

# Engineering Process for IEC 61850

Presented By  
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Sponsoring  
Organization:



Supporting  
Organization:



Organizer:



- CIGRE Technical Brochure 326 Section 7.2 Fig 20

## An Engineer

- A person who, given a problem and a specific set of goals and constraints, finds a technical solution to the problem that satisfies those goals within those constraints. (Wiktionary)
- Engineers are concerned with developing economical and safe solutions to practical problems, by applying mathematics and scientific knowledge while considering technical constraints (Wikipedia)

## After 100 years ....

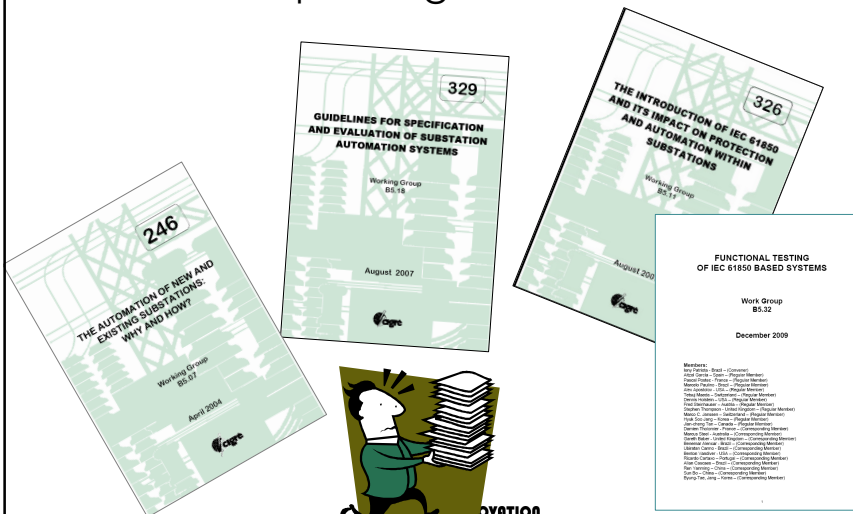
- Need to reduce engineering time
- Need to improve QA on more and more complex designs
- Vendor independence
- free choice of equipment now and in the future
- Wiring becoming more complex
- Need to eliminate wires
- Scheme design and test more complex
- Need more intelligent schemes
- Augmentations need to be easier
- Several stages over several years
- Interfaces to interfaces
- Loss of coherent technology base
- Greater access to information within and without of the substation
- Confusion with protocols that don't work together
- Vendor compliance is not always the same
- New technology has not reduced Op Ex
- ....

## Understanding the Standard

- IEC 61850
- IEC 1346
- IEC 62271
- IEC 62349
- IEC 61400



## Explaining the Standard



## IEC 61850 Part 7 Table 1

	Part 1	Part 5	Part 7-1	Part 7-2	Part 7-3	Part 7-4	Part 6	Part 8-1, 9-x
	Introduction	Requirements	Principles	AGSI	CGC	LN	SCL	mapping to MMS
<b>UTILITY</b>								
Manager								
Engineer								
<b>VENDOR</b>								
Application Engineer								
Communication Engineer								
Product Manager								
Marketing								
<b>CONSULTANT</b>								
Application Engineer								
Communication Engineer								
others								

important	
partly important	
minor importance	

## The Magic Solution?

- "The purpose of the standard is neither to standardise (nor limit in any way) the functions involved in substation operation nor their allocation within the Substation Automation System."  
(IEC 61850 Part 1, Ch 1)

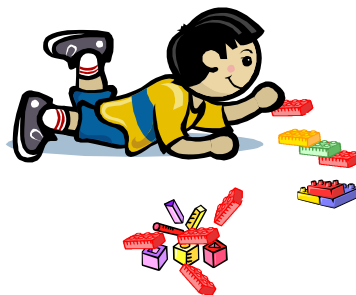
## Interoperability

- 1 Amp CT, 1 Amp relay
  - Relay burden
  - Lead burden
  - Max fault current
  - X/R ratio
  - Circulating current differential
- AS 1675 or AS 60044
  - 10P100 F20 = 5VA 10P 20



## Interoperability

- NOT PLUG & PLAY
- ENGINEER & PLUG IN
  - Conformance Certificate not sufficient on its own
  - Protocol Implementation Conformance Statement



..has not shown to be non-conforming..



