



Тестирование цифровой подстанции – определения, требования, возможности.

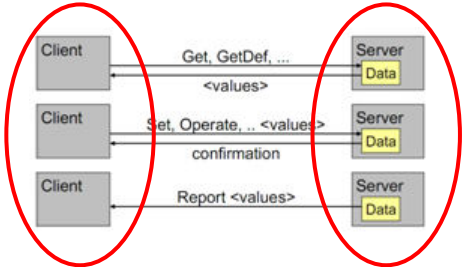
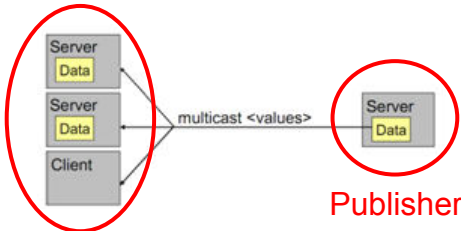
Testing the digital substation. Definitions, requirements and possibilities

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How to approach?

- Definitions in the standard
- Products
- Requirements

The standard: Different communication methods

Client / Server services	Real-Time services
<ul style="list-style-type: none"> > Control center ↔ field devices (SCADA) > Reports, Control, Setting Groups > Non-time-critical > One-to-one connection (Two-Party-Application-Association)  <p style="text-align: center;"> Client Server </p>	<ul style="list-style-type: none"> > Fast interdevice communication and transmission of sampled values > GOOSE and Sampled Values > Time-critical > One-to-many connection (Multicast-Application-Association)  <p style="text-align: center;"> Subscriber Publisher. </p>

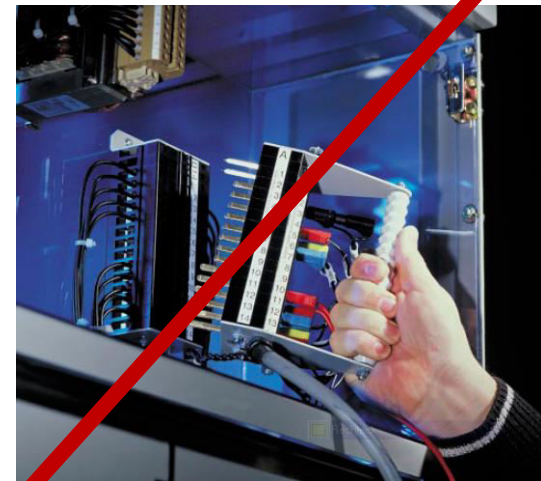
The Standard: No test plugs in IEC 61850

Test plugs:

Disconnect trip,
short-circuit CTs,
inject signals

IEC 61850:

- Many signals on one Ethernet cable
- Unplugging the cable not an option



Solution in IEC 61850

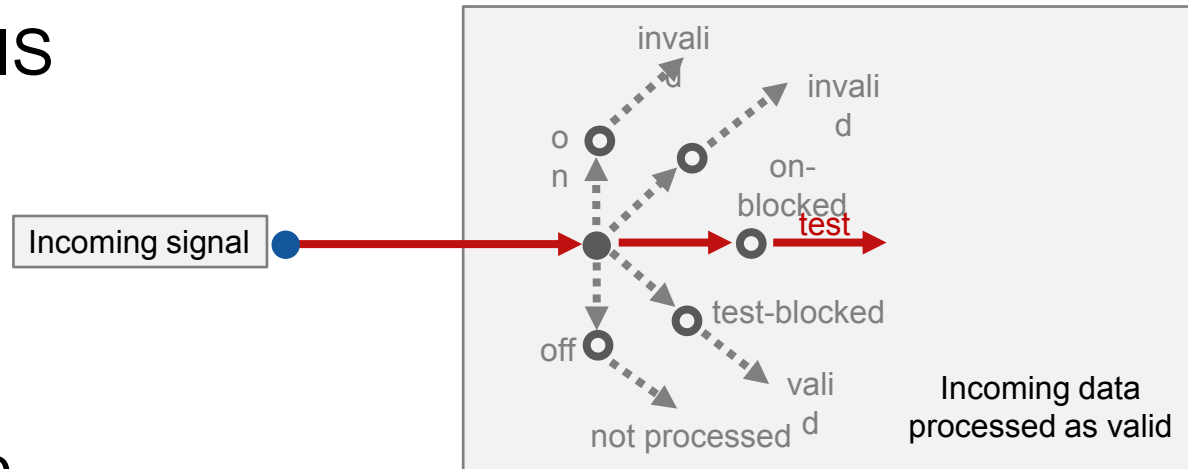
Complex but powerful solution

- Simulation/Test flag in GOOSE & SV
- LPHD.Sim switch in IED
- Test flag in data quality
- Mode/Behavior of LDs and LNs



Solution: Test Mode

- Testing of every logical **node** like PROTECTION.PDIS 1
- Testing of every logical **device** like PROTECTION
- More than a simple „Test mode“:
 - on; on/blocked; test; test/ blocked; off

