Smart Grids Co-Simulations with Low-Cost Hardware

Martin Schvarcbacher and Bruno Rossi

Lab of Software Architectures and Information Systems
FI MU

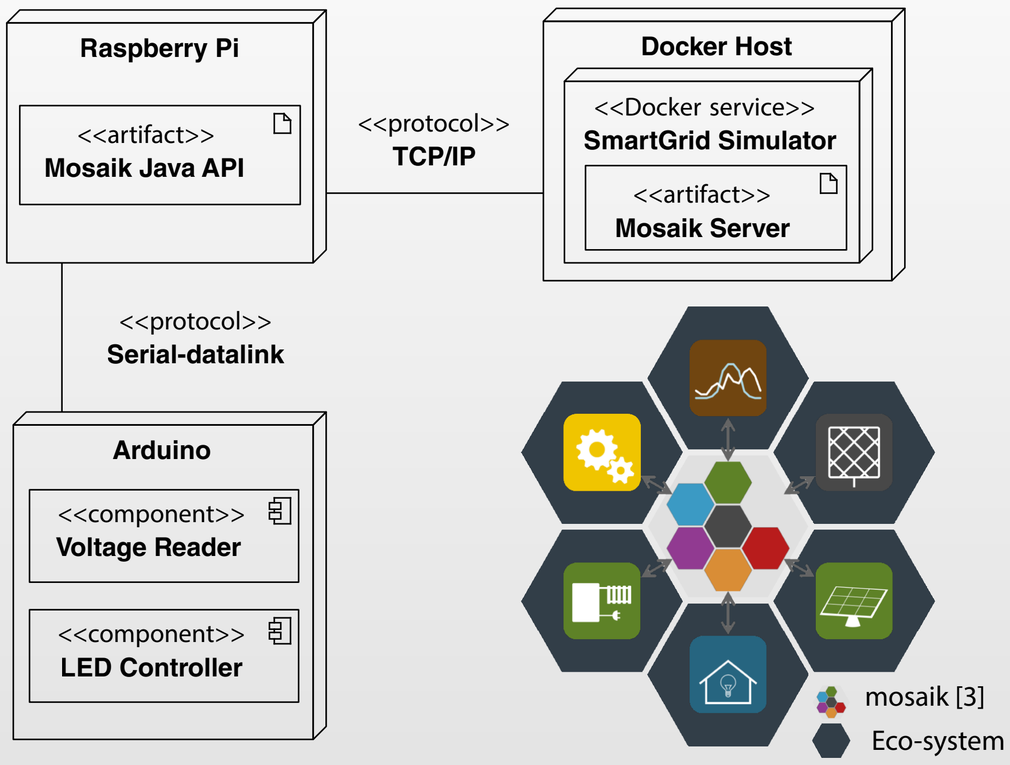
Project Context

We showcase a low-cost environment that students can use to test and validate different Smart Grids scenarios. Such environment can be a first step for looking into hardware-in-the-loop (HIL) and co-simulation environments - environments that are focused on orchestrating several simulations running on different devices, combining also software simulations. This solution can be used for understanding simulations and HIL in an affordable and effective way in an easy to deploy environment [1].

Goals

- ★ Education of students in co-simulation concepts using easily accessible and hands-on training in Smart Grids technologies
- ★ Creating ways for cheaper hardware prototyping of Smart Grids by having low-cost simulation nodes

Architecture



Scenarios

a) Sunlight Levels for a Location

- ★ Uses past weather data to estimate sunlight levels
- ★ Allows evaluating different PV panel deployments
- ★ Each node represents a PV power station in the grid

b) Power Grid Load

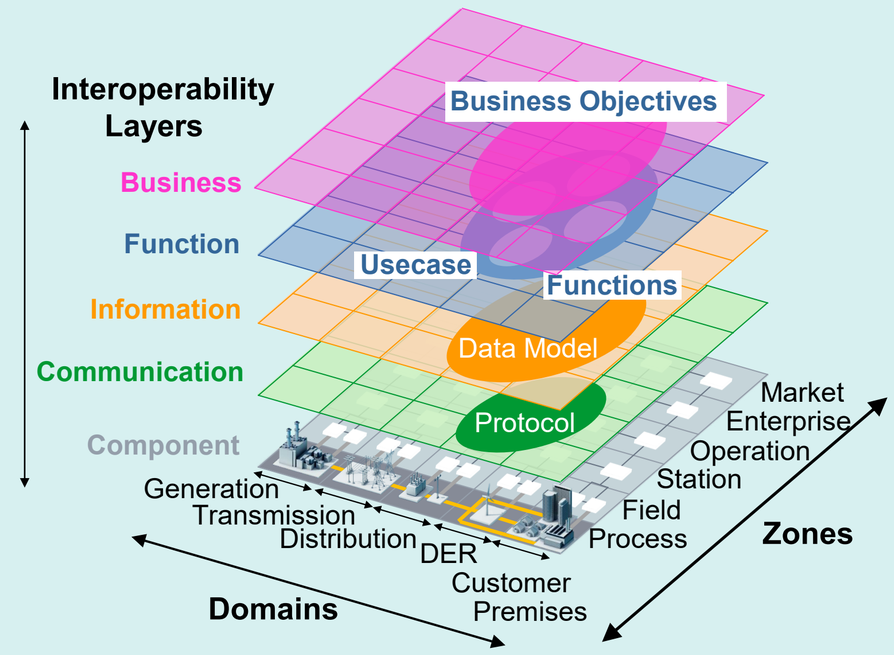
- ★ Knowing whether the power grid can meet the current or near future requirements becomes necessary as more intermittently available renewable resources are added to the power grid [2]
- ★ The amount of power produced is compared to expected grid load to determine power deficiencies when using only renewable resources
- ★ Used to determine when power plants need to be switched on to supplement renewable energy sources
- ★ Predicting the required production capacity can be beneficial for the Smart Grid stability

