

An Innovative Platform for DER Simulation, Testing, and Grid Integration

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Topic

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02 Smart Grid Core Standards and IEC 61850 XMPP

03 Description of XMPP Platform & PV Simulation/
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04 Implementation and Results

05 Conclusion

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Introduction (1/2)

- The increasing penetration of **distributed energy resources (DERs)** poses significant challenges to modern power grids, particularly at the **distribution** level.
- To accommodate this rapid growth, effective **monitoring** and seamless **integration** of DER-related data have become essential.
- An innovative IEC 61850-based **XMPP** platform has been developed at the Taiwan Power Research Institute (TPRI) of Taiwan Power Company (TPC).
- A robust and comprehensive testing facility is crucial to validate the performance and reliability of **DER monitoring** and **control** systems.

Introduction (2/2)

- The proposed platform integrates the IEC 61850 **XMPP** protocol and is deployed with **DER** sites in **distribution networks**, incorporating enhanced **cybersecurity** measures.
- To validate its robustness, performance analyses and stress testing have been conducted.
- A comprehensive **DER simulation and testing framework** has been developed.
- **Test procedures** and **scenarios** are designed to **simulate** a grid-connected **PV** system and ensure compliance with **distribution network** operation requirements.

01 Introduction

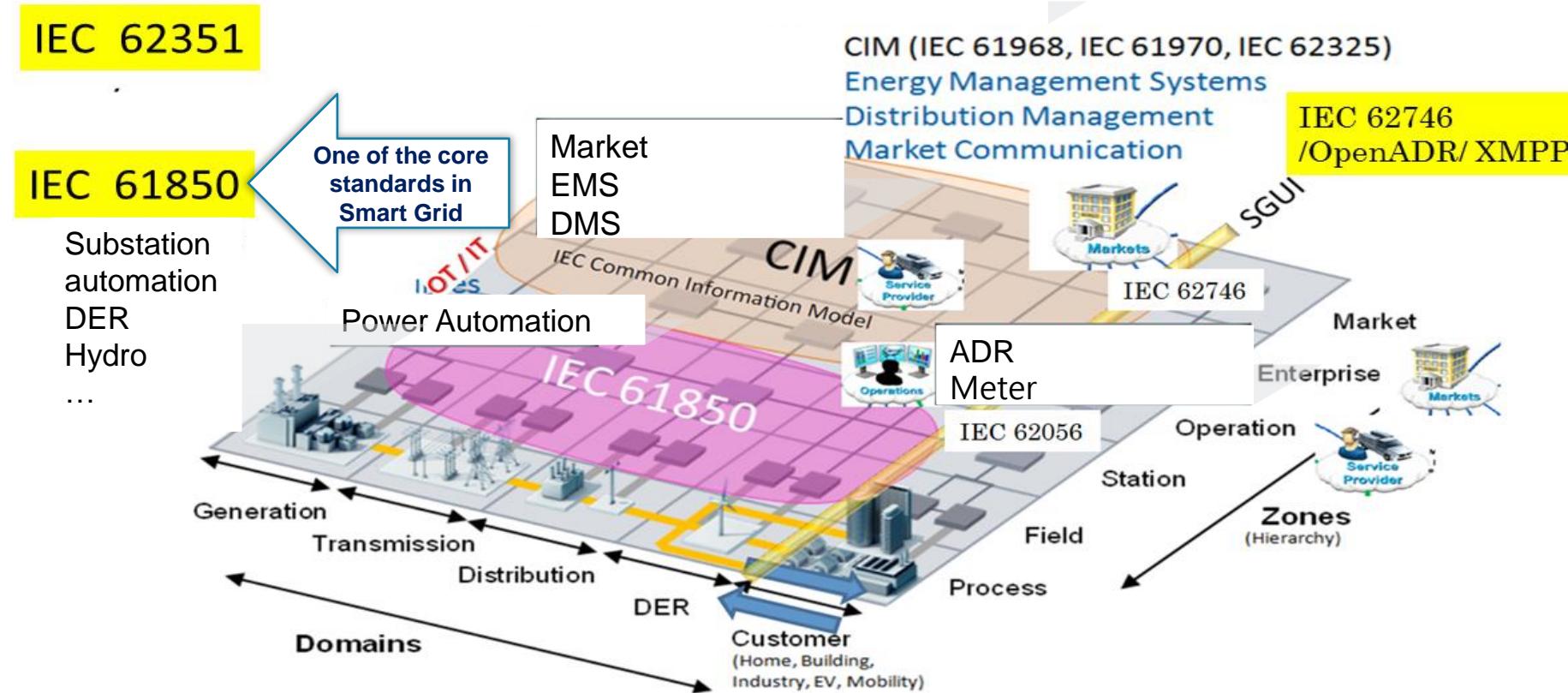
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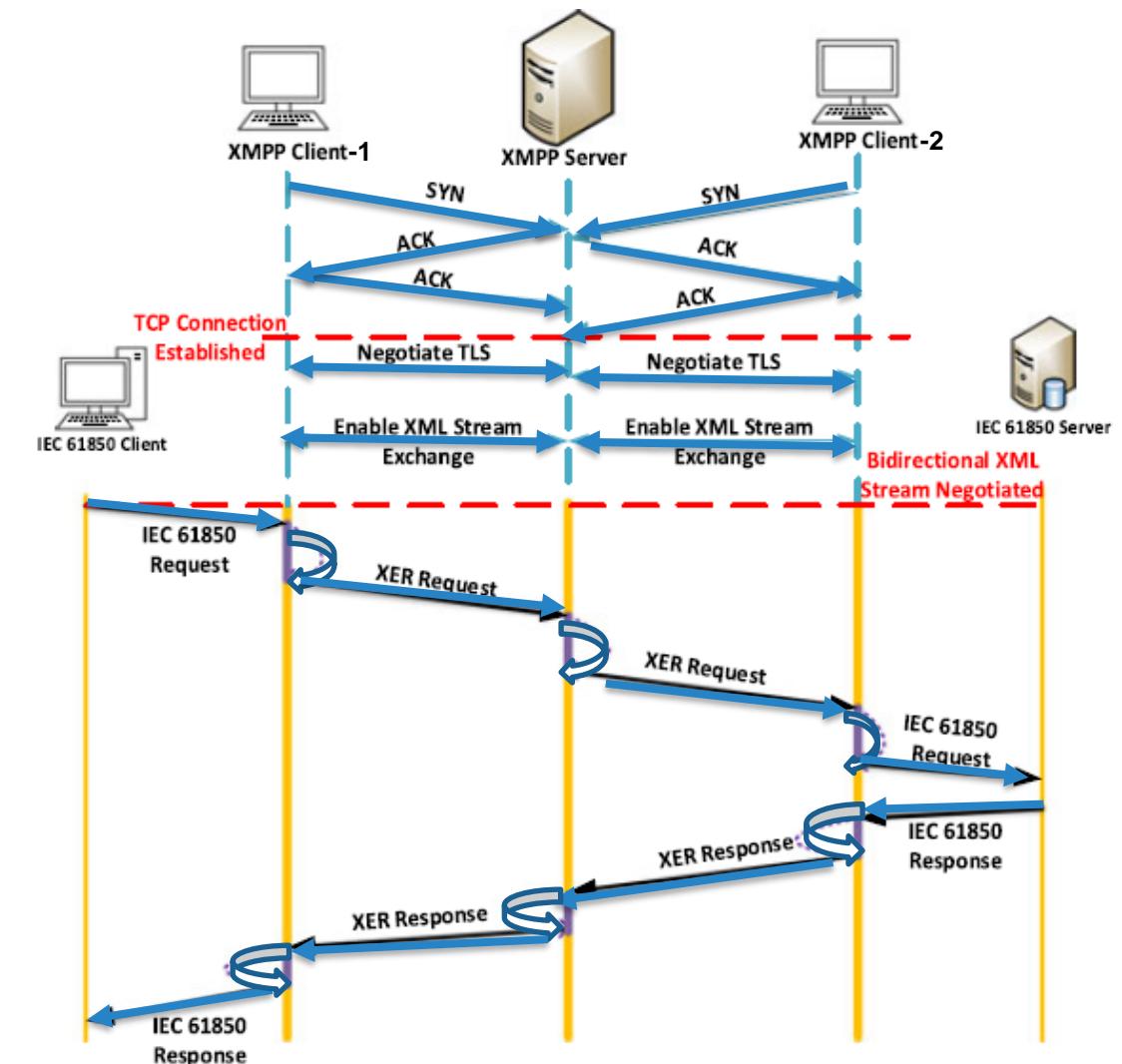
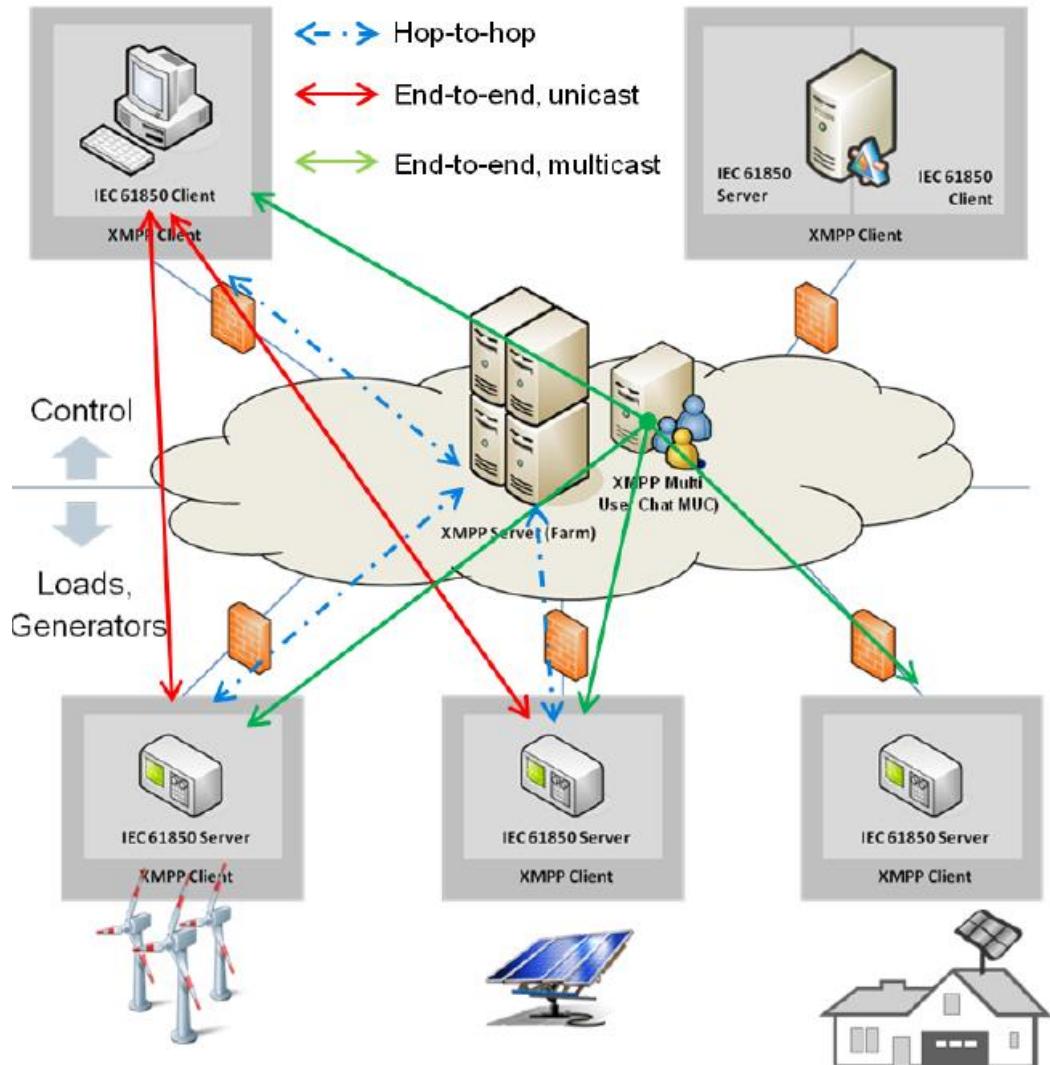
05 Conclusion