**IEC 61850 Certificate Level A<sup>1</sup>**

No. 3052008-Consulting 2005-0513

Issued to:  
ABB Oy  
Distribution Automation  
Muottilie 2 A  
FI-65101 Vaasa  
Finland

For the product:  
REF545 V3.0  
with SPA-ZC 400 V1.02

Issued by: **KEMA**

The product has not shown to be non-conforming to:

**IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1**  
Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 with product's protocol, model and technical issue implementation conformance statements: "IEC 61850 conformance statement for REF545 and SPA-ZC400 v1.4.0rc" and "IEC 61850 Technical conformance statement for REF545 and SPA-ZC 400 v1.0.0rc", and extra information for testing (P007) "IEC 61850 P007 for REF545 and SPA-ZC 400 v1.5.0rc".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases as defined in the IEC 61850 International Users Group Device Test procedures):

Basic Exchange (1929)	Direct Control (411)
Data Sets (25)	Enhanced SBO Control (918)
Unbuffered Reports (1313)	Time Synchronization (34)
Buffered Reports (1415)	



**IEC 61850 Certificate Level A<sup>1</sup>**

No. 3058045-Consulting 2005-0555

Issued to:  
A. Eberle GmbH & Co. KG  
Aulener Straße 30/32  
D-90441 Nürnberg  
Germany

For the product:  
REG-PE controller with REG-D unit  
Software version 2, Revision 9,  
Build V7.98 2005-09-13

Issued by: **KEMA**

The product has not shown to be non-conforming to:

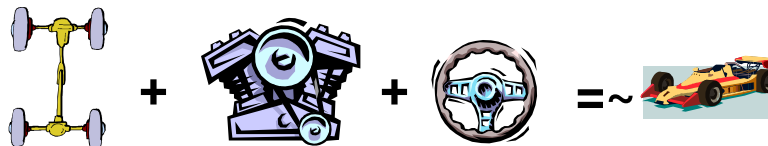
**IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1**  
Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 with product's protocol, model and technical issue implementation conformance statements: "IEC 61850 Protocol Implementation Conformance Statement for REG5000 automatic voltage regulator v1.2" and "IEC 61850 Technical Issue Conformance Statement for REG5000 automatic voltage regulator v1.0", and extra information for testing "Protocol Implementation extra information for testing (P007) of the IEC 61850 communication interface in REG5000 devices v0.1".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases as defined in the IEC 61850 International Users Group Device Test procedures):

1 Basic Exchange (1929)	12a Direct Control (411)
2 Data Sets (25)	13 Time Synchronization (34)
3 Unbuffered Reports (913, without buffer time)	

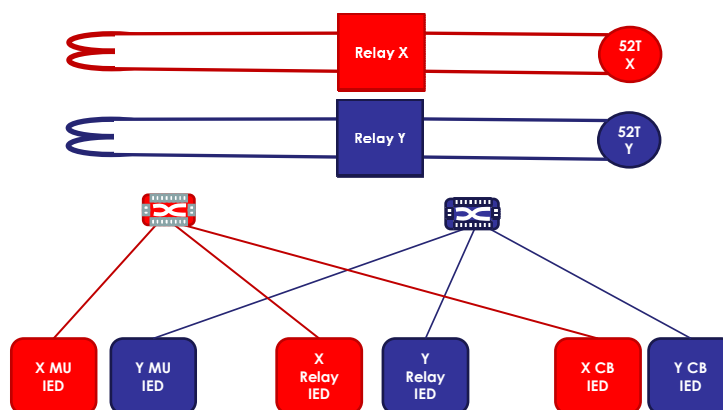
Being Capable



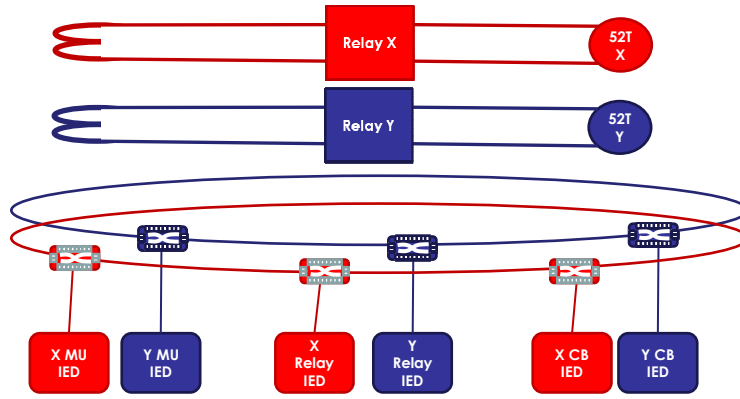
## National Electricity Rules

- S5.1.9 Protection systems and fault clearance times  
Network Users
  - “(d) If the fault clearance time determined under clause S5.1.9(e) of a primary protection system for a two phase to ground short circuit fault is less than 10 seconds, **the primary protection system must have sufficient redundancy** to ensure that it can clear short circuit faults of any fault type within the relevant fault clearance time **with any single protection element (including any communications facility upon which the protection system depends) out of service.**”

