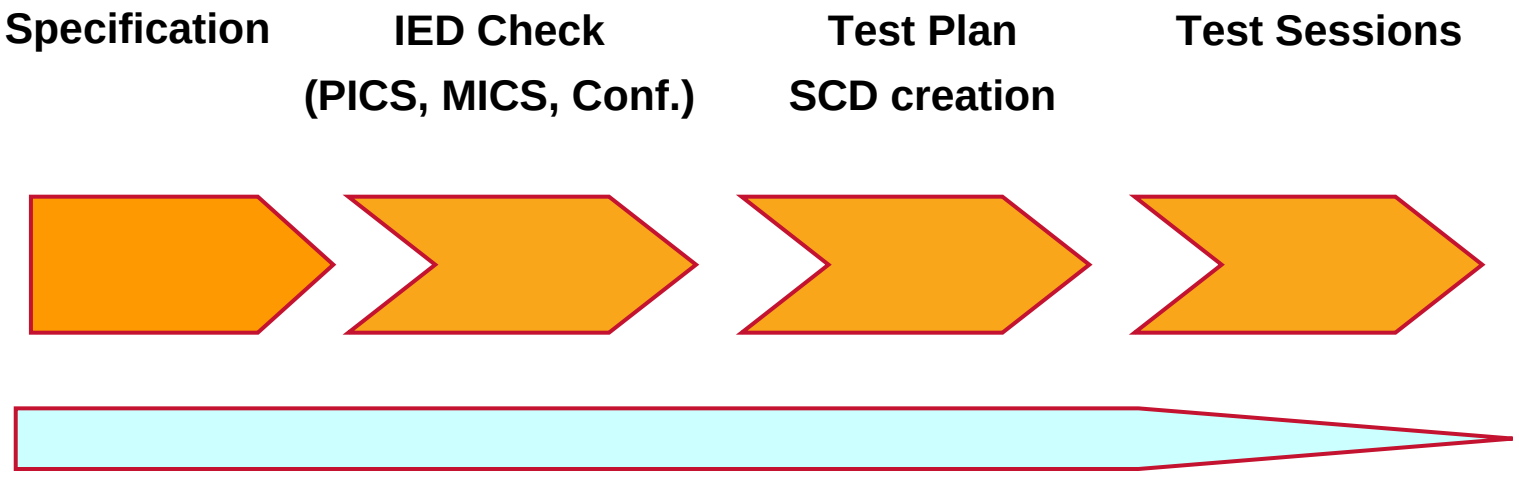
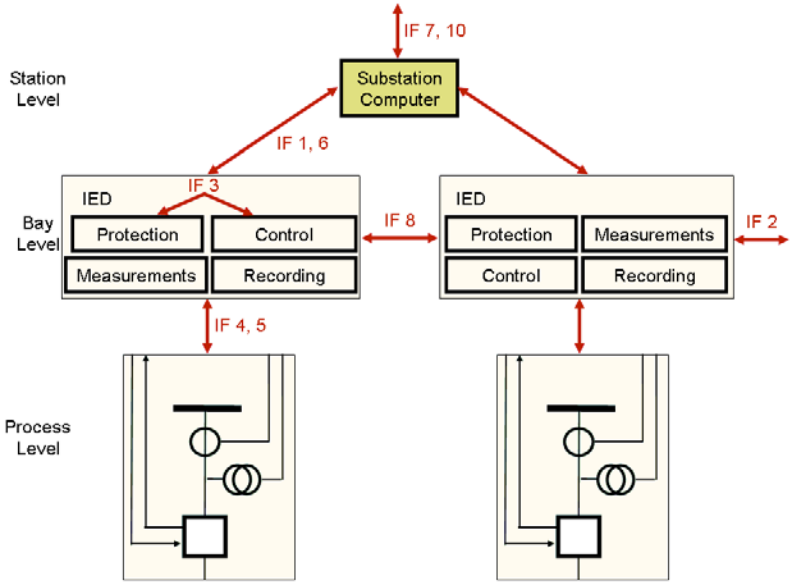


Organization is a must

Do not only ask the suppliers to come with their IEDs

Pilot projects on Process Bus

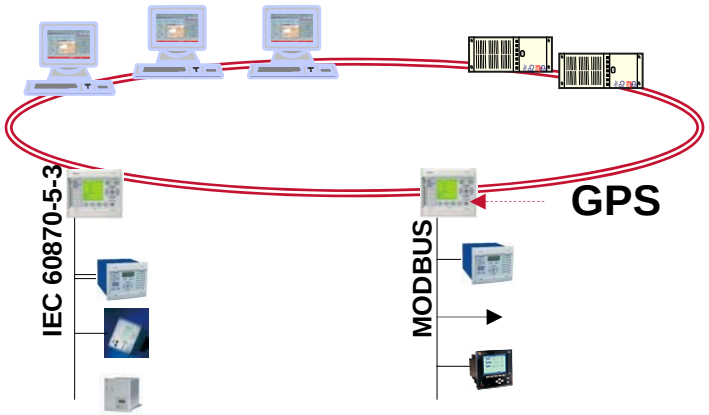


| Z |	Phi	Expected Time	Conventional CT/VT interfaced with merging unit		Optical CT/VT interfaced with merging unit		Conventional CT/VT interfaced directly with relay	
			Real Time	Deviation	Real Time	Deviation	Real Time	Deviation
189.2 mç	4.42 °	0.000 s	27.10 ms	27.10 ms	27.50 ms	27.50 ms	25.30 ms	25.30 ms
243.5 mç	3.43 °	400.0 ms	412.6 ms	3.150 %	407.8 ms	1.950 %	412.7 ms	3.175 %
249.2 mç	3.36 °	400.0 ms	412.0 ms	3.000 %	412.5 ms	3.125 %	405.9 ms	1.475 %
267.7 mç	3.12 °	400.0 ms	407.8 ms	1.950 %	412.6 ms	3.150 %	411.6 ms	2.900 %
303.6 mç	2.75 °	750.0 ms	764.0 ms	1.867 %	756.9 ms	0.9200 %	754.8 ms	0.6400 %
387.9 mç	2.15 °	No Trip	No Trip	n/a	No Trip	n/a	No Trip	n/a

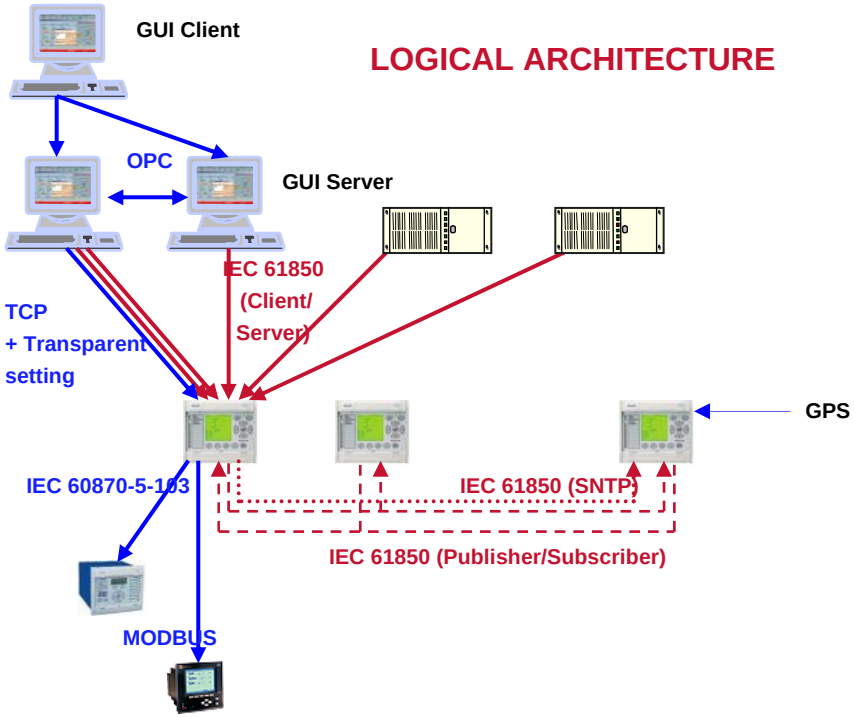
System Design is Key

- Physical architecture is now "simple"
  - All devices are on Ethernet
  - Need to pay attention to the Ethernet infrastructure especially for redundancy

