About me, Andrea Bonetti

1993: Electrical Engineer from "La Sapienza" University, Italy, Rome

1993 - 1995: Relay Protection Engineer at ABB Relays **Italy**, Rome

1995 - 1997: Relay Protection Engineer at ABB Substations, **Italy**, Lodi (Milan)

1998 - 2007: Relay Protection Engineer at ABB Relays, Västerås, **Sweden** (HV Relay Manufacturer)

2008 - 2009: Product Manager for relay test sets and IEC 61850 equipments at "Programma", Täby, **Sweden**

2010 Relay Protection and IEC 61850 Specialist at STRI Västerås, **Sweden**





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About me, Andrea Bonetti

2011 ... 2013 Relay Protection Specialist:
Megger Sweden AB – **Sweden**

2013 Technical Manager Substation Automation at STRI
Västerås, **Sweden**

2014 Technical Manager FMTP Power AB
Sweden

From 2006 member of IEC Group TC 95 – MT4:
MEASURING RELAYS AND PROTECTION EQUIPMENT

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The IEC 61850 standard in Substation Automation

Main purpose of the standard is to achieve **interoperability** among different devices from different vendors within the same substation.

TR 61850-1 © IEC:2003(E)

The industry's experiences have demonstrated the need and the opportunity for developing standard communication protocols, which would support interoperability of IEDs from different manufacturers. Interoperability in this case is the ability to operate on the same network or communication path sharing information and commands. There is also a desire to have IED interchangeability, i.e. the ability to replace a device supplied by one manufacturer with a device supplied by another manufacturer, without making changes to the other elements in the system. Interchangeability is beyond this communication standard.

Interoperability is a common goal for electric utilities, equipment vendors and standardisation bodies.

In fact, in recent years several National and International institutions started activities to achieve this goal (see Annex B).

The IEC 61850 standard in Substation Automation

What is Substation Automation?

We need to know what we are talking about, in order to understand what needs to be standardized.

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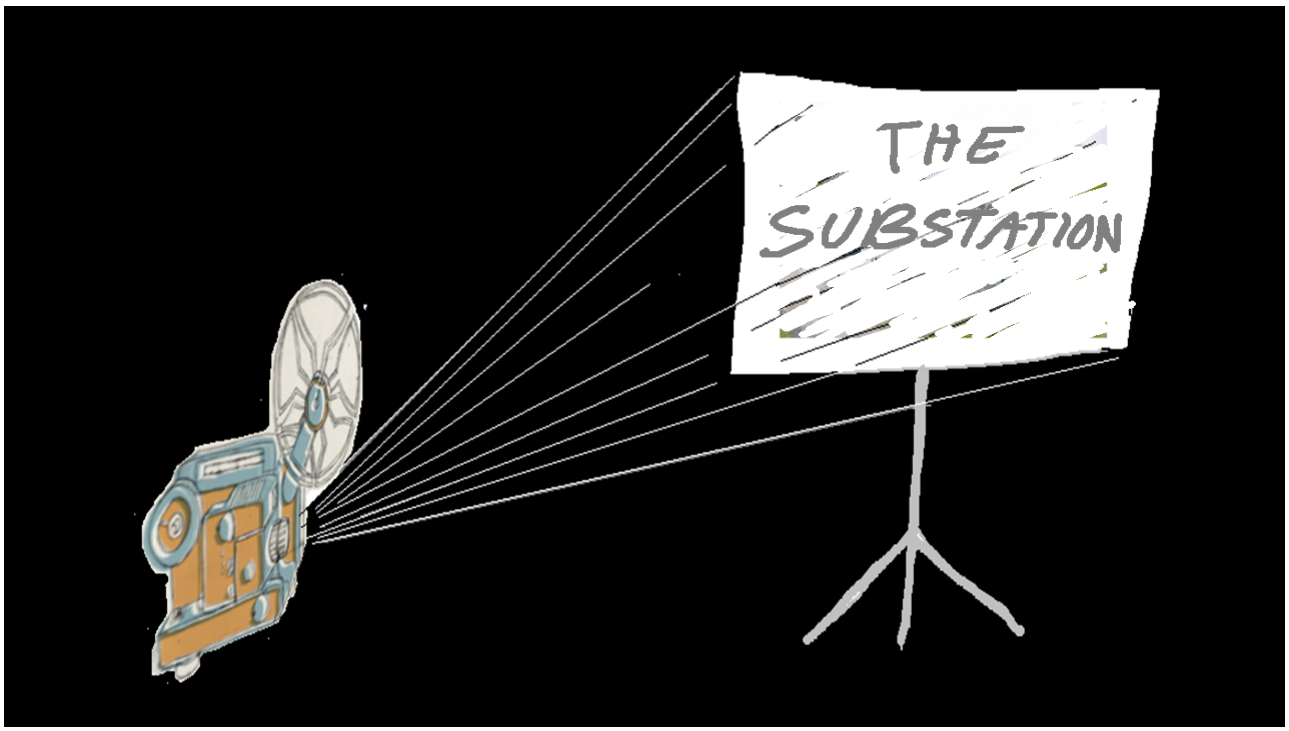
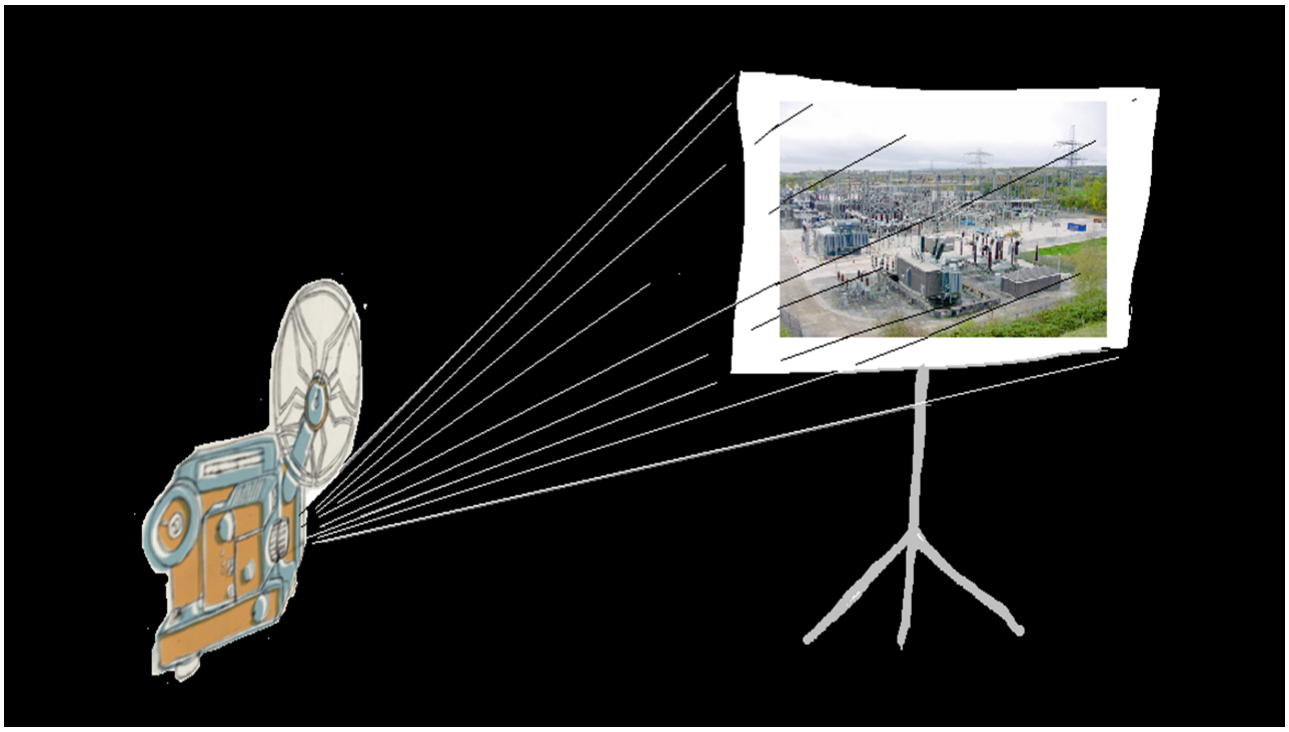
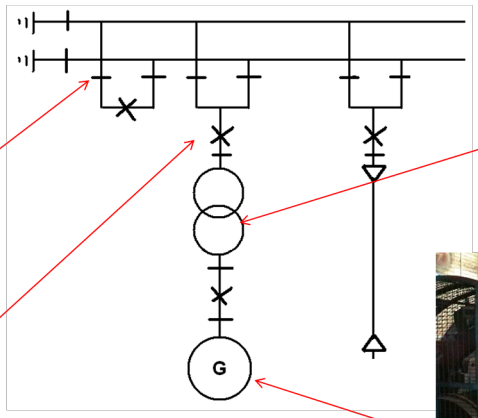
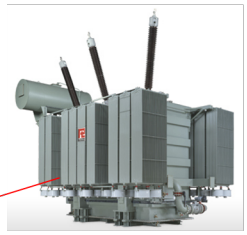


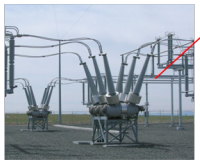


The power substation

In a substation there are Primary Equipments:







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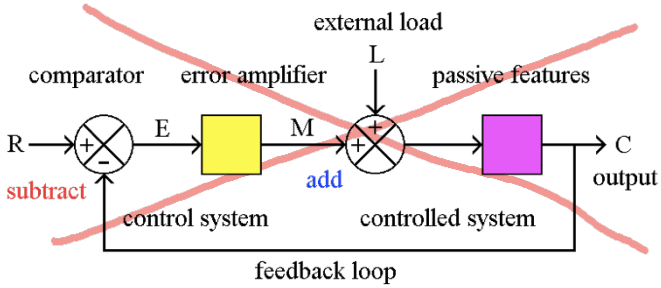
The power substation

The Primary equipments in the Substation need to be ”controlled”.

The word **CONTROL** in a substation has nothing to do with **Process Control**, where the word **CONTROL** is usually associated to ”**feedback systems**”:

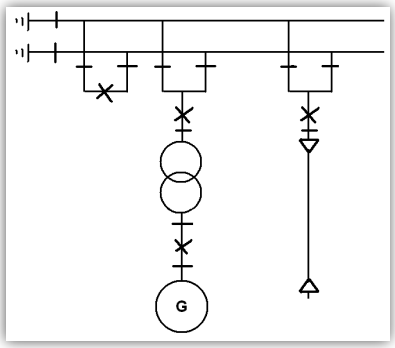


The power substation

In a substation, the power flow may need to be redirected.
Some part of the substation may need to be put out of service for maintenance.