Smart Grid Core Standards

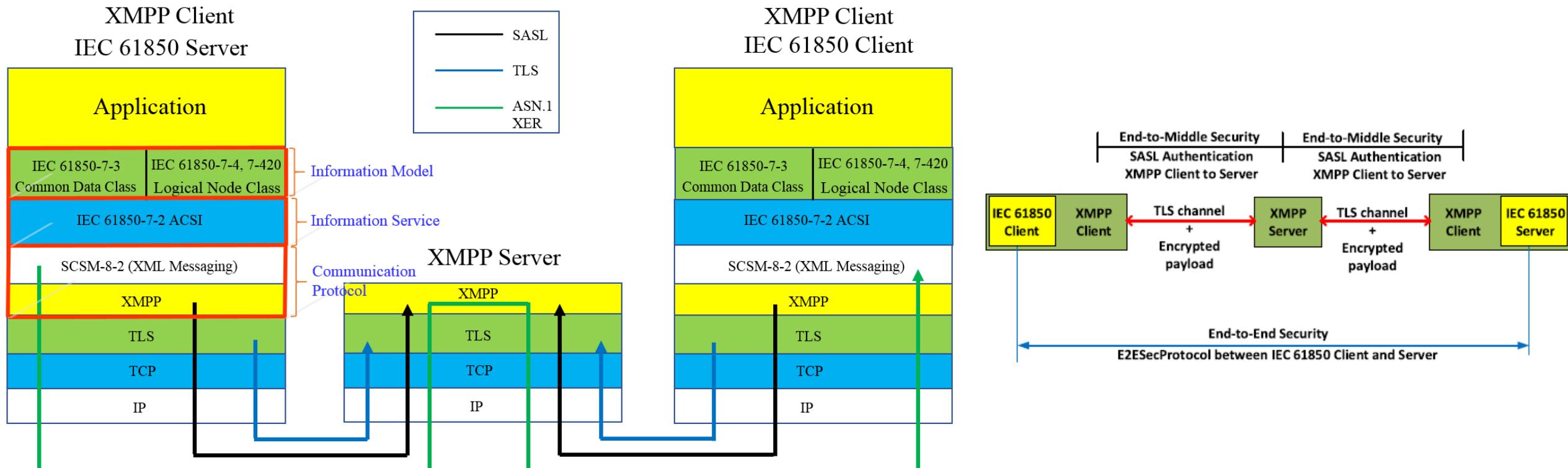


Source : IEC TC 57

IEC 61850-8-2 XMPP

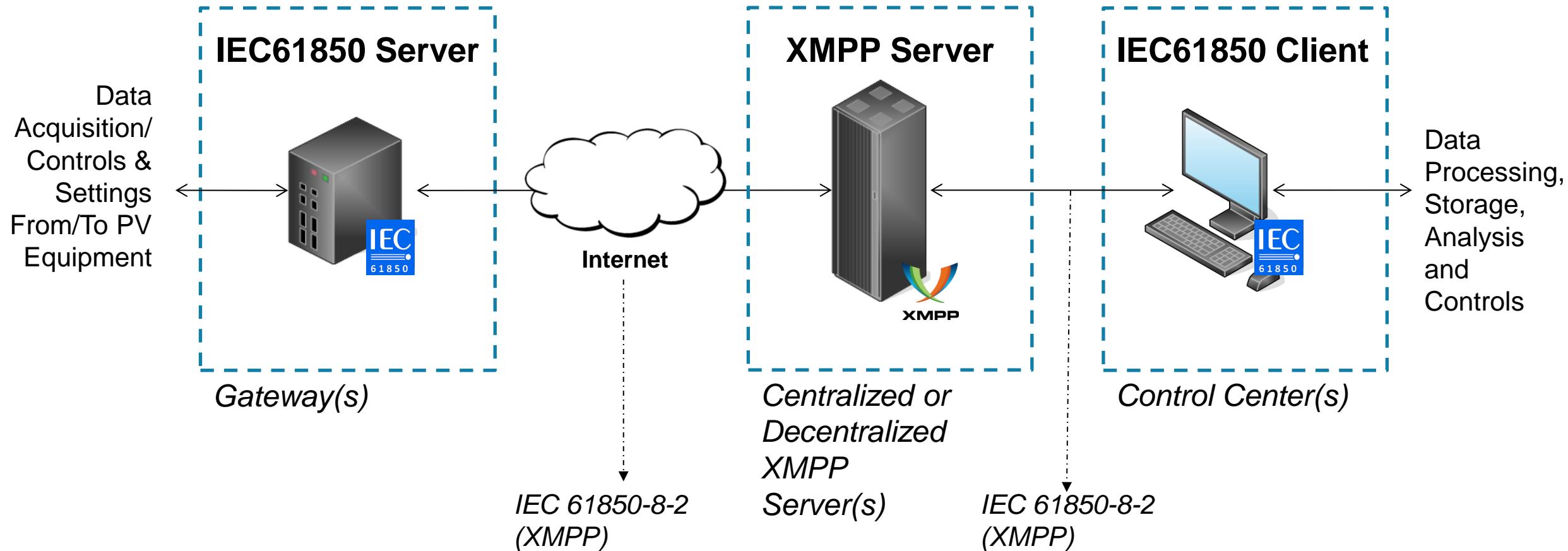


Security Enhancements



Source: IEC 61850 Modeling of DSTATCOM and XMPP Communication for Reactive Power Management in Microgrids, 2018, *IEEE Systems Journal*.

