Vaasan yliopisto
UNIVERSITY OF VAASA

Conventional and Lightweight IEDs Testing

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- **Case study 1:** Conventional and Lightweight IEDs Testing based Real-Time Hardware-in-the-Loop (HIL) Simulation Approach
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- **Results**
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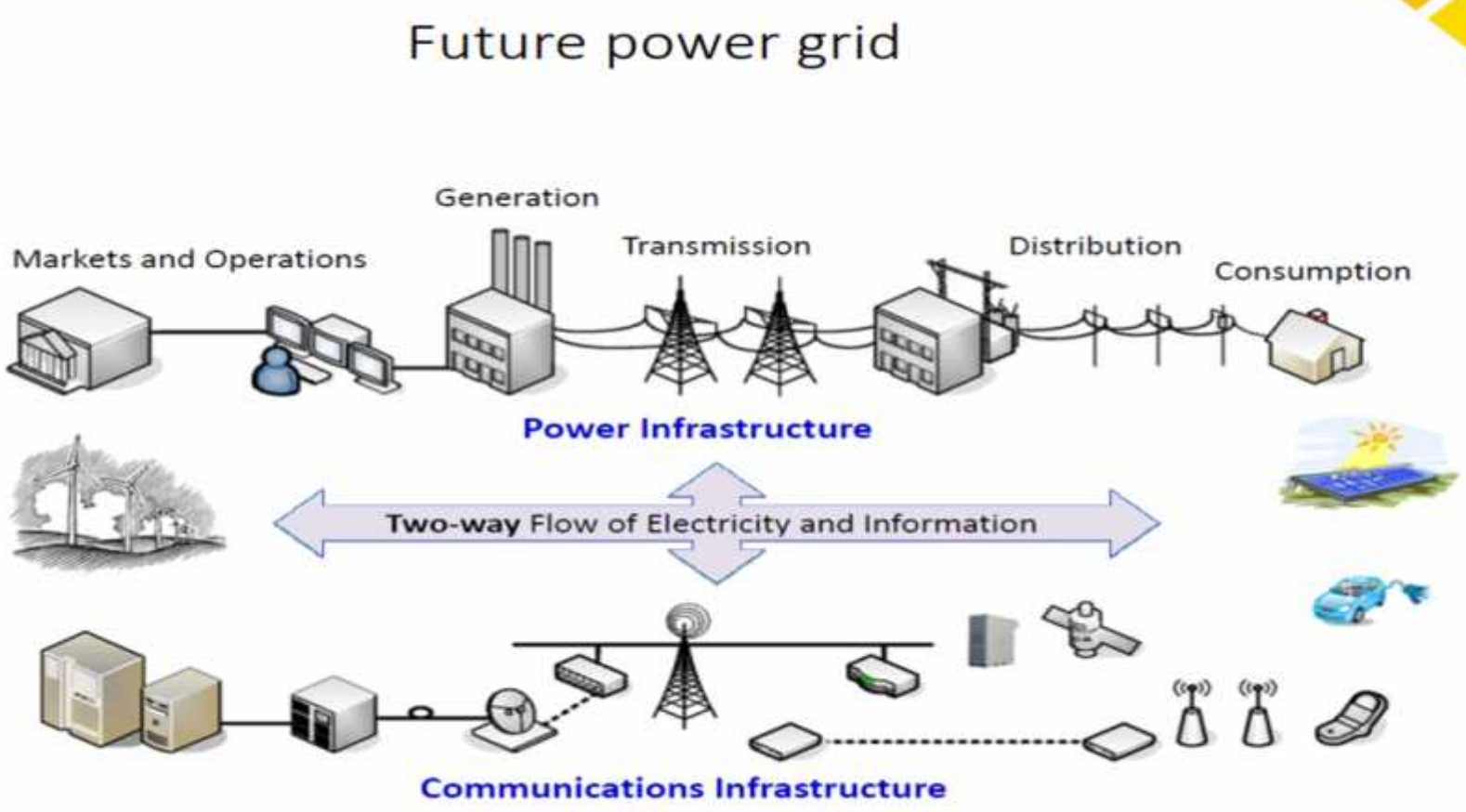
- **Publication**

Introduction

Future power grid



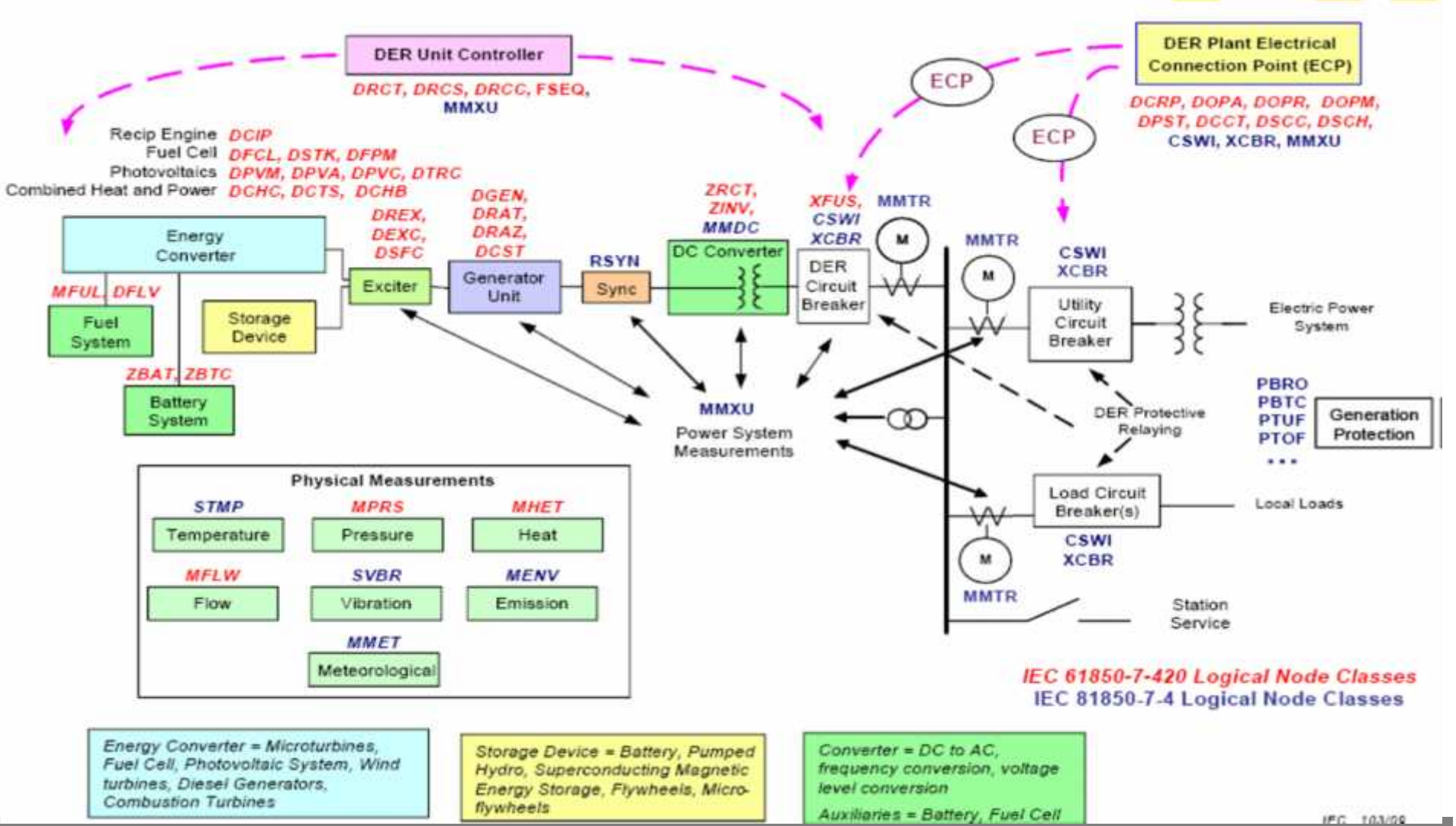
Introduction

Hardware-in-the-Loop (HIL)?

Hardware-in-the-loop means that there is something physically connected to the real-time simulation. This can be a piece of power hardware or intelligent electronic device (IED) ...