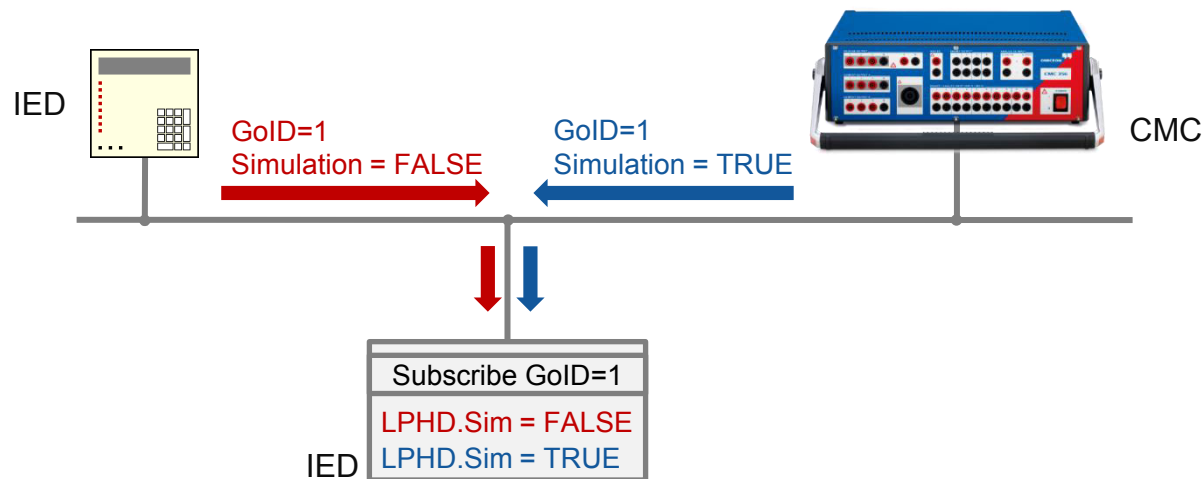


Complex dependencies defined in the standard

MODE/BEHAVIOUR	on	blocked	LNMode XXX.Mod	LDMode LLN0.Mod	LNBeh (read only) XX.Beh	LNBeh Value
			on	on	on	1
			on	on-blocked	on-blocked	2
			on	test	test	3
			on	test/blocked	test/blocked	4
			on	off	off	5
Function behind LN	ON		on-blocked	on	on-blocked	2
Output to the Process (Switchgear) via a non-IEC 61850 link for example wire (typical for X...,Y... and GGIO LNs)	YES		on-blocked	on-blocked	on-blocked	2
			on-blocked	test	test/blocked	4
			on-blocked	test/blocked	test/blocked	4
			on-blocked	off	off	5
Output of FC ST, MX (issued independently from Beh)	value is relevant q is relevant	value i q is r	test	on	test	3
			test	on-blocked	test/blocked	4
			test	test	test	3
Response to (Normal) Command from Client (a+ / a- acknowledgement)	a+ pos. ack.	pos	test	test/blocked	test/blocked	4
			test	off	off	5
Response to TEST Command from Client (a+ / a- acknowledgement)	a- neg. ack.	neg	test/blocked	on	test/blocked	4
			test/blocked	on-blocked	test/blocked	4
			test/blocked	test	test/blocked	4
			test/blocked	test/blocked	test/blocked	4
Incoming data with validity=good AND test=false AND operatorBlocked=false	Processed as valid	Proce v	test/blocked	test/blocked	test/blocked	5
			off	off	off	5
Incoming data with validity=questionable AND test=false AND operatorBlocked=true	Processed as questionable	Proce ques	off	on-blocked	off	5
			off	test	off	5
Incoming data with validity=good AND test=true AND operatorBlocked=false	Processed as invalid	Proce in	off	test/blocked	off	5
			off	off	off	5
Incoming data with validity=questionable AND test=true AND operatorBlocked=true	Processed as invalid	Processed as invalid		Processed as questionable	Processed as questionable	Not Processed
Incoming data with validity=invalid AND test=don't care AND operatorBlocked=don't care	Processed as invalid	Processed as invalid		Processed as invalid	Processed as invalid	Not Processed
Non-IEC 61850 binary (relay, contact) inputs and analogue (instrument transformer) inputs	Processed	Processed		Processed	Processed	Not Processed

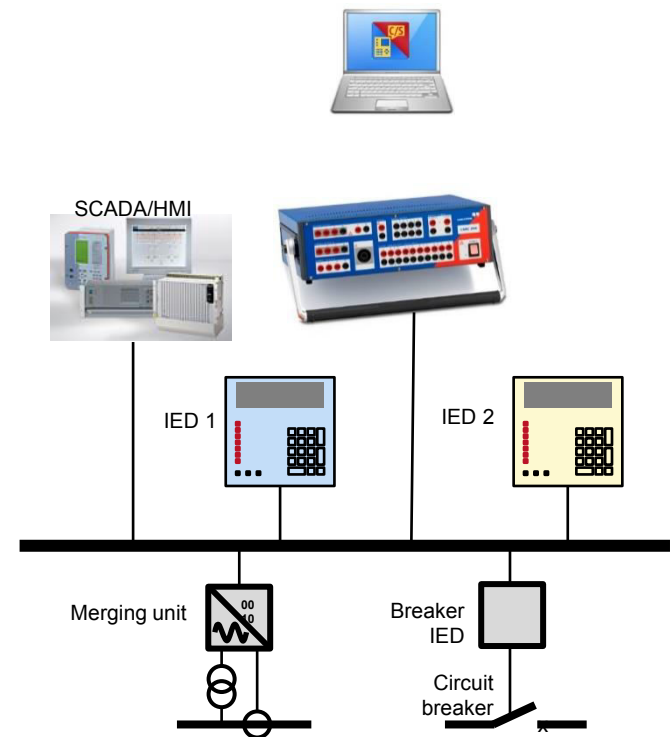
Simulation indication with GOOSE & Sampled Values

- How to distinguish between “real” signals and simulated one?
- Sets the entire IED (“physical device”) in simulation mode LPHD.Sim = True



Requirement: Client integrated in protection test

- LPHD.Sim and Mode handling
- Access to information from IED
- Test SCADA signals while protection testing



Standard: Setting Groups

SIP • Data Model • Ln1_5051OC3phA1 • II_PTOC1

LN II_PTOC1 Time overcurrent

Name	Description	Value
▶ DO TmACrv	Operating curve type	IEC Normal Inverse
▲ DO StrVal	Start value	1500 A
▶ DA units [CF]	Units of the attribute(s) representing the value of the data	A
▶ DA minVal [CF]	Defines together with maxVal the setting range for ctiVal (CDC INC, BSC, ISC), setVal (C...	30 A
▶ DA maxVal [CF]	Defines together with minVal the setting range for ctiVal (CDC INC, BSC, ISC), setVal (C...	35000 A
▶ DA stepSize [CF]	Defines the step between individual values that ctiVal (CDC INC, APC, BAC), setVal (CD...	0 A
▶ DA setMag [SG]	The value of an analogue setting or set point	1500 A
▲ DA setMag [SE]	The value of an analogue setting or set point	
DA f [SE]	Floating point value	

