TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	**vIED**
Title	**Validation of Virtual IED developed for large-scale system-security studies using real-time co-simulation and physical lab environment**
ERIGrid Reference	**05.018-2018**
TA Call No.	**5**

HOST RESEARCH INFRASTRUCTURE			
Name	**MultiPower Laboratory - VTT Technical Research Centre of Finland**		
Country	**Finland**		
Start date	**31.05.2019**	**Nº of Access days**	**20**
End date	**29.06.2019**	**Nº of Stay days**	**31**

USER GROUP	
Name (Leader)	**Sebastian Lehnhoff**
Organization (Leader)	**OFFIS Institut für Informatik**
Country (Leader)	**Germany**
Name	**Shoaib Ansari**
Organization	**OFFIS Institut für Informatik**
Country	**Germany**
Name	**Davood Babazadeh**
Organization	**OFFIS Institut für Informatik**
Country	**Germany**
Name	**Felipe Castro**
Organization	**OFFIS Institut für Informatik**
Country	**Germany**

1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

The aim of the proposed work is to validate the performance of virtual IEC 61850-based Intelligent Electronic Devices (IEDs) that have been developed and tested in a real time co-simulation platform at the The Smart Energy Simulation and Automation (SESA) Laboratory in OFFIS, with a physical hardware testing platform at the MultiPower Laboratory at VTT. The virtual IED has the ability to be scaled and integrated into further applications once validation with the hardware environment is carried out. The test results for simulation scenarios are compared with the real hardware tests and the Key Performance Indicators (KPI) are compared. The simulation and real hardware testing procedure are extracted from the ERIGrid Holistic Testing Approach (HTA). This enables the experiments to be conducted in a systematic and integrated way.

The hardware test scenarios in MultiPower Laboratory in VTT are concerned with feeder protection using high speed GOOSE communication from ABB REF615 IEDs. KPIs for the hardware are the relay tripping time, GOOSE delay and fault clearing time. The experiment specification for running the tests in the relevant Research Infrastructure (RI) is defined according to the ERIGrid Holistic Testing Approach (HTA), to consider the potential interactions and characteristics of both lab environments. The simulation scenarios involve combining the OPALRT simulator with virtual IEDs developed in OFFIS using the IEC 61850 protocol. The feeder protection scheme from the MultiPower laboratory is modelled in eMEGAsim and integrated with the vIED. The effects of tripping time, communication delay and fault clearing are investigated. Figure 1 shows the two research infrastructures.

