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

Speaker: Chi-Shiang Cho

Authors: Chun-Kuei Chang Liao, Yi-Yen Chen

Chin-Tun Wang, Hsu-Liang Tsai

Taiwan Power Research Institute
Taiwan Power Company

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Topic

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.

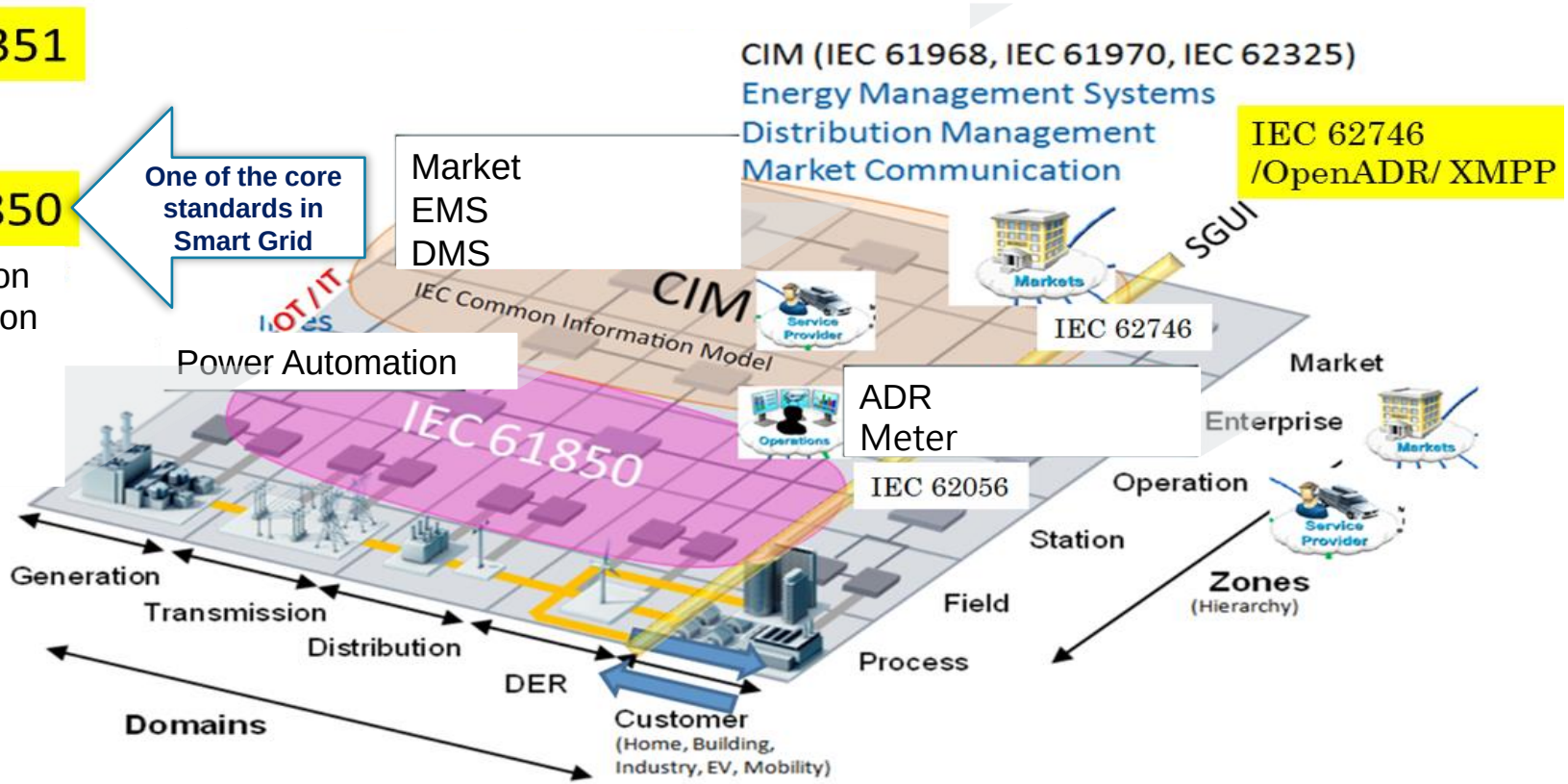