Project Results

- ★ We created a platform for Smart Grid deployment prototyping
- ★ Students can easily setup their own Smart Grid environments and test them under various changing conditions
- ★ Test cases include: Smart Grid deployment, interoperability, stability
- ★ Our goal is a full power grid simulation using only commodity hardware

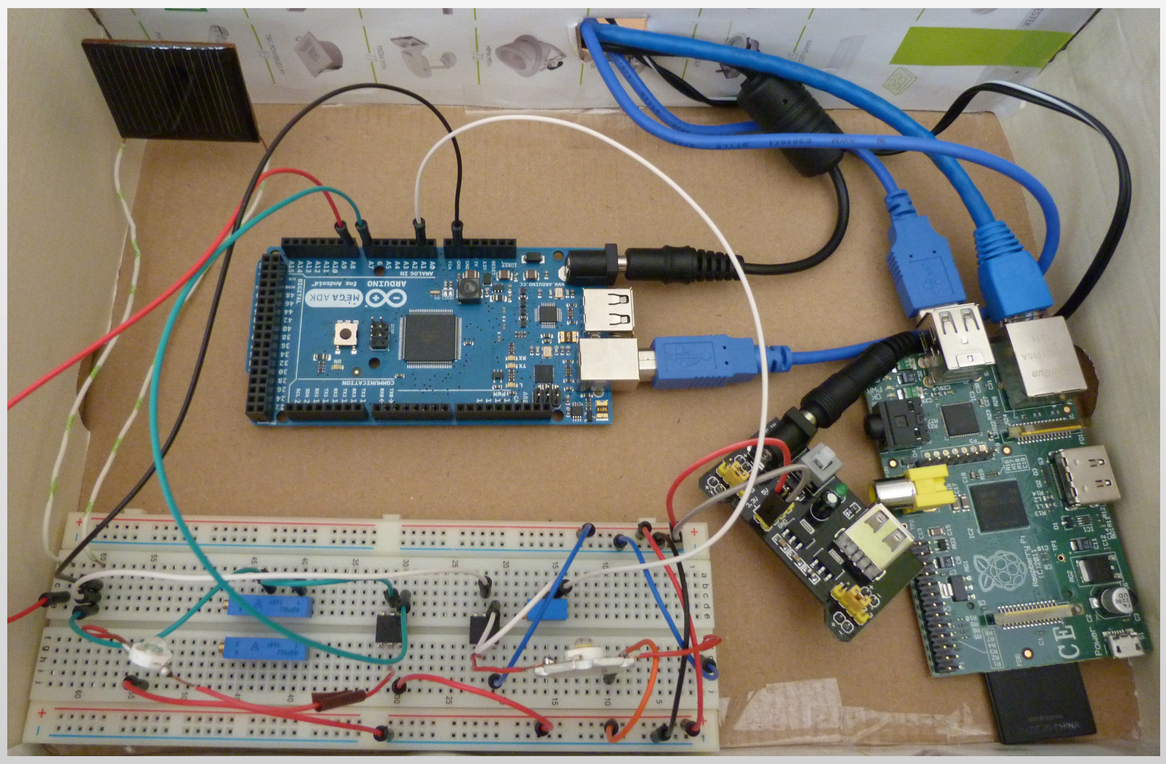
Smart Grids & Lasaris

- ★ The Smart Grid can be regarded as an electricity network that benefits both from two-way cyber-secure communication technologies and computational intelligence for electricity generation, transmission, substations integration and consumption to reach the goals of a safe, secure, reliable, resilient, efficient, and sustainable infrastructure [4].
- ★ Lasaris is involved in research on Smart Grids with industrial partners:
  - ➢ Supporting Smart Grids testing/simulation infastructure
  - ➢ Data analysis for Smart Grids (load control, anomalies detection)



Smart Grid Architecture Model [5, 6]

Simulation Node



Hardware Node Components

- ★ Photo-voltaic (PV) panel:
  - ➢ Produces power proportional to the illumination levels
- ★ LED array:
  - ➢ Generates multiple illumination levels
- ★ Arduino Mega:
  - ➢ Controls the LED array and reads the voltage level from a PV panel
  - ➢ Sends measured data and receives control commands
- ★ Raspberry Pi:
  - ➢ Data collection and network communications

References

[1] M. Schvarcbacher and B. Rossi, "Smart Grids Co-Simulations with Low-Cost Hardware," 43rd Euromicro Conference on Software Engineering and Advanced Applications, Vienna, 2017 (to appear).
[2] S. Chren, B. Rossi and T. Pitner, "Smart grids deployments within EU projects: The role of smart meters," 2016 Smart Cities Symposium Prague (SCSP), Prague, 2016, pp. 1-5.
[3] O. Nannen et al., "Low-cost integration of hardware components into co-simulation for future power and energy systems," IECON 2015 - 41st Annual Conference of the IEEE Industrial Electronics Society, Yokohama, 2015, pp. 5304-5309.
[4] B. Rossi, S. Chren, B. Buhnova and T. Pitner, "Anomaly detection in Smart Grid data: An experience report," 2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC), Budapest, 2016, pp. 2313-2318.
[5] CEN-CENELEC-ETSI, Smart Grid Coordination Group, "Smart Grid Reference Architecture," 2012.
[6] M. Uslar et al, "Standardization in smart grids: Introduction to IT-related methodologies, architectures and standards," Springer Science & Business Media, 2012.