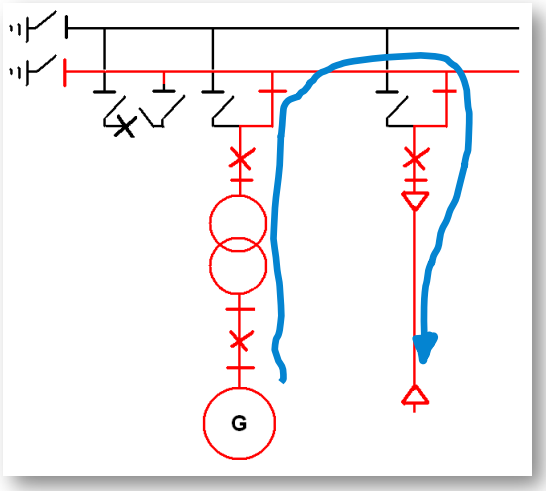
Circuit Breakers, Disconnectors (Isolators), Earthing Switches :
Open/Close

Power Transformar Tap Changers:
Move Up or Down



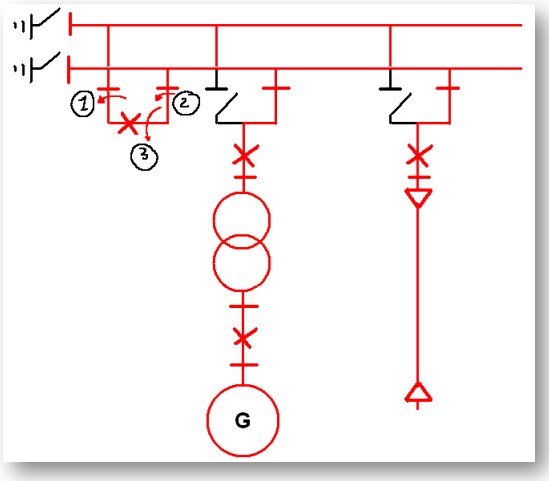
The power substation

Busbar change. Load is on Busbar 2



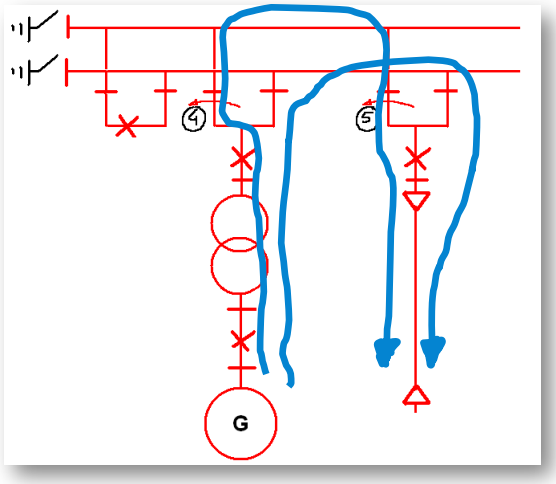
The power substation

Busbar change. Connecting Busbar 1 to Busbar 2



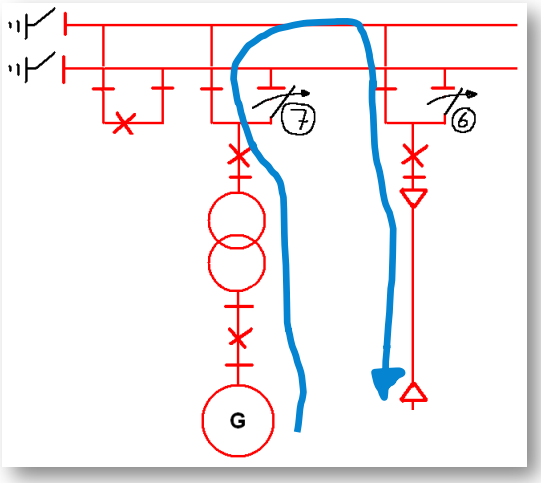
The power substation

Busbar change: Connecting the Feeders to Busbar 1



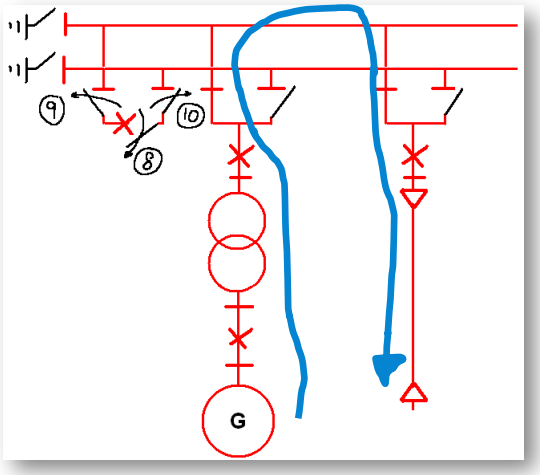
The power substation

Busbar change: Disconnecting feeders from Busbar 2



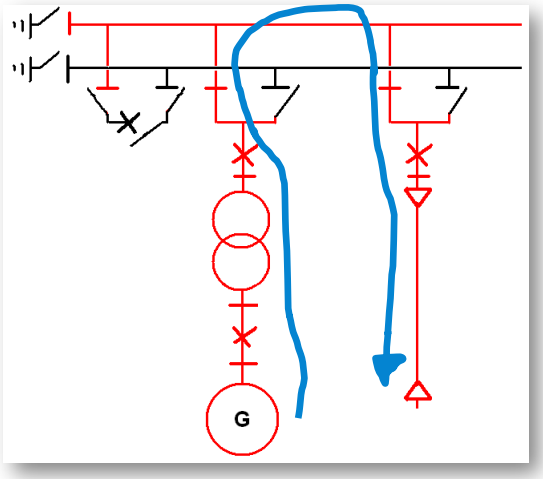
The power substation

Busbar change: Disconecting Busbar 2 from the system



The power substation

Busbar change. Busbar 1 in service



The power substation

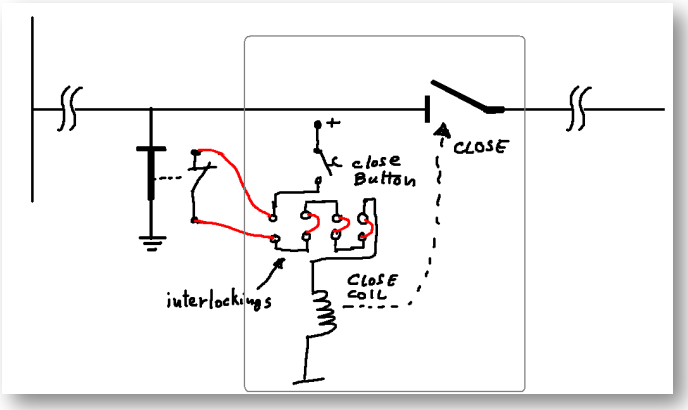
Maneuvering primary equipments is a delicated task.
Dangerous errors can occour, for personnel and equipments.
It must be clear for the operator **WHAT is open** and **WHAT is closed**. What **IS energized**, what **is NOT**.

To minimize the possibility to operate on the wrong equipments with the wrong conditions, **interlockings** are implemented in the substation.

The power substation

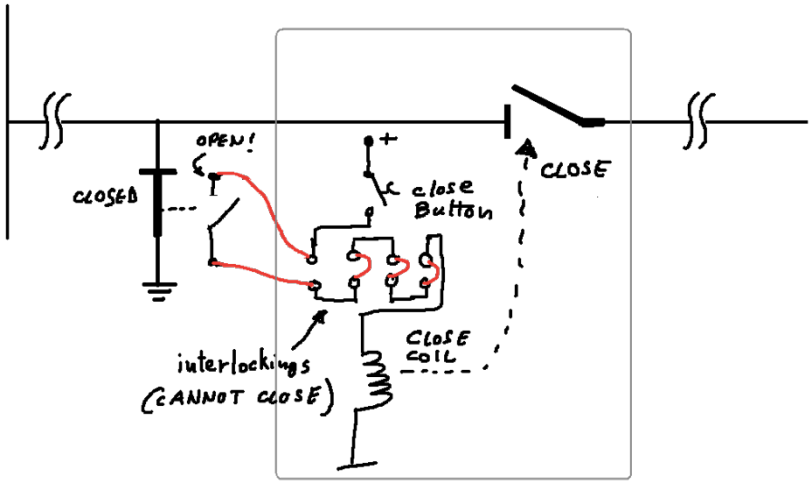
One very simple interlocking:
Earthing Switch and Disconnector

I **can** OPEN / CLOSE the Disconnector ONLY if the Earthing Switch is OPEN.
If the Earthing Switch is CLOSED I **cannot** operate the Disconnector.



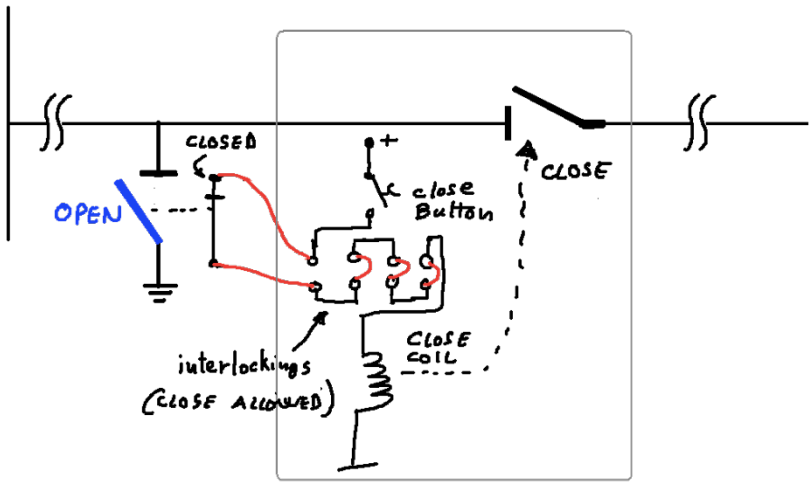
The power substation

EARTHING SWITCH CLOSED



The power substation

EARTHING SWITCH OPEN



The interlocking system

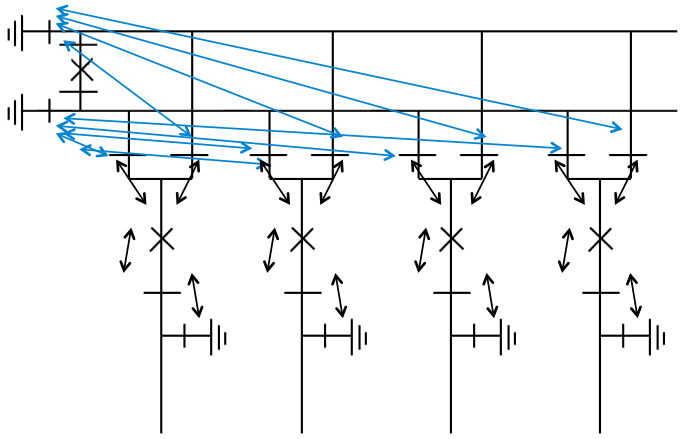
The interlocking rules are in principle simple, but once extended to the entire substation may result to be quite complex.