Smart Grid Core Standards

IEC 62351

IEC 61850

One of the core standards in Smart Grid

Substation automation
DER
Hydro
…



Source：IEC TC 57

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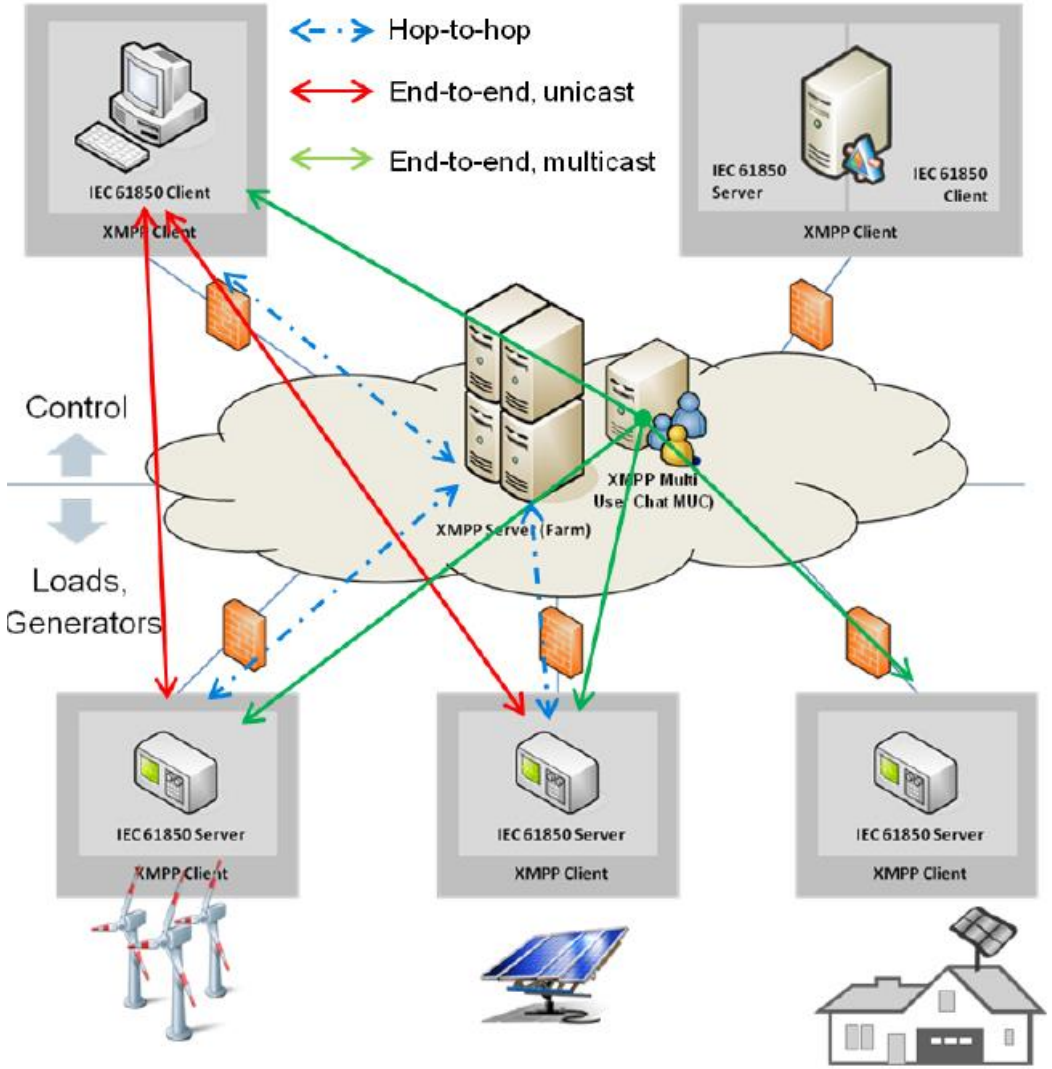
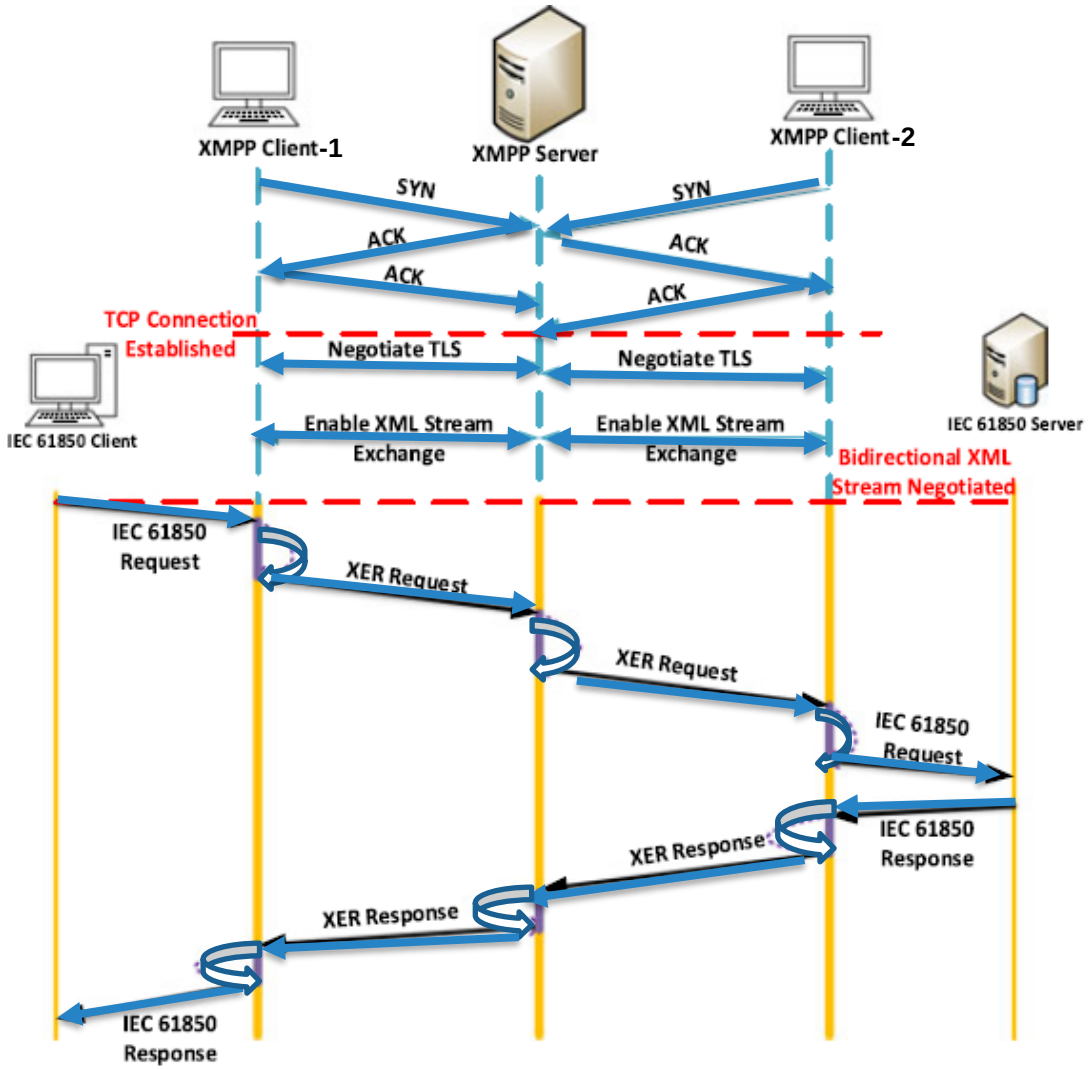
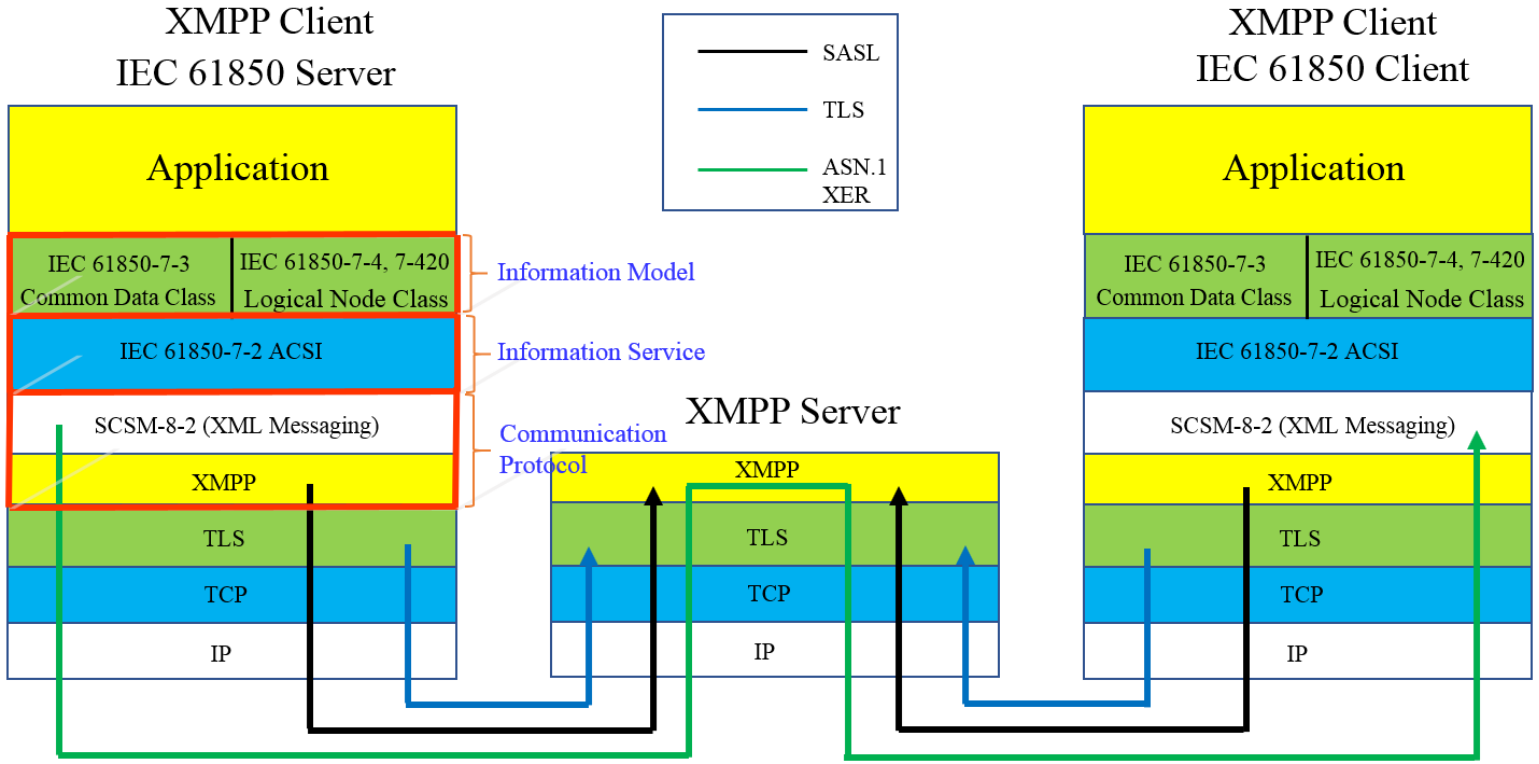
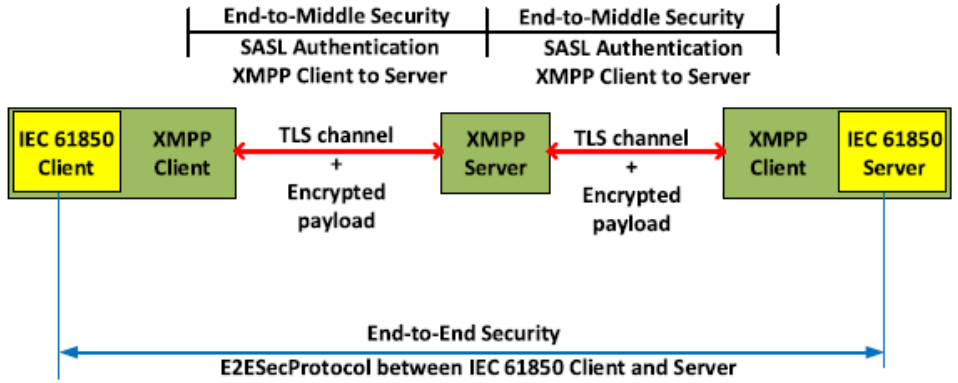
IEC 61850-8-2 XMPP