Light-weight IEDs based IEC 61850

IEC 61850



Light-weight IEDs based IEC 61850

IEC 61850

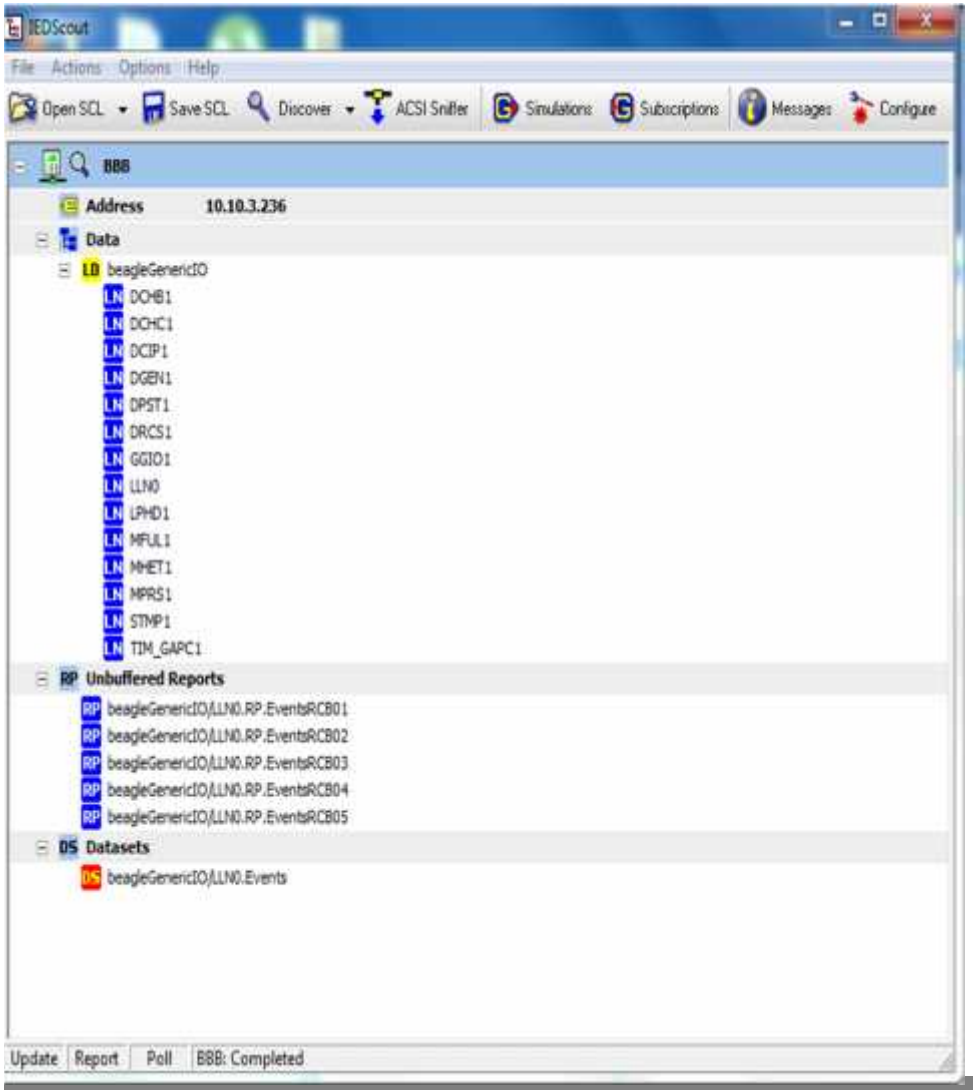
- Since IEC 61850 standards are developed rapidly and there is no IED that support all different Edition 2 LNs

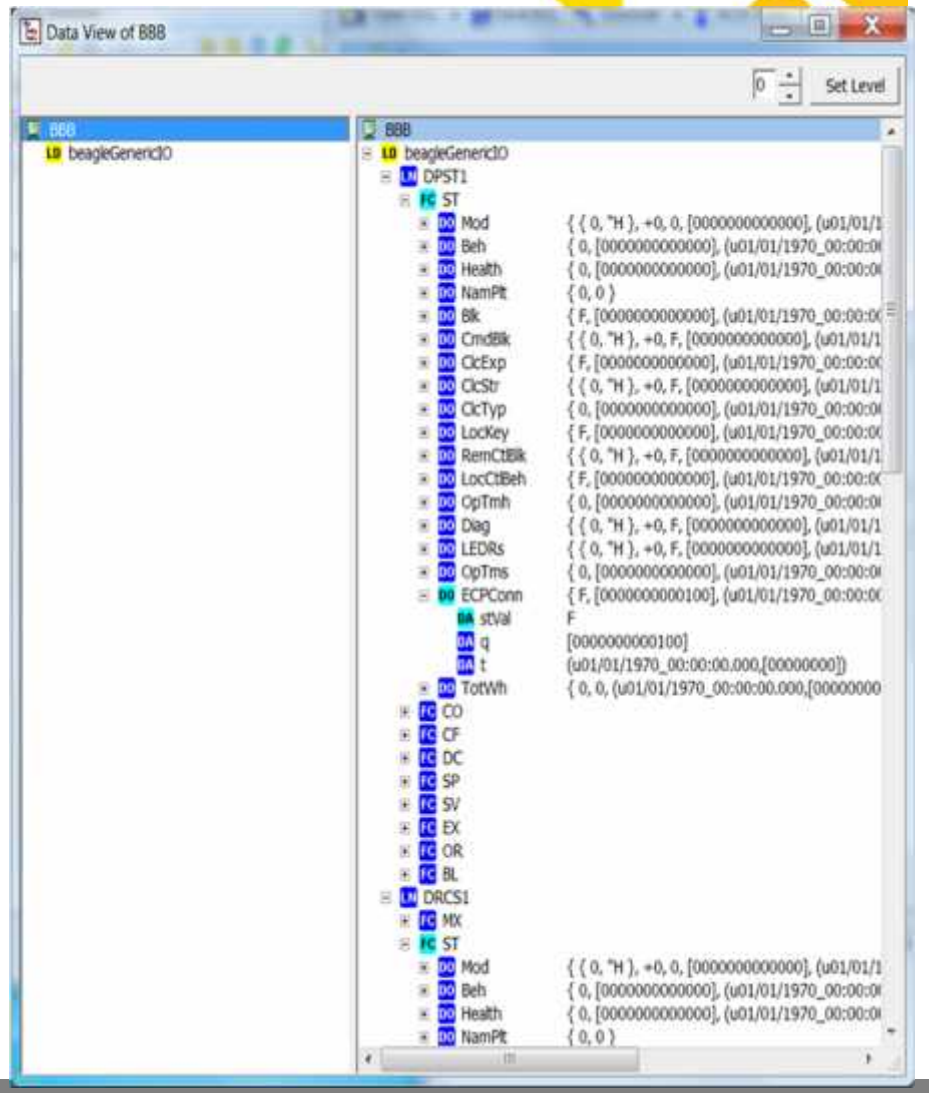
- Routing GOOSE (RG) and routing sample valu (RSV) protocols for exchanging data (inter-substations communication) are under developments

- Therefore, monitoring, control and protection functions may be achieved by developing and implementing the light-weight IEC 61850 IED within various embedded systems, FPGA etc.