Requirements: Setting Group Service

Control Block: Application

Affected Logical Devices: Application, Mod2, PowS, PowS_MeasPointV3ph1, PowS_MeasPointI3ph1, Rec, Rec_FaultRecorder, Mod2_Channel1, Ln1, Ln1_SwitchOntoFault, Ln1_ProcessMonitor, Ln1_Energy, Ln1_OperationalValues, Ln1_FundSymComp, Ln1_67NGFPgndSys1, Ln1_5051NOCgndA1, Ln1_5051OC3phA1, Ln1_67DirOC3phA1, CB1, CB1_Fundamental

Select Setting Group

Active Setting Group: 1

Select Setting Group: 1 [active]

Edit selected Setting: 2

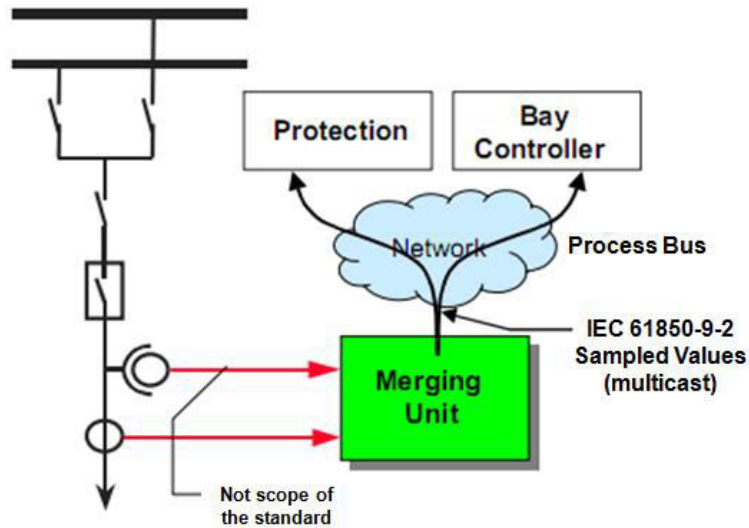
StrVal: 3

Show only changed values

Name	Active value (from SG 1)	Value in SG 1	Description
▶ DA Ln1_5051OC3phA1/ID_PTOC1.StrValBI.set...	1500 A	1500	The value of an analogue setting or set point
▶ DA Ln1_5051OC3phA1/ID_PTOC2.StrVal.setM...	0 A	0	Start value
▶ DA Ln1_5051OC3phA1/ID_PTOC2.StrValRc1C....	2000 A	2000	The value of an analogue setting or set point
▶ DA Ln1_5051OC3phA1/ID_PTOC2.StrValRc2C....	0 A	0	The value of an analogue setting or set point
▶ DA Ln1_5051OC3phA1/ID_PTOC2.StrValRc3C....	2000 A	2000	The value of an analogue setting or set point
▶ DA Ln1_5051OC3phA1/ID_PTOC2.StrValCLP.s...	0 A	0	The value of an analogue setting or set point
▶ DA Ln1_5051OC3phA1/ID_PTOC2.StrValBI.set...	2000 A	2000	The value of an analogue setting or set point