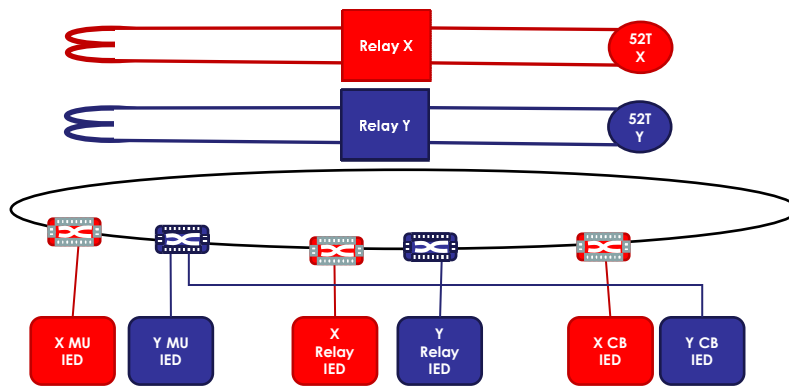
## Applying NER – Duplicate Star



### Applying NER – Duplicate Ring

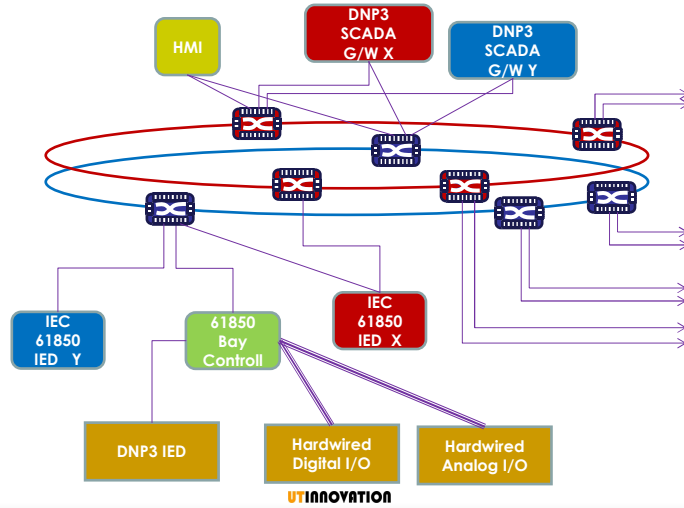


### Applying NER – Single Ring/Star





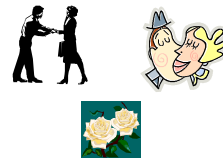
## Reference Architecture



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## Not JUST a Protocol

- Protocols are a process of communication
  - They do not define the nature of information
  - Speak English or French or ....?
  - Speak American, UK or Australian dialect
  - Rose Rose Rose Rose Rose
- IEC61850 defines the nature of objects
  - all other objects know what is available and what it means
  - All devices speak "61850"
  - Communication infrastructure to support the exchange of data



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## No Mere Protocol



- *Communication networks and systems in substations*
  - Defines the structure of elements
  - Sampled Values 0.5mS/0.02mS
  - Deterministic commands
    - 3mS trip commands, application to application
  - Substation design file
  - Inherent testing automation
  - As operating documentation
  - Defined interoperability

## The Axe

- The Corporate Commitment?
  - Changing from a legacy protocol to IEC61850 is not the prime objective or benefit
  - Buying IEC61850 compliant devices doubles engineering if not implemented
- IEC61850 saves engineering
  - Decide when and how cost savings to be implemented



## What Does it Achieve

- Easier implementation of Substation Automation Systems
- Primary plant and secondary systems
- Elimination of copper wires
- Drawings
- Wire numbers
- Circuit testing
- Self describing documentation



## SSD and SCD

- Master design
- Reusable
- Link all primary plant and secondary equipment
- All functions, schemes and communication
- Combination of all electrical drawings
- Integrates device template ICD
- Creates CID
- Feedback in IID