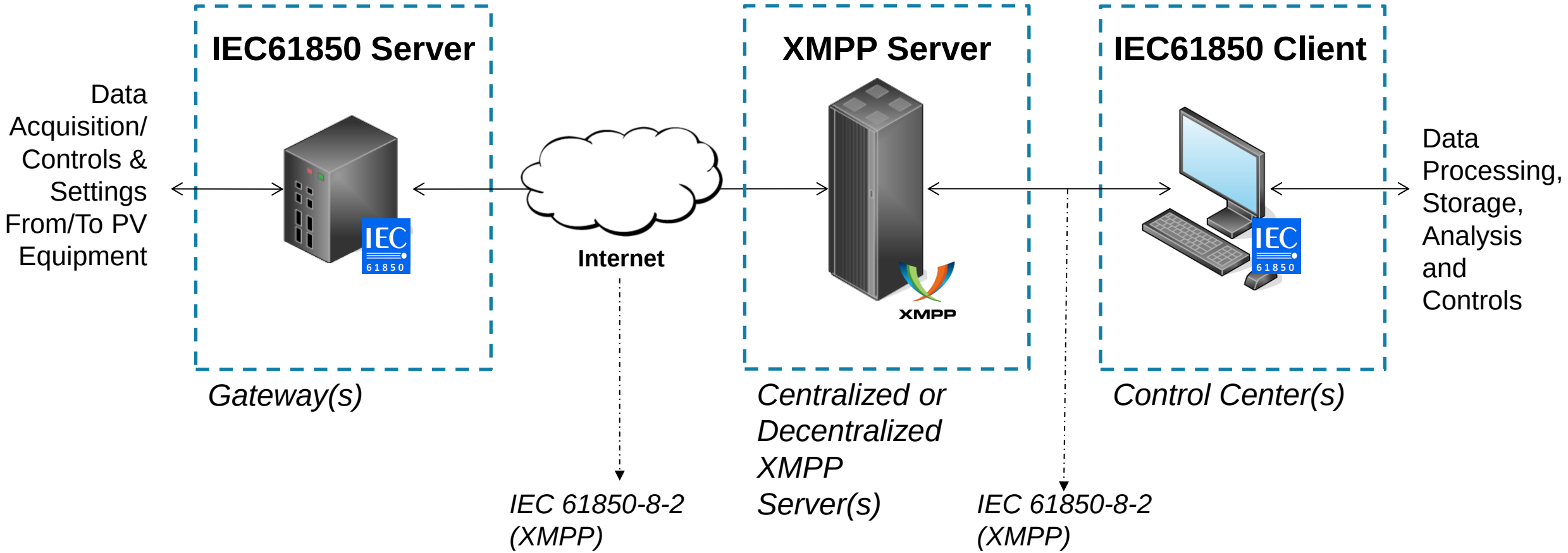
Security Enhancements





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



01 Introduction

02 Smart Grid Core Standards and IEC 61850 XMPP

03 Description of XMPP Platform & PV Simulation/ Test Framework

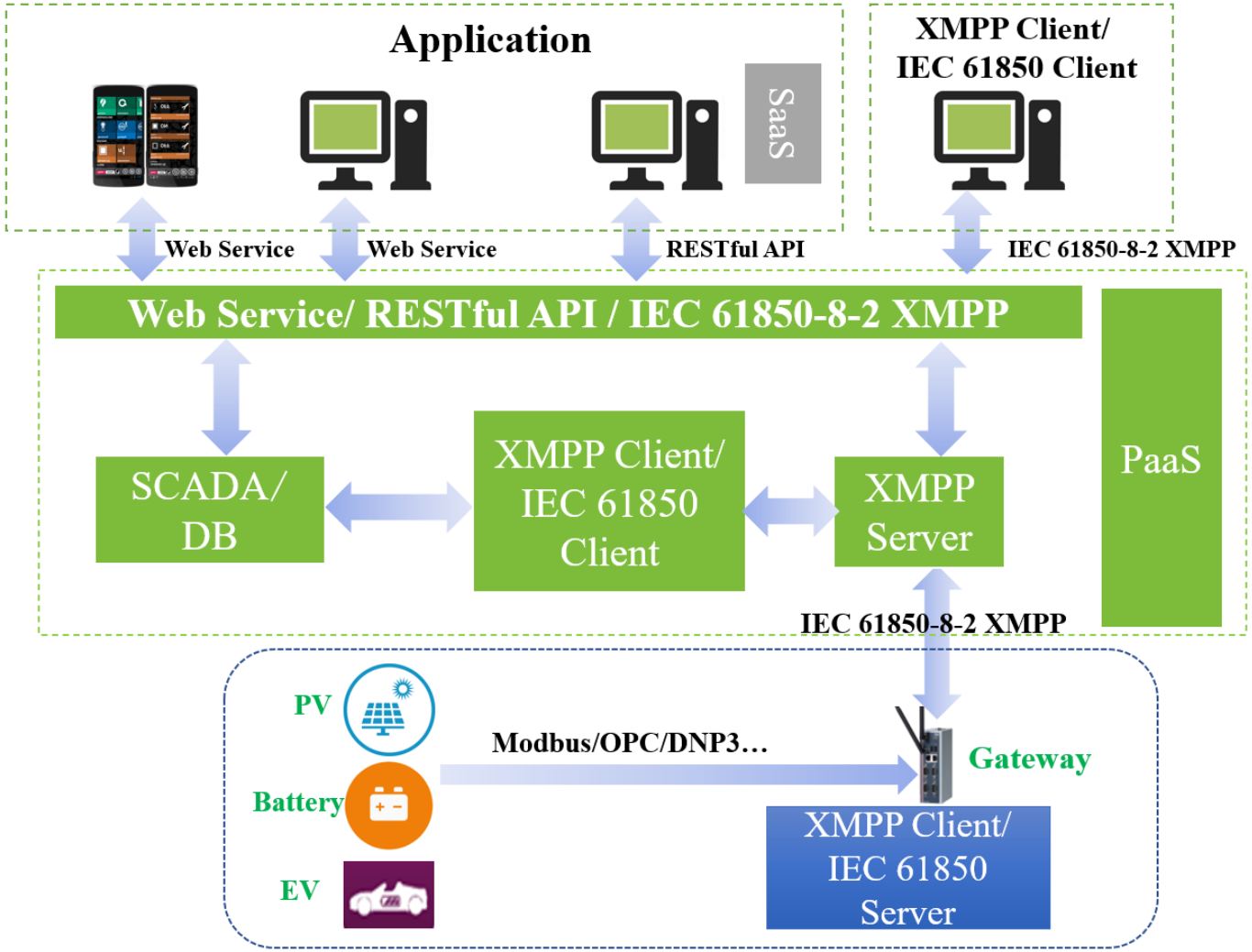
04 Implementation and Results

05 Conclusion

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)