PHYSICAL ARCHITECTURE



LOGICAL ARCHITECTURE

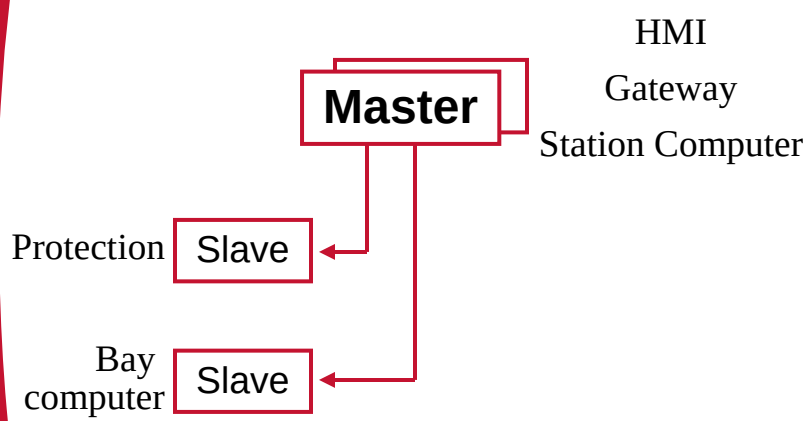


- Logical architecture (data flows) are becoming much more sophisticated
  - This is part of the system design activity
  - Client/Server, Goose, SNTP and non IEC 61850 flows

Architecture is no longer the sole device interconnection

Logical architecture: Data flow

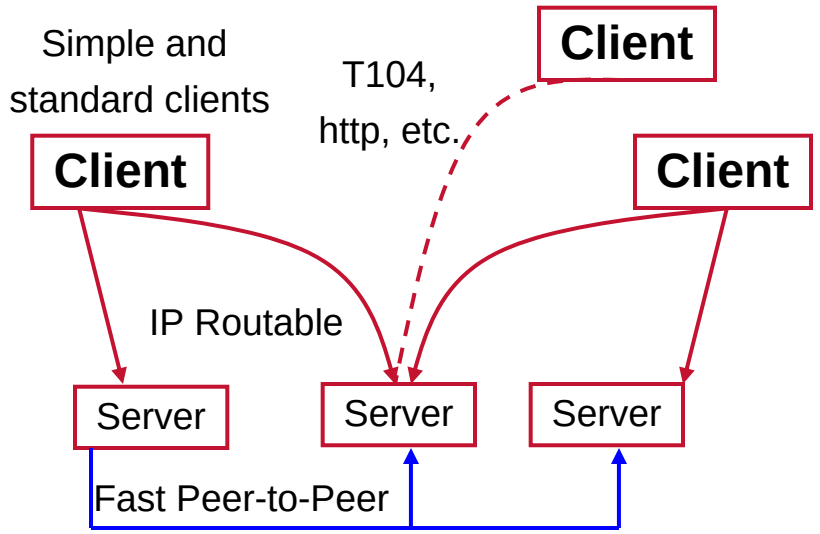
TRADITIONNAL (> 80%)



Central point

Distributed functions limited by performances

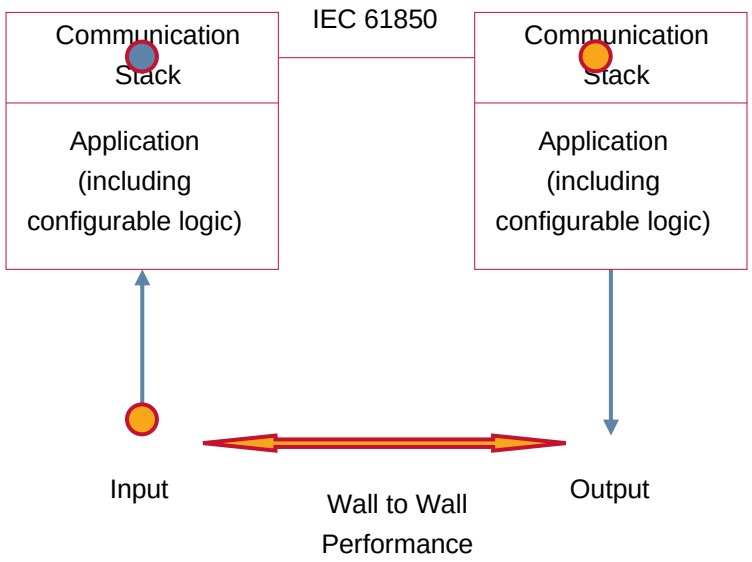
IEC 61850 POTENTIAL IMPACT



Non trivial design for innovative schemes (performances, side effects)

Distributed functions impact on system design

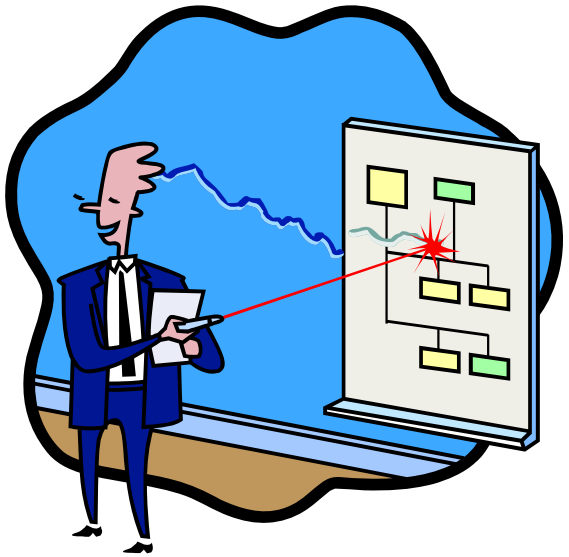
- **Specification of the distribution functions is not defined in the IEC 61850 standard**
  - **A new type of document is needed**
- **IED Conformance to IEC 61850 is interesting but might not be sufficient to cope with the specification**
  - **For instance it shall be checked if the IED configuration capabilities (i.e. GOOSE handling) can match the functional requirement**
- **"Wall to Wall" performance analysis is the next step**
  - **Communication is one aspect, application handling of the communication is another one**



61850 is only one mean and must be complemented by other capabilities

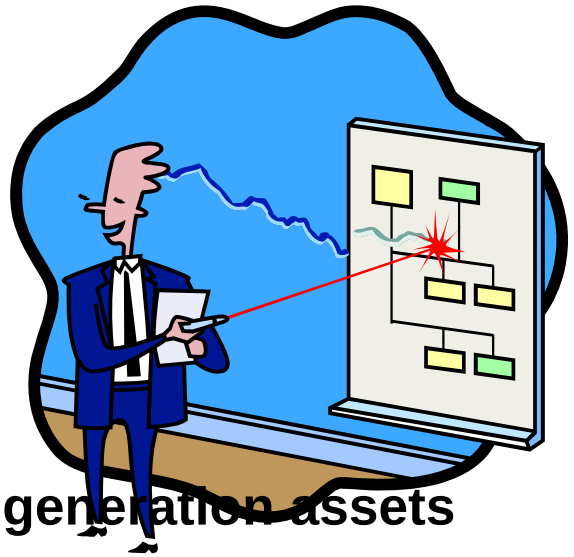
The system architect

- A (“new”) job essential for innovative design and/or mix of different suppliers matching evolving business processes
- Both long term view (defining guidelines) and short term perspective (real projects)
- Short term
  - Guarantee the functional consistency of the various devices working together and the system performances
    - Make sure that distributed functions are fully defined and have acceptable side effects in case of degraded situations
    - Manage the increasing system complexity: version, security, etc.
    - Design with system tests & costs in mind: interoperability, functional validation, performances



