Design, modelling and co-simulation of an industrial and real-time IoT architecture for smart-grids

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Contexte

Smart grids are becoming more and more important for the power distribution.

Smart grids tend to introduce multiple new possibilities such as a smart power transport, increased grid robustness to hard conditions (e.g., bad wheater, storm...), multiple offers to customers through subscription contracts...

To ensure the well power transport, smart grids are composed of multiple nodes, **the substations**

Electrical substations receive the power either from a source energy production (e.g., nuclear power plant) or from another substation. The received power is treated and sent to another point of the grid

Intelligence within the substation comes from the Intelligent Electronic Devices (IED), the latter managing the primary equipment of the substation (e.g., the circuit breaker)

To ensure the operational management of the substation, IEDs need to communicate with each other

Challenges

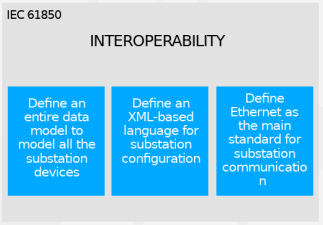
In order to ensure the cooperation between IEDs, the International Electrotechnical Commission (IEC) has developed a new standard : **IEC 61850**

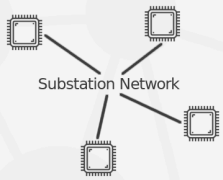
IEC 61850 brings solutions to answer to the interoperability issue between IEDs from different manufacturers. These solutions are focusing on 3 points:

1. The definition of an entirely **new data model** to represent the substation devices, e.g., circuit breaker, power transformer...

2. The definition of a **new XML-based configuration language** that is common for any IED from any manufacturer : The Substation Configuration Langage (SCL)

3. The use of **Ethernet** as the main communication standard





Which network topology ?
How to configure the network topology ?

However, the IEC 61850 standard does not specify how to organize the topology of the network architecture, how to configure it, or how to ensure that the real-time requirements are met!

Therefore, we need to combine the IEC 61850 contributions with the possibility to configure and evaluate the performance of the network architecture

Main objective: Be able to guarantee that the real-time constraints, for a given configuration and a given network architecture will be met !

Transfer time class	Transfer time [ms]	Application examples: Transfer of
TT0	>1 000	Files, events, log contents
TT1	1 000	Events, alarms
TT2	500	Operator commands
TT3	100	Slow automatic interactions
TT4	20	Fast automatic interactions
TT5	10	Releases, status changes
TT6	3	Trips, blockings

Our proposal

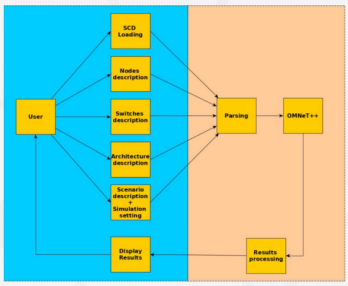
In order to evaluate an IEC 61850 architecture, we need to integrate all the standard specificities within a network model.

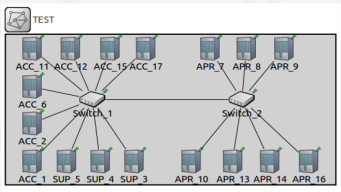
Two possibilities : analytic model or simulation model. For this work, we choose a simulation model,

Proposition of a tool : **the Simulation Tool for Analysis of substation netwoRkS (STARS)**

STARS collects the Substation Configuration Description (SCD) file containing all information about the substation devices then once nodes are retrieved and configured, the user can choose the network topology and how to configure it (e.g., link bandwidth, VLAN...).

Once the simulation is completed, results are available for network assessment.



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<?xml version="1.0"?>
<!-- SCD Template -->
<SCL xmlns="http://ww.ec.ch/61850/2003/SCL" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <Header id="TEST" version="01/04/2019 11:18:46" revision="" nameStructure="IEDName" toolID="CS SCLE 61850">
    <Communication>
    <IED desc="ArkensCP" manufacturer="SCLE SFE" name "SUP 3" type="ArkensCP" owner="TEST">
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    <IED desc="ArkensCP" manufacturer="SCLE SFE" name "APR 9" type="ArkensPR" configVersion="3.1e" owner="TEST">
    <DataTypeTemplates>
</SCL>
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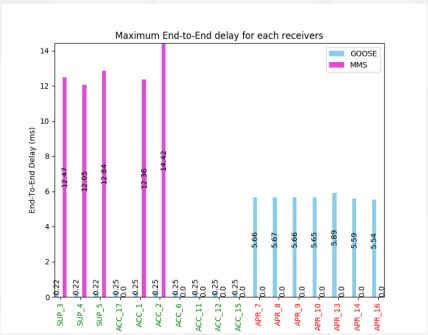
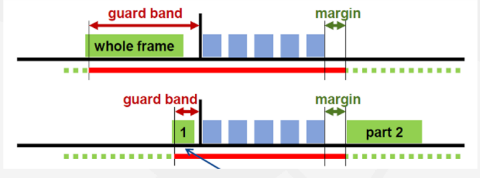


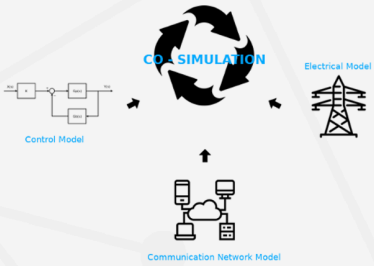
Perspectives

Part of the IEEE 802.1Q standard

Periodic slot reservation to protect the traffic from interferences

Frame preemption to allow express frames to be transmitted before non-urgent frames





In order to improve the fiability of the simulation, we want to model multiple expert-field and integrate them in an unique simulation.

In order to do that, we explore the co-simulation concept.