Light-weight IEDs based IEC 61850

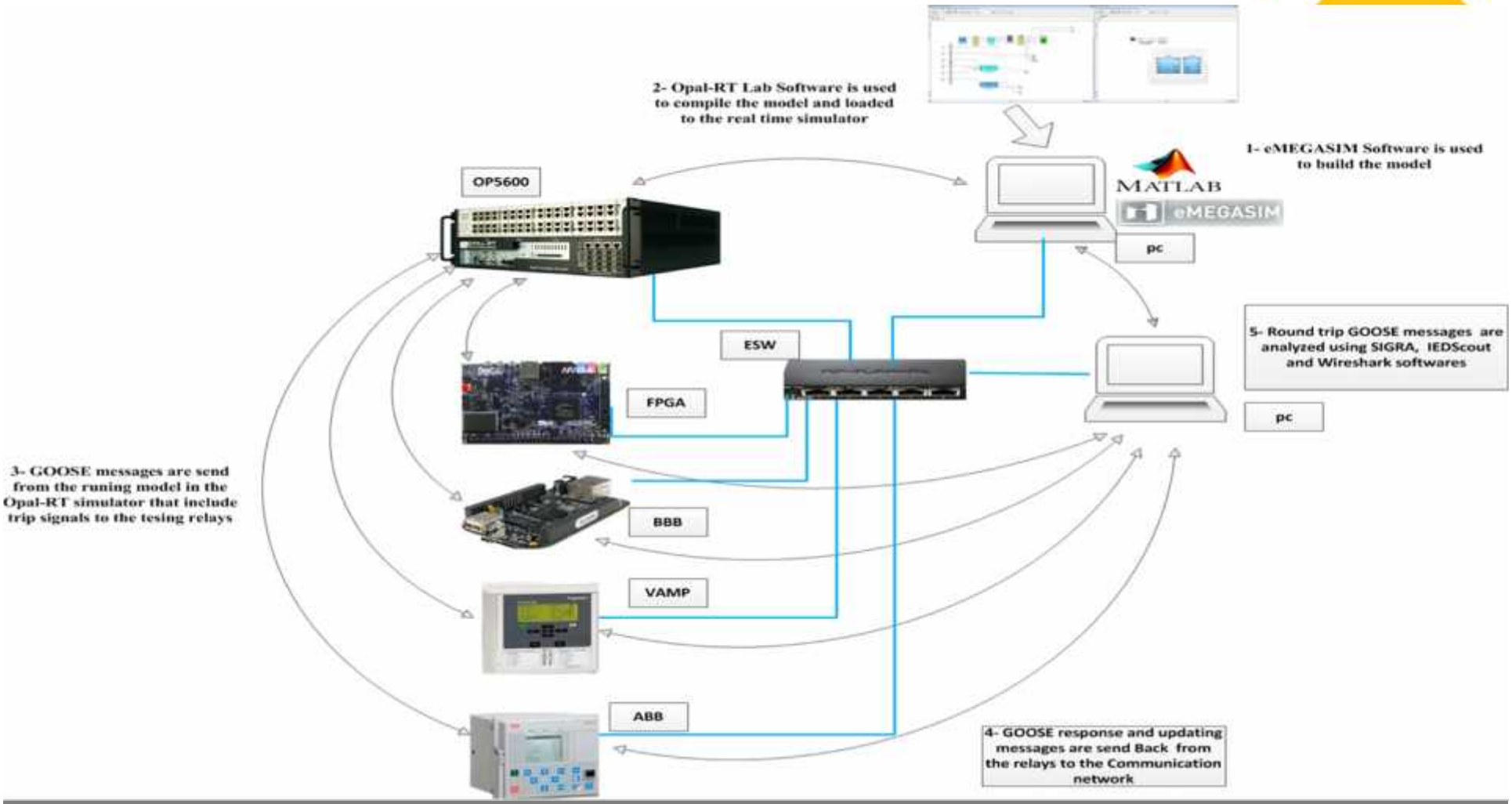
IEC 61850





Case study 1

Conventional and Lightweight IEDs Testing based Real-Time Hardware-in-the-Loop (HIL) Simulation Approach



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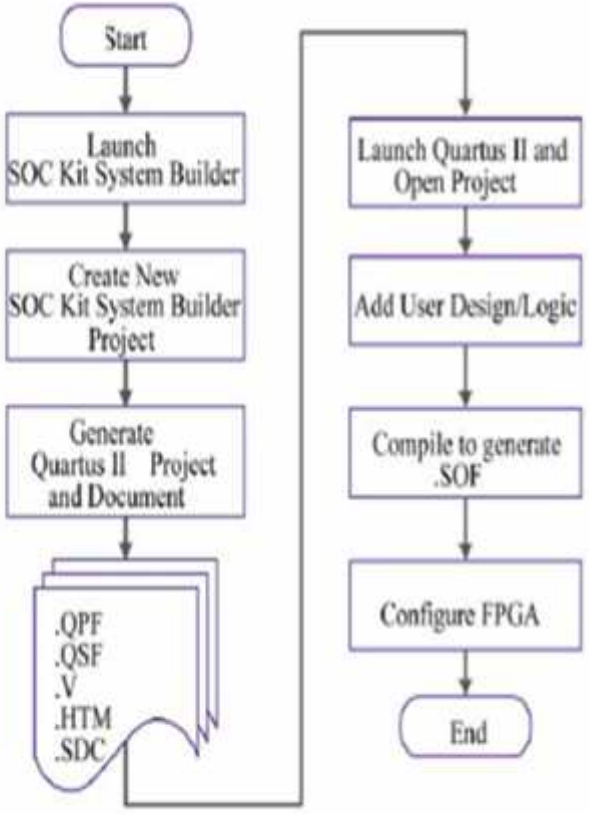

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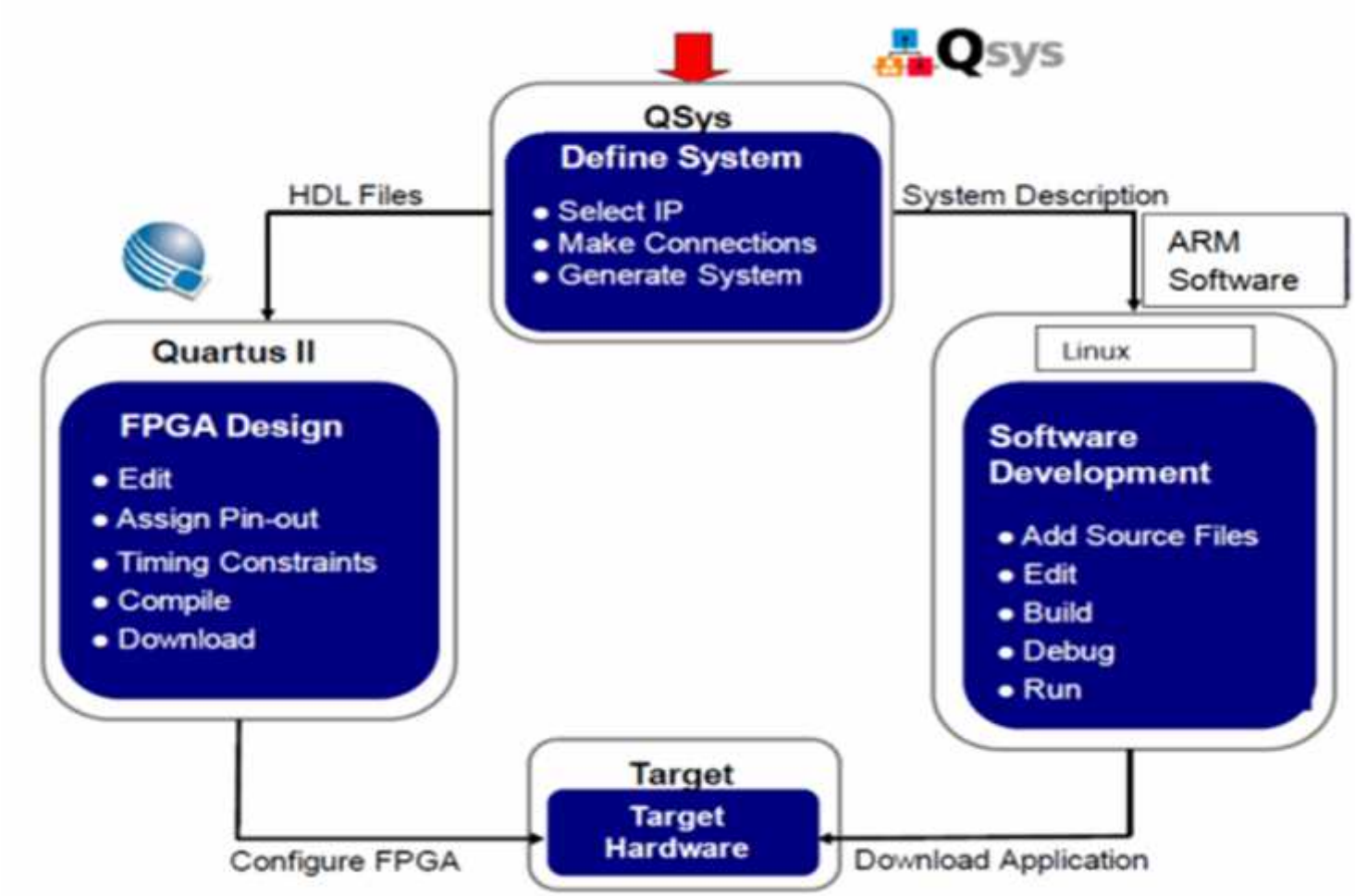