Buttons: Activate selected SG, Write changed values, Close

Standard definitions: Sampled Values



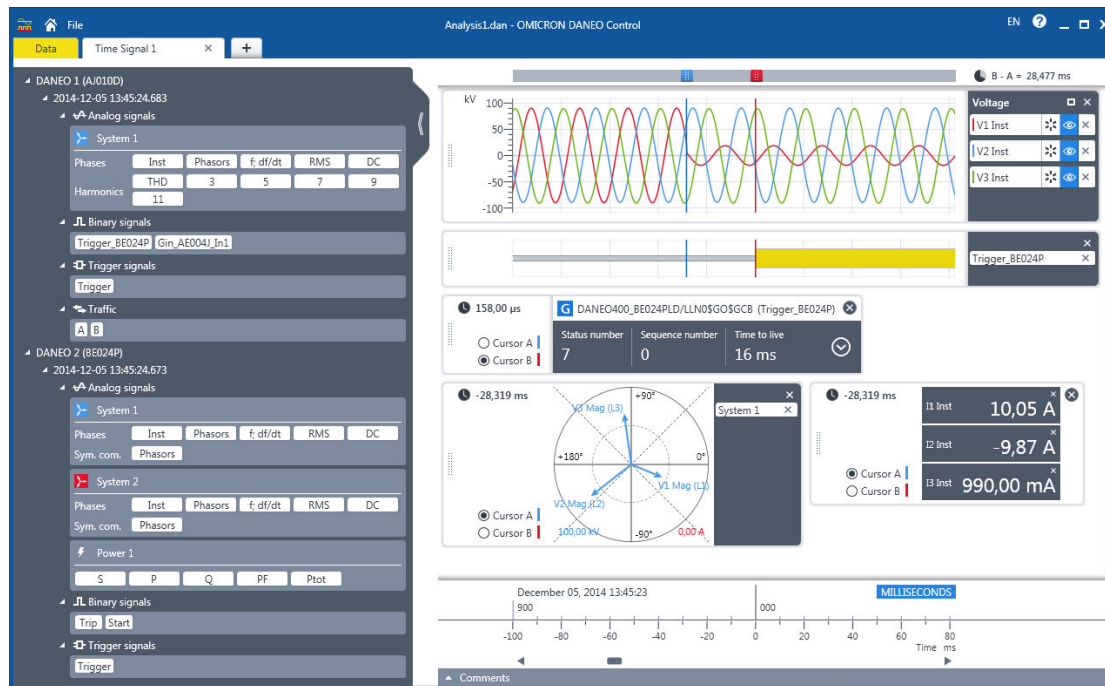
IEC 61850-9-2

Sampling Frequency	Samples per Packet	Packet Frequency	
4000Hz (80SPC @ 50Hz)	1	4000Hz	9-2LE
4800Hz (80SPC @ 60Hz)	1	4800Hz	
12800Hz (256SPC @ 50Hz)	8	1600Hz	
15360Hz (256SPC @ 60Hz)	8	1920Hz	
4800Hz	2	2400Hz	New preferred
14400Hz	6	2400Hz	
5760Hz	1	5760Hz	96SPC @ 60Hz