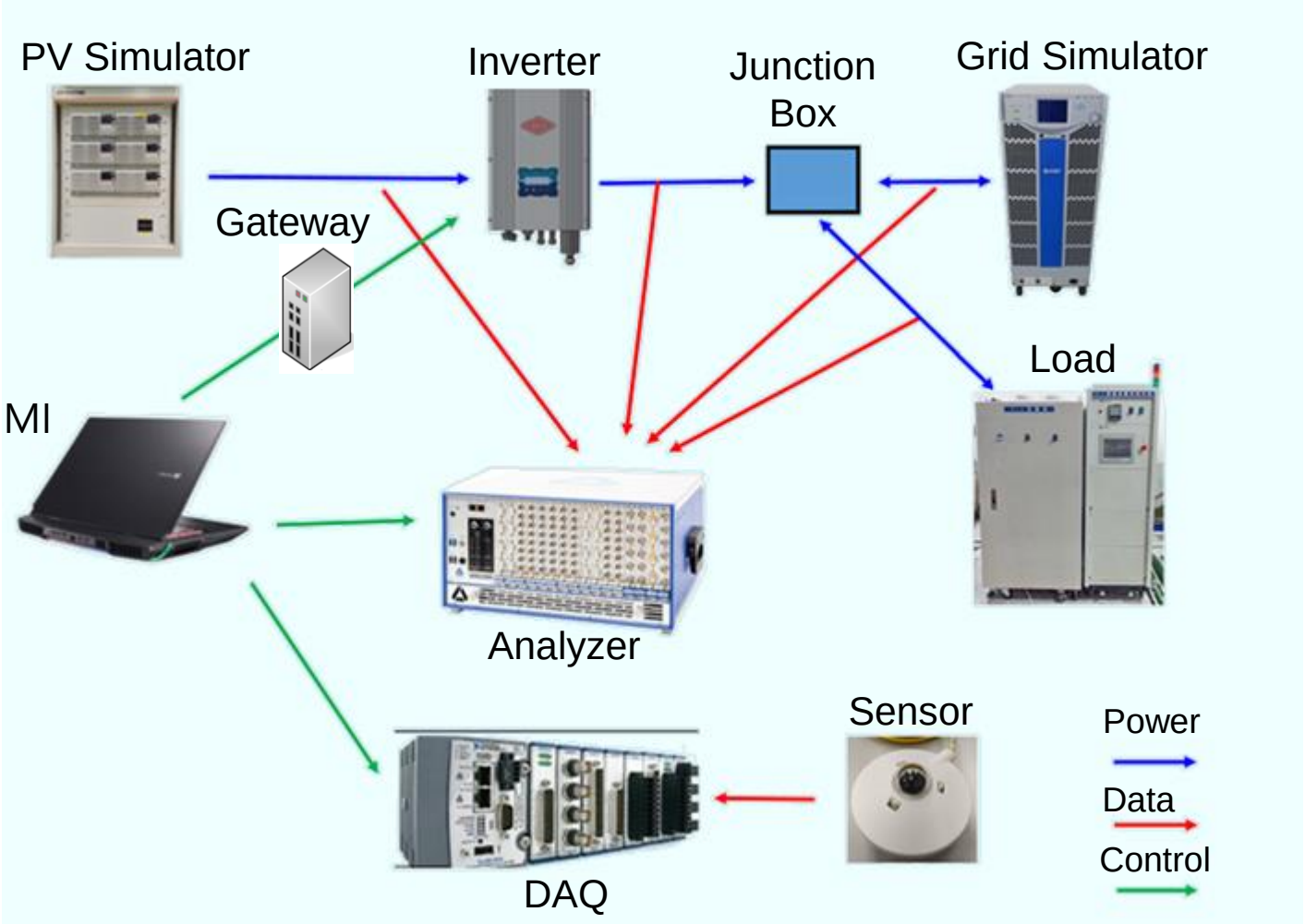


Applications and Services

Cloud Platform

Protocol Conversion

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

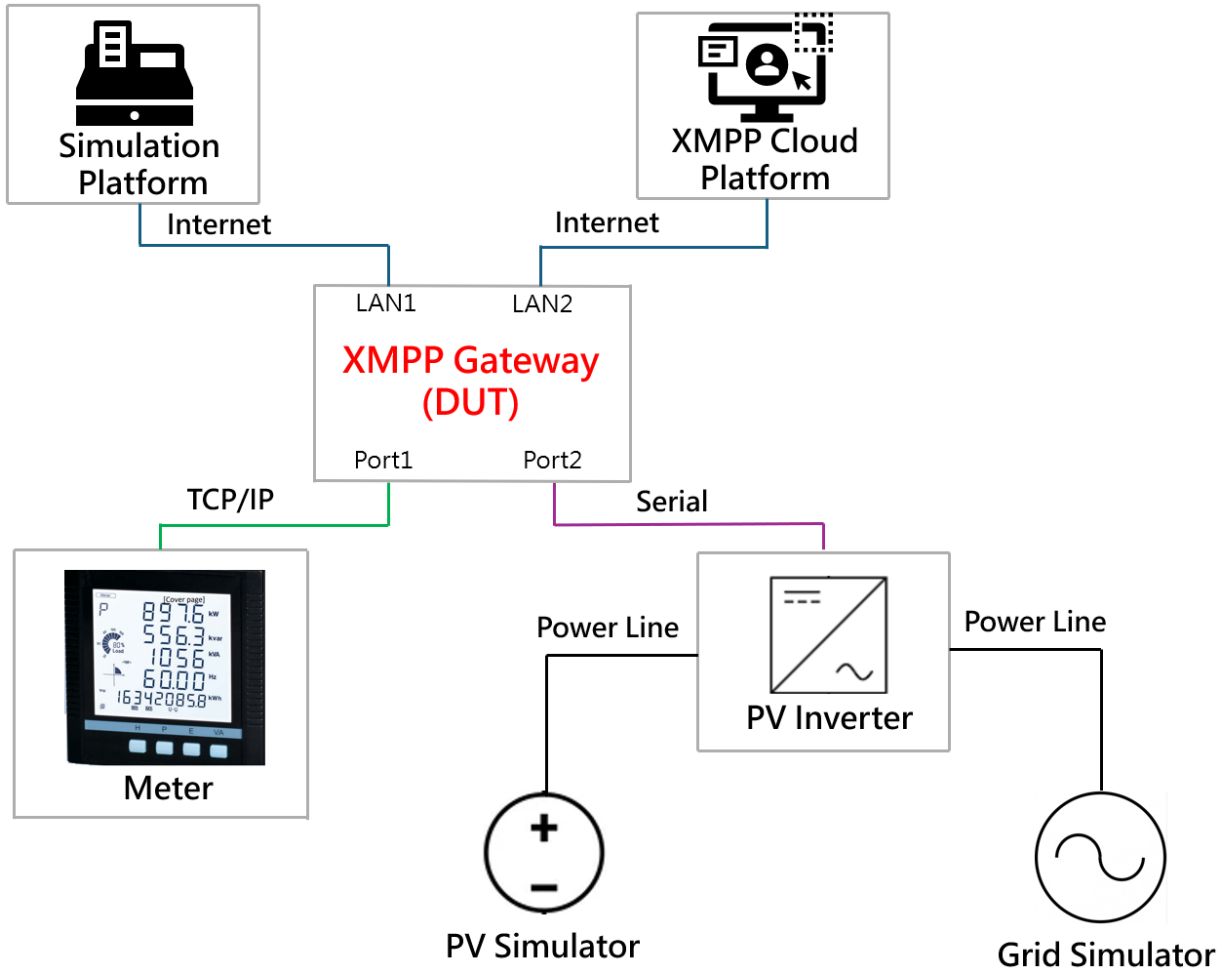


Steps

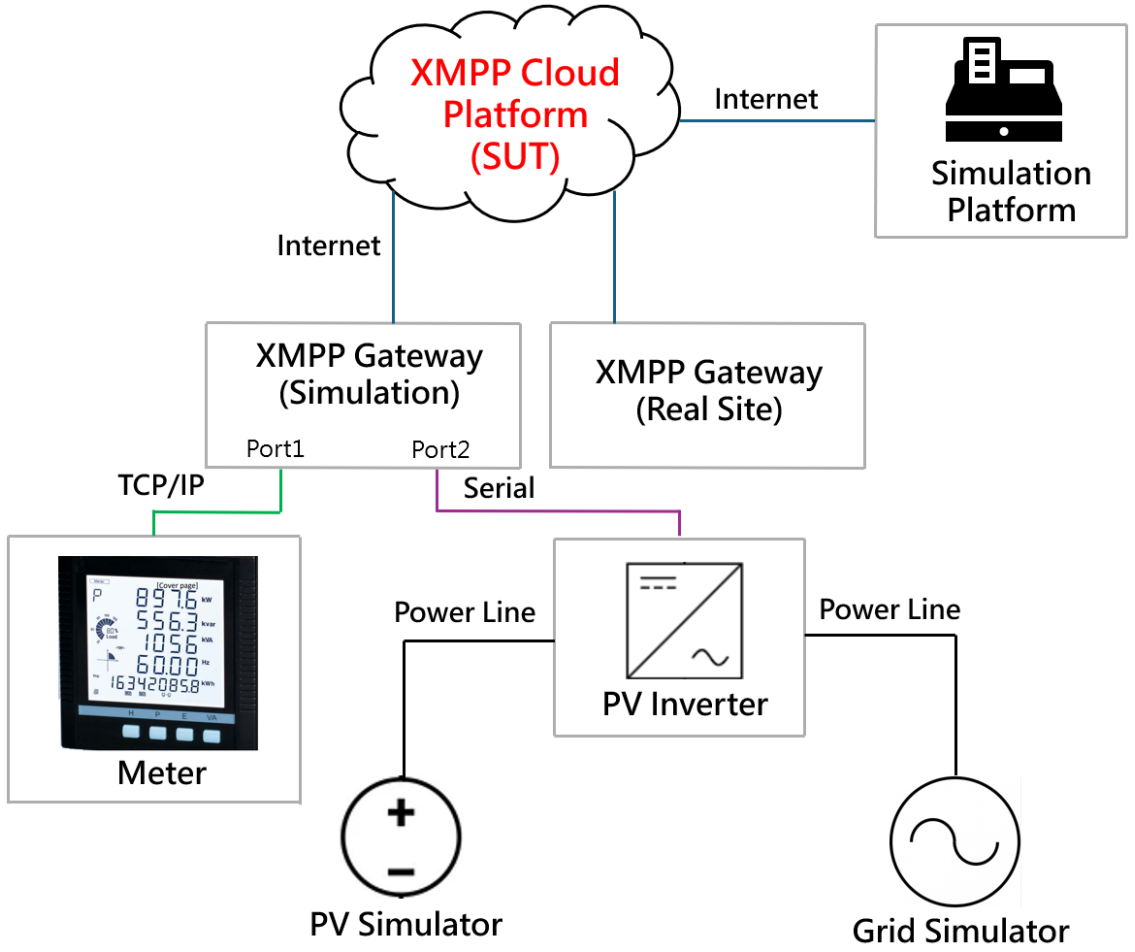
1. Planning XMPP Test Platform