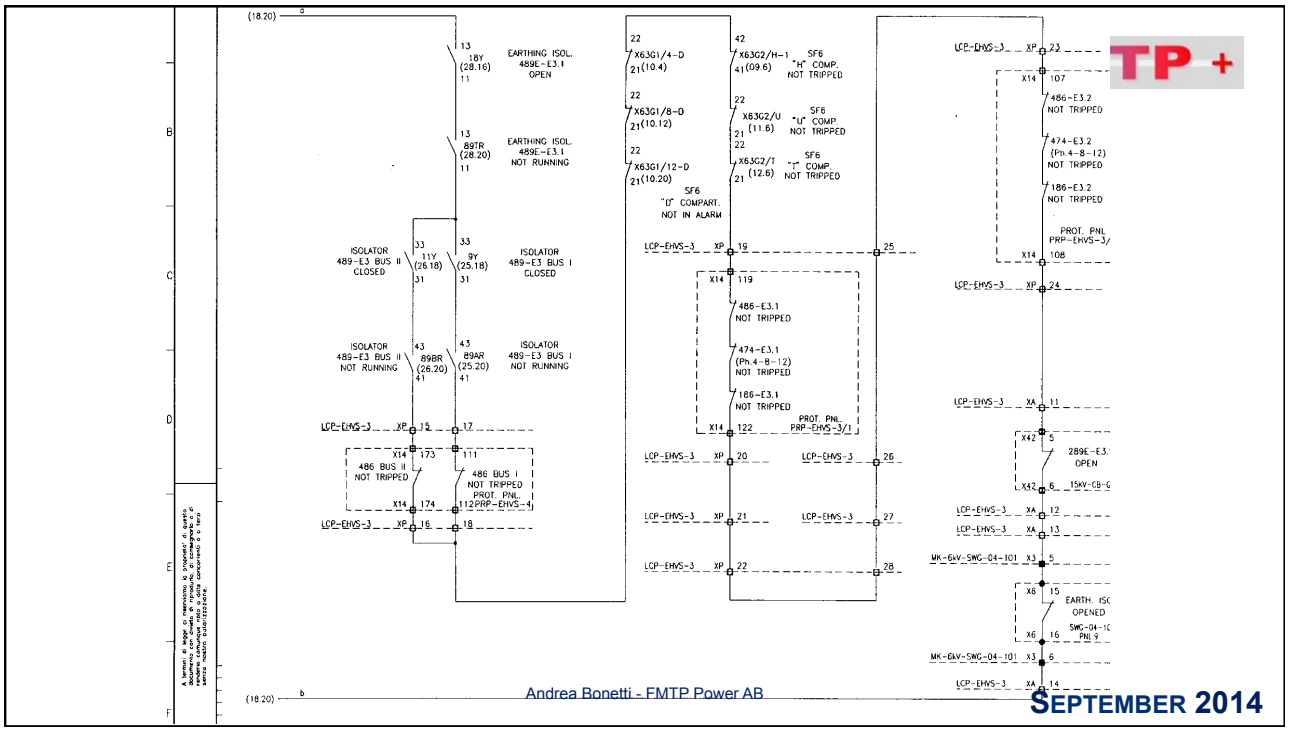
The interlocking system

A Local Action (open/close) may require:

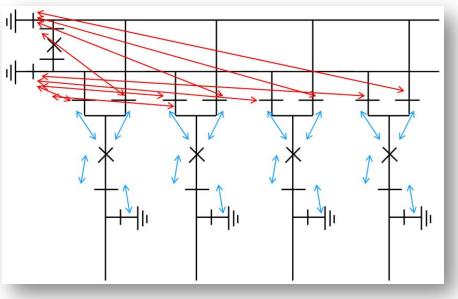
Local information (from the same bay)

Remote information (from different bays)

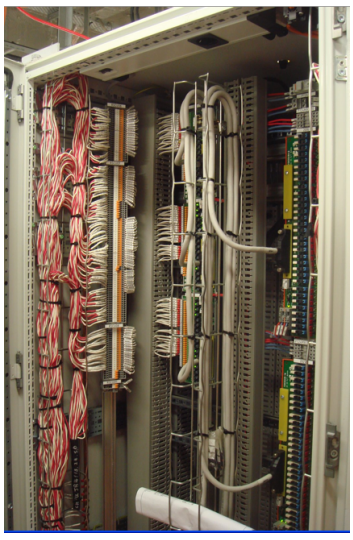


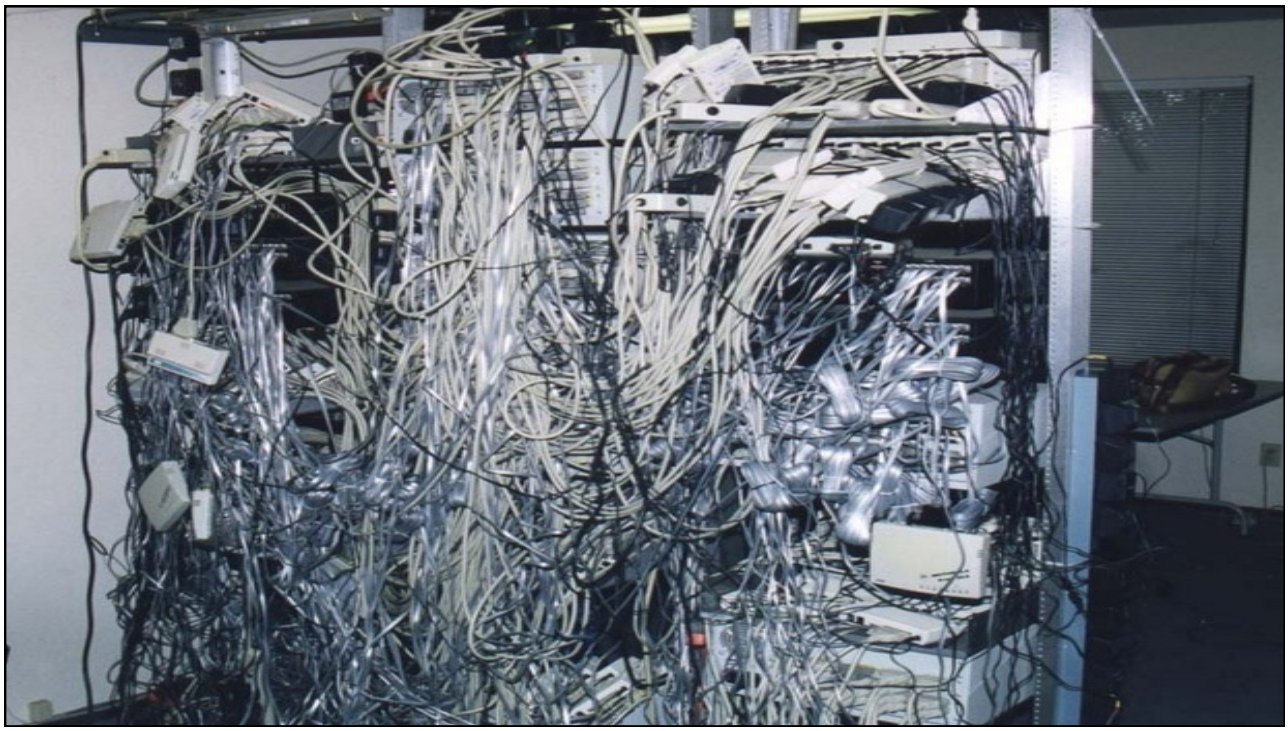


The interlocking system

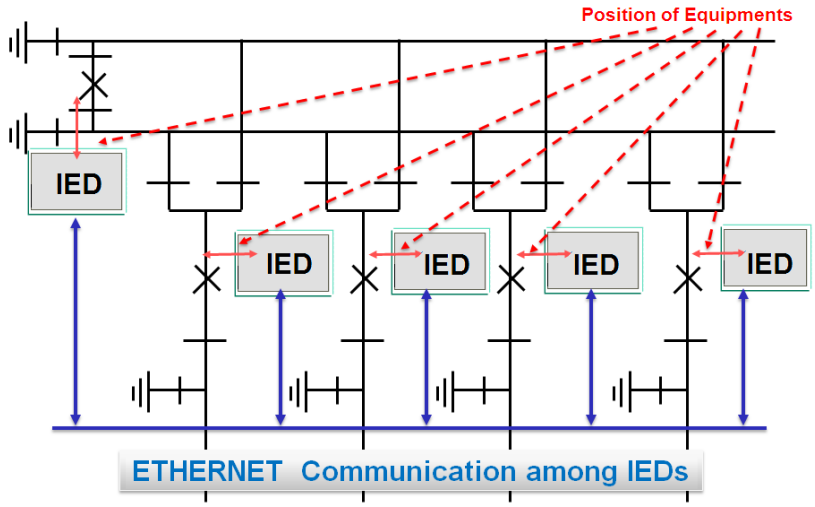


Information is exchanged with extensive cablage and often require the use of several auxiliary relays to multiply the limited amount of contacts (position) available from the primary equipments.





The IEC 61850 interlocking system



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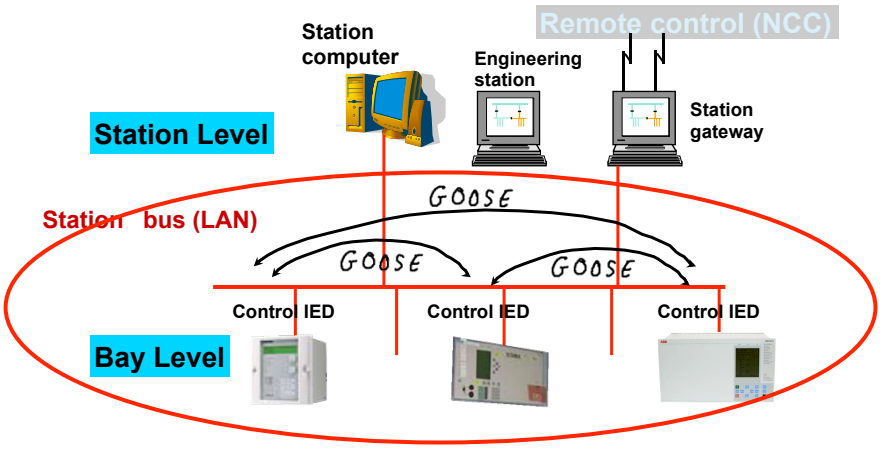
Control / Interlockings in the IEC 61850 substation



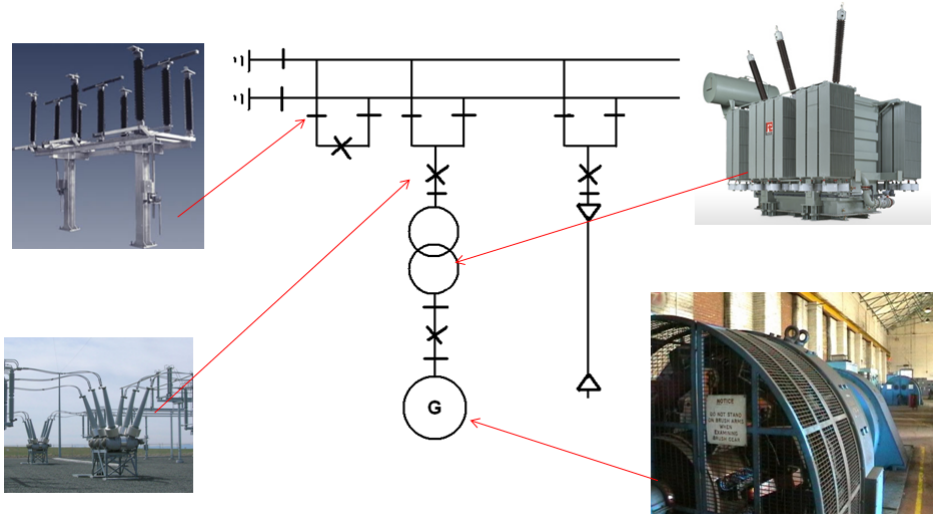
INTERLOCKING/CONTROL signals (CB and Disconnector Positions, reservation, etc.) are sent through the station bus.