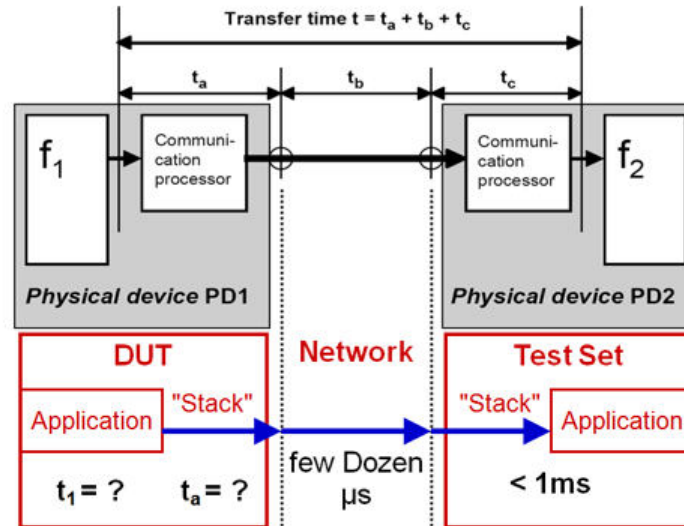
IEC 61869-9

Requirement

- Handle sampled values and conventional signals

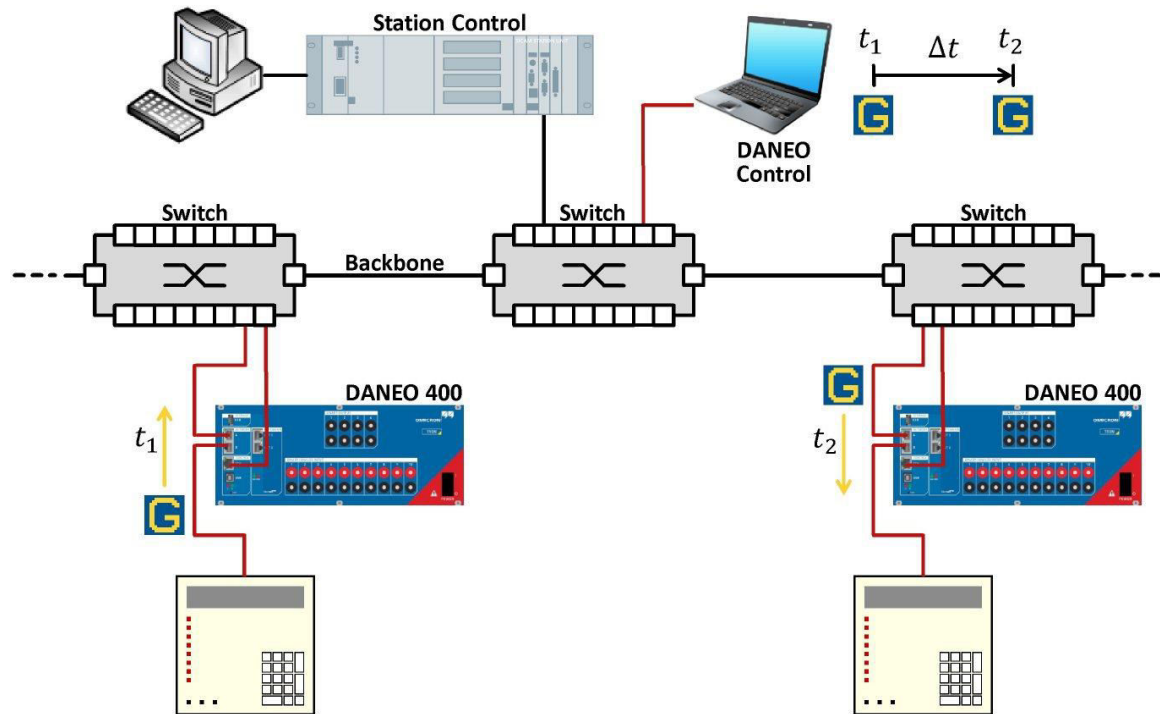


Standard definitions: Performance