2. Building XMPP Test Platform
3. Establishing XMPP Test Procedures
4. Developing XMPP Test Scenarios
5. Enhancing XMPP Test Platform

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

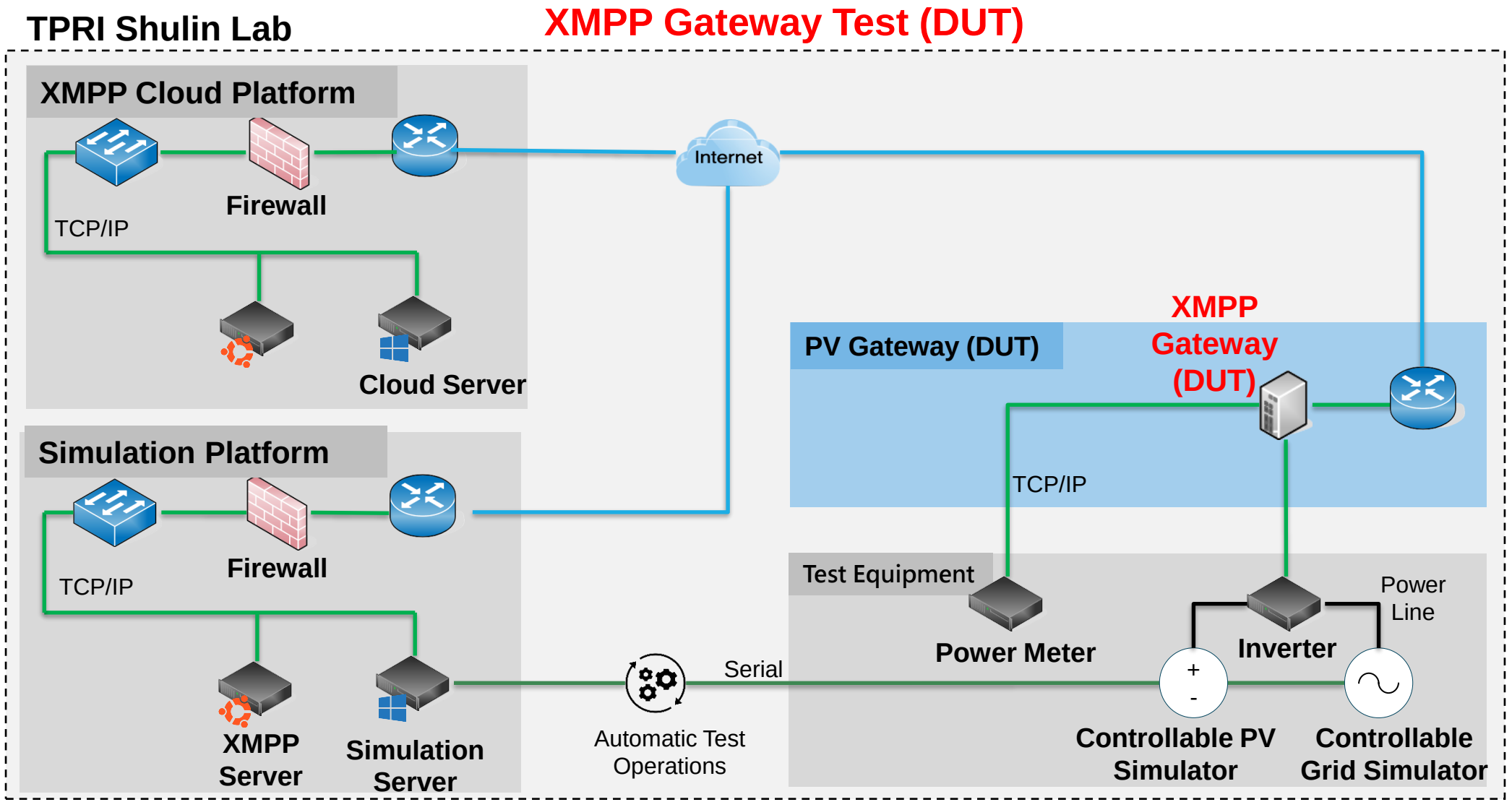
XMPP Gateway Test (DUT)



XMPP Cloud Platform Test (SUT)