IEC 61850-8-2 XMPP Communication



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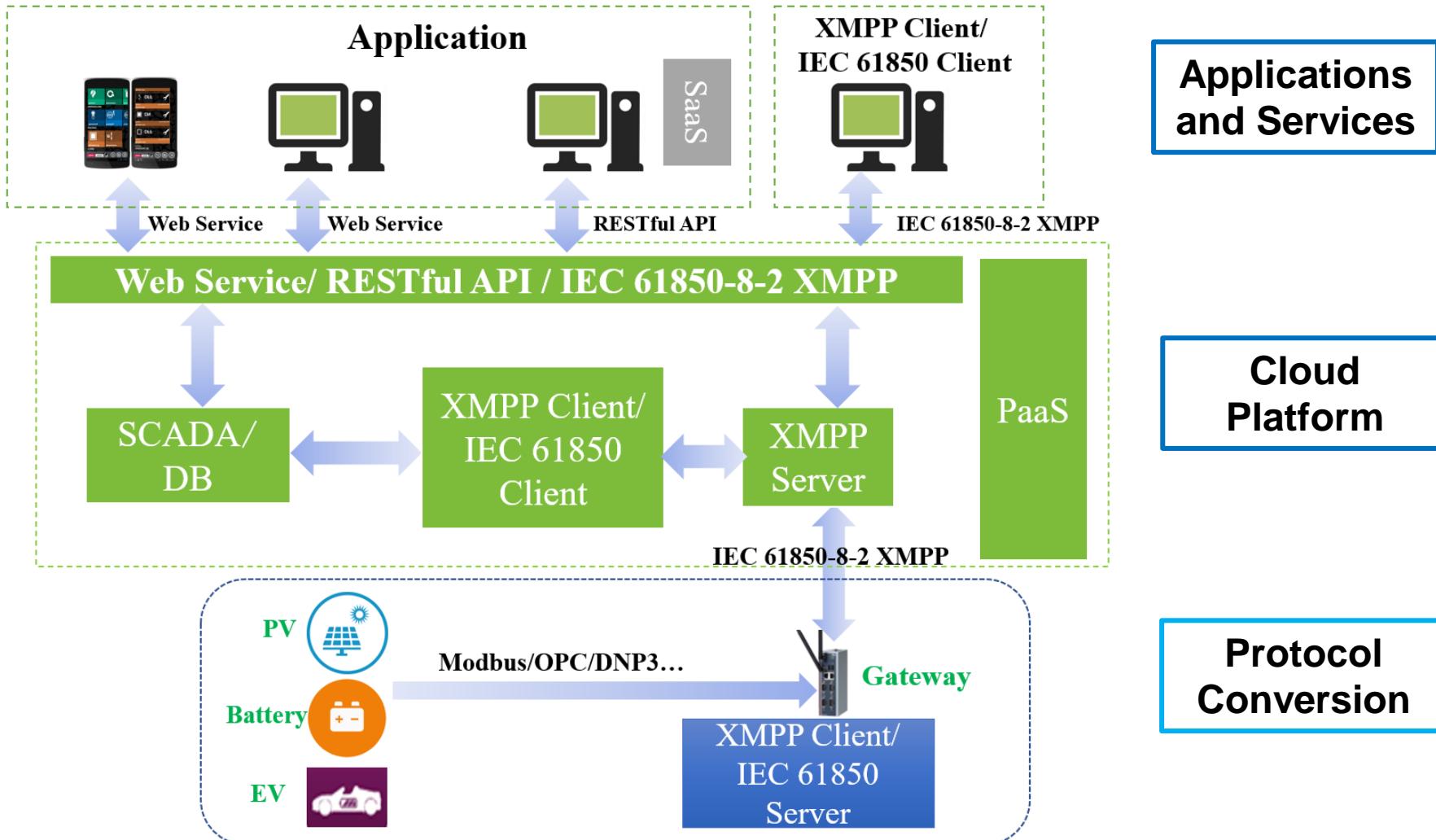
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Xmpp Platform (1/2)