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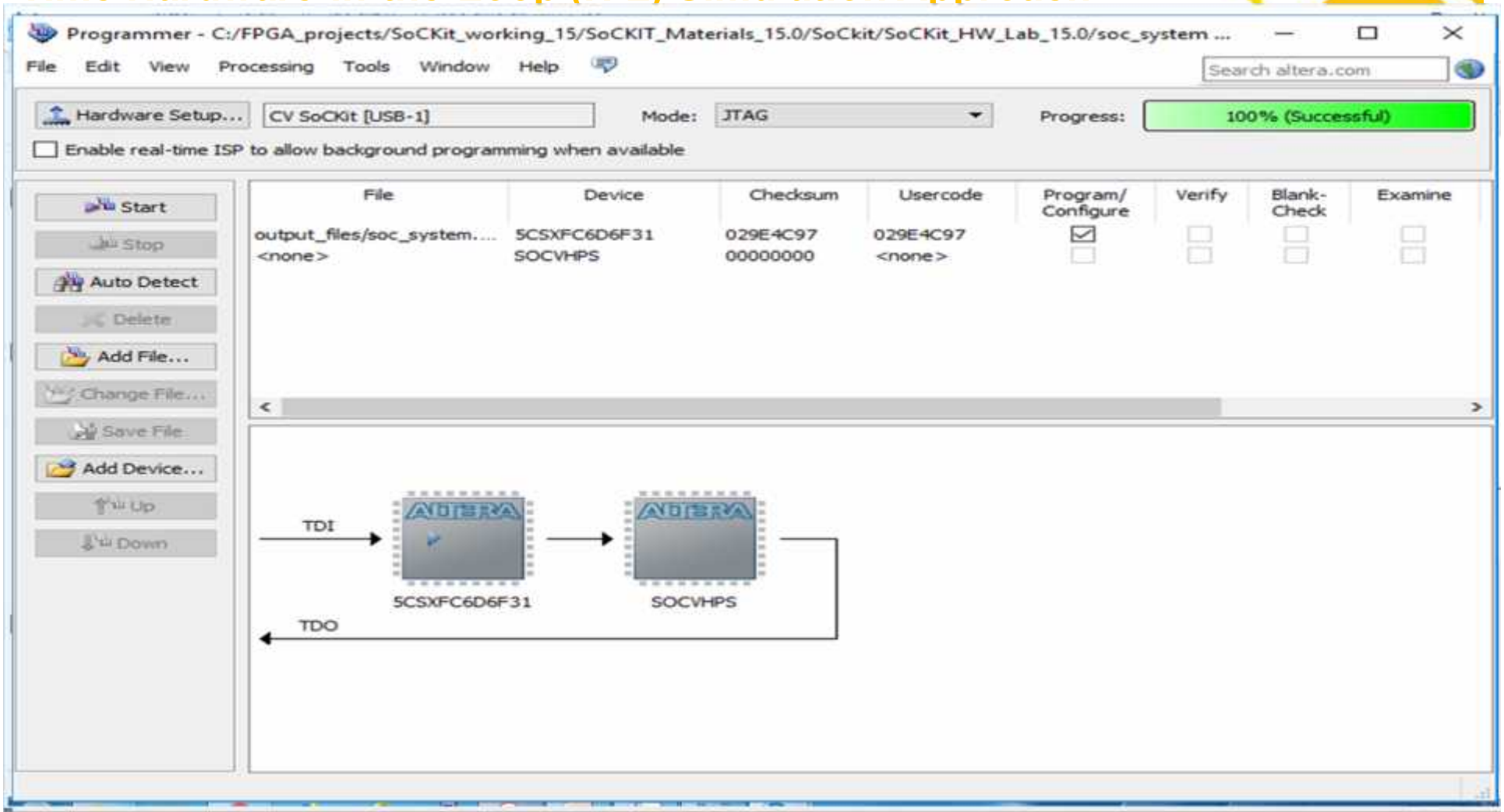

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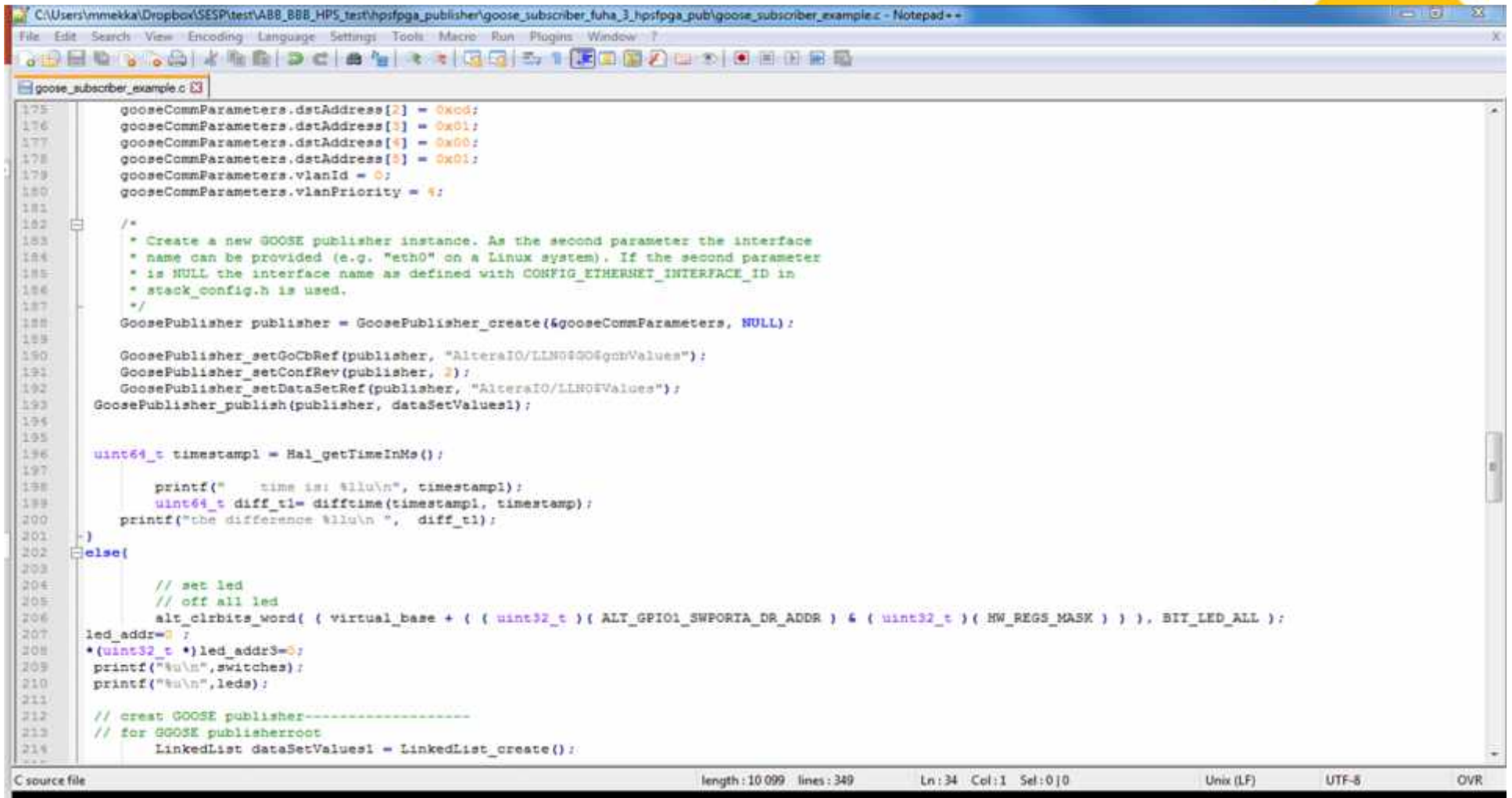

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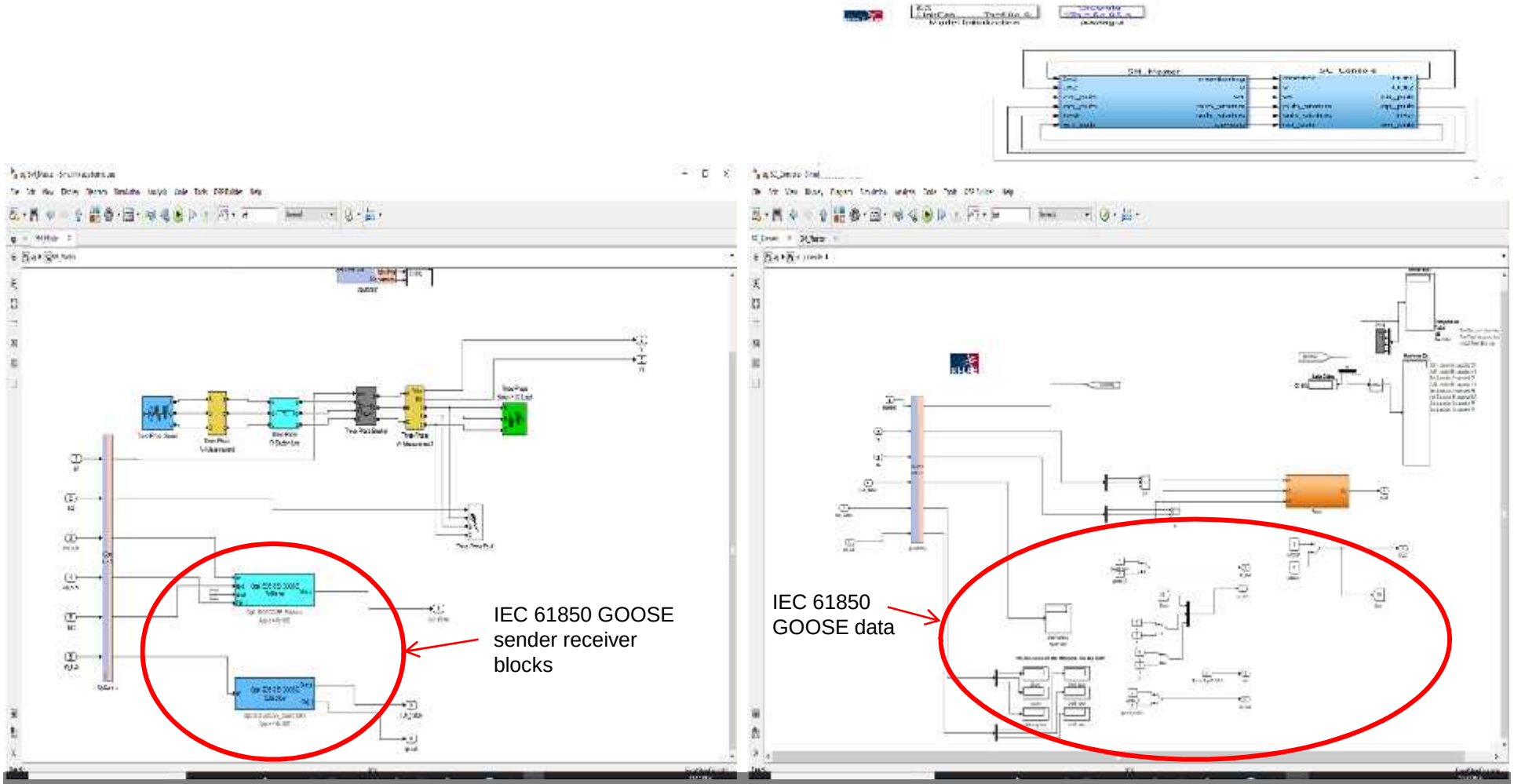