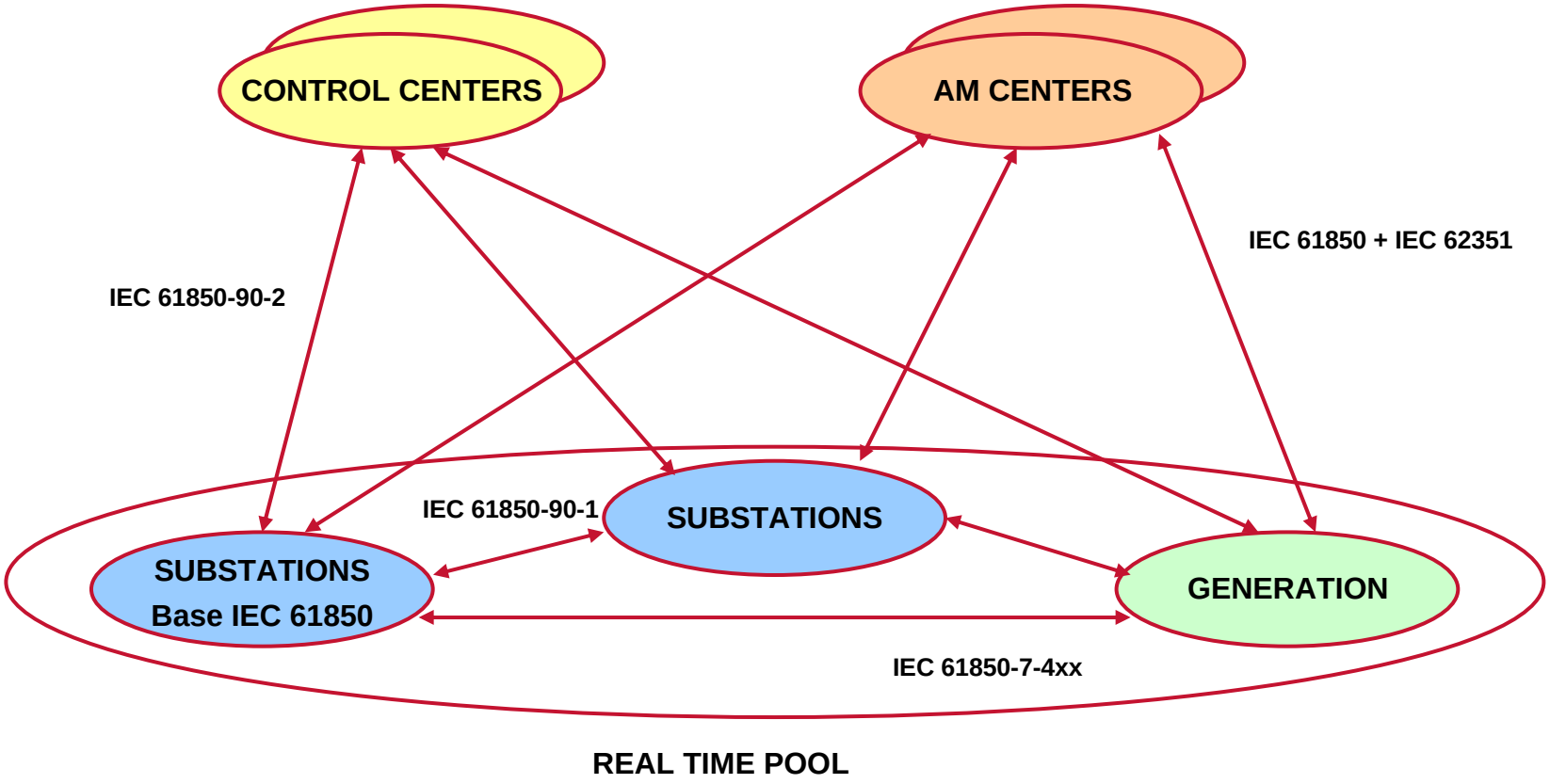
Extension Outside The Substation

- Essentially IEC61850 has been developed for the communication inside the substation
- Now Additional part of the standard and companion standards are at different stage of expansion as illustrated in next slide

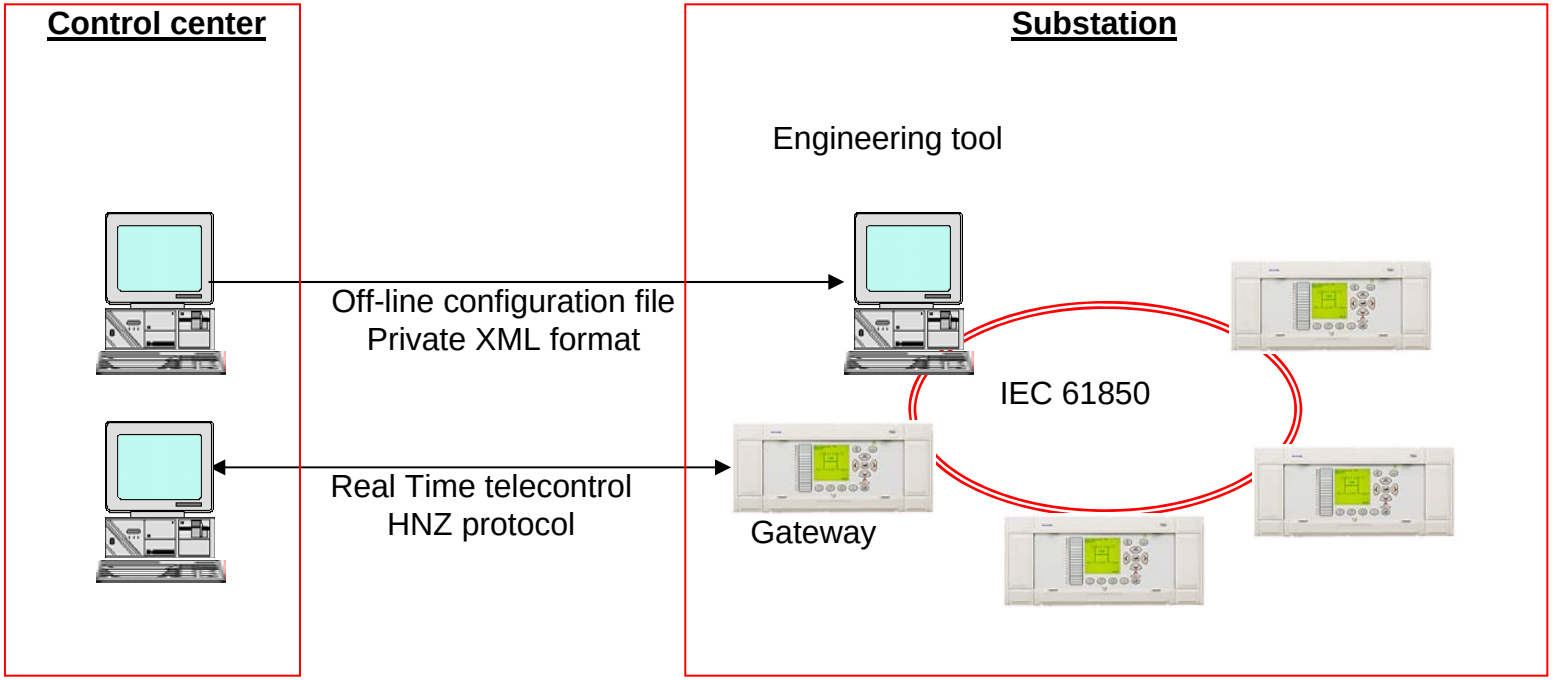


- IEC61850-7-4xx for naming distributed generation assets
- IEC 61850-90-1 Communication between substation
- IEC 61850-90-2 Communication between control centre
- IEC 62351 for Cyber Security
- There is a new grouping called “Real Time Pool”: “This is set of set of substation and Generation plants that communicate one with other inorder to contribute to grid stability””

IEC 61850 Directions

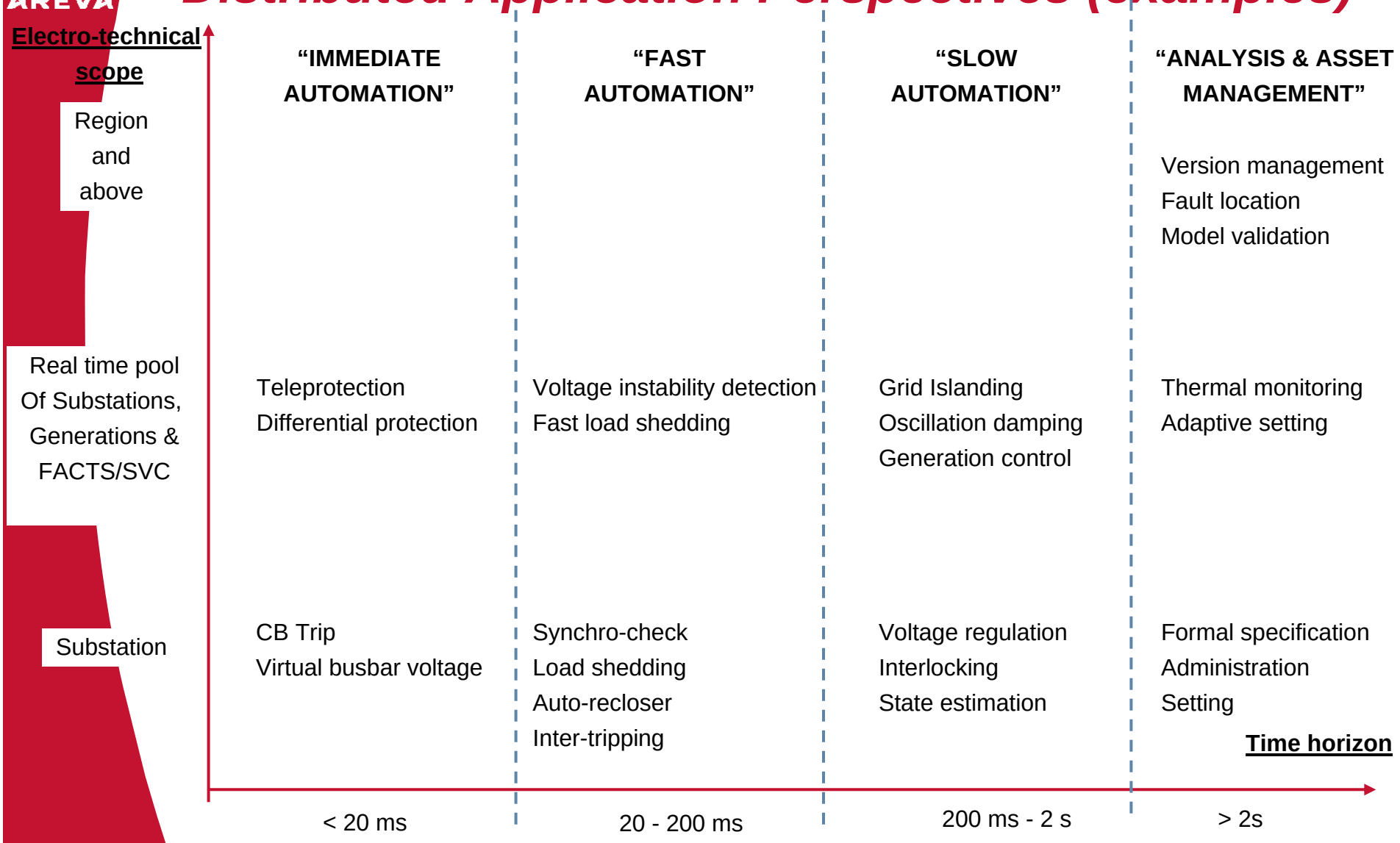


Configuration integration – The RTE example (France)