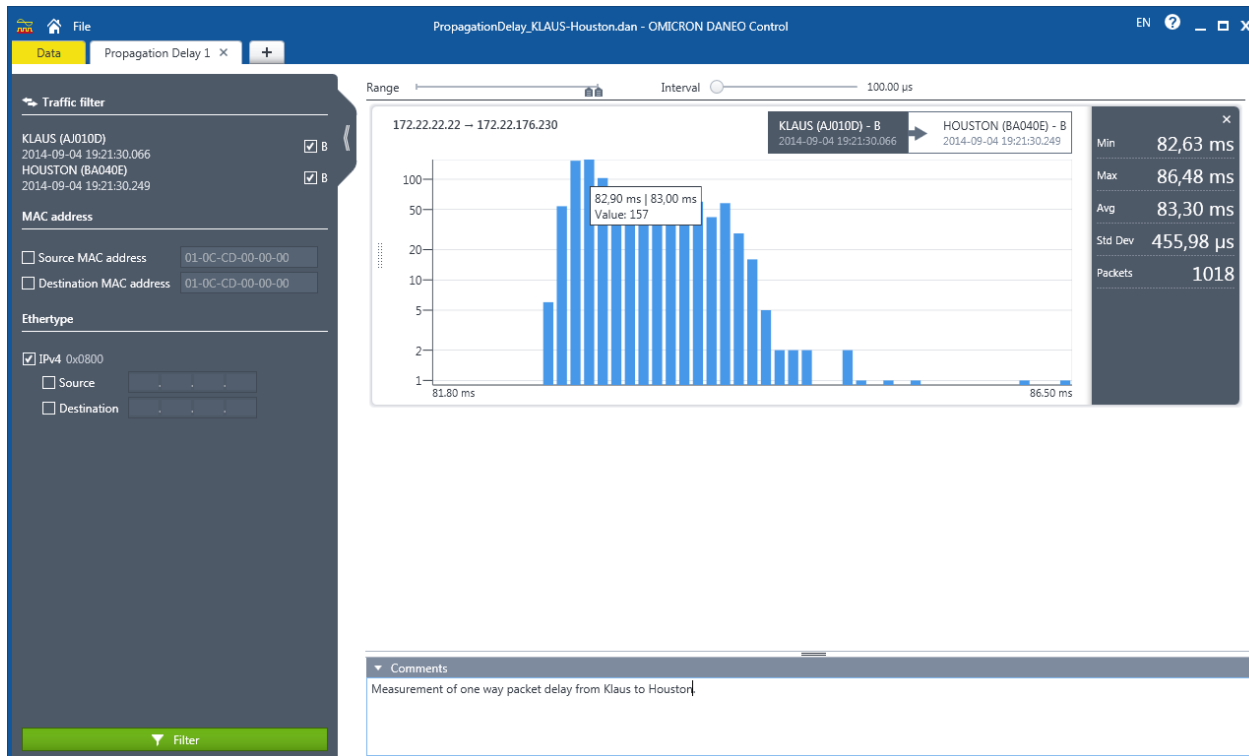


Message Type	Description	Performance Class	Max. overall time
Type 1A "Trip"	Fast message	P1	10ms
		P2/P3	3ms
Type 1B "Others"	Fast message	P1	100ms
		P2/P3	20ms
Type 2	Medium speed	-	100ms