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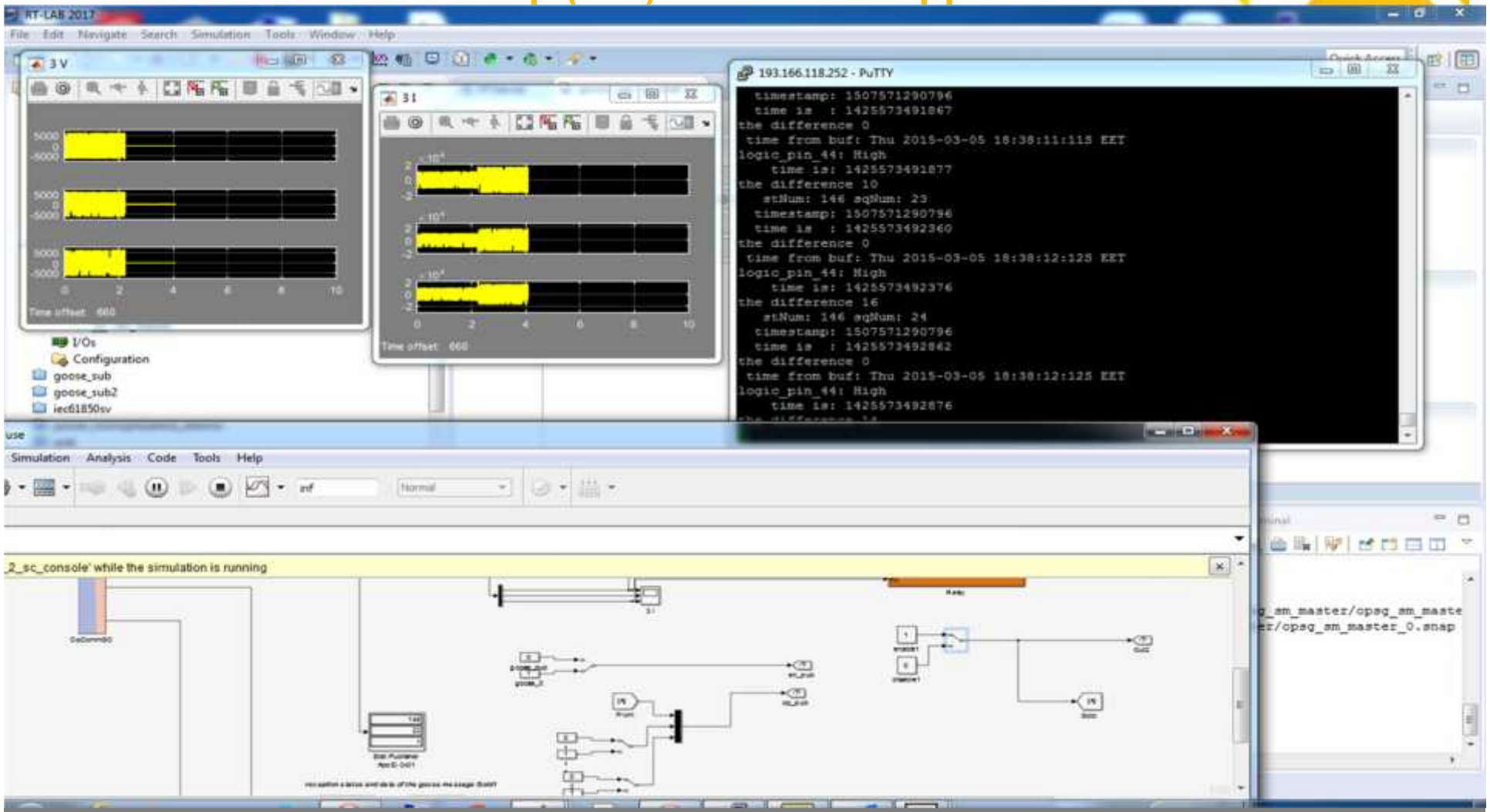