Unifying the engineering tools

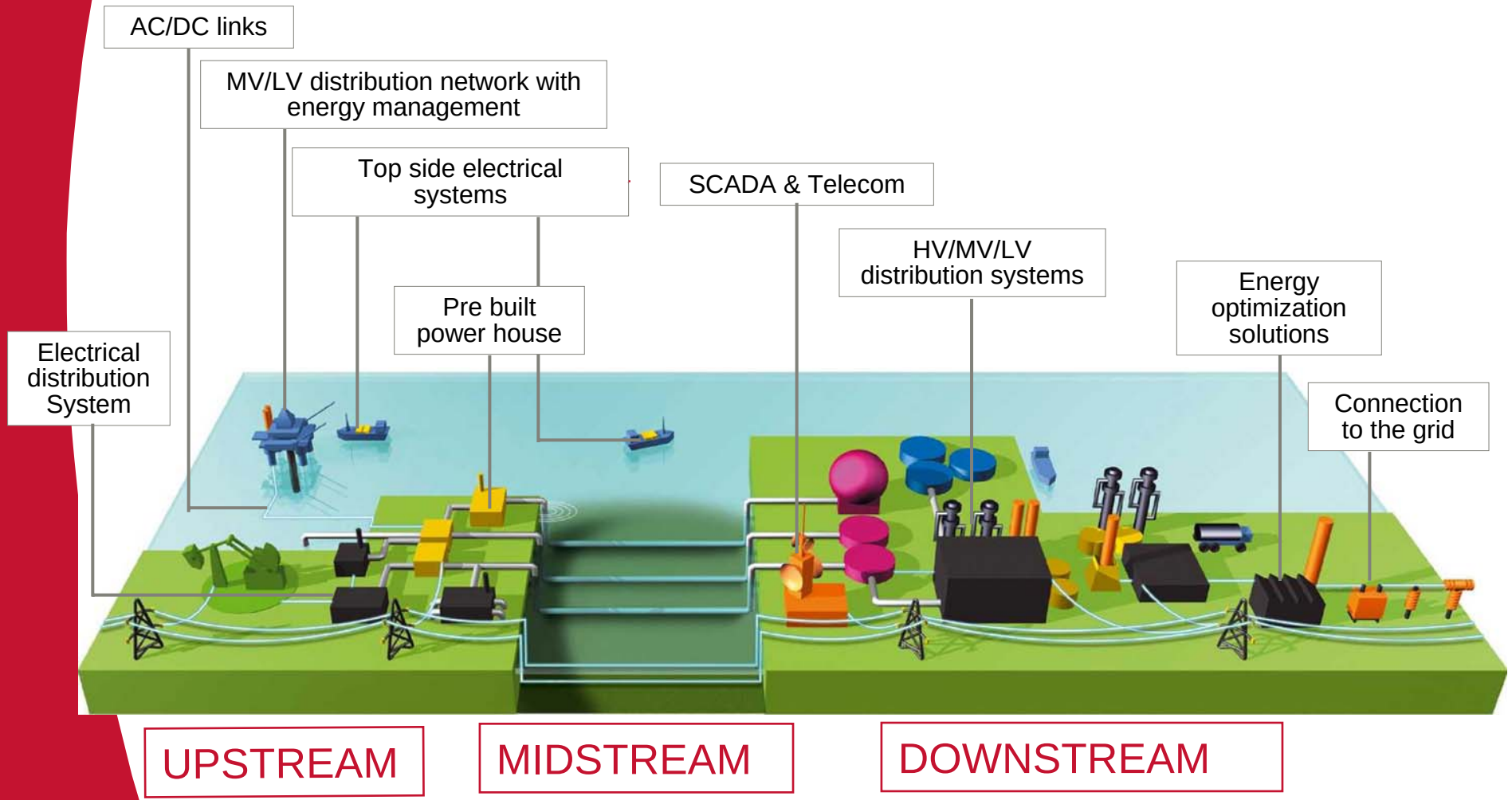
Distributed Application Perspectives (examples)



Innovation pipe

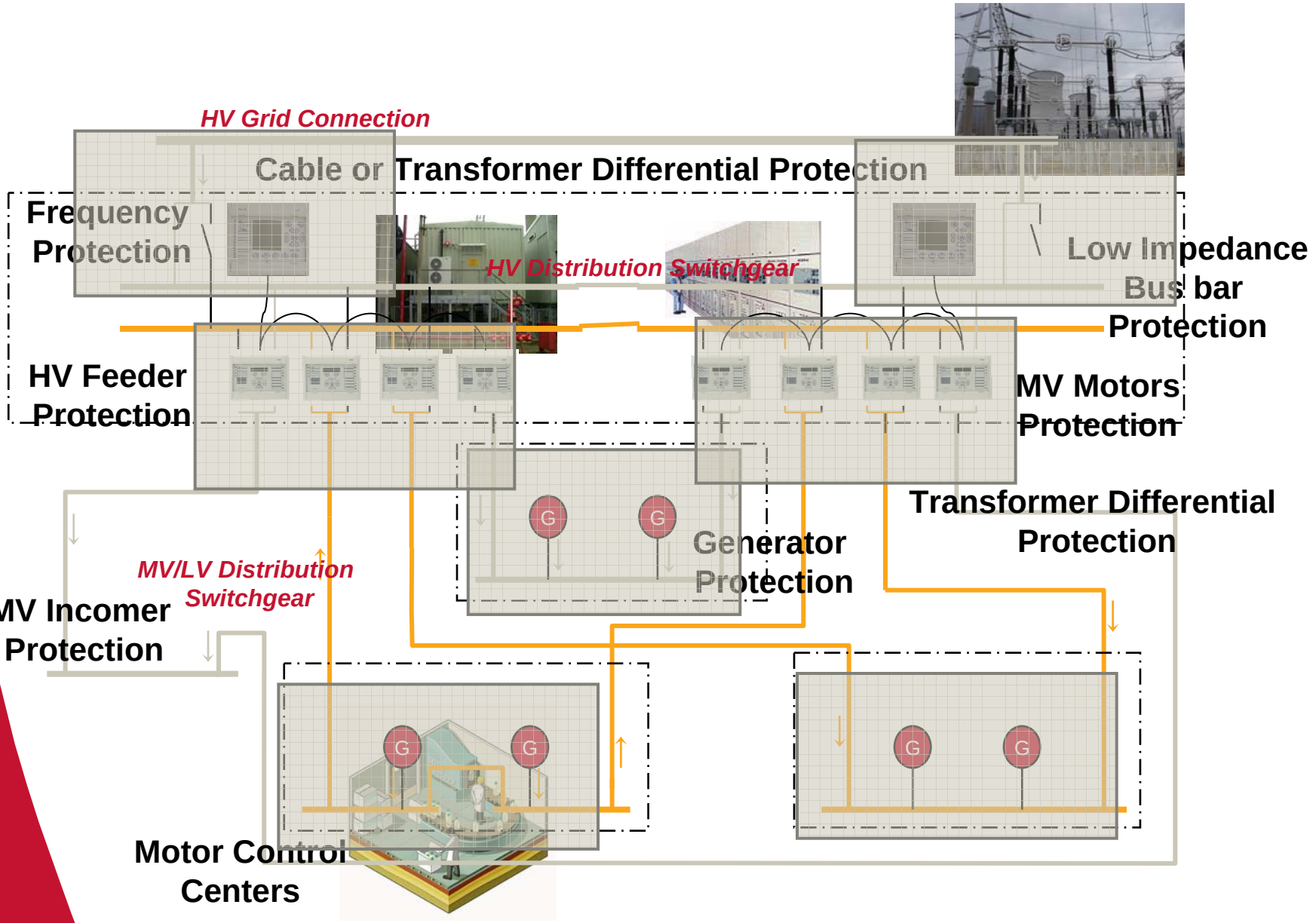
Technical Category / Maturity Stage		Concept → Application			
		IEC 61850 Standard	Base technology	Processes and tools	Application
Research ↓	Not yet there	Behavior configuration	PoE / Wifi	Performance modeling	Distributed synchro-check
	Preliminary stage	Bumpless redundancy	Cyber-security	Robust to change design	Grid automation
	Industrialization in progress	Edition 2	Process bus	Interoperability tests	Standard clients
Industrial	Mature phase	Edition 1	Station bus	Standard bays	Interlocking