<b>SSD</b>	<b>System Specification Description</b>
<b>SCD</b>	<b>System Configuration Description</b>
<b>ICD</b>	<b>IED Capability Description</b>
<b>CID</b>	<b>Configured IED Description</b>
<b>IID</b>	<b>Instantiated IED Description</b>

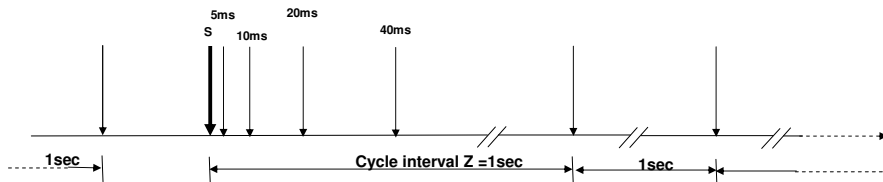


## GOOSE

- Collation of essential information
- Reports
- Commands
- Reusable design
- Reduced retesting

## Generic Object Oriented Substation Event

- on the occurrence of any change of state, an IED will multicast a high speed, binary object, Generic Object Oriented Substation Event (GOOSE) report by exception, typically containing the double command state of each of its status inputs, starters, output elements and relays, actual and virtual.
- This report is re-issued sequentially, typically after the first report, again at intervals of 2, 4, 8...60000 ms. (The first repetition delay value is an open value it may be either shorter or longer).
- A GOOSE report enables high speed trip signals to be issued with a high probability of delivery



## Message Classes

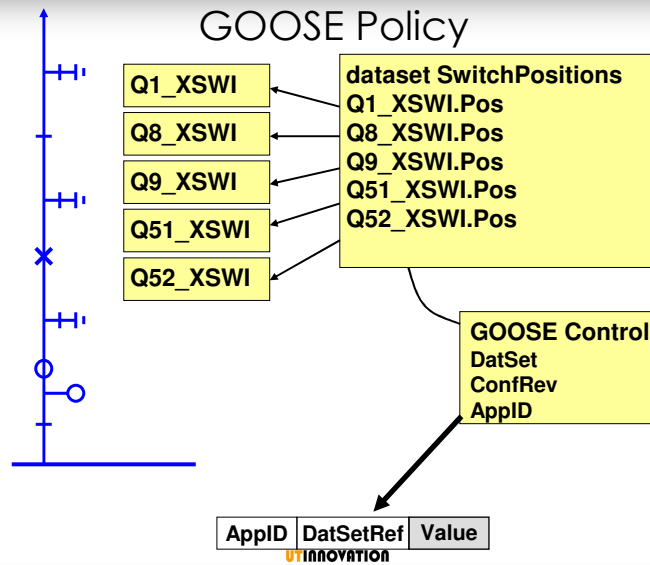
- Type 1 Fast Trip/Close/Start/Stop/Block/Unblock/Trigger/Release
  - 1A P1 <10ms
  - 1A P2/3 <3ms
  - 1B P1 <100ms
  - 1B P2/3 <20ms
- Type 2 Medium <100ms
- Type 3 Low <500ms
- Type 4 Raw Data
- Type 5 File Transfer >1000ms
- Type 6 Synchronisation
  - T1 +/- 1ms
  - T2 +/- 0.1ms
  - T3 +/- 25us
  - T4 +/- 4us
  - T5 +/- 1us
- Type 7 as per Type 3 with access control

Table 1 – Raw data for protection and control

Data type	Class	Transmission time (ms) defined by trip time	Resolution (Bits) Amplitude	Rate (Samples/s) Frequency
Voltage	P1	10.0	13	480
Current			13	
Voltage	P2	3.0	16	960
Current			16	
Voltage	P3	3.0	16	1 920
Current			16	

Table 2 – Raw data for metering

Data type	Class	Accuracy classes and harmonics	Resolution (Bits) Amplitude	Rate (Samples/s) Frequency
Voltage	M1	Class 0.5 (IEC 62053-22) Class 0.2 (IEC 60044-8) Up to 5 <sup>th</sup> harmonic	12	1 500
Current			14	
Voltage	M2	Class 0.2 (IEC 62053-22) Class 0.1 (IEC 60044-8) Up to 13 <sup>th</sup> harmonic	14	4 000
Current			16	
Voltage	M3	Class 0.1 (not defined by IEC) Up to 49 <sup>th</sup> harmonic	16	12 000
Current			18	