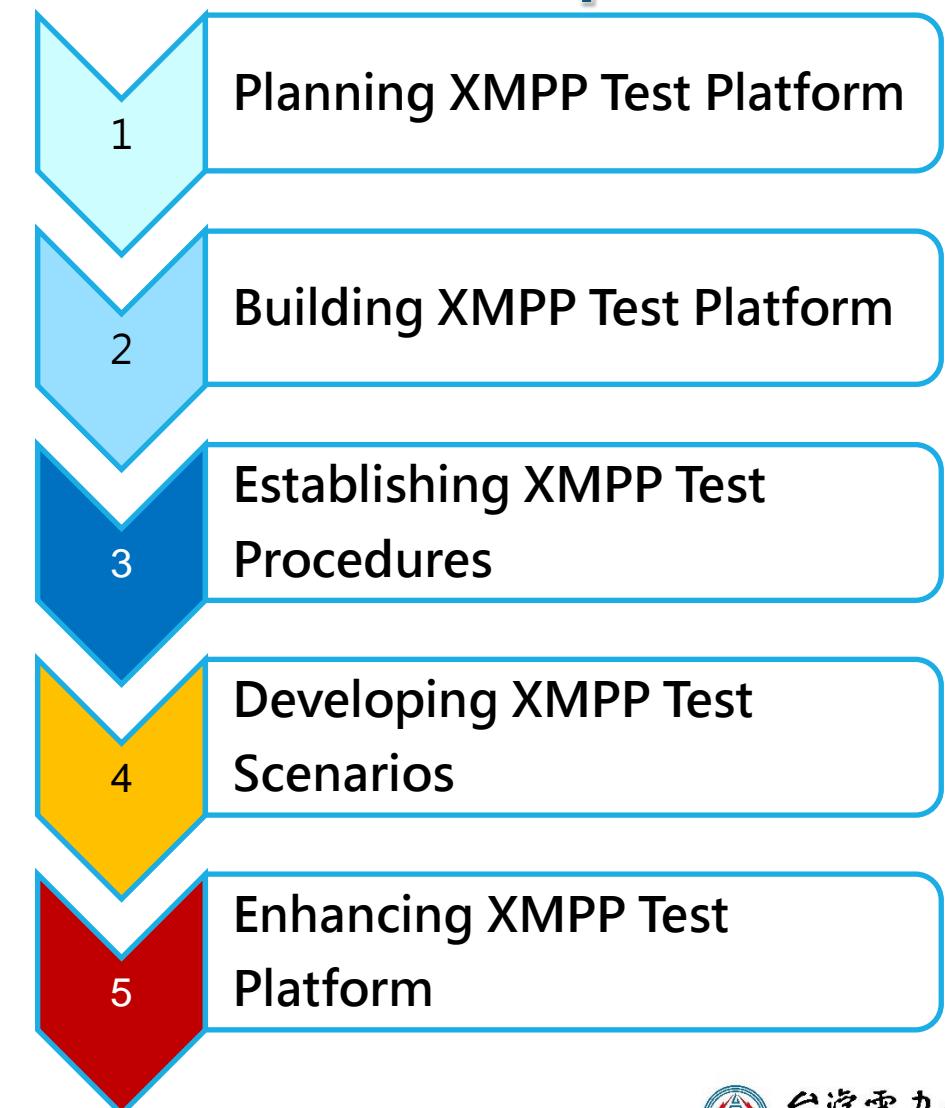
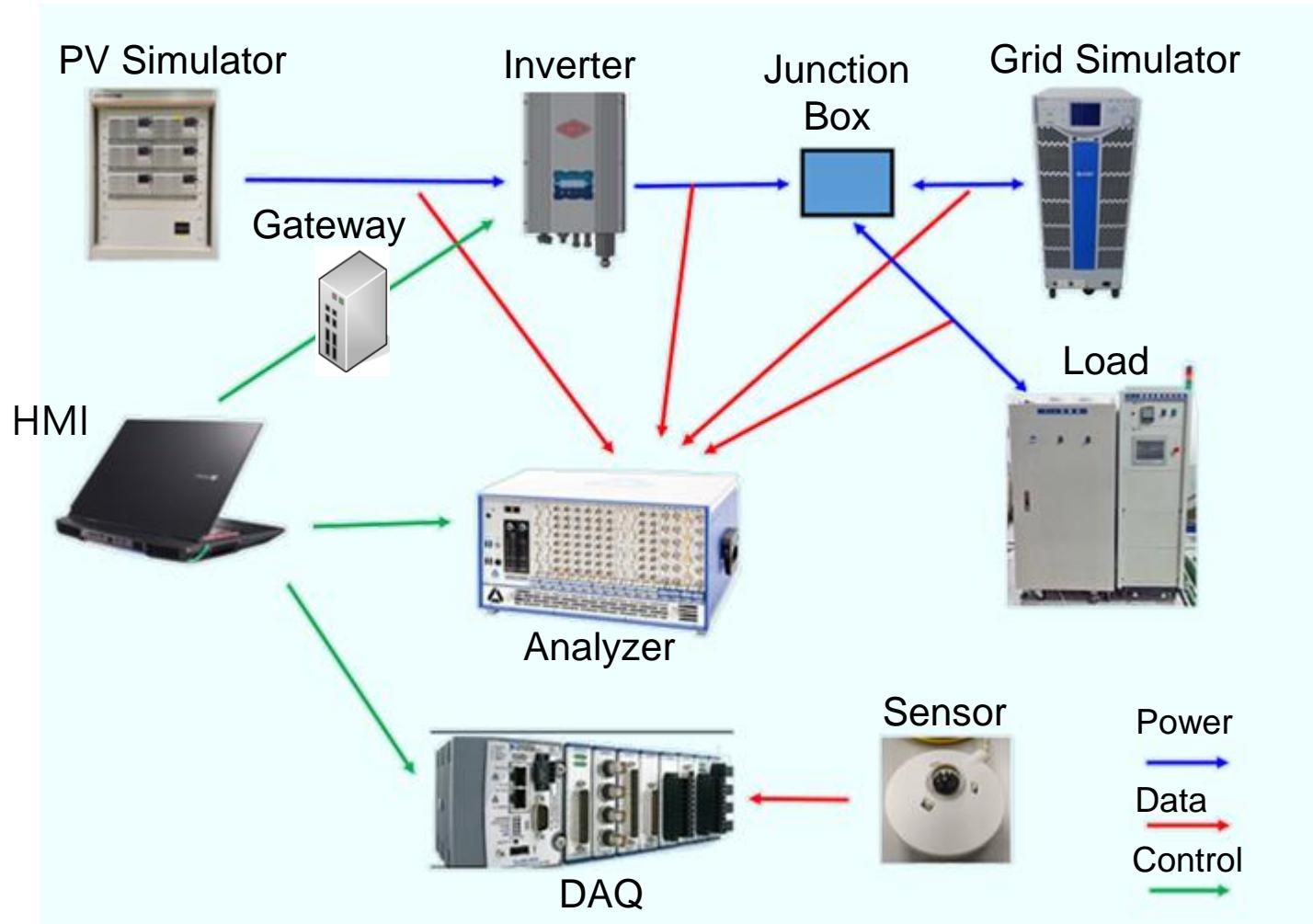
- The platform follows **IEC 62357** smart grid architecture model.
- The information model is based on **IEC 61850-7-4** and **IEC 61850-7-420**.
- The communication protocol is based on **IEC 61850-8-2 XMPP**.
- **Gateways** are provided at DER sites to facilitate standardization, information modeling, and seamless integration.

XMPP Platform (2/2)



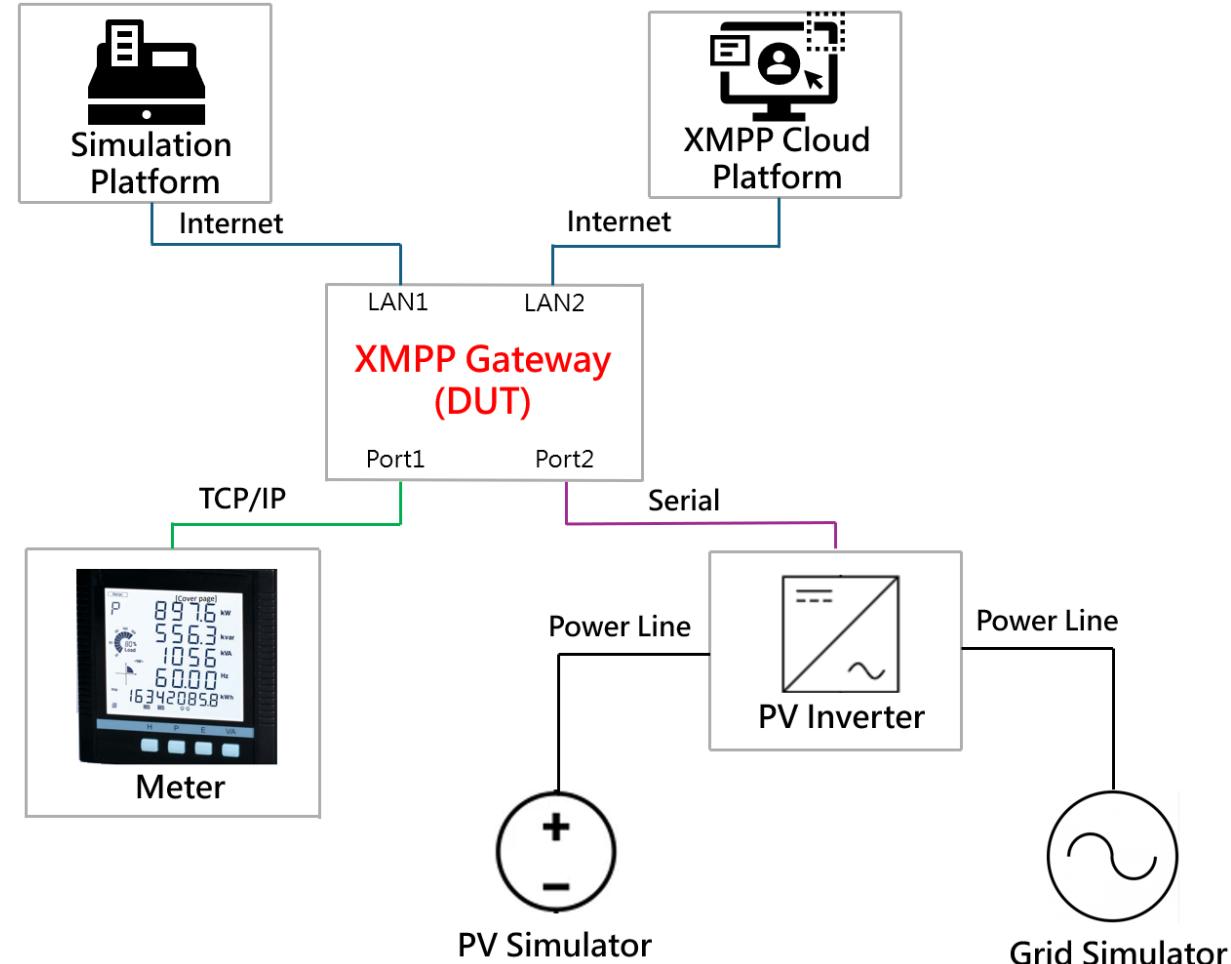
The PV Simulation/Test Framework at TPRI Lab (1/4)