Horizontal communication

IEC 61850 standard

The power substation

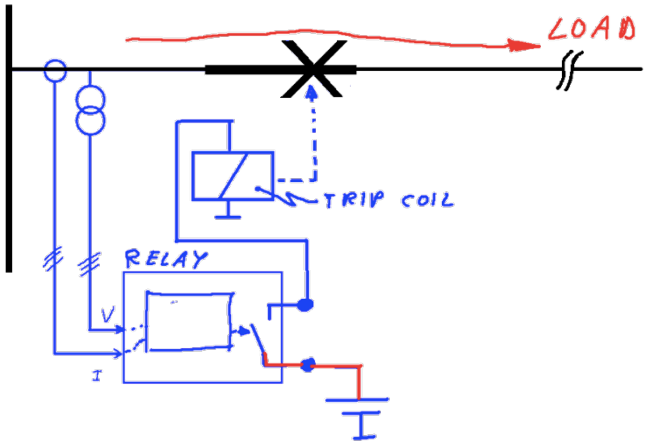
In a substation there are Primary Equipments…..



The power substation

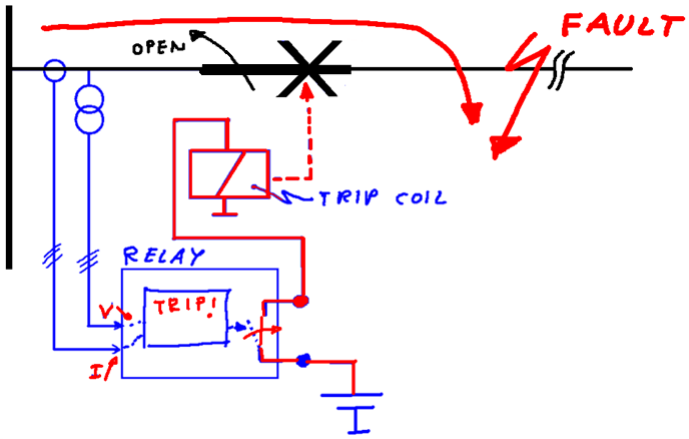
… that must be protected.

Protection relays



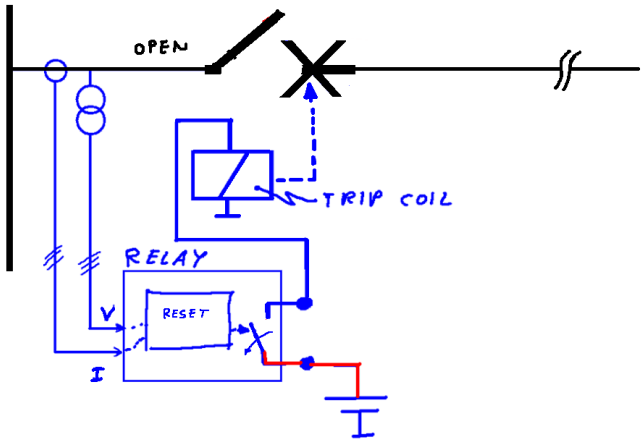
In a substation there are Secondary Equipments (Protection Relays). They monitor the electrical quantities of the protected system (voltages, currents) ….

Protection relays



… and based on ”protection algorithms” they decide that there is an electrical fault and issue the opening command to the circuit breaker

Protection relays



The circuit breaker opens and interrupts the fault current. The relay sees no fault conditions anymore and it resets. Circuit breaker remains open, the fault has been cleared.

The protection system

Sometimes protection relays need to talk together.
Usually this is done to speed-up the fault clearing time or to achieve a better knowledge on where the fault is positioned (selectivity)

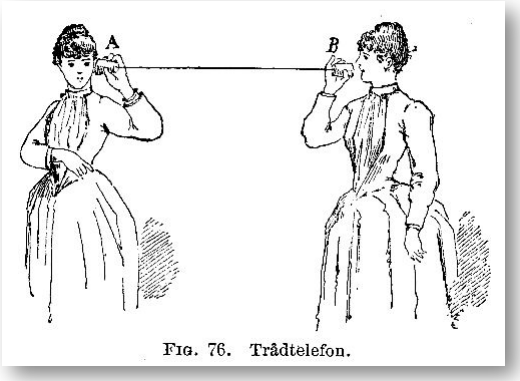
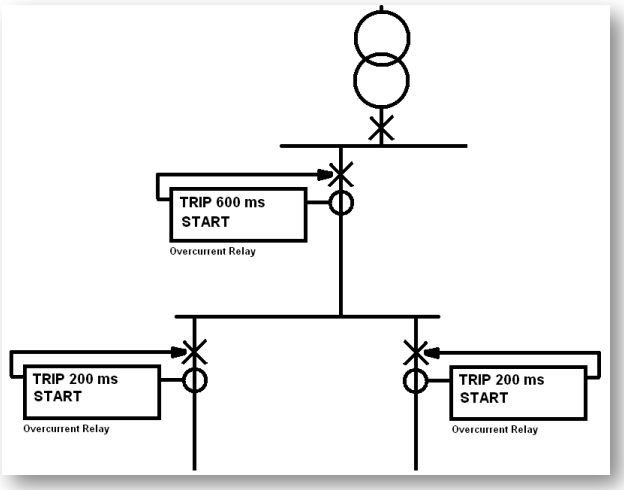


Fig. 76. Trådtelefon.