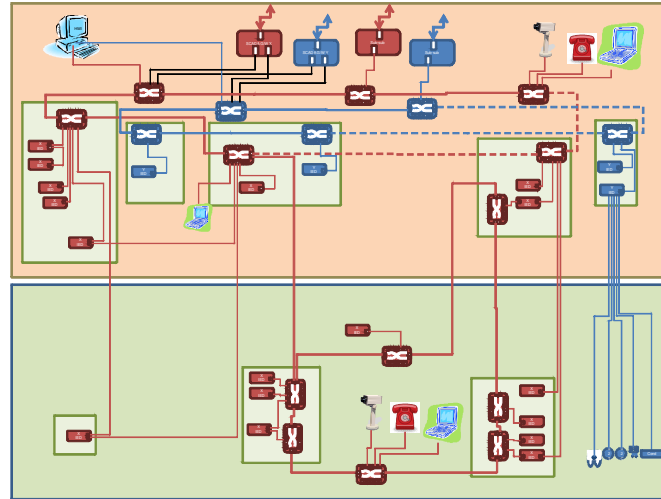
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## Process bus ... why not yet?

- Process bus data rates are constant
  - Station bus varies
- Merging Units are not new technology
- NCIT are not new technology
- Synchronisation is proven
  - 1pps
  - IEEE1588 emerging

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## Total SAS LAN



UTINNOVATION

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## Total Process Bus Network

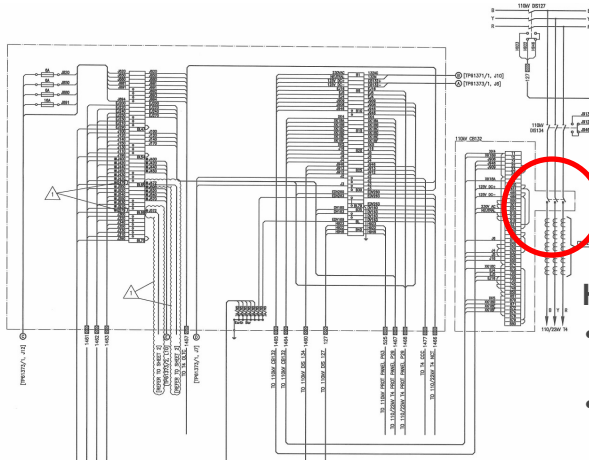
- Trip/close commands
- Sampled values (SV)
- Non conventional instrument transformers (NCIT – optical CT/VT, Rogowski coil)
- Status information (open/closed, on/off)
- Condition monitoring information (such as transformer gas monitoring & temperature)
- Control signals such as for voltage regulation or fan controls
- Telephone in the yard using VOIP
- Video surveillance of plant and for security
- Maintenance, test, & operating staff connecting a laptop in the yard

UTINNOVATION

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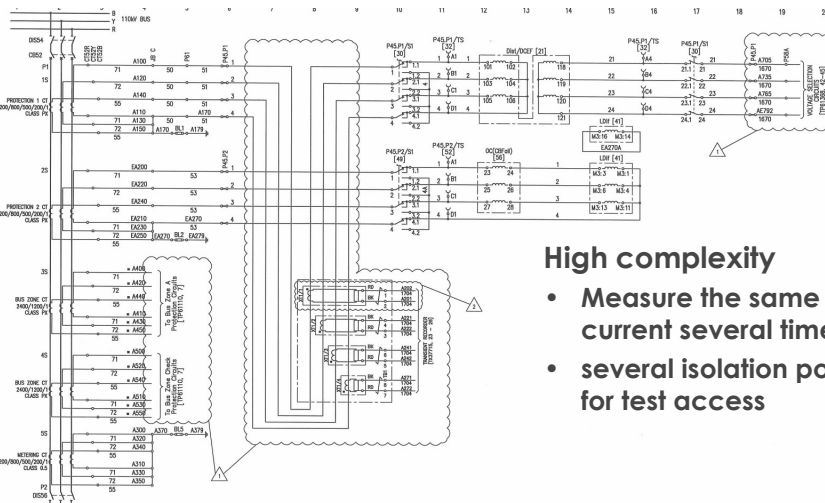
## Conventional Circuit Breaker Wiring



High complexity

- Measure the same status several times
- several isolation points for test access