Steps

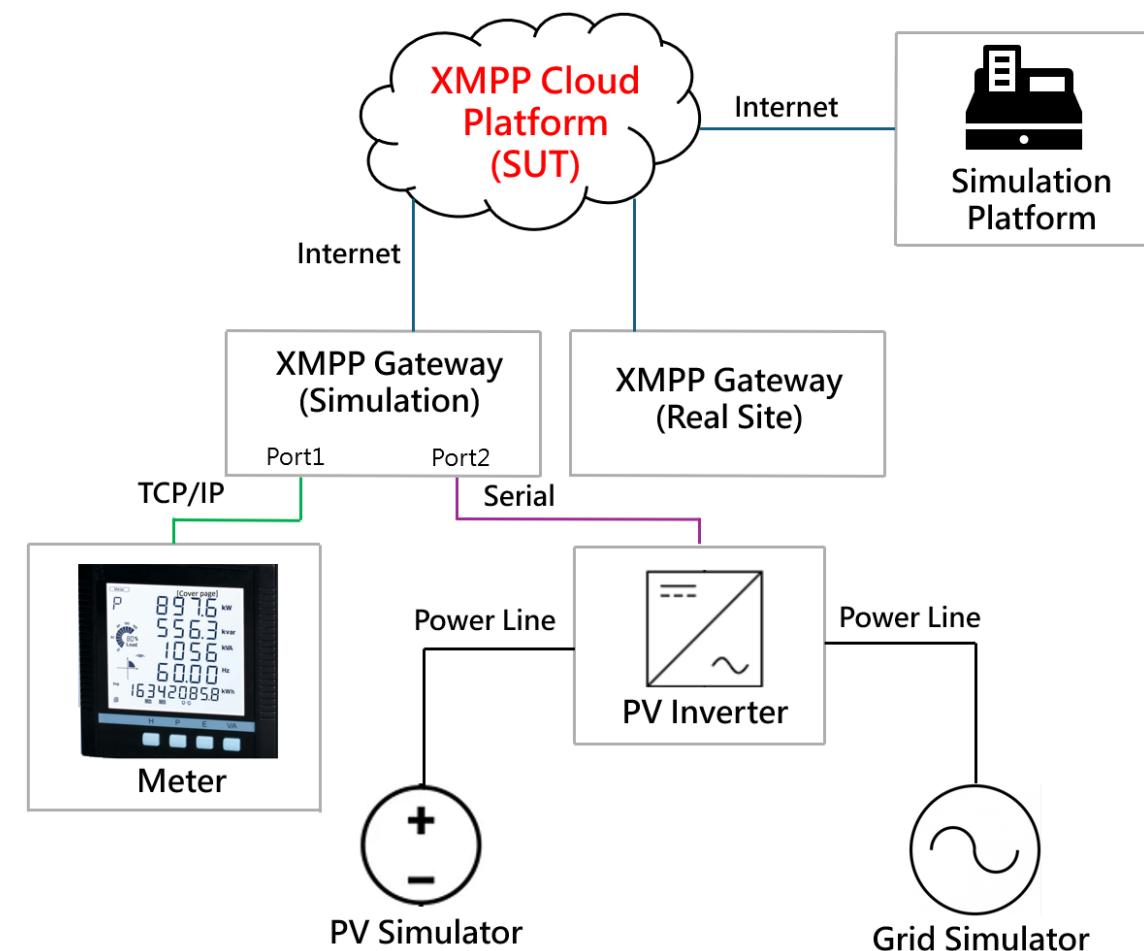


The PV Simulation/Test Framework at TPRI Lab (2/4)

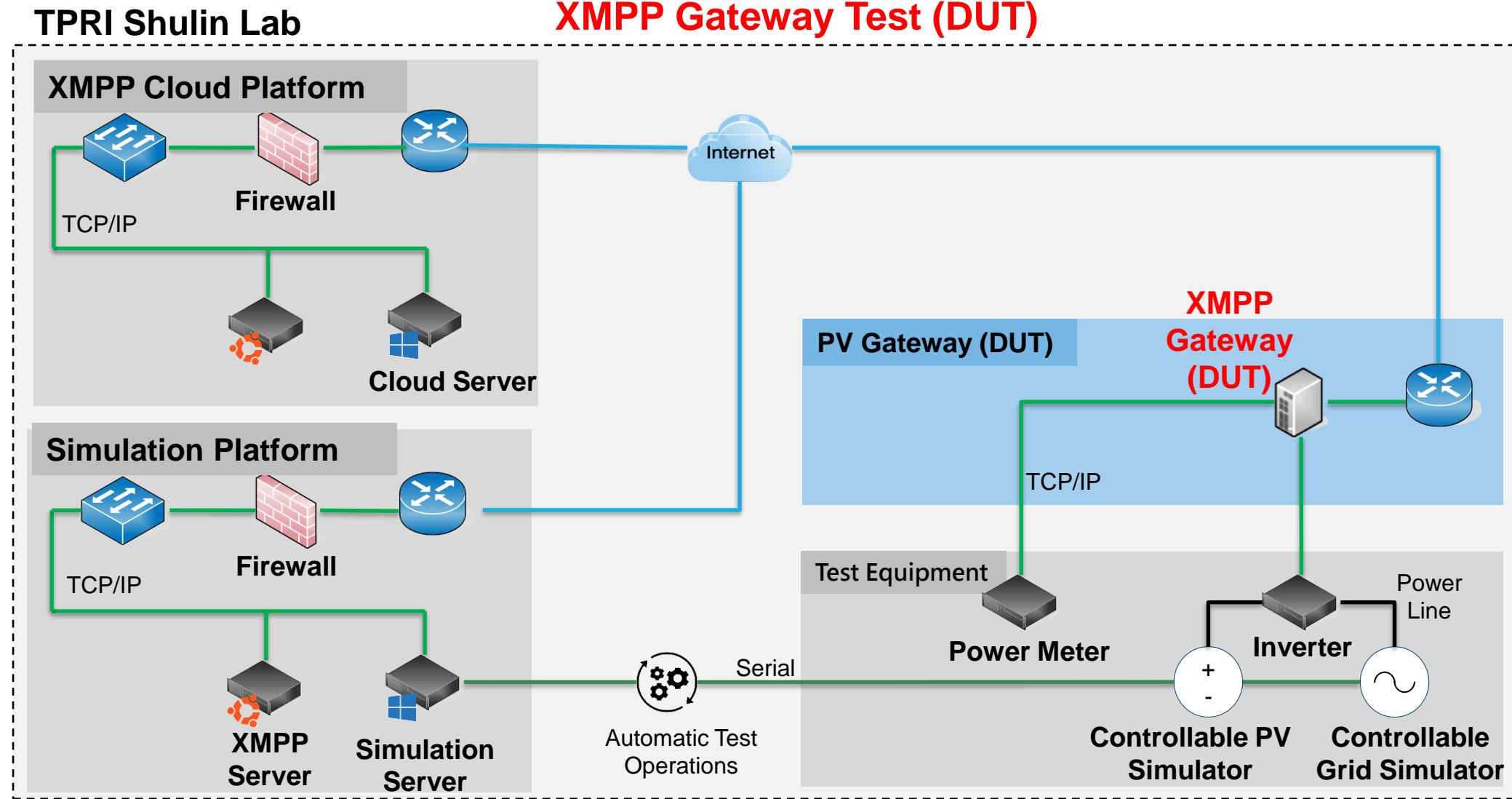
XMPP Gateway Test (DUT)



XMPP Cloud Platform Test (SUT)