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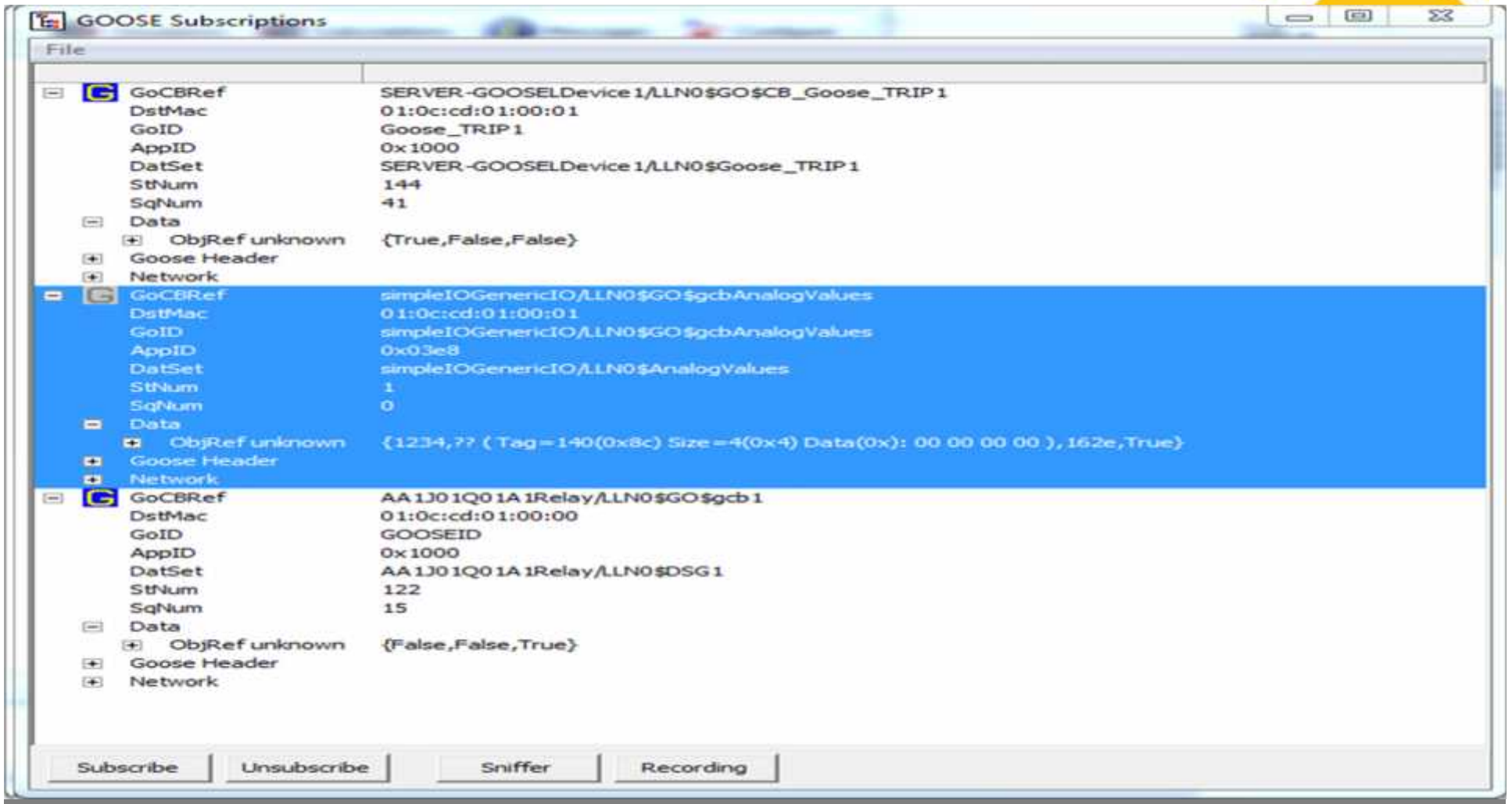
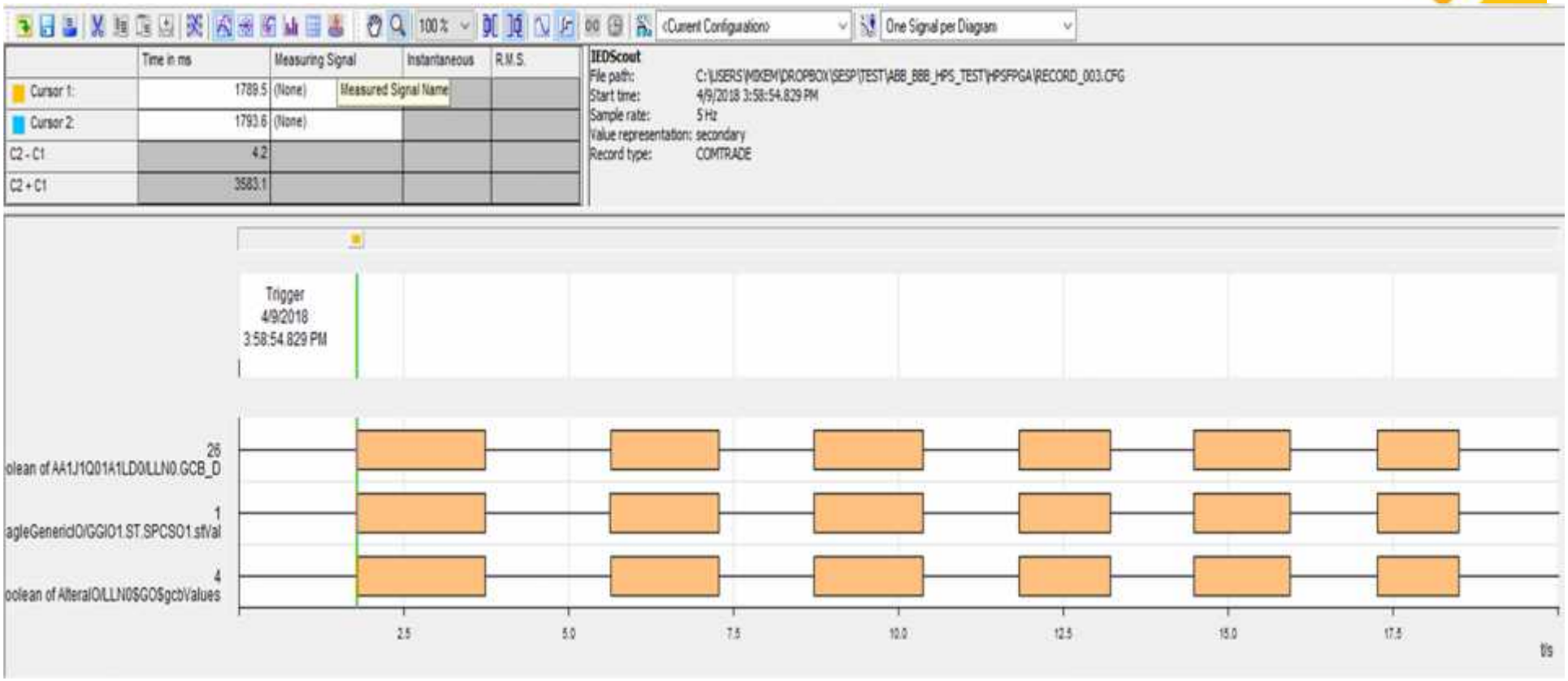


Results

Conventional and Lightweight IEDs Testing based Real-Time Hardware-in-the-Loop (HIL) Simulation Approach



Results

Conventional and Lightweight IEDs Testing based Real-Time Hardware-in-the-Loop (HIL) Simulation Approach

$$\bar{t}_{RT} = \bar{t}_{out.TS} + \bar{t}_{net} + \bar{t}_{in.DUT} + \bar{t}_{App} + \bar{t}_{out.DUT} + \bar{t}_{net} + \bar{t}_{in.TS}$$

GOOSE round trip				
	BBB	Vamp52	ABB	FPGA
Mean val. ms	11.2	18.8	3.6	4.2

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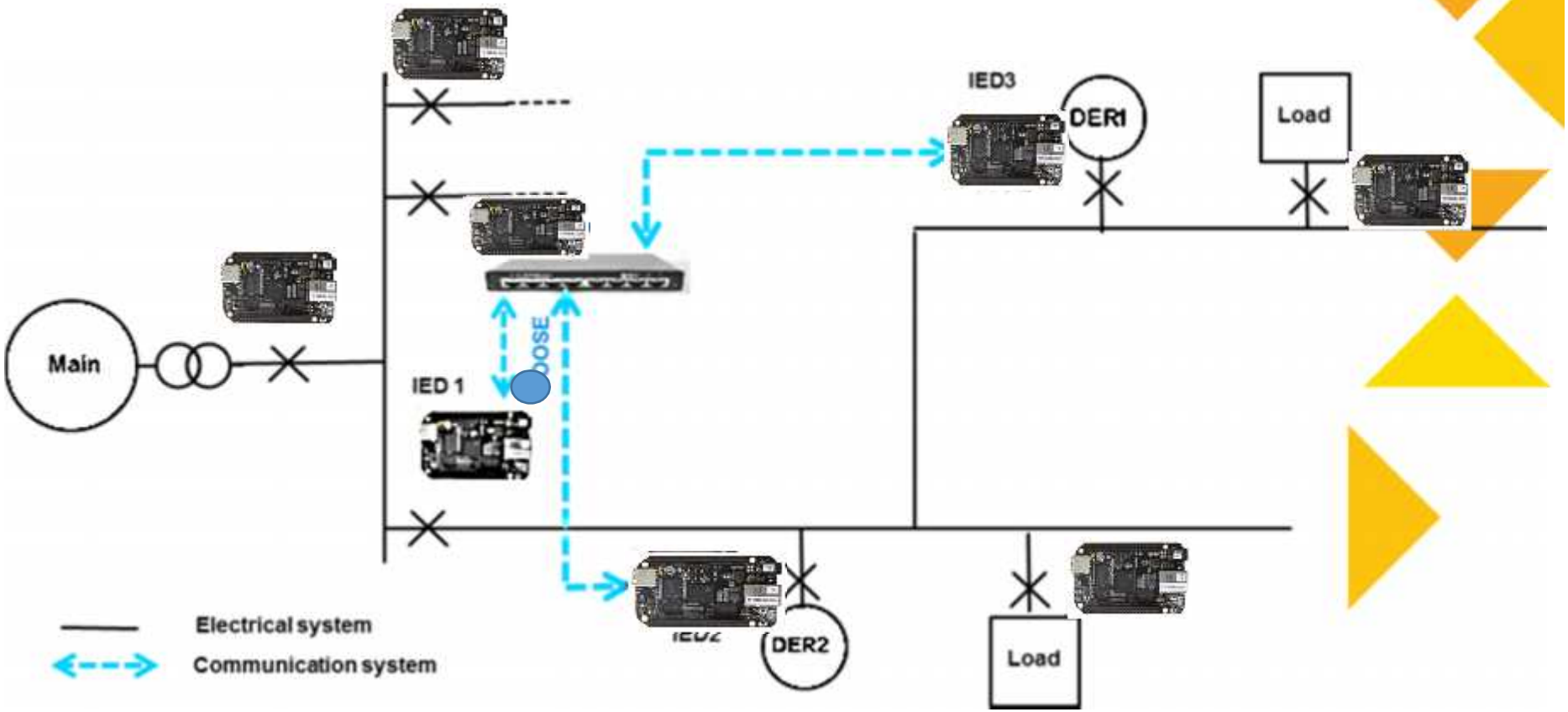
Light-Weight IEC 61850 GOOSE Based Loss of Mains Protection for Smart Grid