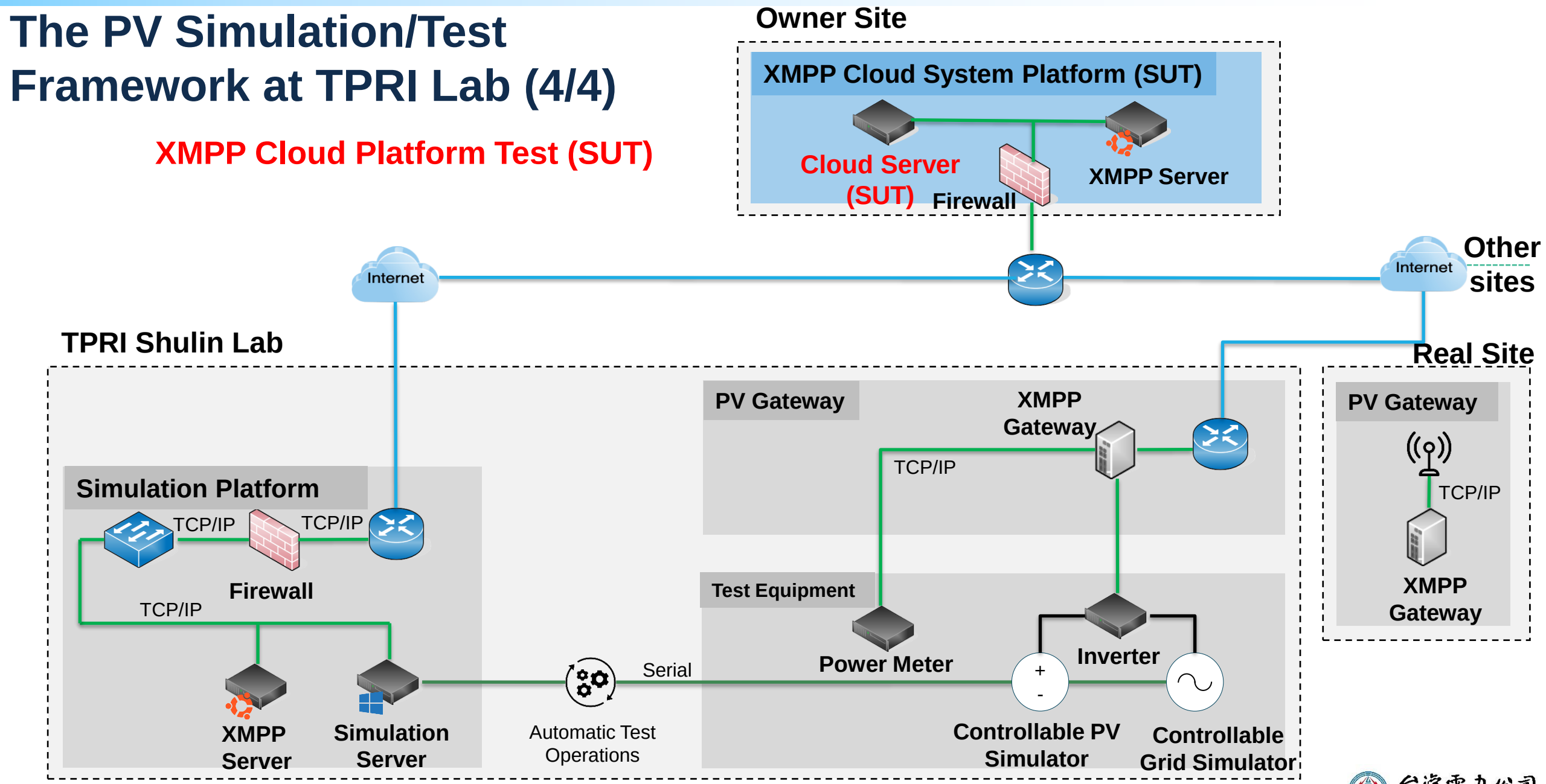


The PV Simulation/Test Framework at TPRI Lab (3/4)

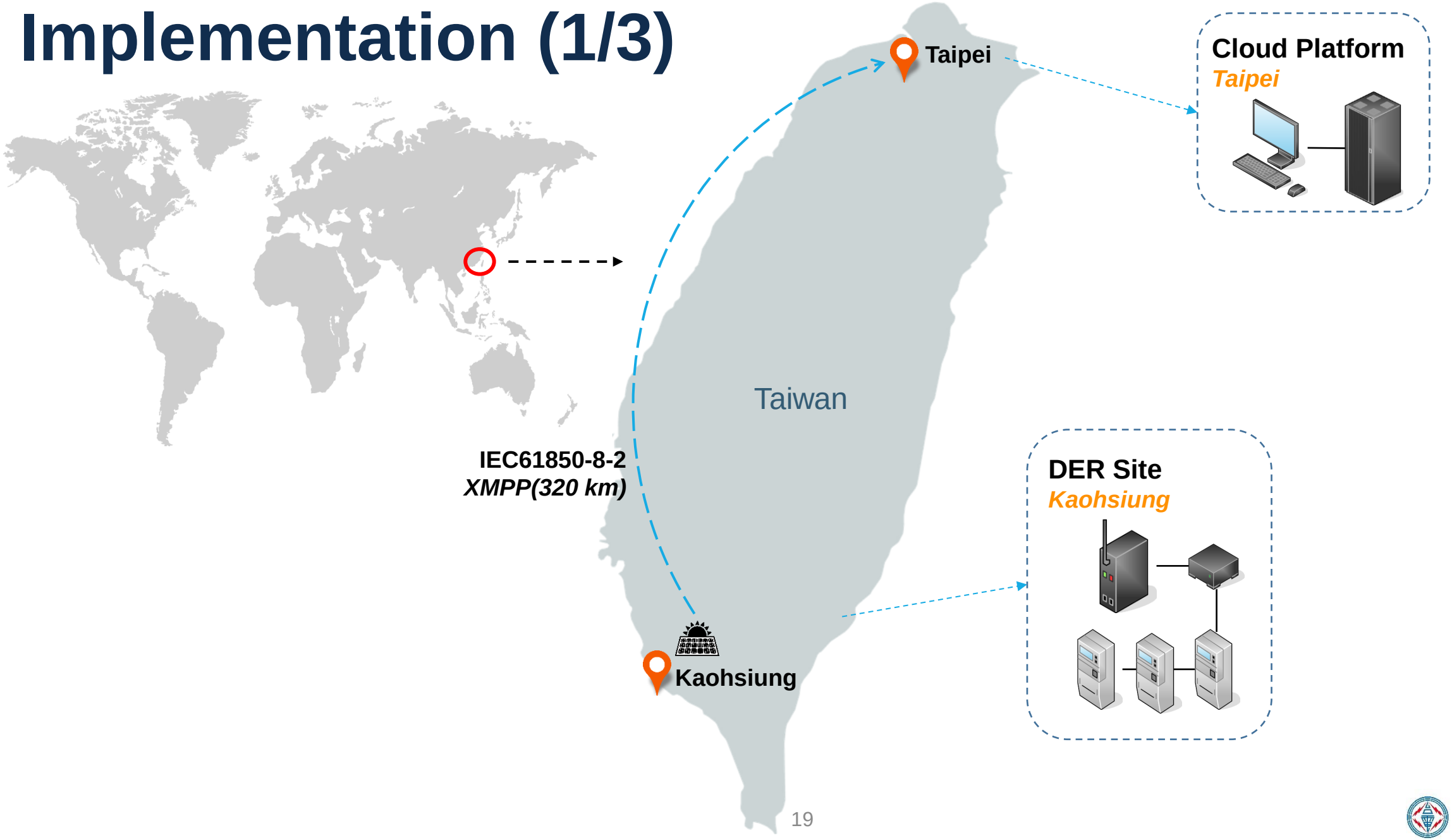


The PV Simulation/Test Framework at TPRI Lab (4/4)

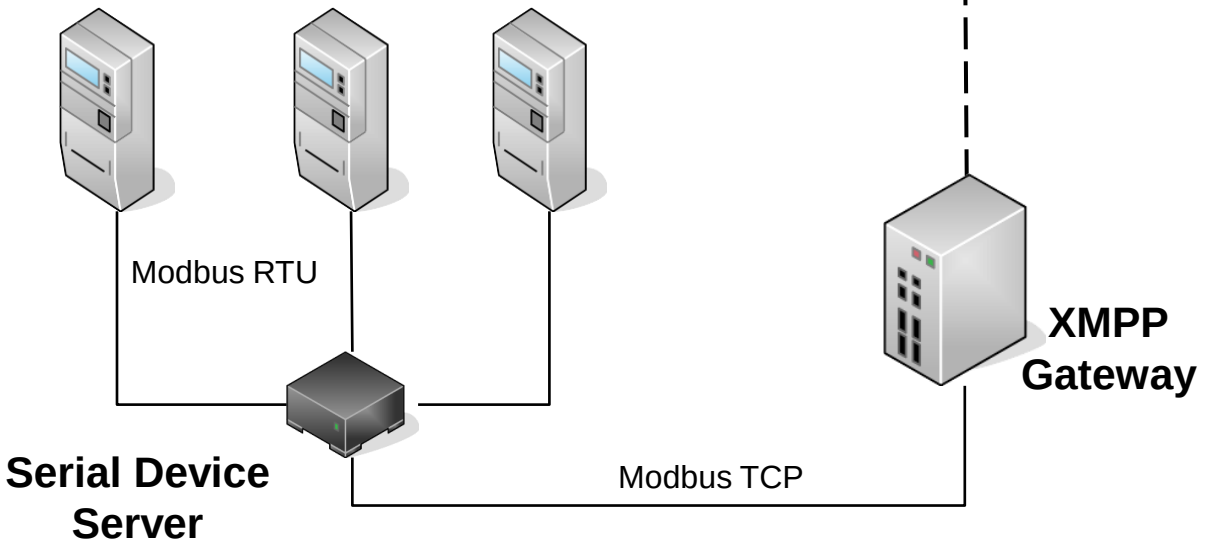
XMPP Cloud Platform Test (SUT)