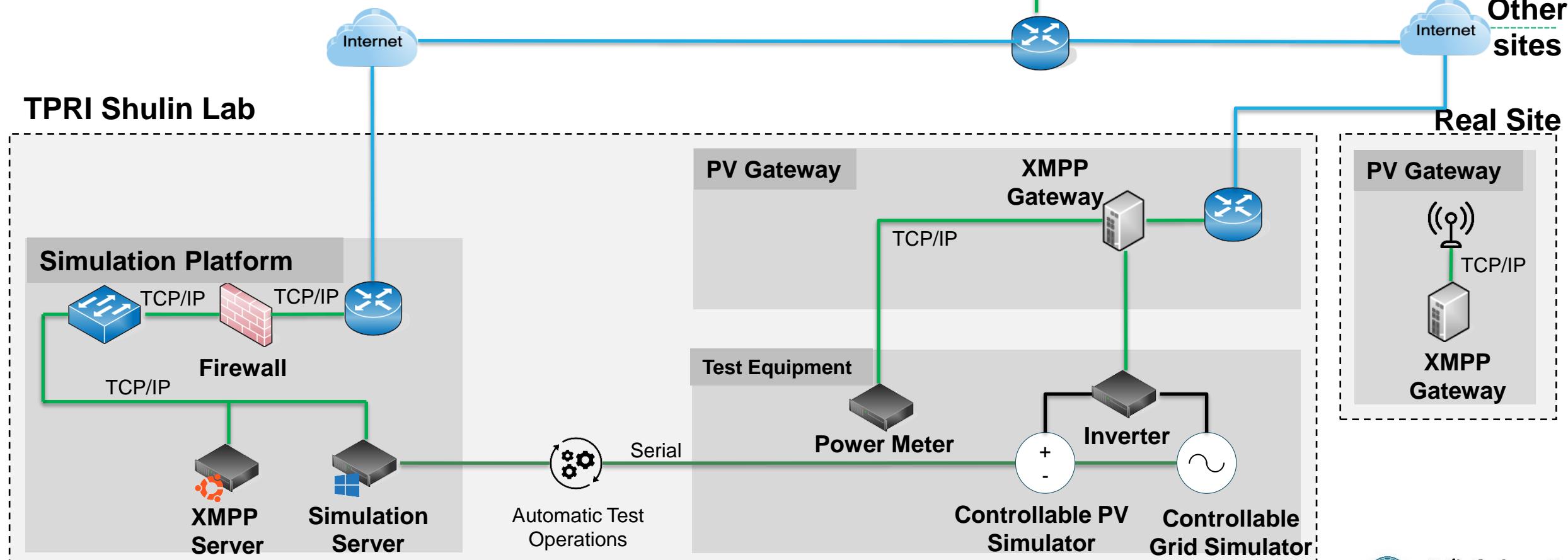


The PV Simulation/Test Framework at TPRI Lab (3/4)



The PV Simulation/Test Framework at TPRI Lab (4/4)

XMPP Cloud Platform Test (SUT)



01 Introduction

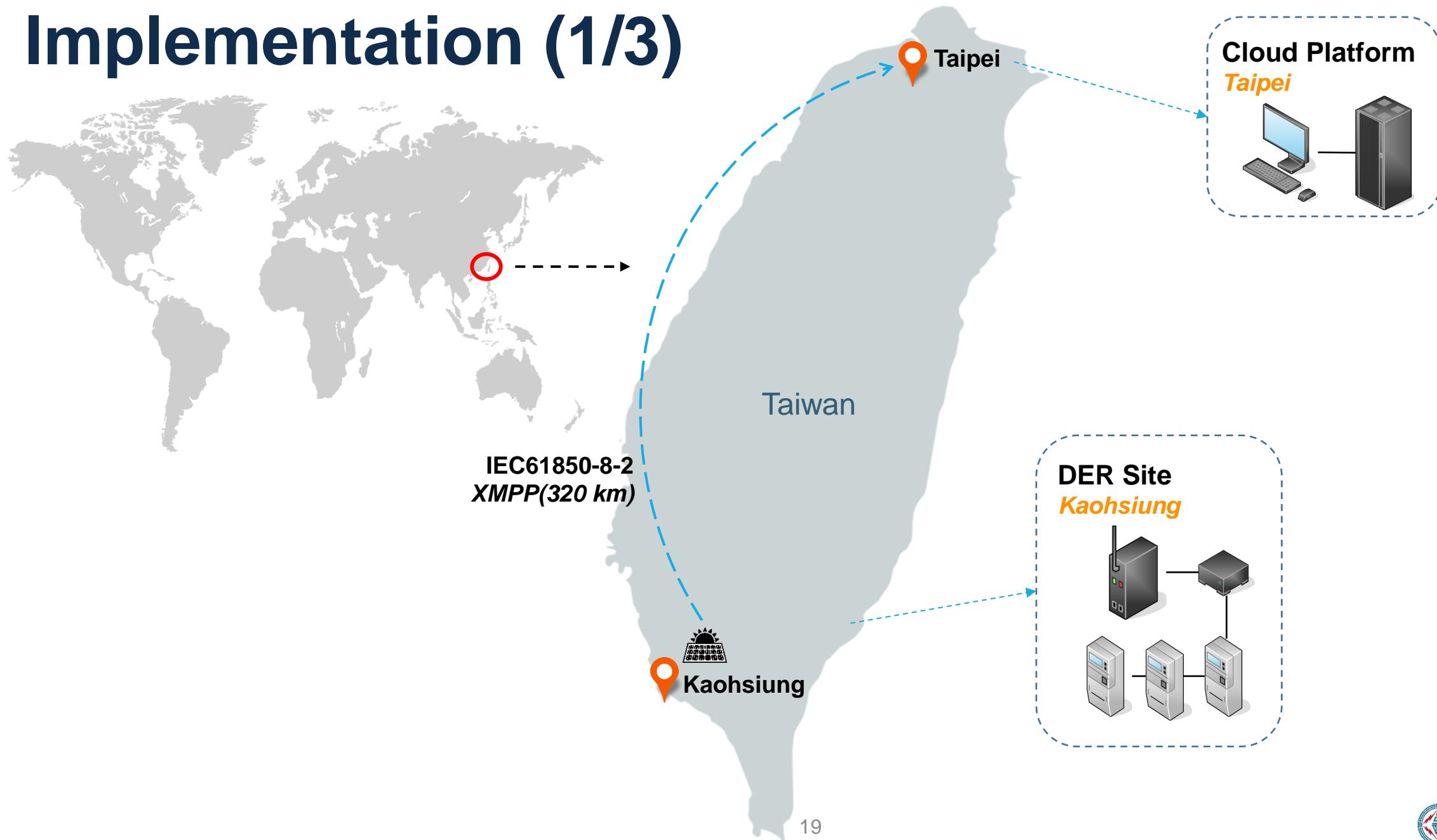
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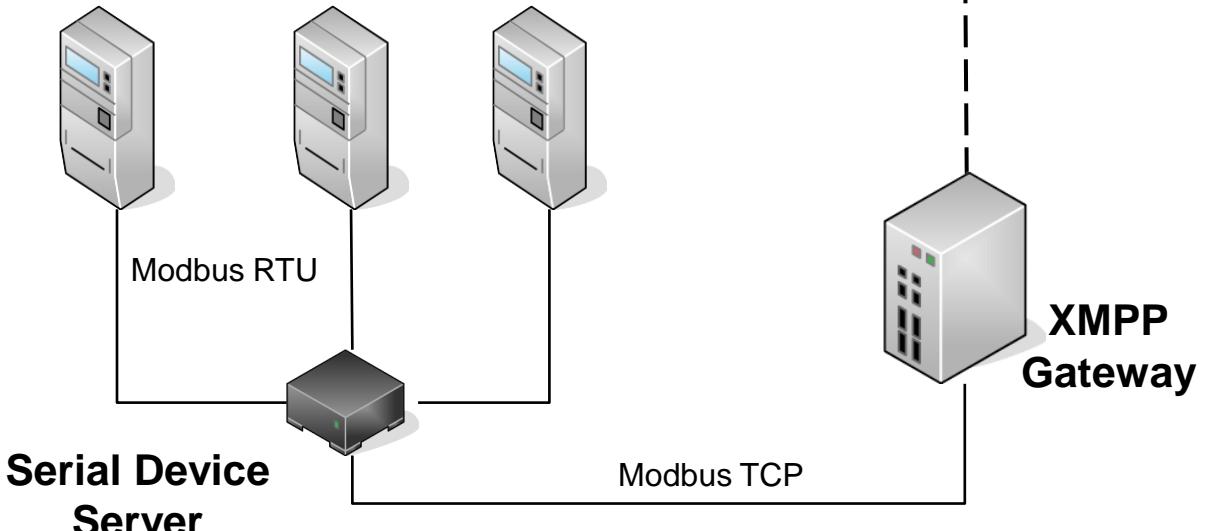
Implementation (1/3)



Implementation (2/3)



PV Inverter 1 PV Inverter 2 PV Inverter 3



(1) Modbus

Modbus Address	Name	Type
0x0148	Generator Current Line 1	uint32
0x004C	Grid Voltage	uint32
0x004E	Grid Frequency	uint32
0x00E8	GRID Output Energy This Hour	uint32