Oil & Gas



We are covering a large scope of O&G field

Typical Large Onshore Oil & Gas Network Configuration

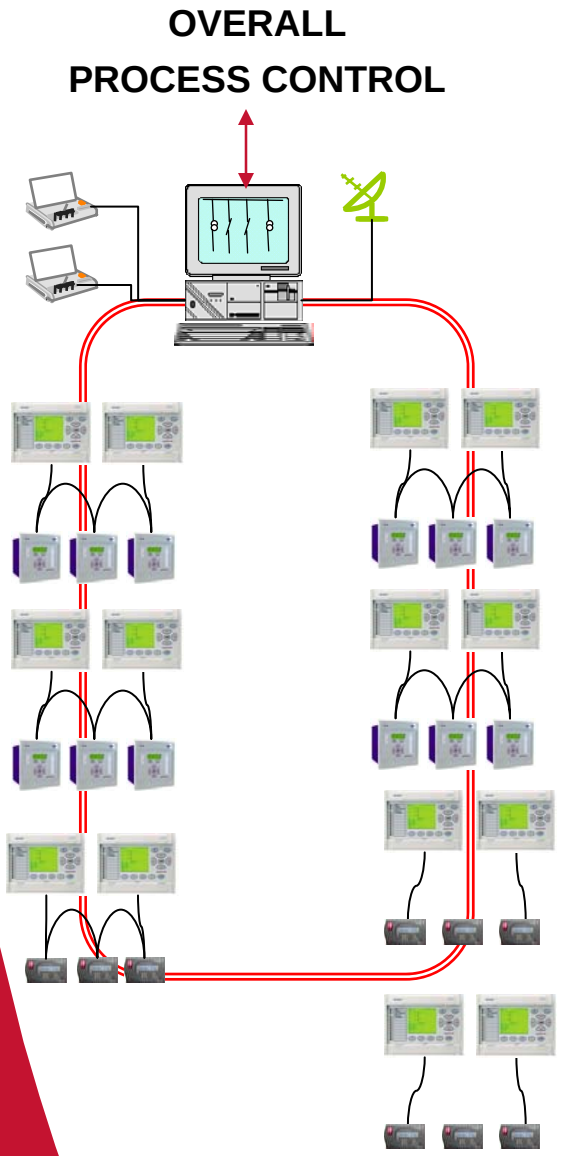


O&G Power Management System : Definition

- **The Power Management System (PMS) is part of the Energy Management System (EMS) in charge of the electrical supply of the O&G plant with the highest security and lowest interruption levels**

- **The PMS is directly part of the O&G plant permanent availability**

Monitoring and control system



Secure

- *Type tested with international utility standard including select before execute, interlocking, scalable redundancy, etc.*

Accurate

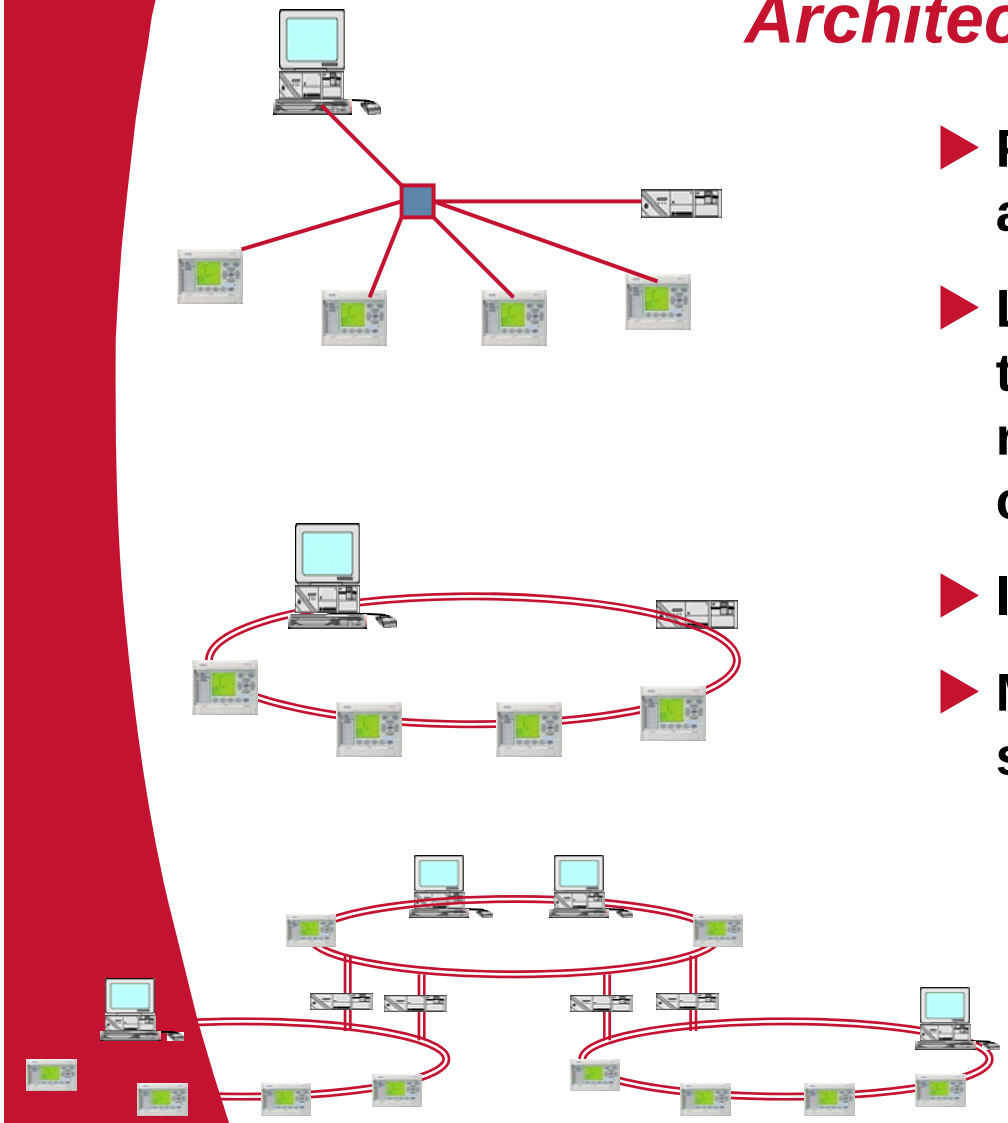
- *1 ms Sequence of Events, Automatic disturbance records upload, State of the art analysis tools.*

Standardization

- *Communication protocols, automation schemes, engineering processes*

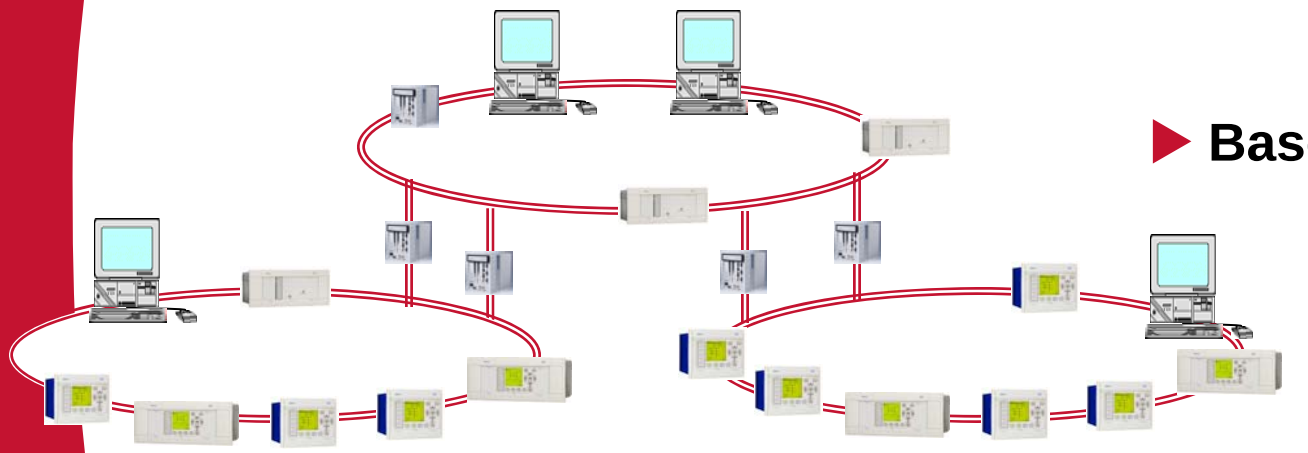
Get more than what the process control system provides

Monitoring and Control System Architecture Principle (IEC61850)



- Physical architecture is made of a star, single loop or multiple loops
- Loop is generally preferred since there is an in-built communication redundancy (self-healing) with no central switch extra-cost
- loop switch-over < 1 ms
- Multiple loops are used for large systems:
  - Performances
  - Project phases & installation constraints
  - Faults confinement
- Multiple loops are interconnected using proxy gateways