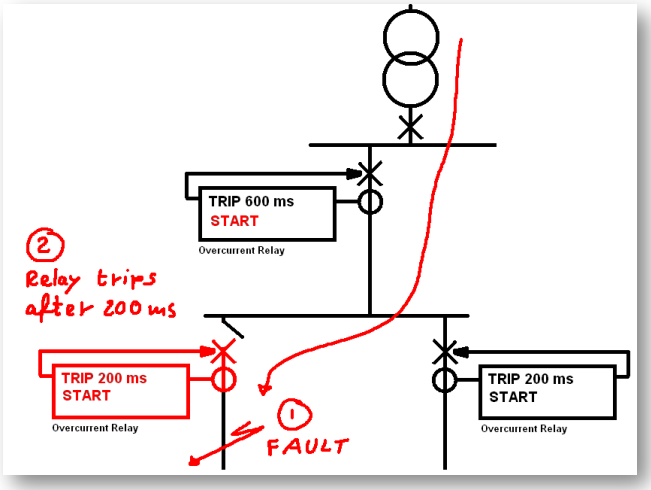
The protection system

Radial Feeders: No communication



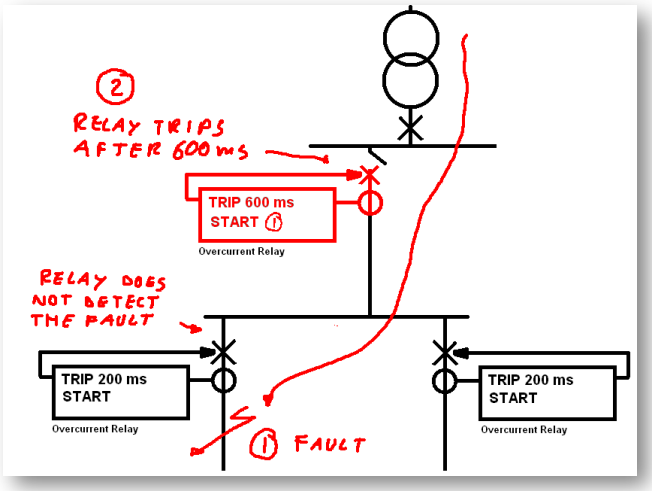
The protection system

Radial Feeders: No communication



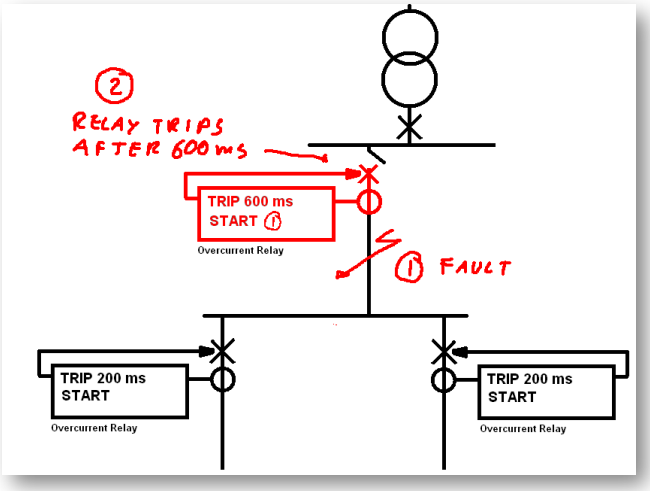
The protection system

Radial Feeders: No communication



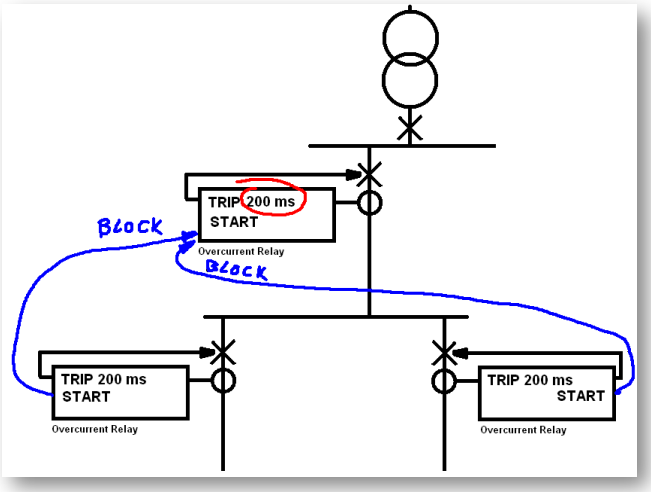
The protection system

Radial Feeders: No communication



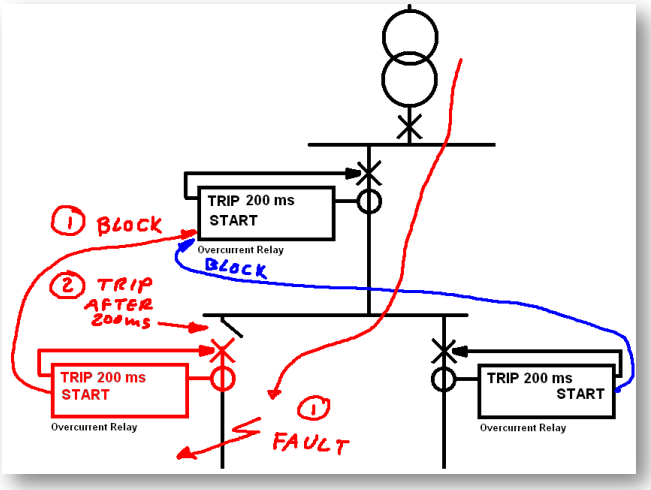
The protection system

Radial Feeders: Communication



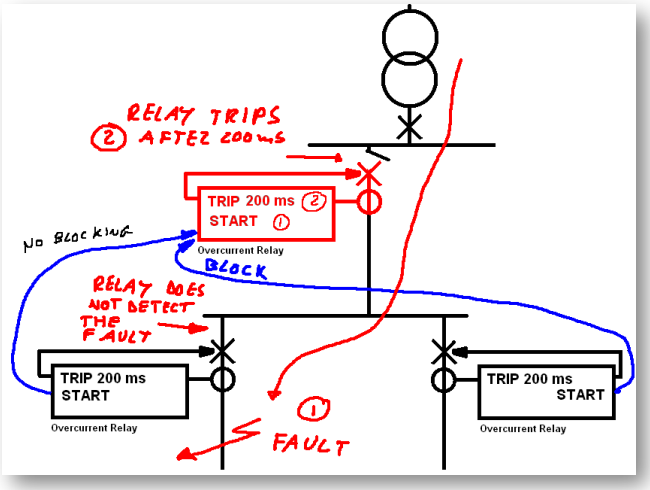
The protection system

Radial Feeders: Communication



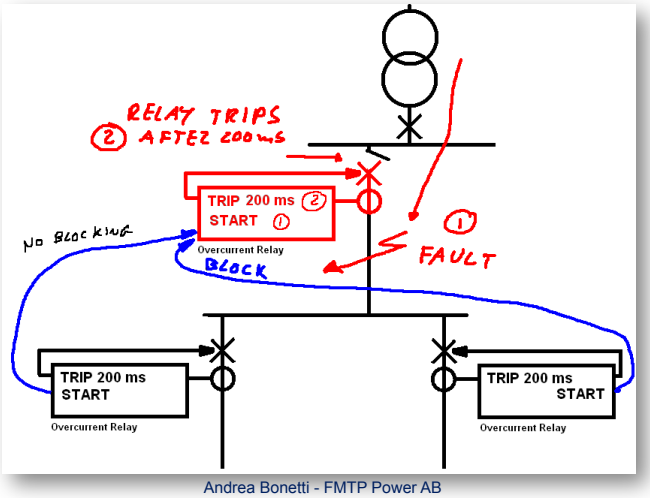
The protection system

Radial Feeders: Communication

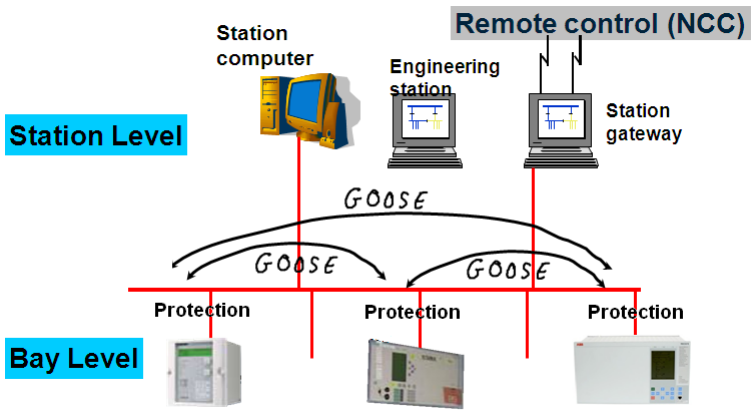


The protection system

Radial Feeders: Communication



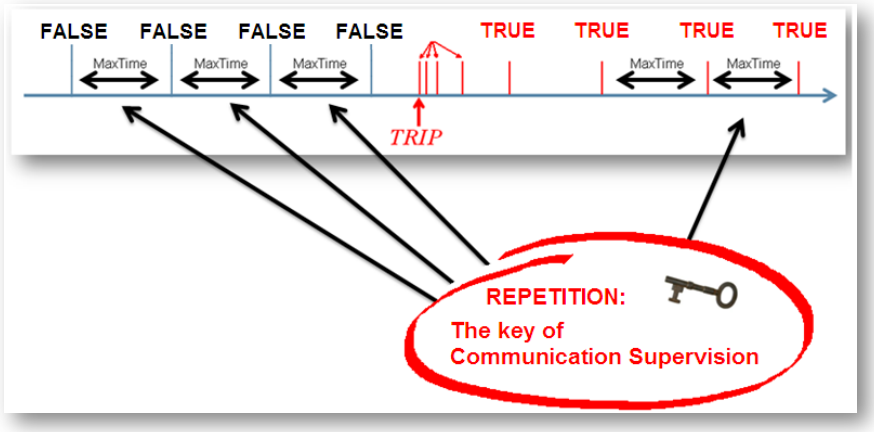
The IEC 61850 protection system



PROTECTION signals (Trip, Block, Acceleration..) are sent through the station bus.
Horizontal communication

GOOSE MESSAGE communication supervision

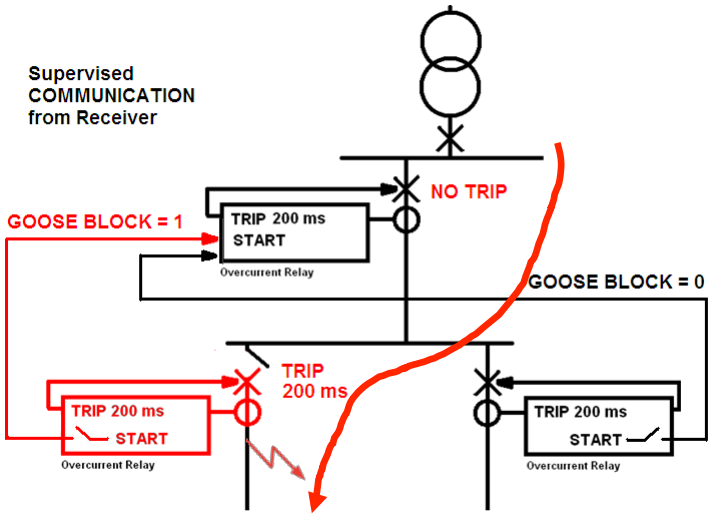
The GOOSE message is repeated with a certain strategy allowing the **supervision** of the Horizontal Communication.



The IEC 61850 protection system - security

- FMTP +

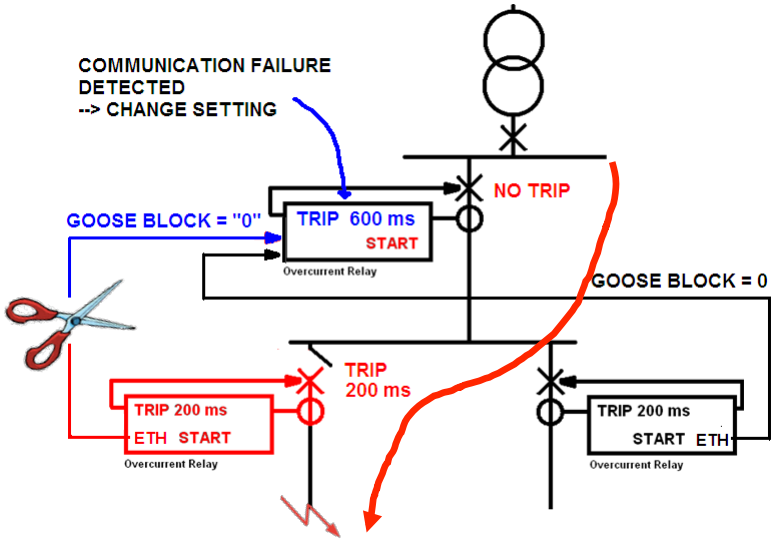
Upstream Blocking with GOOSE Technology



The IEC 61850 protection system - security

- FMTP +

Upstream Blocking with GOOSE Technology



GOOSE MESSAGE

The GOOSE message is the standardized digital message by the IEC 61850 standard (IEC 61850-8-1).

GOOSE means: **Generic Object Oriented System Event.**

GOOSE is a unacknowledged multicast message, sent through the Ethernet network.
The GOOSE message is not based on IP Addressing

The GOOSE message is ”originated” (engineered) in the SCL files, that are used to instruct the IEDs about what messages they have to send (**GOOSE Control Blocks** and **Datasets**) and to receive (**Input Section**).

To **SEND** a GOOSE message → To **PUBLISH** a GOOSE message

To **RECEIVE** a GOOSE message → To **SUBSCRIBE** to a GOOSE message.

The IEC 61850 protection system - availability

Transfer time measurement for protection relay applications with the IEC 61850 standard

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Abstract— **This paper describes a practical method to verify the GOOSE performances of IEC 61850 protection relays. With reference to a breaker failure protection situation, one protection IED sends a direct intertrip command to another protection IED. The tests performed measure and compare the total operate time of the direct intertrip relay application implemented with GOOSE technology and with conventional technology. Measurements of the partial times in the system chain suggest an additional test method - compared to the so called ping pong time (or loop back time) - that could give IEC 61850 GOOSE information that more related to relay protection applications.**

Keywords - Performance Recommendations for IEC 61850 Applications; Methods to Evaluate Transfer time; Comparison of GOOSE technology with conventional technology; GOOSE Performance test

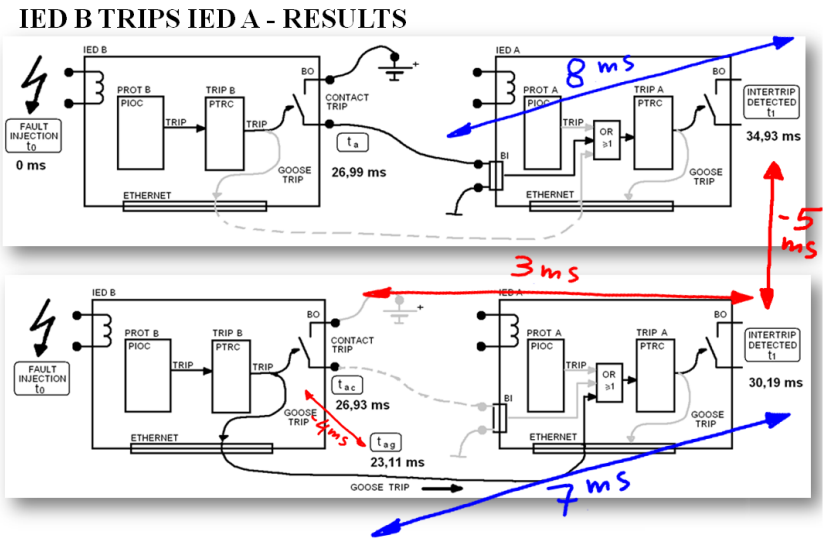
I. INTRODUCTION

The international standard for power utility automation, IEC 61850, has quickly been established in the substation engineering for several applications like vertical communication (reporting) to Station HMI and horizontal communication (GOOSE) among Intelligent Electronic