Protocol Conversion

(2) DNP 3

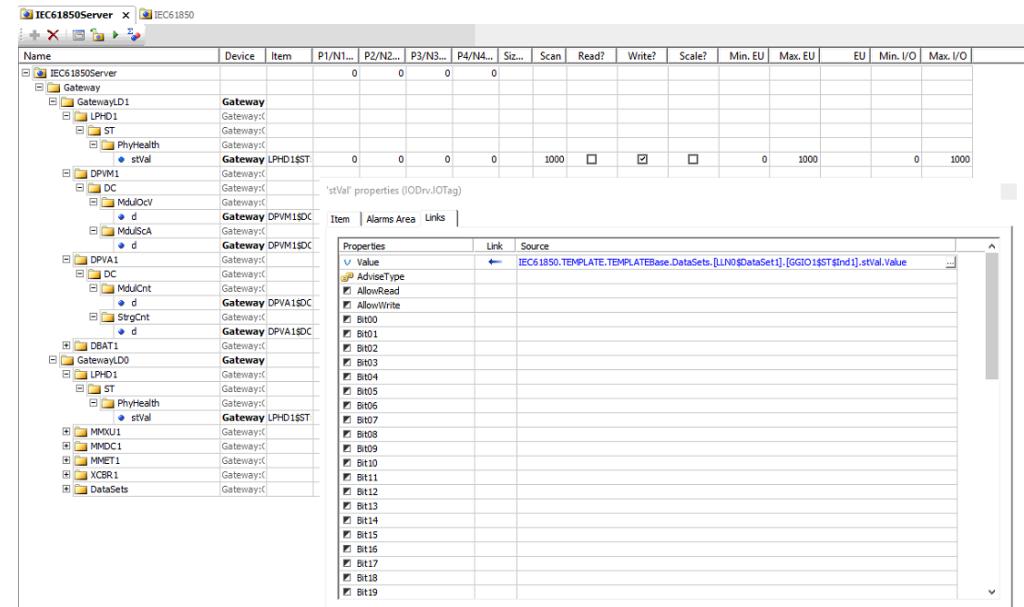
Point Index	Name / Description
8	Inverter active power output - Present real power output level (negative = charging)
9	Inverter reactive output - Present reactive power output level (negative = absorbing)
10	Frequency at the connection point
11	Active power at the connection point
12	Reactive power at connection point
13	Power factor at the connection point
14	Phase A Volts at connection point
15	Phase A Volts angle
16	Phase B Volts at connection point
17	Phase B Volts angle
18	Phase C Volts at connection point
19	Phase C Volts angle
20	DC Inverter input power
21	DC current level available to inverter
22	DC voltage between PV system and inverter

(3) OPC

ObjectType	Name
OPCDriver	
OPCGroup	OPCGroup1
OPCTag	OPCGroup1.Ambient_Temp
OPCTag	OPCGroup1.Module_Temp
OPCFolder	OPCGroup1.Inverter
OPCTag	OPCGroup1.Inverter.ac_output_power
OPCTag	OPCGroup1.Inverter.input_power_a
OPCTag	OPCGroup1.Inverter.input_power_b
OPCFolder	OPCGroup1.MP960
OPCTag	OPCGroup1.MP960.Current
OPCTag	OPCGroup1.MP960.Freq
OPCTag	OPCGroup1.MP960.Imp_kWH_Hi
OPCTag	OPCGroup1.MP960.Imp_kWH_Low
OPCTag	OPCGroup1.MP960.Imp_kWH_Mid
OPCTag	OPCGroup1.MP960.kW
OPCTag	OPCGroup1.MP960.PF
OPCTag	OPCGroup1.MP960.Voltage
OPCFolder	OPCGroup1.Solar_Radionation
OPCTag	OPCGroup1.Solar_Radionation.PV

Implementation (3/3)

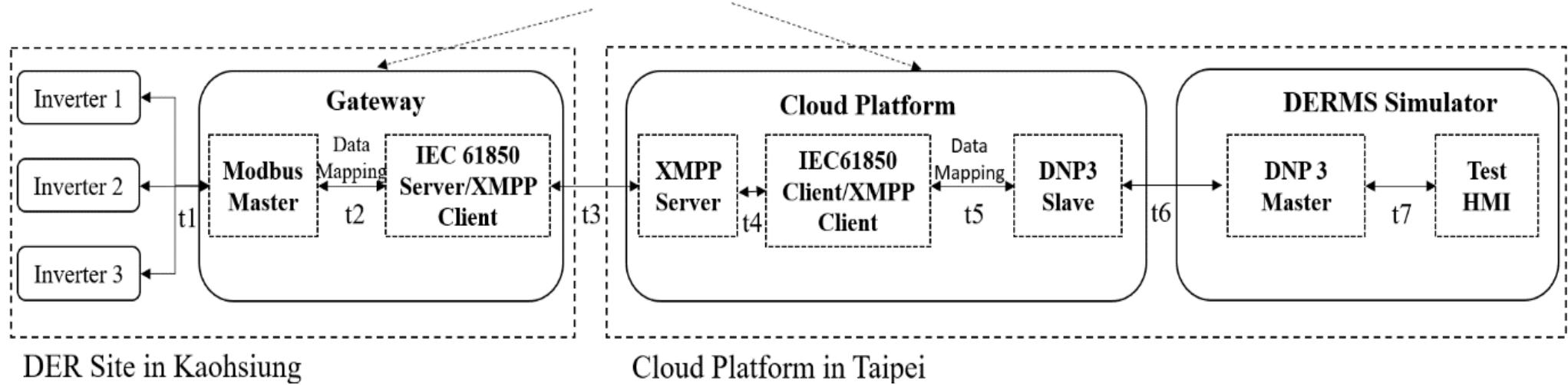
IEC 61850 Information Model



Results (1/4)

Latency

Gateway and Cloud Platform are Synchronized by Time Server



t1	t2	t3	t4	t5
2384	1866	1912	1506	1465
t6	t7	t8	t9	t10
1789	2654	1369	94	1795

Average : 1683 ms

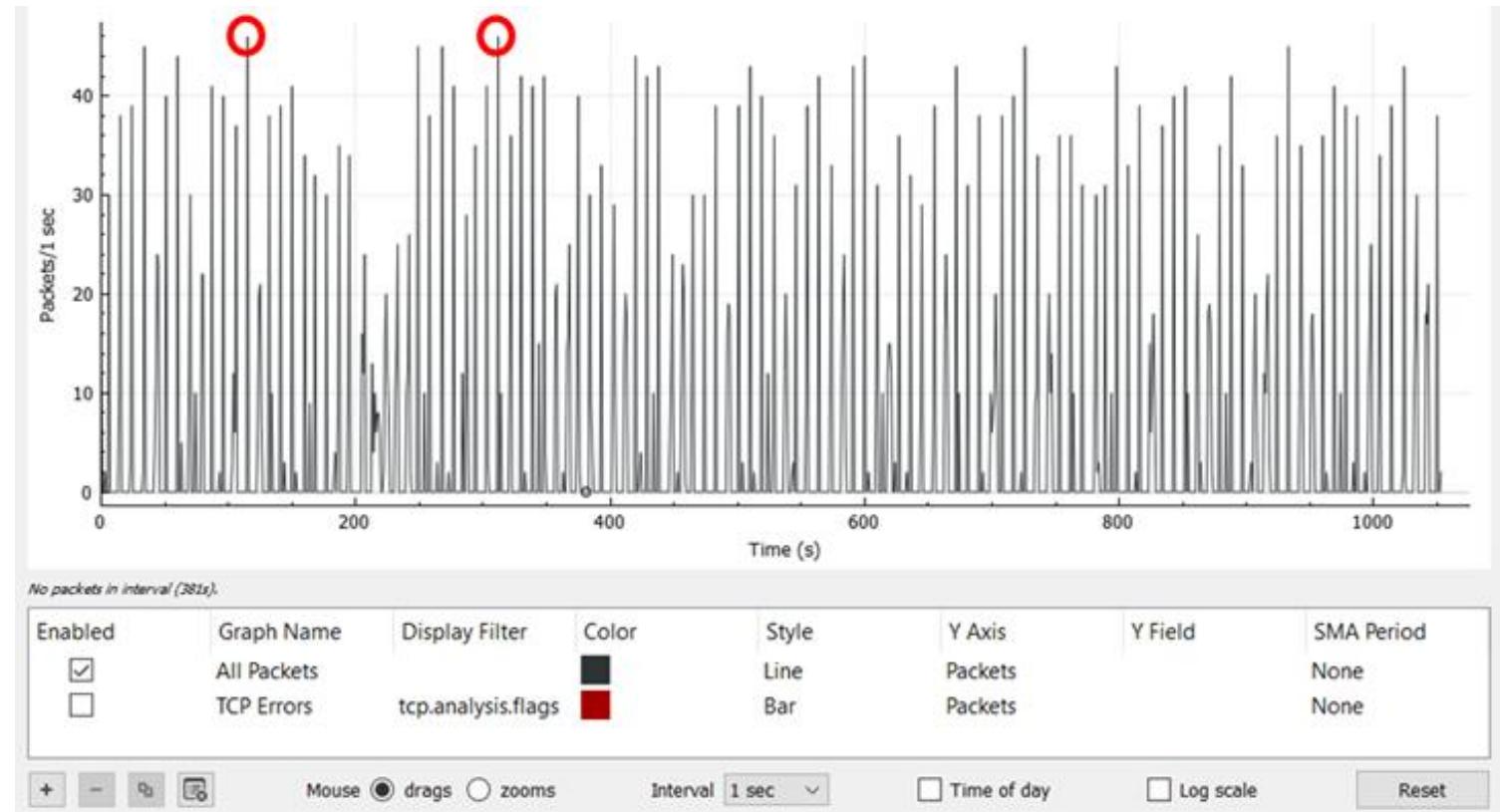
Latency class	Latency	Application example
TT0	> 1000 ms	File, events, log contents
TT1	≤ 1000 ms	Alarms and Events
TT2	≤ 500 ms	Operator commands
TT3	≤ 50 ms	Slow automatic interaction
TT4	≤ 20 ms	Fast automatic interaction
TT5	≤ 10 ms	Releases, status change
TT6	≤ 3 ms	Trip, blockings