Power Management - Architecture



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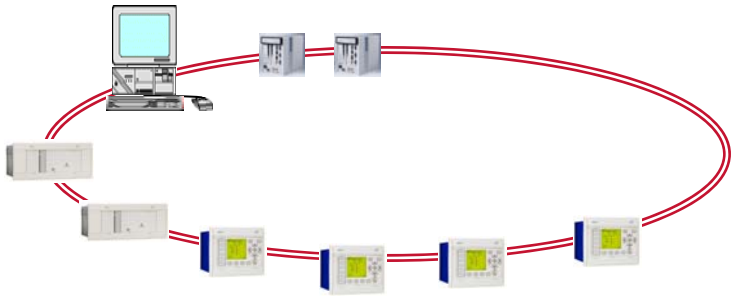
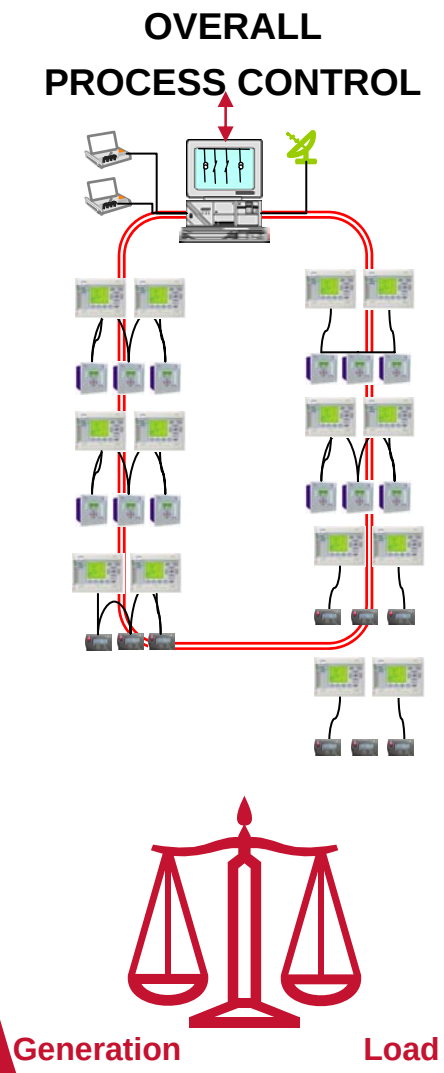


- Base architecture
- Dedicated load shedding network
  - One bay computer per generator and set of loads to be shed

Power Management - Functions



- Load sharing (active and reactive) between generators
- Islanding and reconnection (including synchronization)
- Fast load shedding in case of a sudden generator fault or grid weakness
- Load shedding simulation mode
- Motor start sequences
- Network simulation for contingency analysis

AREVA

Intelligent Load-Management
Load Shedding

T&D

Power Management - Fast Load Shedding

Base Sequence for each island

Spinning reserve calculation

Generator i fault simulation

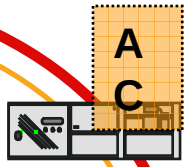
Impact on spinning reserve

Spinning reserve < 0

Load Shedding Level Pre-setting in case of generator i fault

Load Shedding Level Generator i

Spinning Reserve Exchanges



Generator Bay Computer

Load Shedding Level Generator i

Bay Computer

Bay Computer

Bay Module Preset Memory

Generator	Feeder 80-EE-XX	Feeder 80-EE-XX	Feeder 80-EE-XX	Feeder 80-EE-XX
G1	●		●	
G2				●
G3	●		●	
G4				
G5		●		
G6				●

Load shedding – Principle

Fixing the rules :

- The Operator fills the Priority Matrix according to the site process constraints.
- Each feeder is determined as sheddable or not in the FLS HMI.
- 64 FLS levels available
  - from 0 = Non Sheddable
  - to 64 = the lowest level or the first feeder to open)

		G101	G102	G103	G104	G105	G106
Substation 1	Feeder 1	X					
Substation 1	Feeder 2		X		X	X	
Substation 1	....						
Substation 1	Feeder ##		X				
Substation 7	Feeder 1				X		
Substation 7	Feeder 2		X	X	X		
Substation 7	....						
Substation 7	Feeder ##						
Substation 21	Feeder 1	X					
Substation 21	Feeder 2						X
Substation 21	....	X					X
Substation 21	Feeder ##						X
Substation 24	Feeder 1		X				
Substation 24	Feeder 2						
Substation 24	....	X				X	
Substation 24	Feeder ##			X			

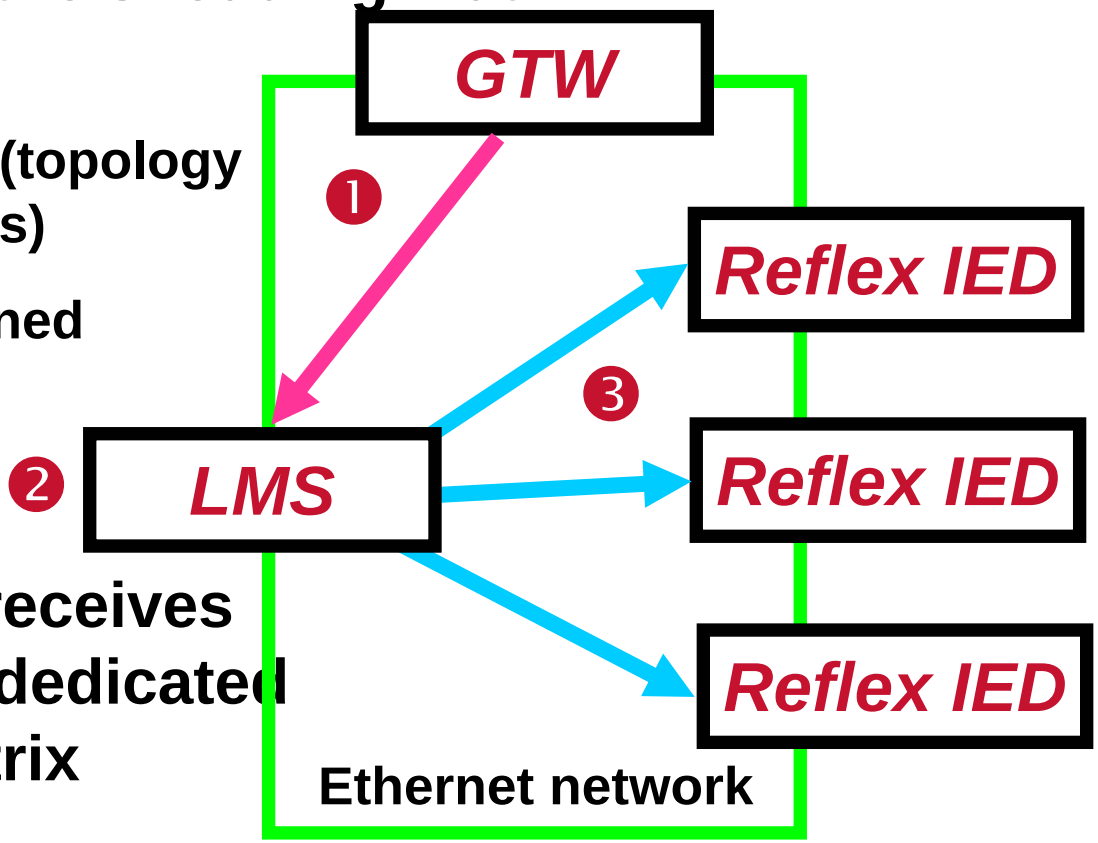
Load shedding – Principle

Automatic FLS update :

1. The topological and measurement data are collected by the LMS every 10s (average)

2. LMS recalculates the shedding matrix for all reflex IEDs
   1. The updated data (topology and measurements)
   2. The priorities defined by the operator