## Conventional CT circuit



High complexity

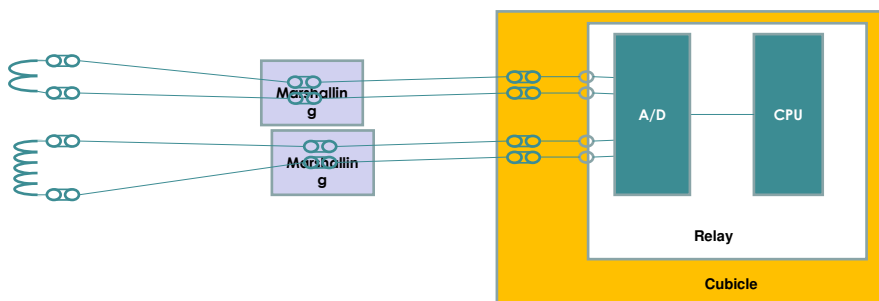
- Measure the same current several times
- several isolation points for test access

## Current & Voltage Sensing Options

- NCIT may or may not imply use of SV
- SV may or may not imply use of NCIT

1. NCIT input, IEC 61850 SV output
2. Conventional sensor input, IEC 61850 SV output
3. NCIT input, analogue output (1A/110V, or 0-10V)
4. Conventional sensor input, analogue output

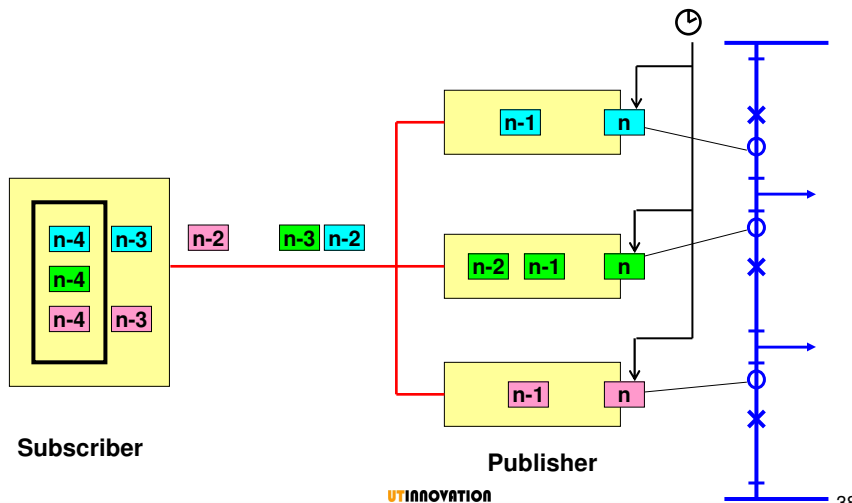
## Conventional Sensor & Relay



### IEC 61850 Merging Unit

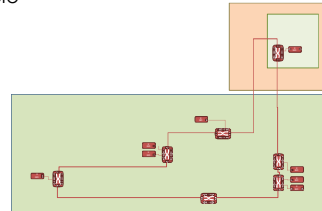


### Time Alignment



## Time Synchronisation

- Need to accurately time stamp samples
  - Distance relay with a current and voltage sample
  - Bus bar protection from several current sensors
- Number of switches
- Bandwidth
- VLAN
  
- 1PPS well proven =>> IEC 61850 9-2 LE
  - Needs separate cabling
- IEEE 1588 uses same LAN



## NCIT

- Eliminate
  - open circuit CT explosions
  - gassing
  - CT saturation
  - poor low end accuracy
  - saturation problems
  - multiple cores
    - metering, line protection, bus protection, circuit breaker failure
  - CVT transient performance and frequency response
- lighter and smaller body mass
- eliminate separate CT/VT stanchion for the sensors

## Traditional Questions

- Different MU vendors?
  - No common mode X and Y failure modes
- Installation of high accuracy electronics in yard?
- Installation of switches in the yard?
- Different NCIT technologies?
- Installation on stanchions and bushing?

## Considering the process bus

- LAN in yard will exist – opportunity to utilize benefits
- CB Trip / Close must be applied with appropriate network engineering
- MUs and SV will eliminate significant wiring and sensor cores
- NCIT will eliminate CT/VT performance issues
- Time synchronization can be solved in different ways
- Traditional protection engineering questions apply

## Engineering into IEC 61850

- Understand what it is
- Develop new skills and domains of knowledge
- Apply our conventional wisdom
- Leverage experience

## Contacts

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