HYPERSIM and EXata - RT Simulator Guidance

WP6 output 2: CR-DES Project

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CPS

Cybersecurity and Resilie

Host PC

- Scenario creation
- Interface Mapping
- Execution Control
- Cyber Attacks
- Animation
- Analysis / Results

Real-Time Co-simulation Target

- Electromagnetic
- Electromechanical
- Mechanical
- Network
- Communications
- Cybersecurity



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CPS Platform - RT Simulator

Cybersecurity and Resilience of Digital Energy Systems (CR-DES)

Host PC

- Scenario creation
- Interface Mapping
- **Execution Control**
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HYPERSIM

ePHASORsim 20.000 Real-Time Transient Stability Simulator Windows based Detailed Large-Scale Power 10 ms time step 10,000 System software developed by Hydro-Québec (over 1000 3-phase buses) with 2.000 **HYPERsim** more than 300 validated power system Large Scale Power System Number of Simulation for Utilities & Manufacturers components and controllers 3-Phase 1,000 25 µs to 100 µs time step Buses 500 **TestView**: Automated testing with (supports Python) e*MEGA*sim 100 Power System & Power Electronics Simulation 10 µs to 100 µs time step **ScopeView**: Signal visualization, data 10 analysis and monitoring **HyperView**: enables monitoring simulation 1 s 50 µs 10 ms (1 Hz) (20 KHz) (100 Hz) uomena sim kestävää kasvua ja työtä -ohje performance in real-time Period (frequency) of transient phenomena simulated Euroopan unioni

10 µs

(100 KHz)

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Starting with HYPERSIM

HYPERSIM

• Right click on HYPERSIM icon, and chose the "Run as administrator"

Step 1: the option window will pops up

Step 2: from the option window chose "New Default Document" under "Creat New Design" section

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Starting with HYPERSIM

 Right click on HYPERSIM icon, and chose the "Run as administrator" Step 3: Saving option window pops up, name new design file and save it to the work space directory within a predefined project folder

HYPERSIM

Step 4: Full HYPERSIM GUI pops up, create new model as per guidelines provided in OPAL-RT HYPERSIM manual, also examples provided can be used as a platform to build or develop advance new model.

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HYPERSIM



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HYPERSIM

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• **ScopeView**: Signal visualization, data analysis and monitoring





• **HyperView**: enables monitoring simulation performance in real-time







HYPERSIM HYPERSIM

Starting with HYPERSIM

• Running the model at real-time requires the following steps

Step 1: Targets --> click (+) sign to add target

Step 2: Add New Target --> pops up window, define IP address for the target and name, --> ok target will appear at the target Manager window Step 3: Simulation Settings --> Target Configuration --> chose the target, and at the "Simulation mode" chose "Real-time"

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asan vliopisto								Task Manager	Close			



Starting with HYPERSIM

• Running the model at real-time requires the following steps

Step 4: Start --> the tasks are mapped automatically to the various cores, the code is compiled and the simulation starts running.

Step 5: ScopeView--> visualize the simulation results







SCALABLE EXata CPS

Windows based high-fidelity network emulator/simulation, which simulates the • network communications of electrical grids, attacks, defenders etc. EXata CPS is integrated with OPAL-RT's HYPERSIM real-time simulator on the same hardware to offer a complete real-time cyber-physical solution for the development, testing, and assessment of electrical grids, support 100s and 1000s of devices.

- Develop emulation/simulation models for new networking technologies. Design new • communications protocol models using the OSI-style
- Connect real networks, applications, and devices with EXata emulated network .
- Analyze and manage EXata virtual networks with popular, industry-standard, tools
- Develop, test and evaluate, and train users on cyber warfare and network security technologies. estävää











Common Attack Vectors

- Backdoors and holes in network perimeter
- Exploitation of vulnerabilities in SCADA protocols
- Communications hijacking and man-in-the-middle attacks
- Database attacks
- Bogus input data to the controller introduced by compromised sensors and/or exploited network link between the controller and the sensors
- Manipulated and misleading output data to the actuators/reactors from the controller due to compromised network link between the controller and the actuators
- Attacks on timing and synchronization









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Attack models encompassing the protocol stack :









EXata

(Toolset Panel open)

Bottom Panels





EXataCPS GUI starting by default with new design mode







EXataCPS GUI new design file window and file Explorer window

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EXataCPS GUI model design

 Step 1: Click EXataCPS symbole GUI window will pops up--> do one from the following

- Step 2: File --> New --> new design file will open
- Step 3: File --> Open file --> new file Explorer window will pops up to navigate to existing design file
- Step 4: File --> Open Example --> a new file Explorer window will open, and the user should navigate to the SCALABLE examples folder. Other options are available under the File toolbar menu, which the user can explore.
- Step 5: after user open one from the above, at the open canvas user may create a model accordance with the guidelines provided in the SCALABLE EXataCPS "Product Tour" documents. The examples provided can also be used as a platform for the examples provided can also





- EXataCPS GUI model execution
- To run the model in real-time after it has been built in EXataCPS, the model must be transported to the OPAL-RT real-time simulator, where initialization and execution can begin as follows

EXata

Run Settings

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visualise mode





EXataCPS GUI model execution

 To run the model in real-time after it has been built in EXataCPS, the model must be transported to the OPAL-RT real-time simulator, where initialization and execution can begin as follows

- Step 1: click Run Settings
 —-> pops up window of Run Settings, make the admin SSH access to the target and define the directory for the execution folder at the target --> ok
- Step 2: select execution mode --> Target Configuration -->
- Step 3: click initialize Simulation --> pops up window, ask user to save example scenario
 Step 4 dot
- Step 4: A copy of the scenario is saved --> the design mode will change to visualize mode
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EXataCPS GUI model execution

 To run the model in real-time after it has been built in EXataCPS, the model must be transported to the OPAL-RT real-time simulator, where initialization and execution can begin as follows

- Step 5: Click play button \bigcirc --> to run the scenario in real-time
- Step 6: Click he Analyze Results button ____ --> simulation results in EXataCPS Analyzer

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Cyber Physical system security of Digital Energy Systems (CR-DES)

- Test and predict power systems and communication networks behavior under attack.
- Ability to scale to represent the entire network.
- Integration of the developed real time simulation models with equipment and power grid HIL, PHIL etc.
- Run 'what-if' scenarios about critical infrastructure under cyber-attack without threatening operations.
- Assess effectiveness of tools, techniques and architectures to ensure system availability. Kestävää kasvua ja työtä -ohjelma

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Measure and improve system resiliency.