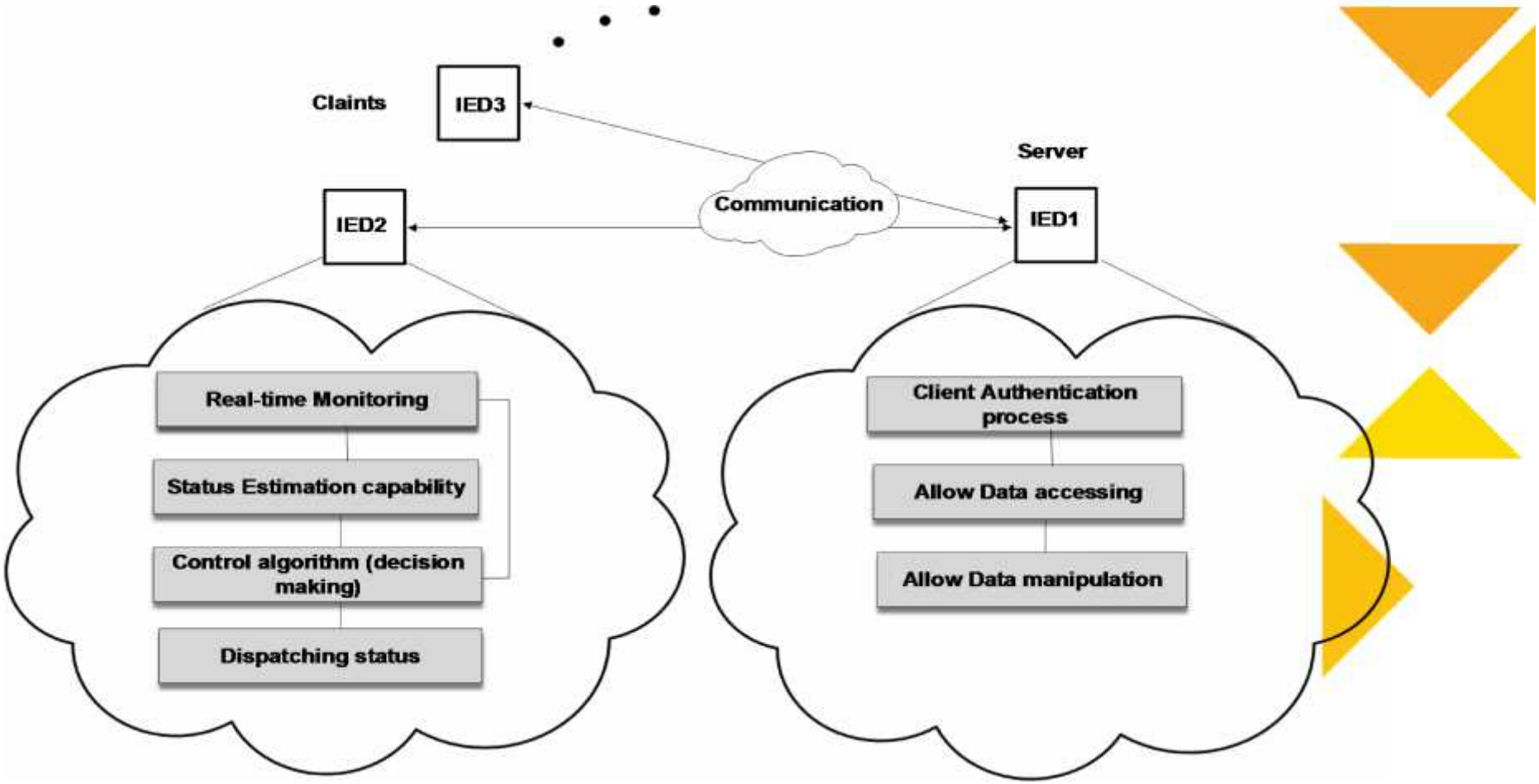
Case study 2

Light-Weight IEC 61850 GOOSE Based Loss of Mains Protection for Smart Grid



Case study 2

Light-Weight IEC 61850 MMS Based Loss of Mains Protection for Smart Grid



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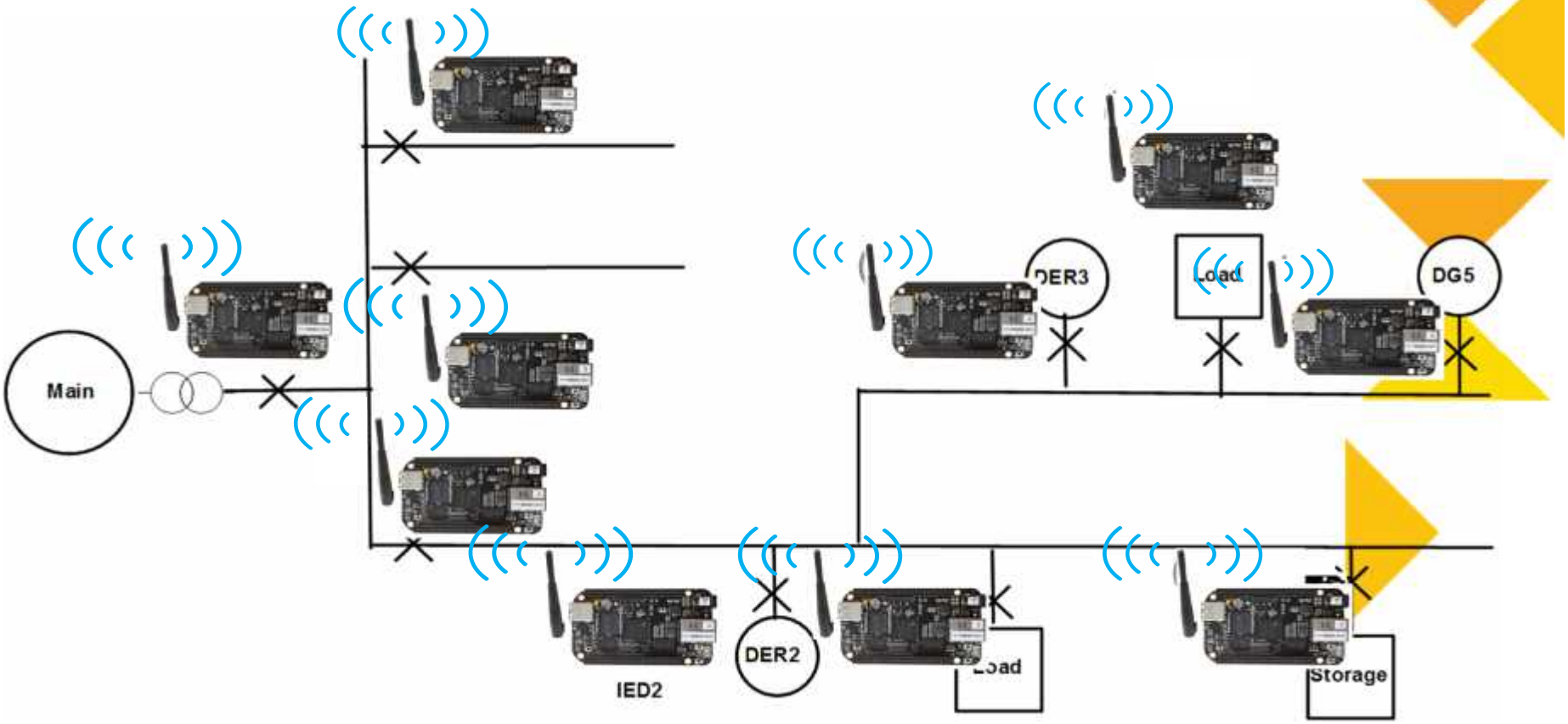
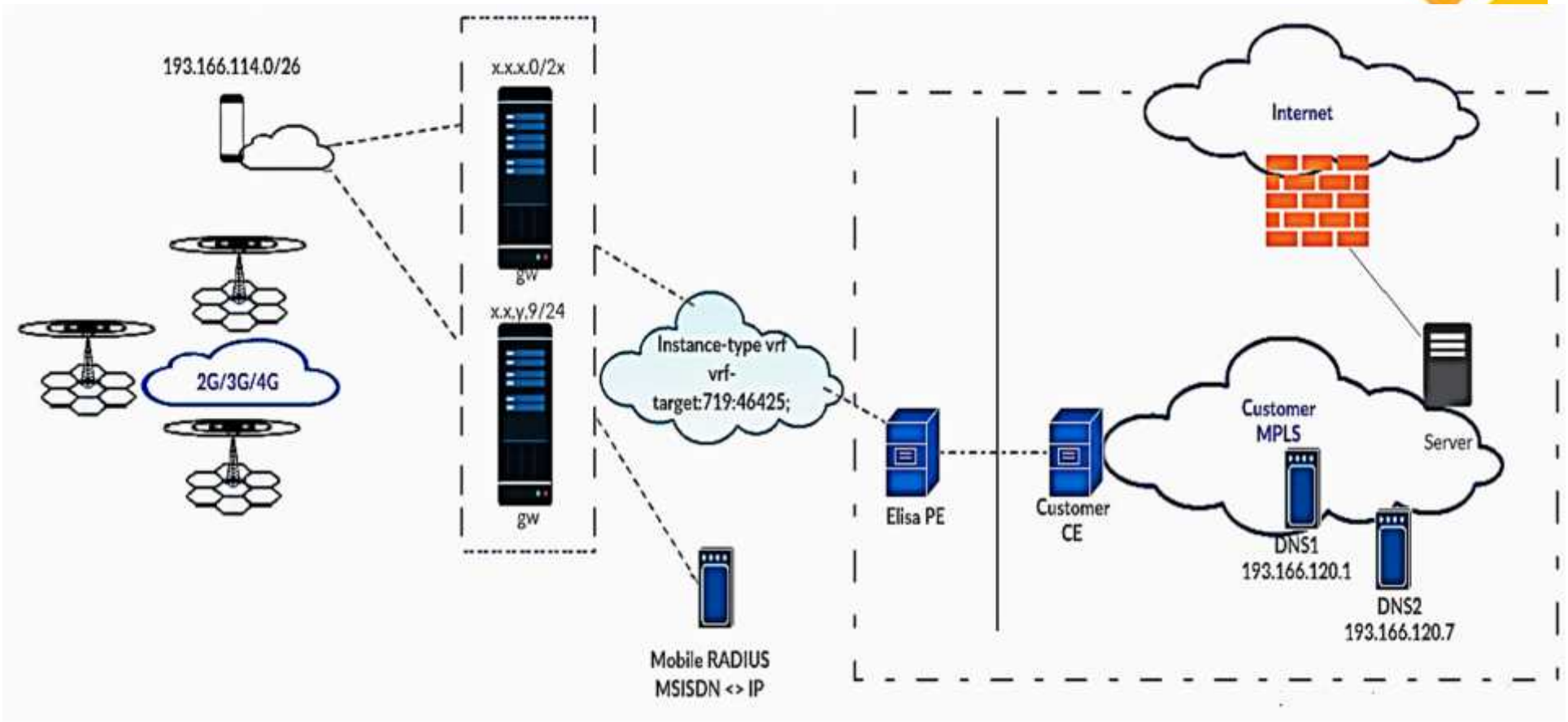