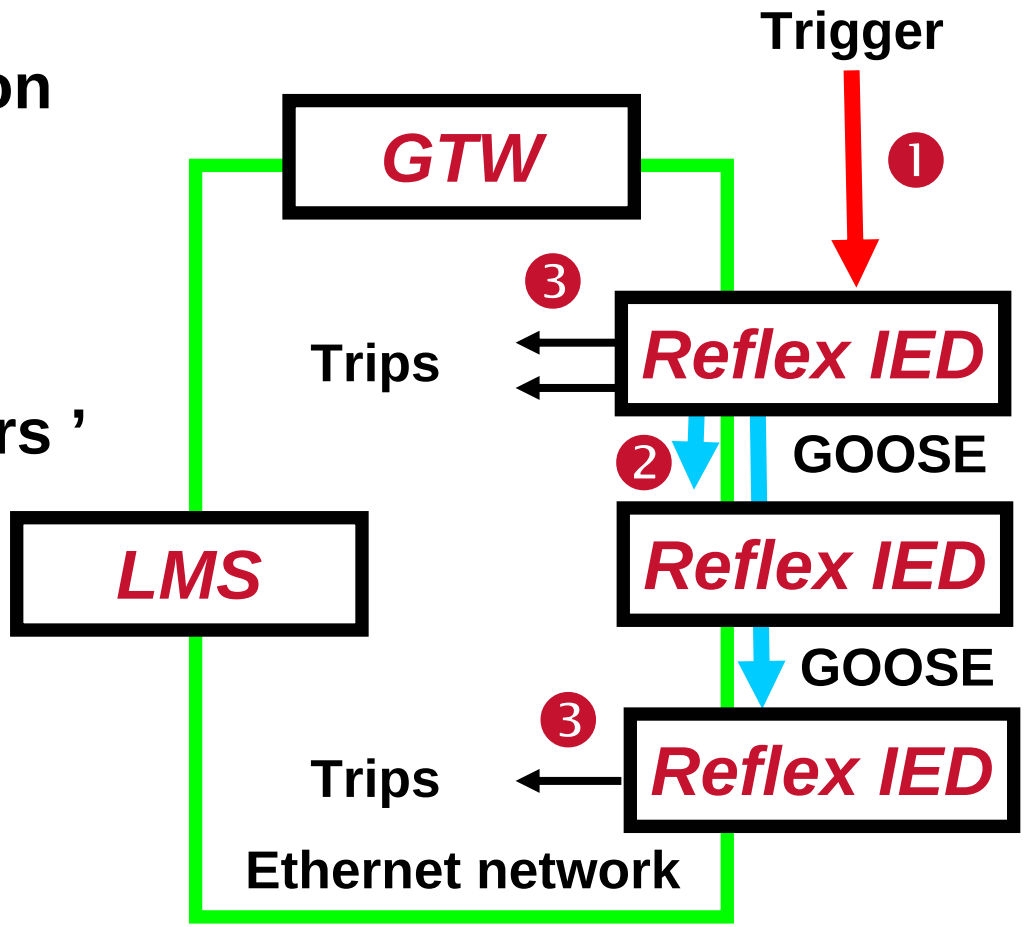
3. Every Reflex IED receives from the LMS the dedicated extract of the matrix



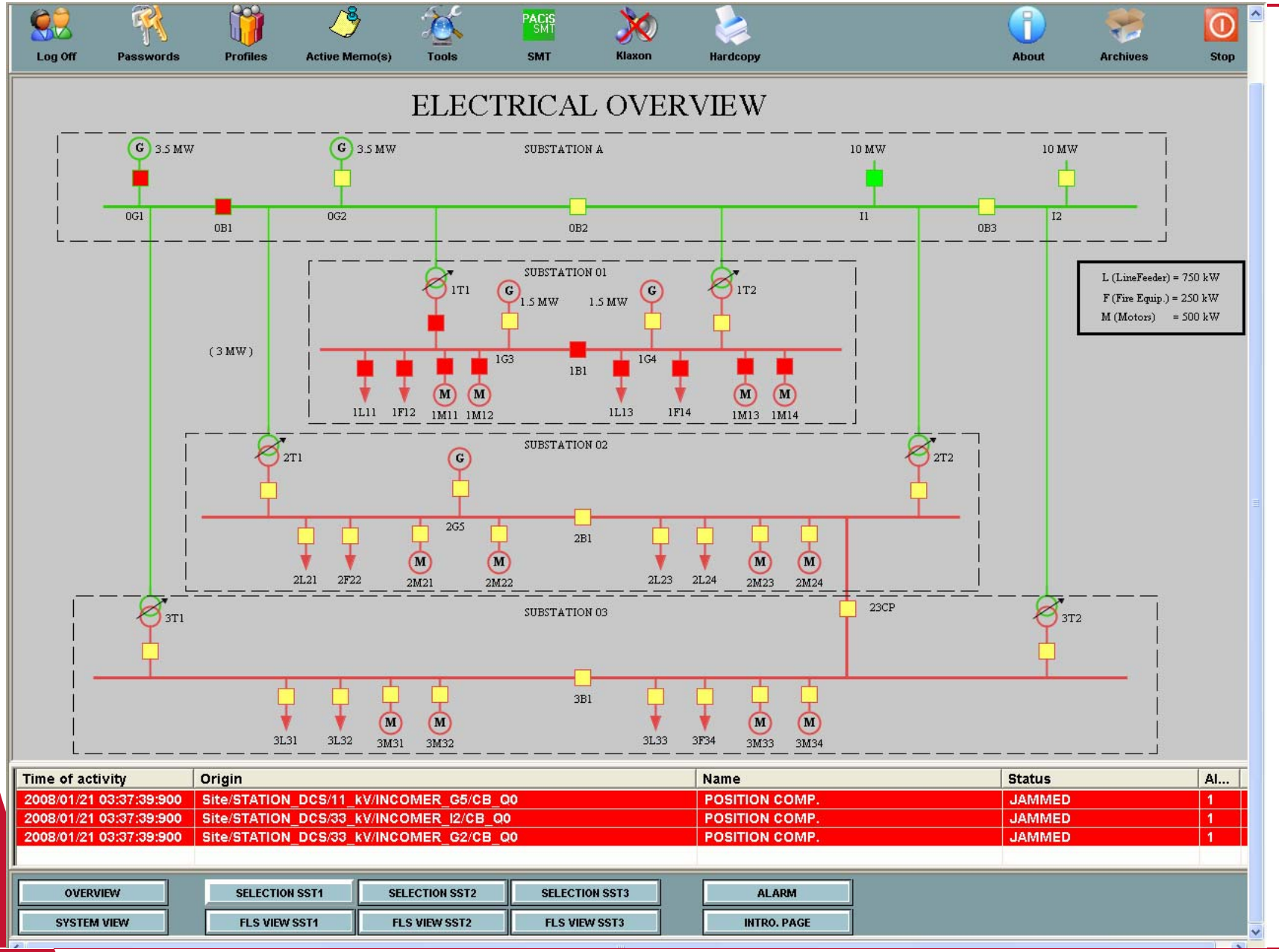
Load shedding – Loss of a generator

Fault happends

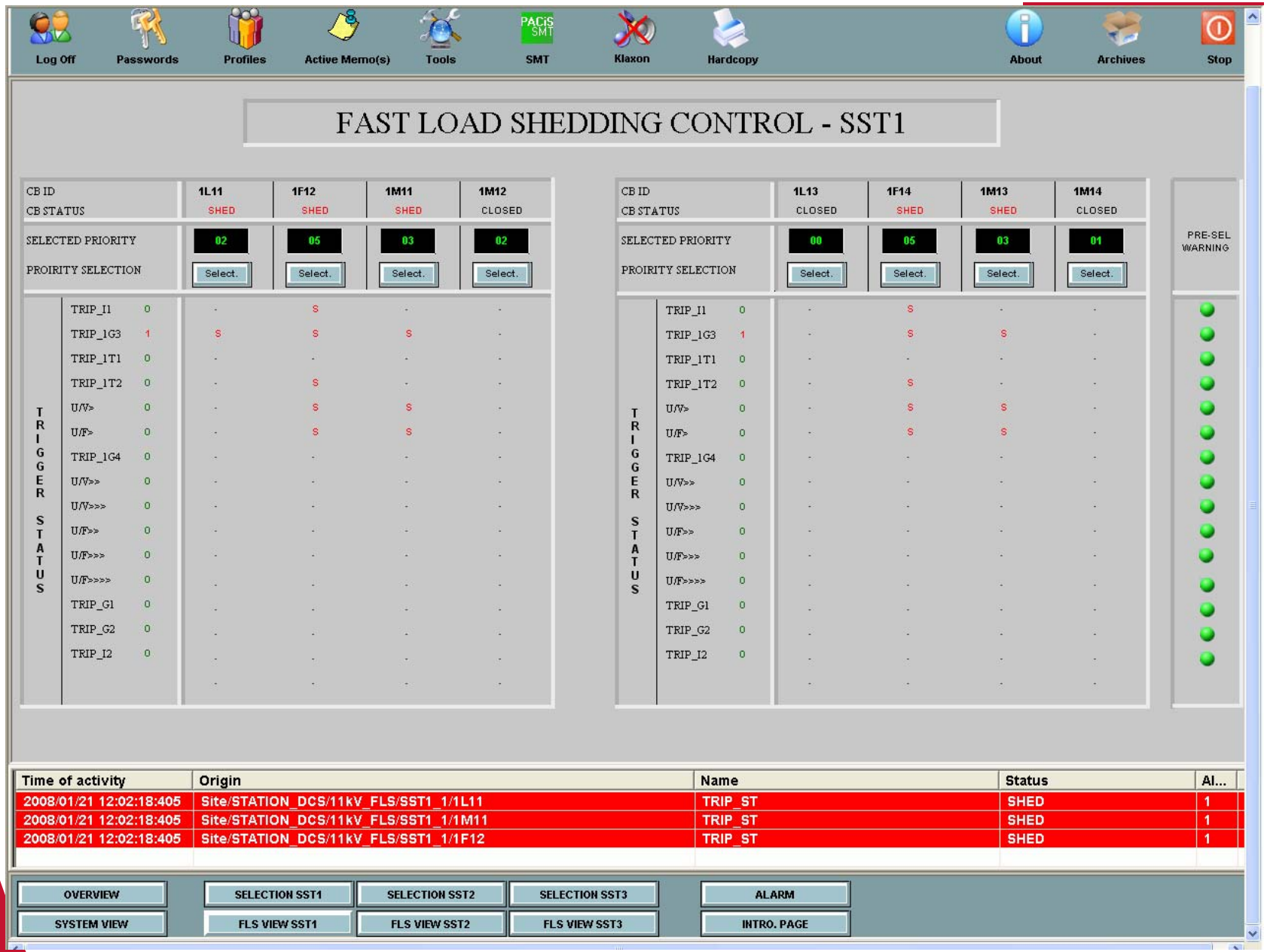
1. Generator fault is detected by CB associated trigger on a Reflex IED
2. Trip signal is broadcasted via GOOSE to all feeders ' IEDs
3. According to their database, proper feeders are load shedded