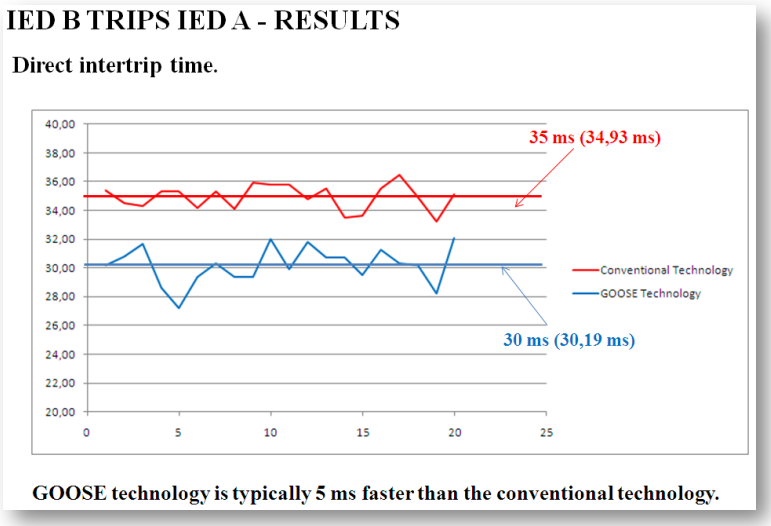
Message type	Performance Class	Type/Kind of signal	Transfer Time
Control and protection	P1, typically distribution bay	1A, Trip signal 4, Sampled values 1B, command and other fast messages	10 ms 10 ms 100 ms
	P2, typically transmission bay	1A, Trip signal 4, Sampled values 1B, other fast message	3 ms 3 ms 20 ms
	P3, bay with synchronizing or breaker differential	Same as for P2 above	

TABLE I: Performance requirements for different signal types according to IEC 61850-5. Partial table

Comparison "Conventional – GOOSE"



Comparison "Conventional – GOOSE"

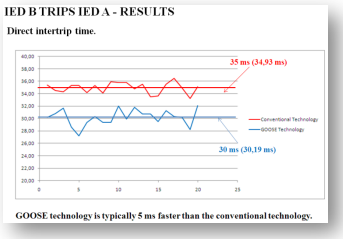


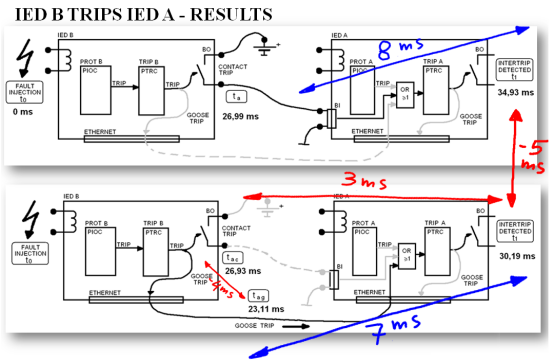
Comparison "Conventional – GOOSE"

Interest in GOOSE has been focused on the AVAILABILITY of the protection system

Several papers and discussions have drawn the attention on the GOOSE transfer time, GOOSE communication reliability etc.

The attention is naturally drawn to the availability of the numerical (IEC 61850) protection system compared to the conventional tehcnology





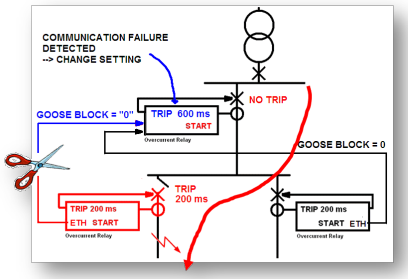
Comparison "Conventional – GOOSE"

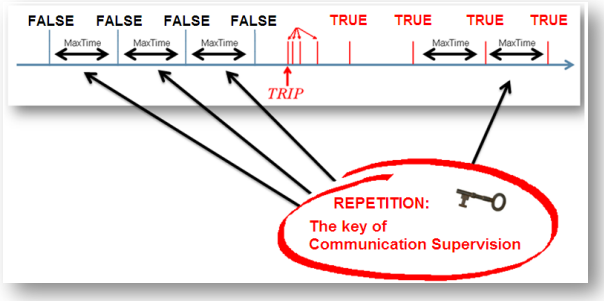
GOOSE increases the SECURITY of the protection system

Comparing the security of protection schemes with conventional technology and numerical technology (GOOSE), we see that GOOSE offers the possibility to **increase the security** of the protection schemes

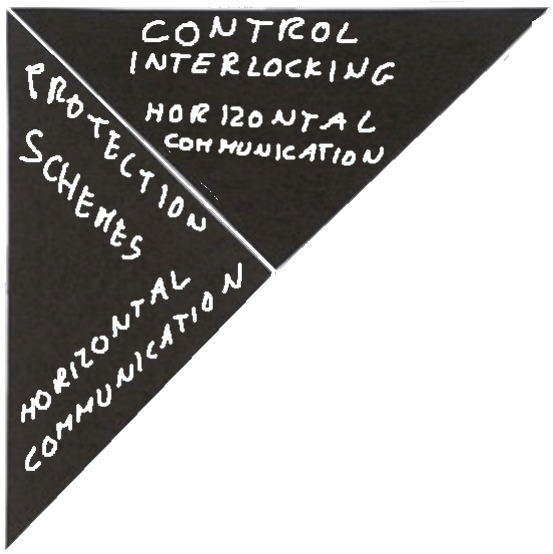
Communication Supervision
At the Receiving IED

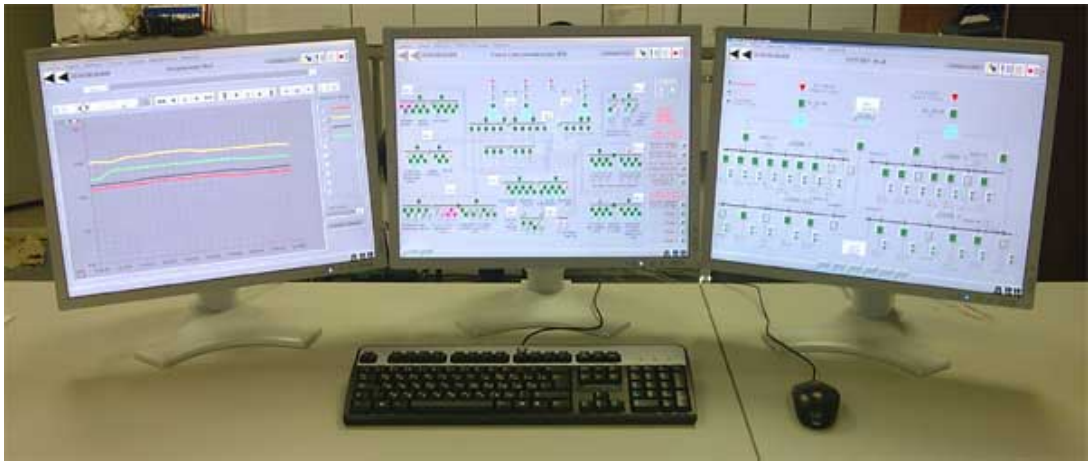
It Requires Engineering!





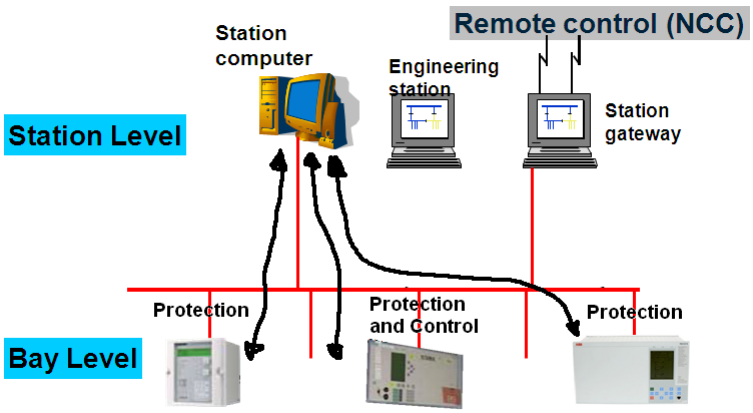
IEC 61850 standard





Andrea Bonetti - FMTP Power AB
SEPTEMBER 2014

IEC 61850 APPLICATION: REPORTING TO SCADA / RTU



IEDs from different vendors can **exchange and use information** over a common communications media. No need to have protocol converters.
Reporting: **Vertical Communication**.

HMI/SCADA Communication

Communication between station level and bay level devices uses services defined in IEC 61850-7-2.

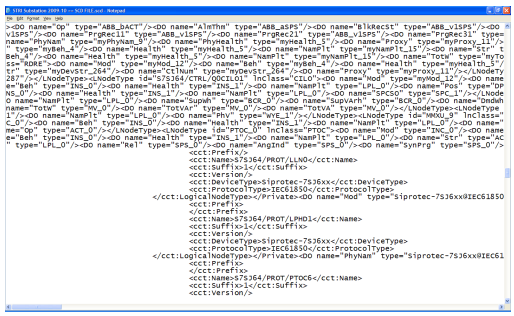
- These include:
  - **Control** (operating of primary objects, Commands)
  - **Reporting of events** (MMS, Report Control Blocks)
  - (Logging)
  - (Statistical data)
  - **Disturbance files upload** (ftp, COMTRADE)

- All these services:
  - Use Ethernet TCP/IP
  - Are base on client-server-communication

This is Client/Server communication.
"High Level" TCP-IP communication, based on IP Address

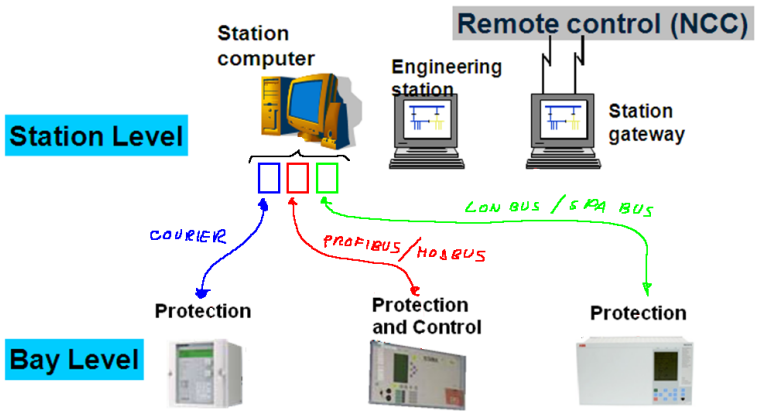
We have been using SCADA systems since the 80's! What's new with it?