Case study 2

Light-Weight IEC 61850 MMS Based Loss of Mains Protection for Smart Grid

APN mob.uwasa communication system network configuration



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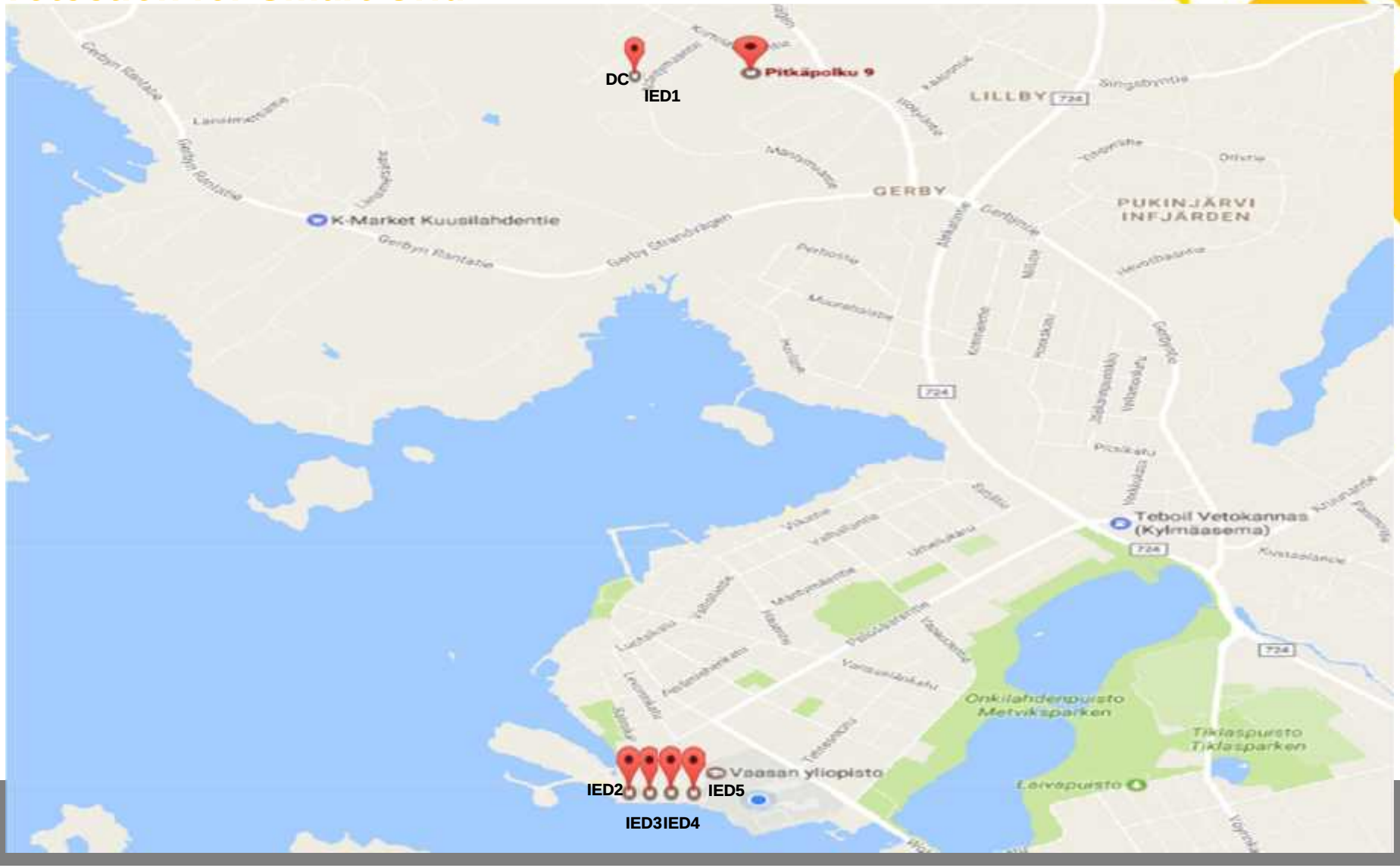

Results

Light-Weight IEC 61850 GOOSE Based Loss of Mains Protection for Smart Grid

$$\bar{t}_{RT} = \bar{t}_{out.TS} + \bar{t}_{net} + \bar{t}_{in.DUT} + \bar{t}_{App} + \bar{t}_{out.DUT} + \bar{t}_{net} + \bar{t}_{in.TS}$$

$$\pm^2_{RT} = \pm^2_{outTS} + \pm^2_{net} + \pm^2_{in.DUT} + \pm^2_{App} + \pm^2_{out.DUT} + \pm^2_{net} + \pm^2_{in.TS}$$

LoM Based GOOSE

	DPST.ECPConn		DRCS.ModOnConn	
	IED1-IED2	IED1-IED3	IED1-IED2	IED1-IED3
Mean val. ms	18.006	15.180	24.505	18.871
Std. dev.	5.083	3.209	6.627	3.332

LoM based Clients-Server communication MMS

	DPST.ECPConn			
	IED1-IED2	IED1-IED3	IED1-IED4	IED1-IED5
Mean value ms	645.434	648.222	1548.406	636.714
Std. dev.	377.384	316.597	486.493	370.383

Conclusion

- Designing and implementing light-weight IEC 61850 IEDs that support new LNs for different DERs
- Using the GOOSE and MMS IEC 61850 protocols based LoMs protection
- Exchanging real time data between different DERs based on IEC 61850
- Remotely monitoring and controlling DERs and within the acceptable range of latency

Future work

- To be used for the WAMPAC functions for example fault detecting and locating, interlocking etc.
- Classification of other Electrical Systems events (Supervisory Situation Awareness)
- Upgrade and refurbish legacy relays (to support IEC 61850 or even wireless IEC 61850 IED)
- To be used in Power Management in smart grid
- Distribute the client IEDs over wide geographical area for example over different cities in Finland to get a better view about the communication jitter for the WAMPAC applications

Publication

- **“***Wireless Light-Weight IEC 61850 Based Loss of Mains Protection for Smart Grid”* published in **The National Biannual Automation Conference Automaatiopäivät22, held in Vaasa 23-24 March 2017 Vaasa energy week.**
- The extended version of the paper “*Wireless Light-Weight IEC 61850 Based Loss of Mains Protection for Smart Grid”* has been requested and submitted in to the **Open Engineering – Special Issue Automation in Finland Journal**
- *“Light-Weight IEC 61850 GOOSE Based Loss of Mains Protection for Smart Grid”* has been published in WORKSHOP 2018 ON MICROGRIDS AND LOCAL ENERGY COMMUNITIES **CIRED2018 7-8 JUNE 2018 Ljubljana, Slovenia**

Thank you

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