Load shedding – Operator view



Load shedding – Operator view



PROJECT DOLPHIN-PDCS ARCHITECTUR

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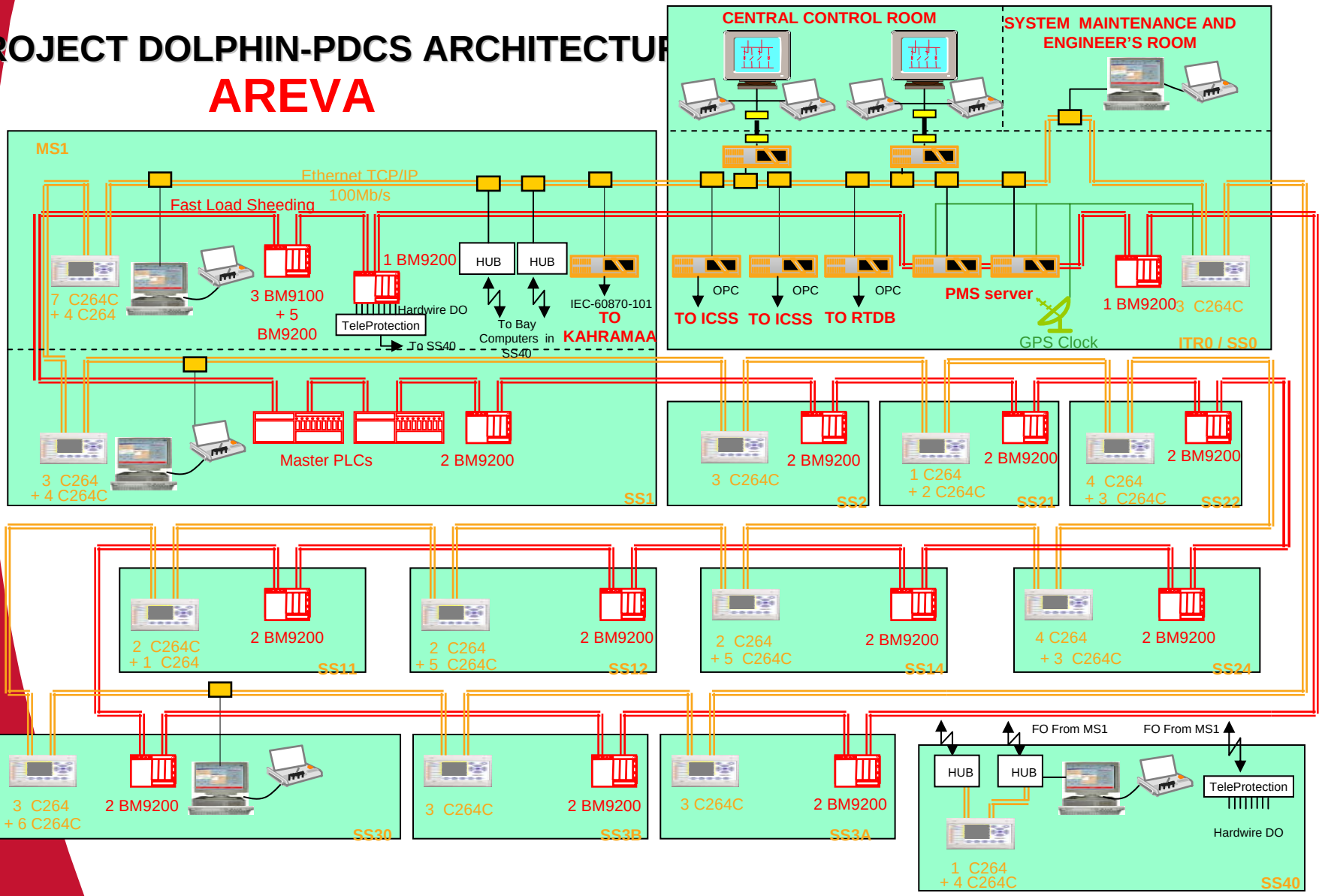
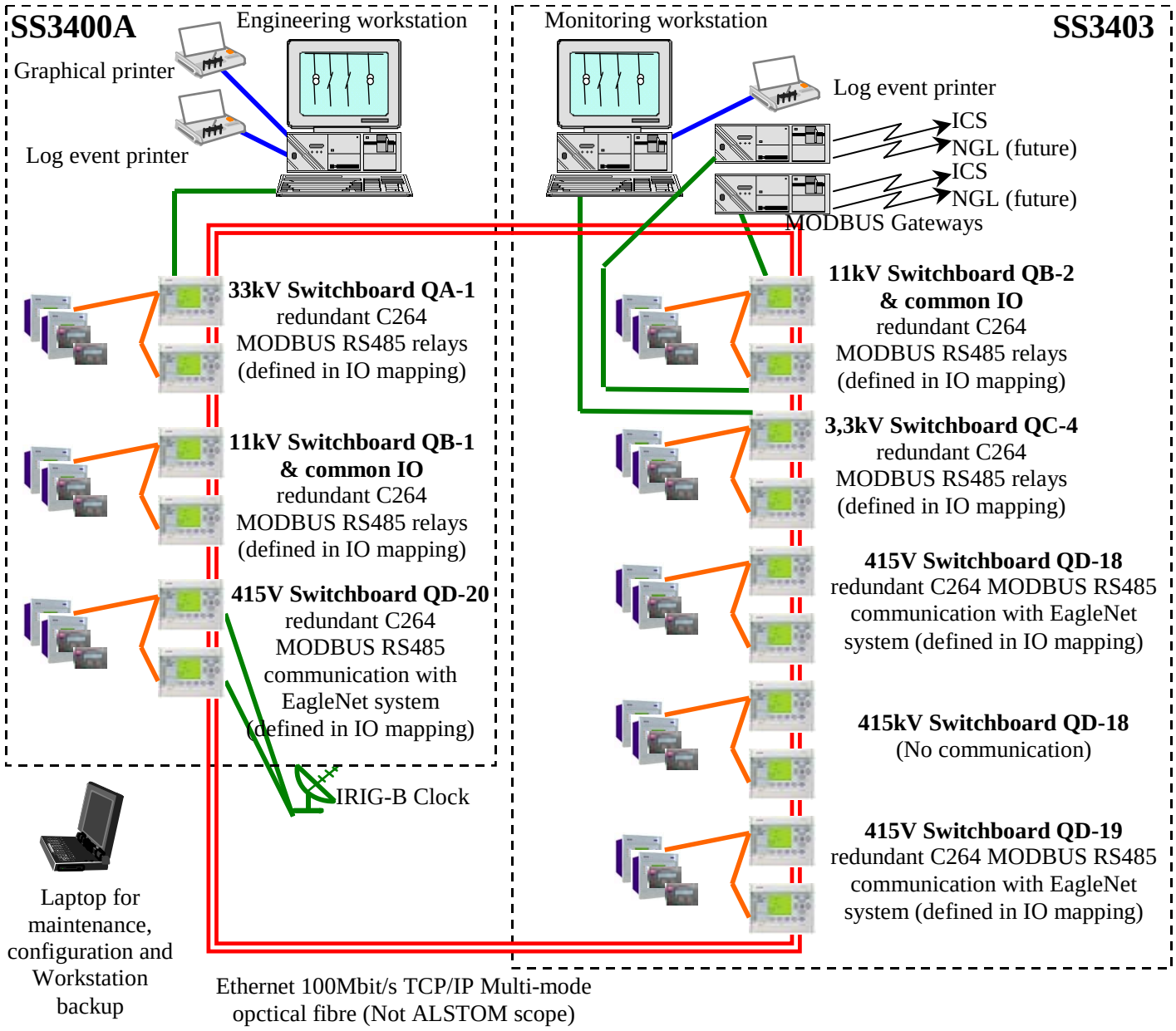


MESSAIED PDMS Architecture



Conclusion

- IEC 61850 offers fantastic opportunities for cost reduction and process improvement
- The current projects are first a copy of what has been done with the previous technology
- There is a need to change the traditional project engineering to fully and safely benefit from the new standard
- Like for most IT areas the architect role is likely to emerge, in addition to the system integrator

Thanks

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