Implementation (1/3)



Implementation (2/3)



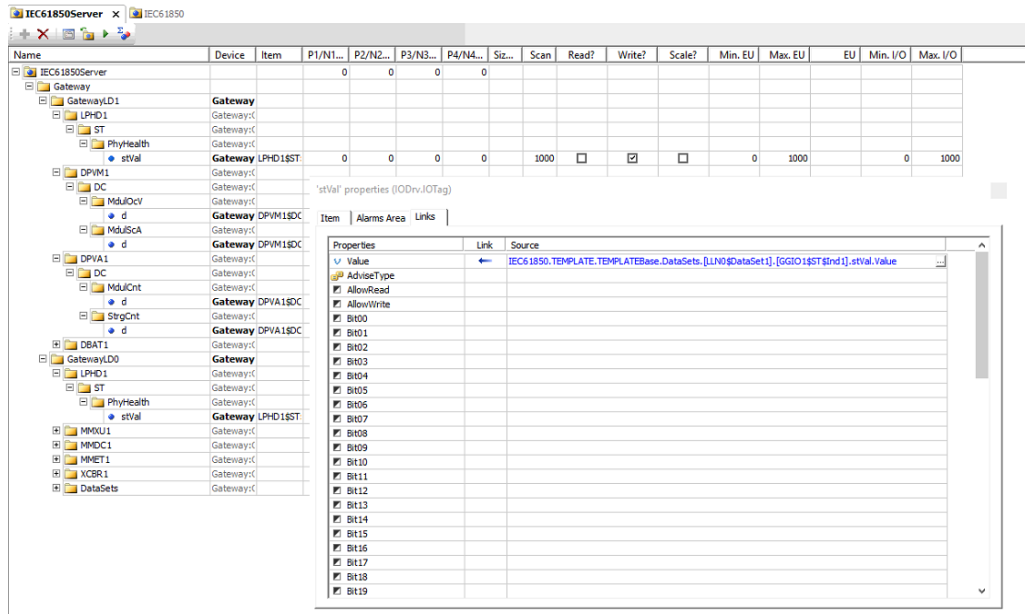
Implementation (3/3)

(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

IEC 61850 Information Model



(2) DNP 3

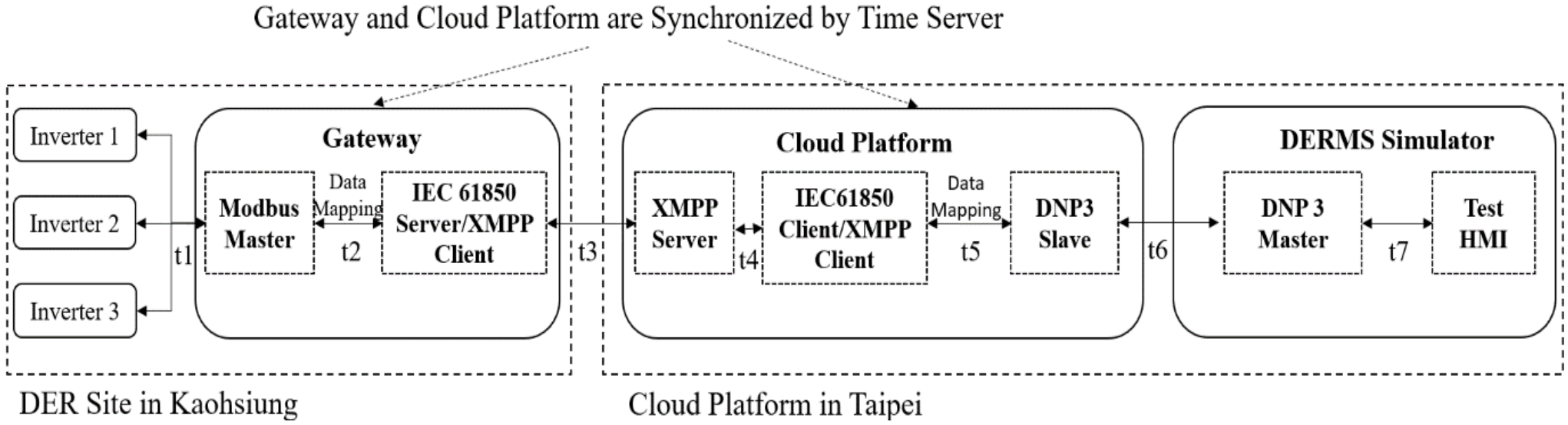
Point Index	Name / Description
8	Inverter active power output - Present real power output level (negative = charging)
9	Inverter reactive output - Present reactive power output level (negative = absorbing)
10	Frequency at the connection point
11	Active power at the connection point
12	Reactive power 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

Results (1/4)

Latency



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

Average：1683 ms

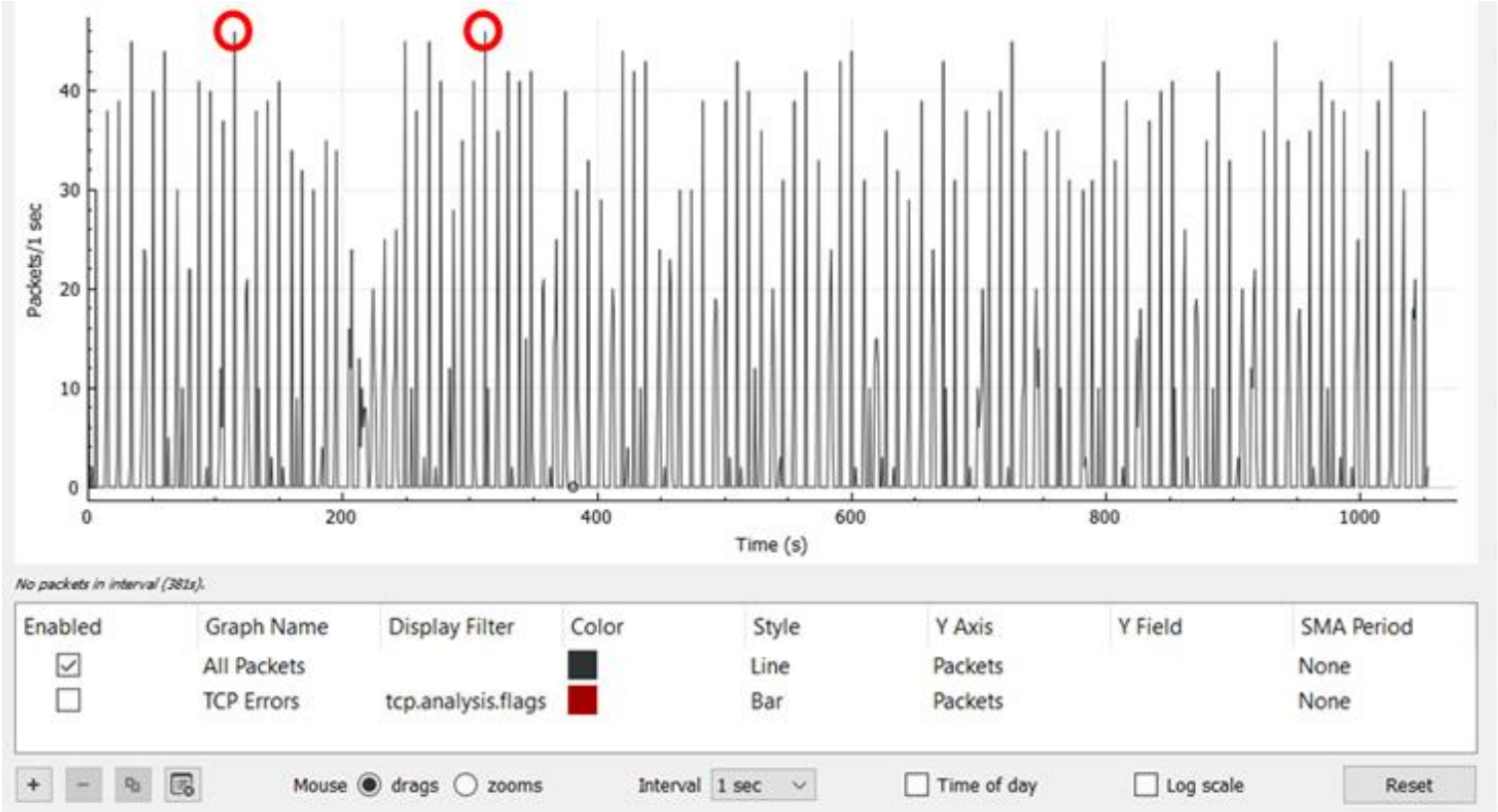
Latency class	Latency	Application example
TT0	> 1000 ms	File, events, log contents
TT1	≦1000 ms	Alarms and Events
TT2	≦500 ms	Operator commands
TT3	≦50 ms	Slow automatic interaction
TT4	≦20 ms	Fast automatic interaction
TT5	≦10 ms	Releases, status change
TT6	≦3 ms	Trip, blockings