- Event driven – Intelligent Electronic Devices send processed data
  (before dump relays with cyclic sending of raw data)
- Non need for protocol converters
- The substation is described by one XML file - called SCD
  (Substation Configuration Description, part of the Substation Configuration Language, SCL)



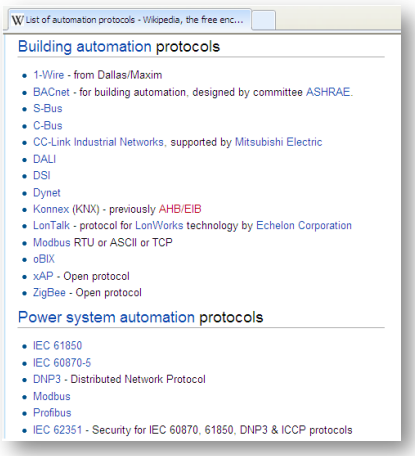
STRI
Substation
SCD FILE.scd

"BEFORE standardisation": REPORTING TO SCADA / RTU



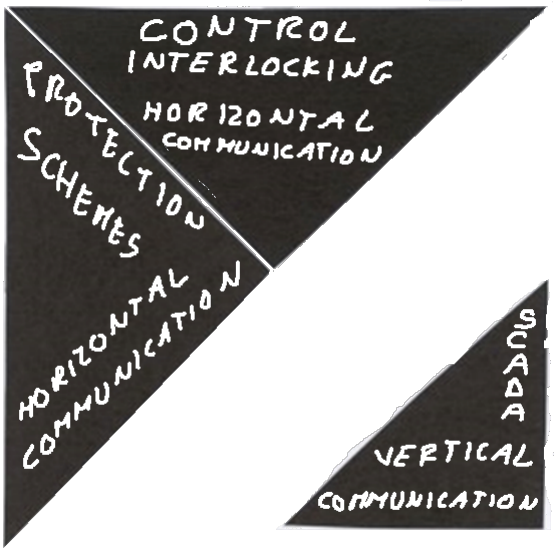
Proprietary communication protocols were / are available. The correct handling of all protocols was and is still a challenge

”BEFORE”: PROTOCOL CONVERTERS / IMPLEMENTATIONS



	Protocols already supported and available at standard prices	Protocols that can be implemented at special prices
ABB	**SPA Bus**	**Indactic 33/1**
	RP570	Indactic 33/41
	RP571	MicroSCADA CPI API
AREVA	**Courier RS485/RS232**	
SEL	**SEL 451**	
	SEL 421	
	SEL 311	
	SEL 300G	
Schneider	**Modbus RTU - SEPAM**	
Westinghouse		**Wisp+**
		Wisp++
Others	**Altus**	**CONITEL**
	RTK	GE SRTP
	EXCOM	
	CMC Master	
	SPORT	
	Triguard Peer-To-Peer	
	ODBC	

IEC 61850 standard

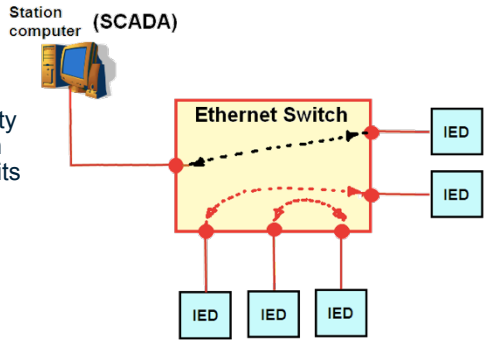


Ethernet network – Ethernet switches

The data traffic runs on Ethernet, 100 Mbit/s.

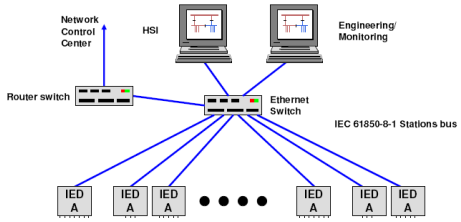
This means that in the IEC 61850 substation there are Ethernet switches.

Protection and Control signals are dependent on the correct functionality of the communication system, which has in the Ethernet switches one of its most important factors.

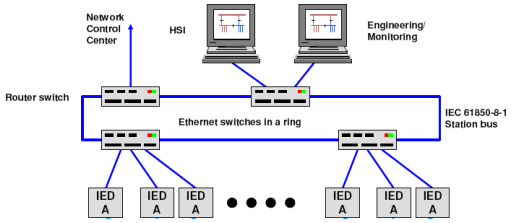


Network topologies

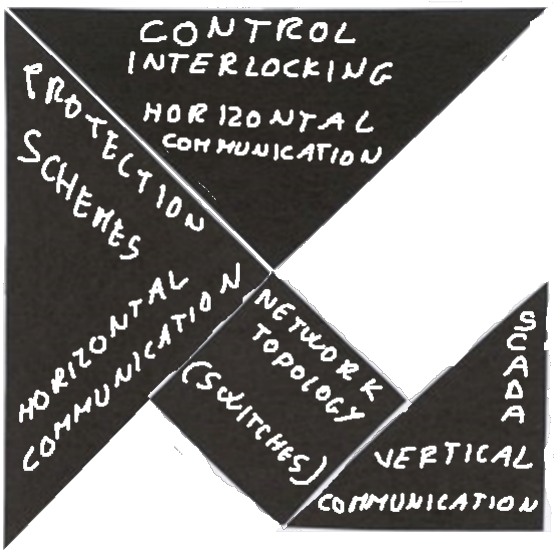
Star



Ring



IEC 61850 standard

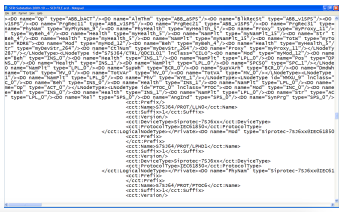


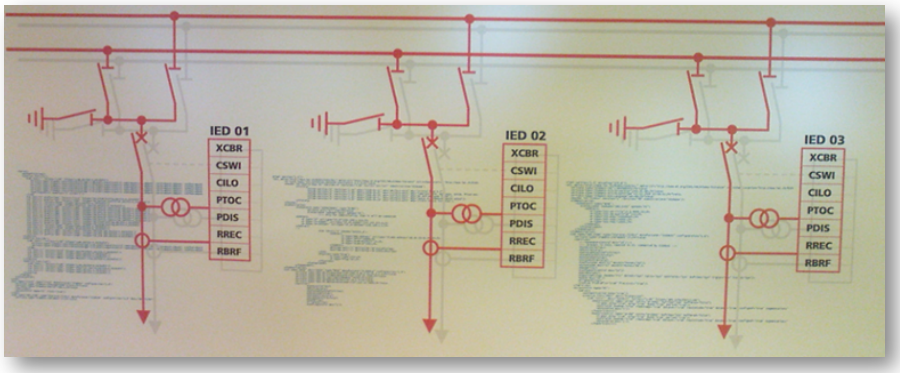
IEC 61850: The SCL language

IEDs and Substations are described through XML files.

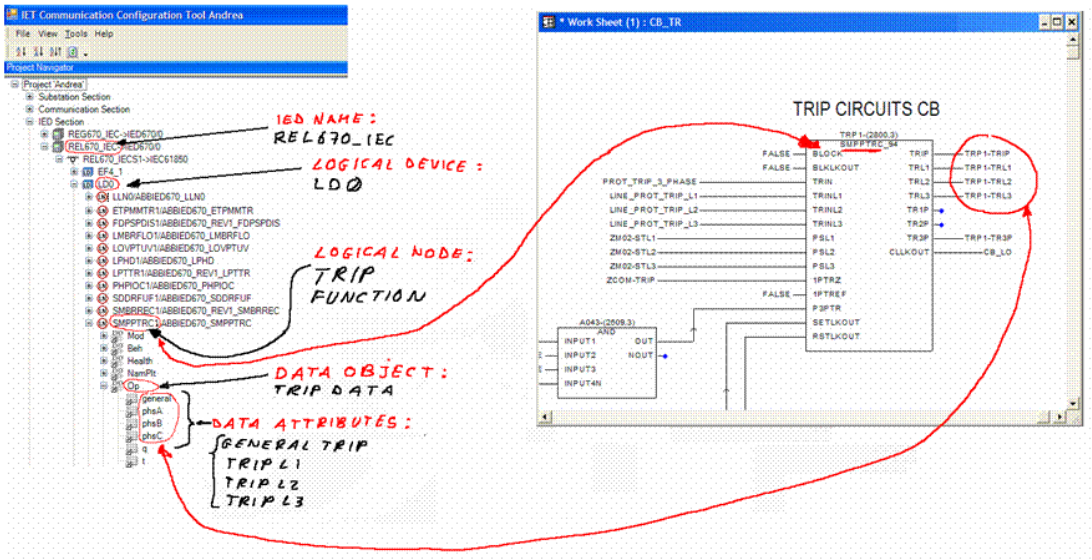
The "IEC 61850 language used in the XML files" is called SCL language.

SCL: Substation Configuration Language.





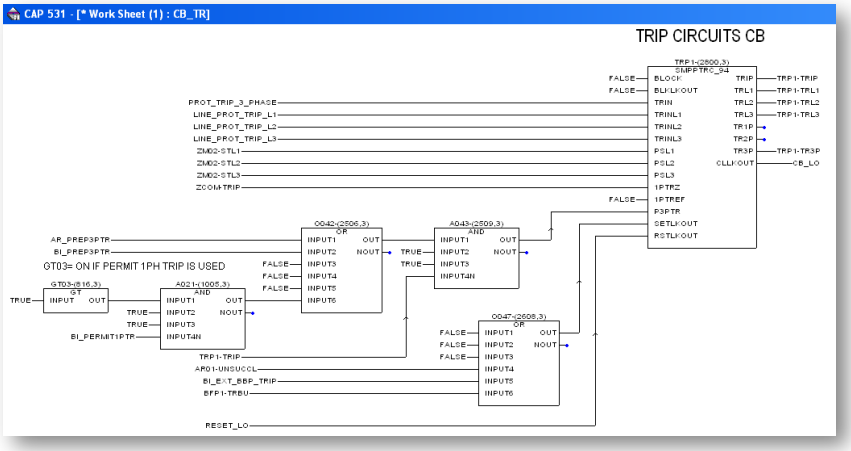
IEC 61850: The SCL language (IED Modelling)



IEC 61850: The SCL language (IED Modelling)

Bay A — Bay Unit (IED)

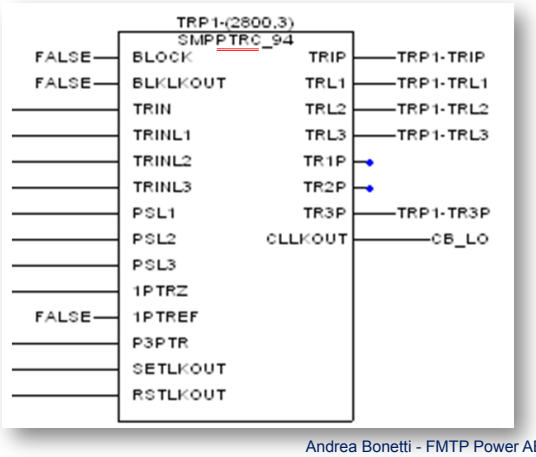
PTRC (Trip, Operate)