Results (2/4)

Packet evaluation of XMPP protocol

The maximum packet is 43 per second

The average bandwidth is 26 Kbps



Results (3/4)

xmpp.pcapng

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No.	Time	Source	Destination	Protocol	Length	Info
29206	9.810305	192.168.31.122	192.168.31.123	TDS	117	Response
29207	9.810633	192.168.31.123	192.168.31.122	TDS	748	SQL batch
29208	9.810948	192.168.31.123	192.168.31.122	TDS	748	SQL batch
29209	9.811068	192.168.31.122	192.168.31.123	TDS	117	Response
29210	9.811230	192.168.31.123	192.168.31.122	TDS	748	SQL batch
29211	9.811301	192.168.31.124	60.248.158.251	XMPP/XML	588	UNKNOWN PACKET
29212	9.811382	192.168.31.122	192.168.31.123	TDS	117	Response
29213	9.811492	192.168.31.124	60.248.158.251	TCP	588	57226 → 5222 [PSH, ACK] Seq=535 Ack=2403 Win=2053 Len=534 [TCP segment of a reassembled PDU]
29214	9.811575	192.168.31.122	192.168.31.123	TDS	117	Response
29215	9.811575	192.168.31.123	192.168.31.122	TDS	748	SQL batch
29216	9.811833	192.168.31.123	192.168.31.122	TDS	748	SQL batch

```

> Flags: 0x018 (PSH, ACK)
Window: 2049
[Calculated window size: 2049]
[Window size scaling factor: -1 (unknown)]
Checksum: 0xbe48 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
> [SEQ/ACK analysis]
> [Timestamps]
TCP payload (534 bytes)
TCP segment data (534 bytes)
> [9 Reassembled TCP Segments (4806 bytes): #1622(534), #5828(534), #10302(534), #12634(534), #15268(534), #15585(534), #18270(534), #19639(534), #29211(534)]
> XMPP Protocol

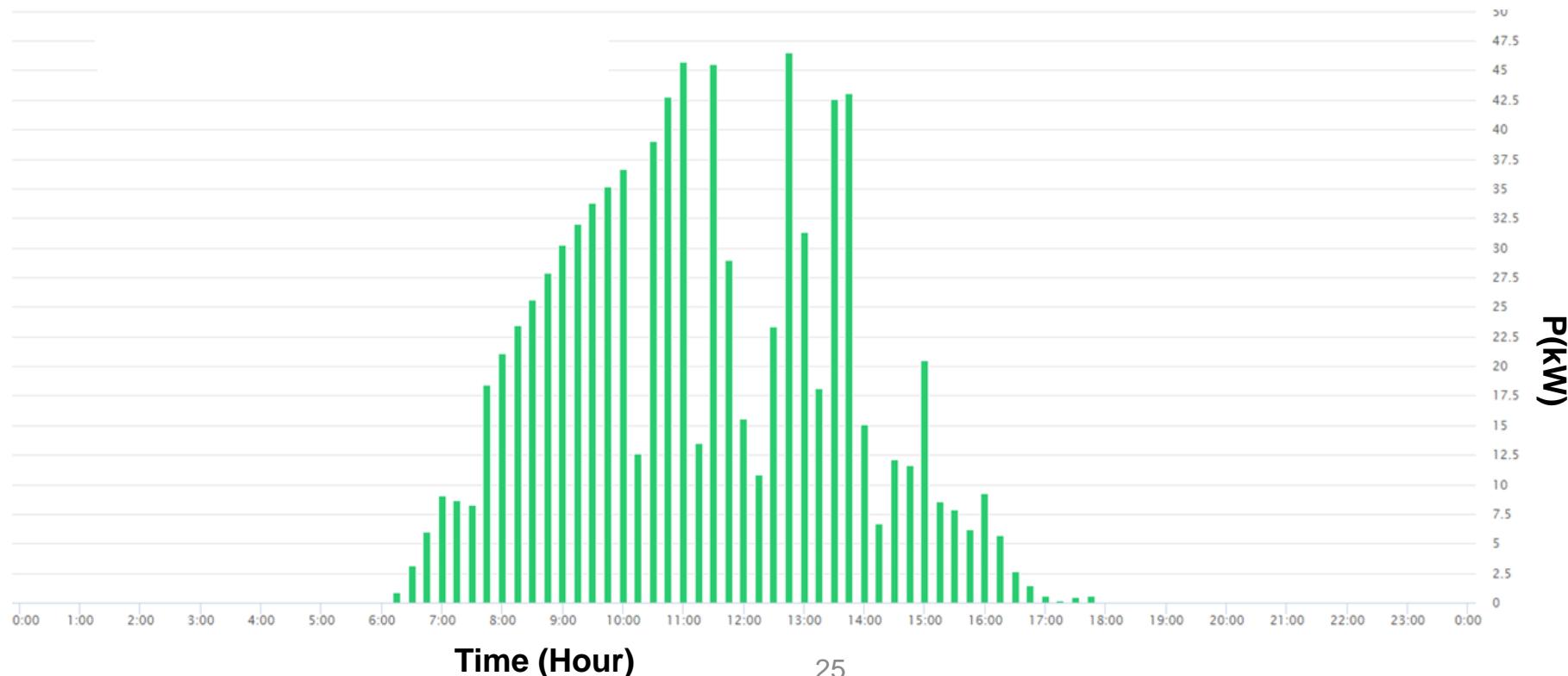
```

Hex	Dec	Text
0000	e0 23 ff 3a 28 da 00 0c	·#·:(...)·I&·E·
0010	02 3e 1e fd 40 00 80 06	>·@.... <·
0020	00 00 c0 a8 1f 7c 3c f8f ·*FP·
0030	9e fb df 1c 14 66 20 1b	...H·.....
0040	ac ca bc 2a 07 46 50 18	·p···] · ..dj..·.
0050	08 01 be 48 00 00 17 03	·49(··· ·K··v··c
0060	03 02 11 00 00 00 00 00	··2··J< ··TG···I
0070	a4 cf 34 39 28 c2 07 01	··V···x e·ufrc··
0080	a8 4b e3 e7 76 b1 f5 63	·P···D6
0090	09 6b 32 cd ef 4a 11 3c	·m··d·b 6···xk%
00a0	b1 a3 54 47 02 e1 85 49	~···w· ..v··c
00b0	65 03 75 66 72 43 c6 bb	"·+!/g· ·8··1Pi
00c0	1c 88 a8 14 51 80 67 af	··~··l@··Zo
00d0	b3 59 56 44 6d 35 ae 63	

Results (4/4)

Rated Power (kW)	Active Power	Phase A Current	Phase B Current	Phase C Current
53.04	7.99	12.00	12.10	12.00

Line AB Voltage	Line BC Voltage	Line CA Voltage	Reactive Frequency	Power
226.80	228.10	229.10	60.00	0.19



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Conclusion

- For **DER**, if **international standards** are adopted from the **source**, the system will be simplified.
- Adopting **XMPP** communication protocol will meet **INTERNET**, massive deployment, **PLUG & PLAY** and security.
- A **PV simulation and testing facility** has been developed.
- **Test procedures** and **scenarios** are designed to **simulate** grid-connected PV system and ensure compliance with distribution operation requirements.
- **XMPP** achieves good performance of **DER** grid integration for **data acquisition and monitoring**.

Thanks for your attention

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