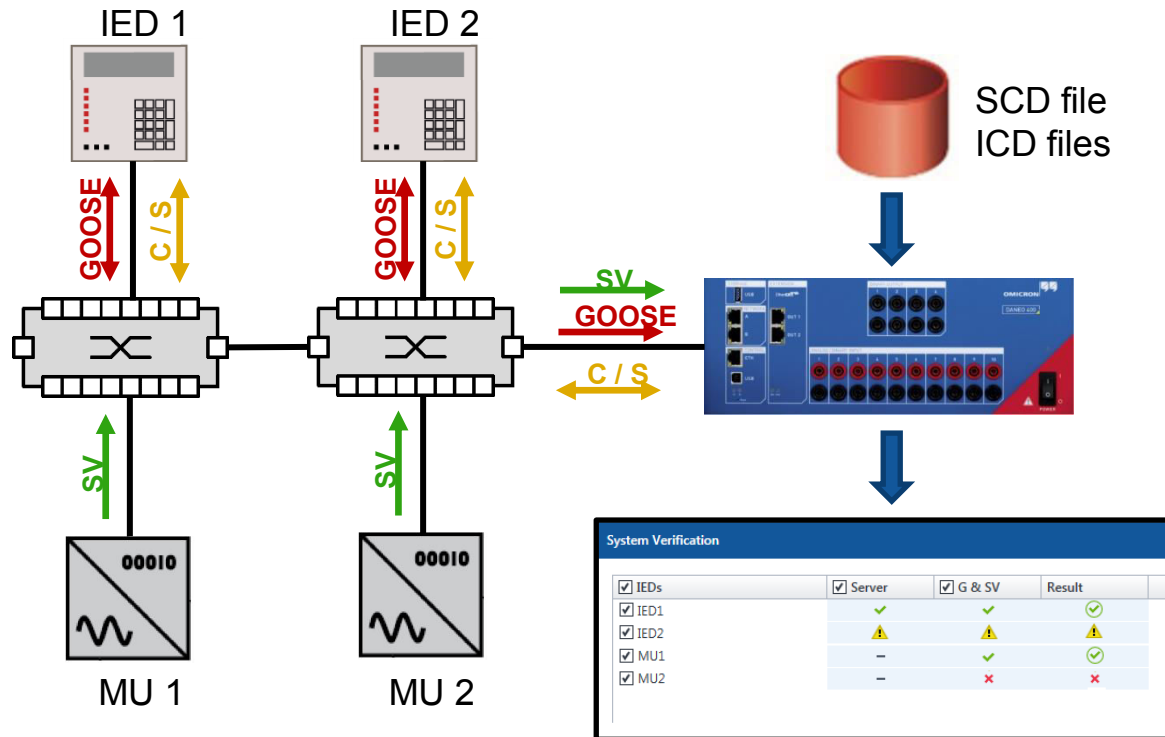
FAT or SAT scenarios in substations



Requirement – Propagation delays measurement



Requirement: Engineering (SCD)



Requirement Verification & Supervision

System Verification			
<input checked="" type="checkbox"/> IEDs	<input checked="" type="checkbox"/> Server	<input checked="" type="checkbox"/> G & SV	Result
<input checked="" type="checkbox"/> Feld1	✓	✓	✓
<input checked="" type="checkbox"/> A02440_	✓	✓	✓
<input checked="" type="checkbox"/> S7SA84	✓	✓	✓
<input checked="" type="checkbox"/> S7SJ86	✗	—	✗
<input checked="" type="checkbox"/> ISIO_BF218K	✓	✓	✓
<input checked="" type="checkbox"/> ISIO_BF253	✓	✓	✓
<input checked="" type="checkbox"/> P645SV1	✓	⚠	⚠
<input checked="" type="checkbox"/> QO_	✓	⚠	⚠

Event list			
Date and Time	Device	Category	
✗ 2015-10-16 15:49:35.049	DANE0 1 (AJ023D)	GOOSE	
i 2015-10-16 15:48:44.576	DANE0 1 (AJ023D)	Device	
✗ 2015-10-16 15:48:43.109	DANE0 1 (AJ023D)	GOOSE	
i 2015-10-16 15:48:34.576	DANE0 1 (AJ023D)	Device	
i 2015-10-16 15:45:56.572	DANE0 1 (AJ023D)	Device	
i 2015-10-16 15:45:47.571	DANE0 1 (AJ023D)	Device	
i 2015-10-16 15:45:27.099	DANE0 1 (AJ023D)	Recording	
i 2015-10-16 15:45:23.672	DANE0 1 (AJ023D)	PTP	
i 2015-10-16 15:45:23.672	DANE0 1 (AJ023D)	Device	
i 2015-10-16 15:45:21.950	DANE0 1 (AJ023D)	Recording	
i 2015-10-16 15:45:18.663	DANE0 1 (AJ023D)	PTP	

Details	
Severity	Error
Date and Time	2015-10-16 15:49:35.049
Device	DANE0 1 (AJ023D)
Category	GOOSE
Type	Out of sequence
Port	B
Control block reference	ISIO_AM174KBX/LLN0\$GO\$GCB
Destination MAC address	01-0C-CD-01-00-00
Source MAC address	20-B7-C0-00-3E-89
Application ID	1
GOOSE ID	GoID
DataSet reference	ISIO_AM174KBX/LLN0\$GooseDataSet1
Simulation/Test	False
Status number	1 (previous: 1)
Sequence number	0 (previous: 34)

Summary

- different possibilities in the standard require modern testing tools with new capabilities
- Clients become important
- Test equipment to be used in conventional and digital substations
- Time synchronization



Thanks for your attention!