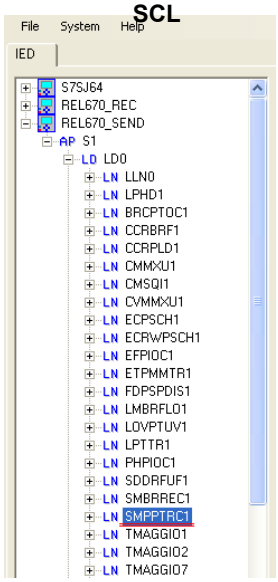
IEC 61850: The SCL language (IED Modelling)

Bay A — Bay Unit (IED)

PTRC (Trip, Operate)



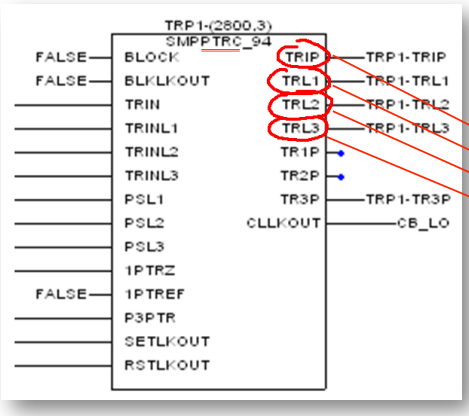
SCL



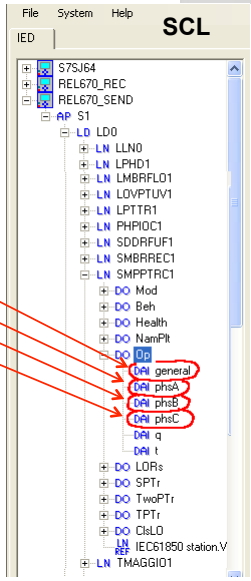
IEC 61850: The SCL language (IED Modelling)

Bay A — Bay Unit (IED)

PTRC (Trip, Operate)



SCL



IEC 61850: The SCL language (IED Modelling)

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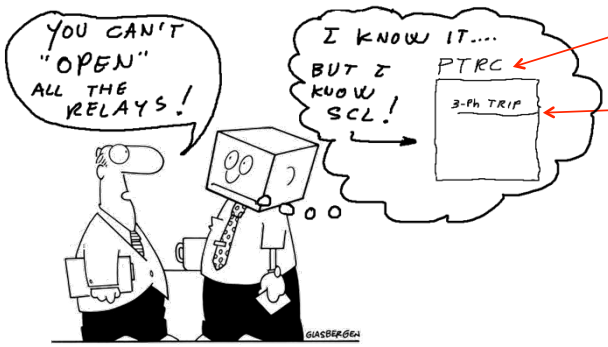
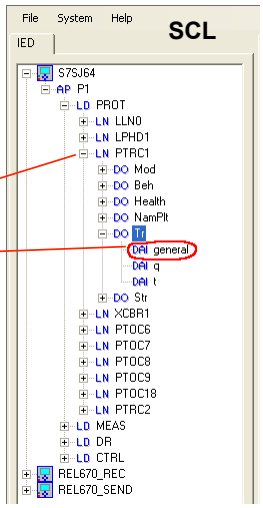
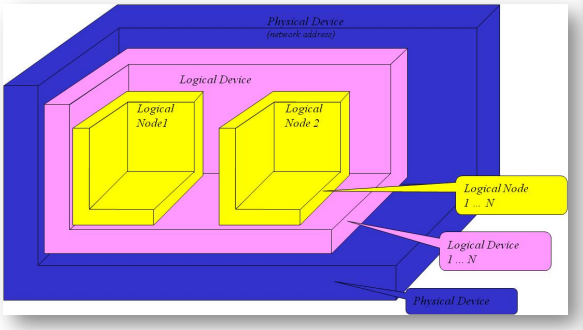
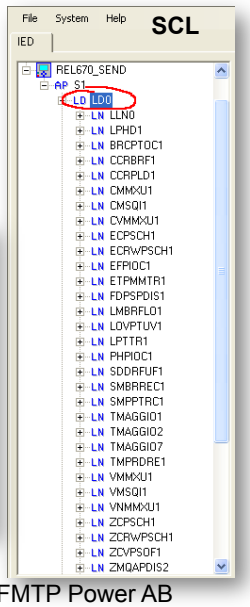


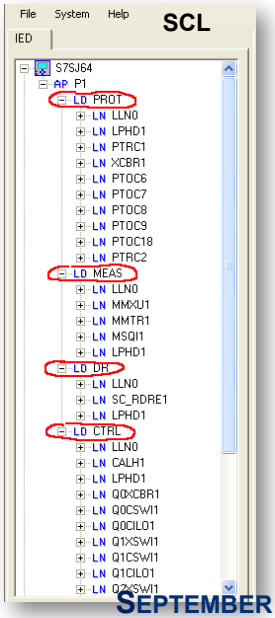


IEC 61850: The SCL language (IED Modelling)

It is possible to "structure" the Logical Nodes, and group them under different Logical Devices.
The "rules" of this structure are described in the XML file.







IEC 61850: The SCL language (IED Modelling)

The SCL file also describes **what the IED can do (services).**

In this right case the IED cannot offer upload of disturbance recorder file, as the "**FileHandling Service" is not listed**:

```
- <IED configVersion="3.0" desc="Generator" manufacturer="Schn
    <Private type="SchneiderElectric-IED-Type">ACE850</Priva
  - <Services>
      <DynAssociation />
      <SettingGroups />
      <GetDirectory />
      <GetDataObjectDefinition />
      <DataObjectDirectory />
      <GetDataSetValue />
      <DataSetDirectory />
      <ConfDataSet max="8" maxAttributes="200" modify="true" />
      <ReadWrite />
      <ConfReportControl max="16" />
      <GetCBValues />
      <ReportSettings bufTime="Dyn" cbName="Conf" datSet="Cor
      <GSESettings appID="Conf" cbName="Conf" datSet="Conf" /
      <GSEDir />
      <GOOSE max="4" />
      <ConfLNs fixLnInst="true" fixPrefix="true" />
      <FileHandling />
    </Services>
```

```
- <IED name="SEL_751A_1" desc="Add new Analogs and Digitals." type="SEL_751A"
    D20090109">
  - <Services>
      <DynAssociation />
      <GetDirectory />
      <GetDataObjectDefinition />
      <DataObjectDirectory />
      <GetDataSetValue />
      <SetDataSetValue />
      <DataSetDirectory />
      <ConfDataSet max="21" maxAttributes="200" />
      <ReadWrite />
      <ConfReportControl max="12" />
      <GetCBValues />
      <ReportSettings cbName="Conf" datSet="Conf" rptID="Conf" optFields="Dyn" buf
      <GSESettings cbName="Conf" datSet="Conf" appID="Conf" />
      <GOOSE max="8" />
      <ConfLNs />
    </Services>
```

While this IED to the left allows to upload the disturbance recorder files "**FileHandling Service" is listed.**

IEC 61850: Different SCL files

Depending on the information they carry, there are different types of SCL files:

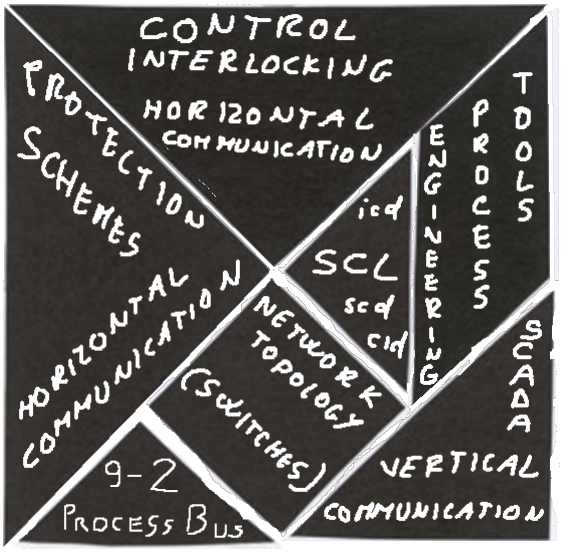
ICD (IED Capability Description)
CID (Configured IED Description)
SCD (Substation Configuration Description)

SSD (System Specification Description)

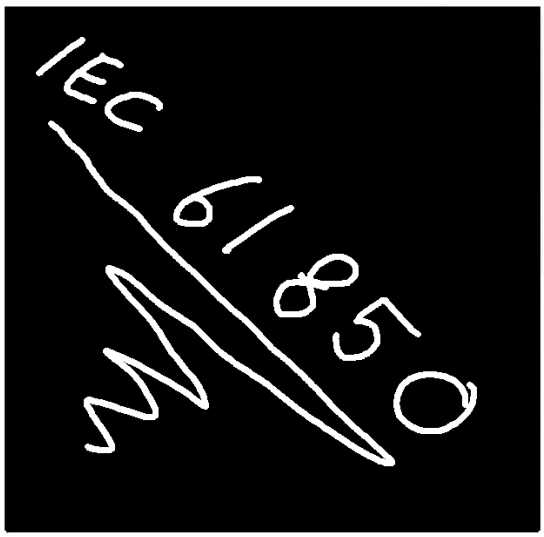
IID (Instantiated IED Description)
SED (System Exchange Description)

EDITION 2

IEC 61850 Standard



IEC 61850 Standard



IEC 61850: TESTING

How do we test all of this?

How do we test the **Network Topology (Switches)?**

How do we test the **Vertical Communication to SCADA?**
(IEC 61850-8-1, MMS, Reporting)

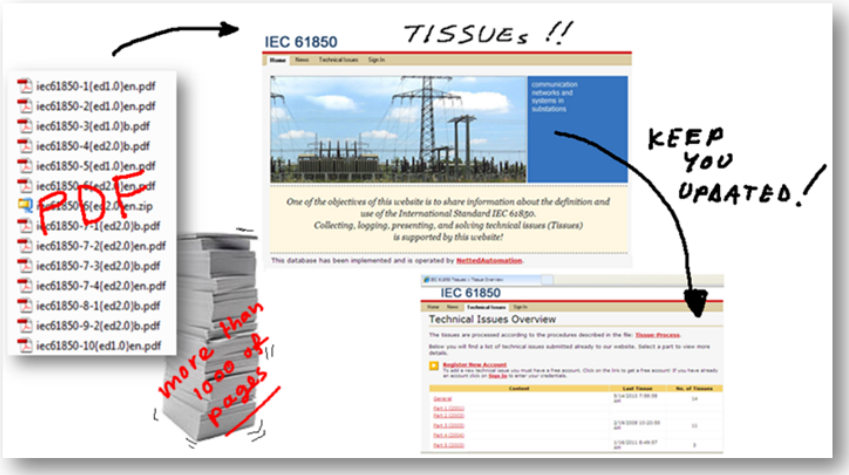
How do we test **Interlockings?**
(IEC 61850-8-1 GOOSE)

How do we test **Protection Schemes?**
(IEC 61850-8-1 GOOSE and IEC 61850-9-2 SV)

IEC 61850 Standard

Tissues (Technical Issues) database
www.tissues.iec61850.com

IEC 61850 standard is a **dynamic standard**!. You must follow it!




THANK
YOU !