Results (2/4)

Packet evaluation of XMPP protocol

The maximum packet is 43 per second

The average bandwidth is 26 Kbps



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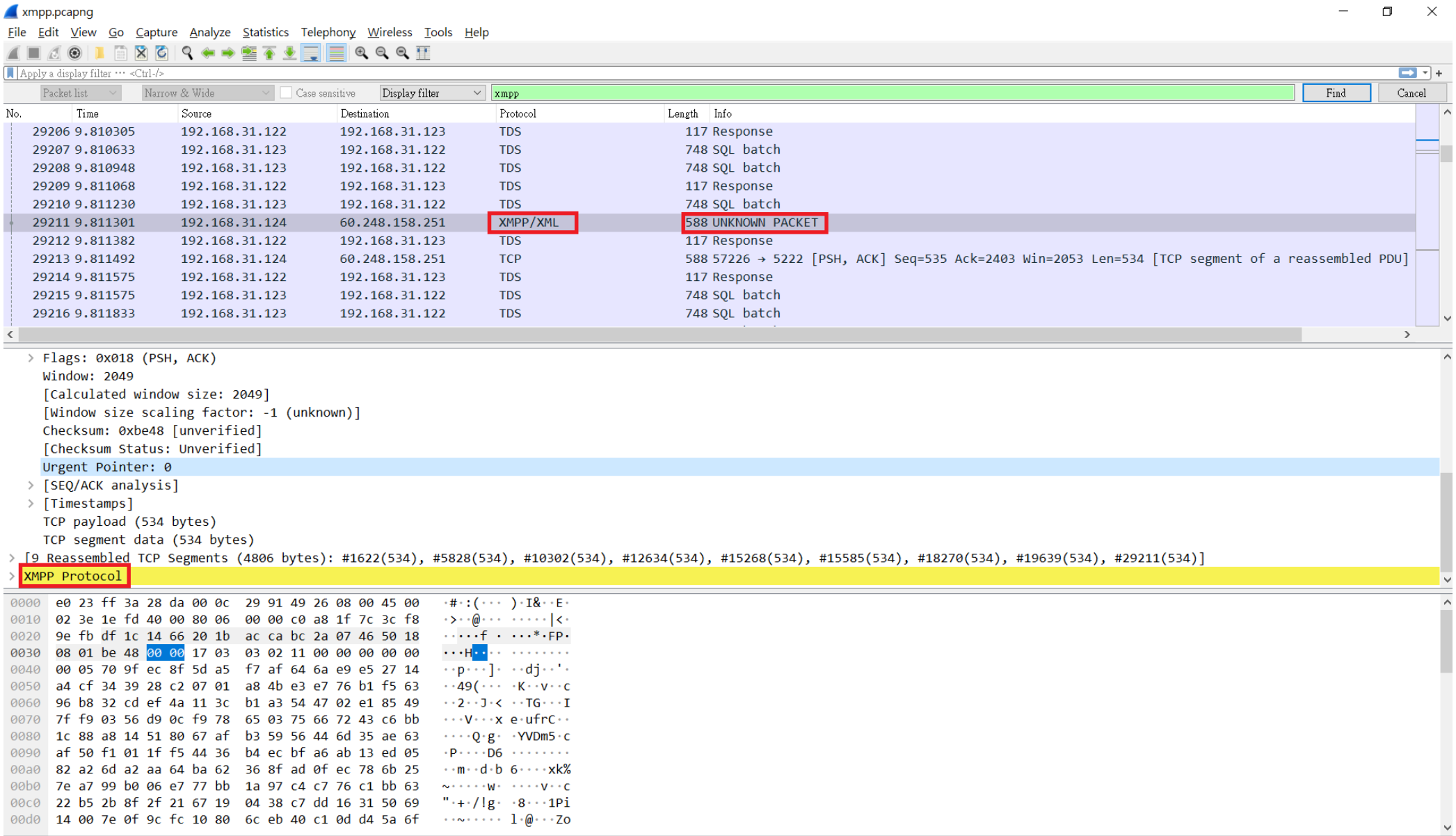
Results (3/4)



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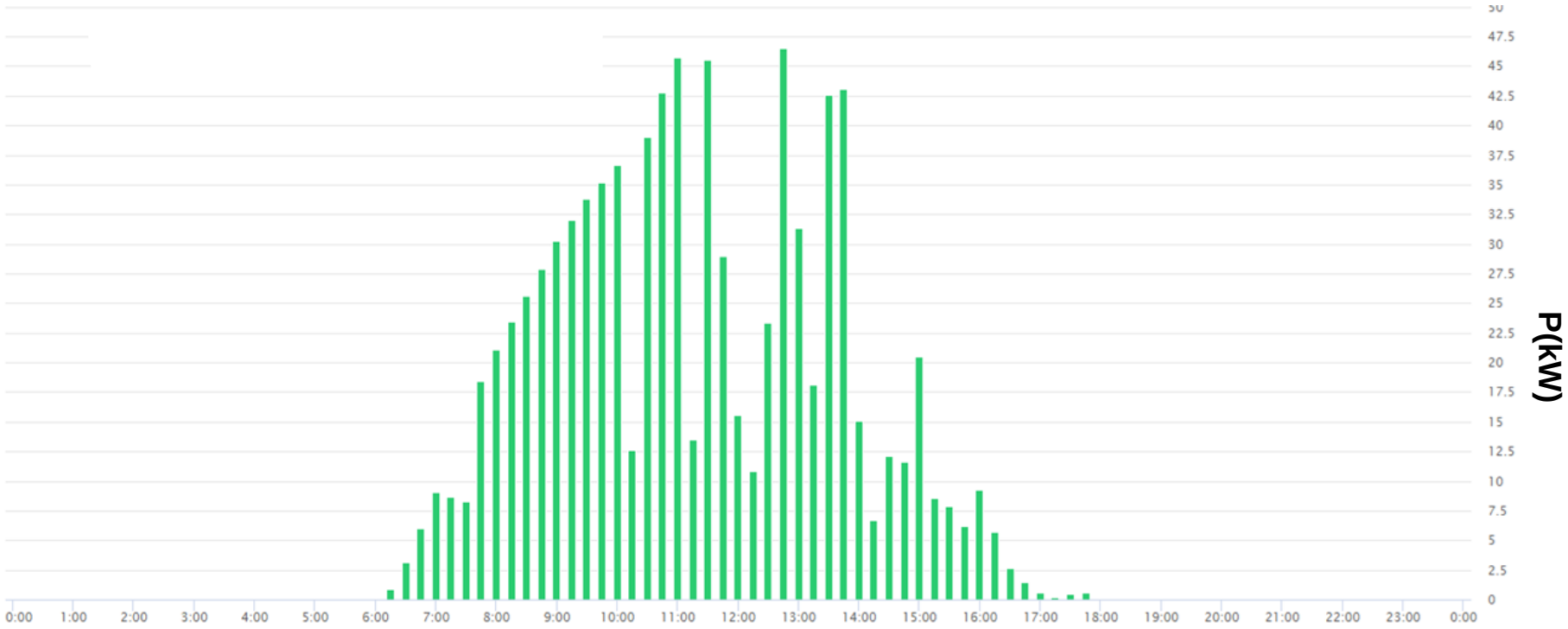
Results (4/4)

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	Frequency	Reactive 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

u772677@taipower.com.tw