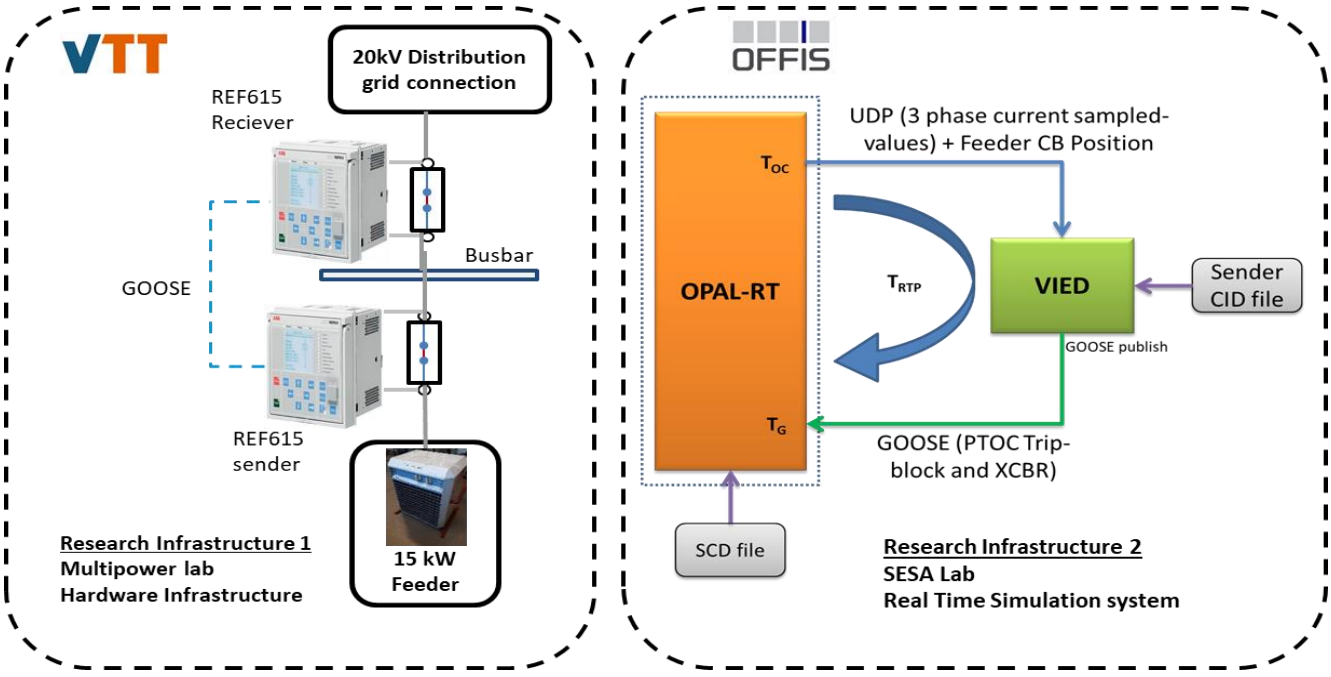

Figure 1: Research infrastructure at VTT and OFFIS

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

In this research work, the results for both hardware IED and real time simulation systems with vIED, are compared and analysed. The measurements for the current values, the GOOSE stNum, GOOSE sqNum and the timings of the tripping and the blocking are measured. The results for the GOOSE show that in the real time simulation, once the substation event of overcurrent occurs, the GOOSE message is faster than the ABB REF615 relays. For the hardware infrastructure, the operational time of the relays and the processing time of physical inputs of the current measurements could account for the higher GOOSE delay. In the virtual environment, the vIED runs on a VM and hence the hardware operating delays and the processing time of the relays is minimised. **Table 1** and **Table 2** show the results and the differences of the results for the two research infrastructures.

Table 1 Results from VTT testing

Event	Time(ms)
GOOSE retransmission	1.71
Feeder trip	46

Table 2 Results from vIED testing

Event	Annotation	Time(ms)
GOOSE round trip	T_{RTP}	0.6
Maximum	T_{MC}	67.8

The research work validates the performance of the real time simulation environment with the hardware infrastructure. The performance of the virtual environment can be further improved by having a time synchronisation PTP server for future work. Also, more complex protection scenarios can be modelled and simulated using the virtual platform and vIED can be further developed to deal with complex protection functions. The communication for Sampled Values is also incorporated in the vIED software and will be a useful feature to test current and voltage measurements for sampled value scenarios. Ongoing work is also underway to develop cybersecurity attacks for the vIED which can disrupt or attack the operating system of the vIED and can cause undesirable delays for the IEC 61850 communication. These cyber security feature will help to test the security vulnerabilities for IEDs and IEC 61850

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

The results, methodoligies and the background is explained in the ERIGrid technical report. This technical report gives in depth details of the RIs and the testing which was carried out for this project. This would help future ERIGrid studies in the domain of virtualization, protection testing and IEC 61850 communication. The results and testing has also been compiled in a scientific paper which has been submitted for DPSP 2020. The result for the acceptance is still awaited.

The project has also been presented internally in OFFIS for feedback. The use cases were also presented recently in KIT for a one day workshop on real time simulation and at the ERIGrid workshop in Trondheim. The test cases would also be the basis, for future work on these RIs and would be a good reference for future scientific works.