Development of a model-based control application compliant with IEC 61499 for building energy systems with a focus on photovoltaics

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System configurations

Motivation and objectives

- Political marginal conditions for PV systems, such as feed-in tariffs, have resulted in the need for intelligent operation strategies.
- Proprietary solutions available on the market today are costly and intelligent controllers for building energy systems can thus be classified as luxury products.
- There is a need for generic software based on standards for the control of multi-generator systems. This contribution aims to provide an open-source solution that can be used on a variety of inexpensive hardware.

Objectives:
- Development of communication libraries that enable co-simulations between IEC 61499 control systems and simulation software (Polysun/Matlab).
- Design and validation of an IEC 61499 control application in 4diac using the communication libraries and simulation software.
- Development of the application and use in field tests.
- Decoupling of the controller using the MVC design pattern.
- Establishment of an open-source community in the field of energy management.

Model-View-Controller design pattern

Matlab-4diac co-simulations: PVprog (forecast based battery operation) and curtailing

Polysun-4diac co-simulations: PVprog, curtailing, and SG Ready heat pump DSM

Hardware deployment: Initial field tests with a Raspberry Pi

Apart from the ability to design complex control systems, the main advantages of IEC 61499 compared to the current industry standard, IEC 61131, are platform independence. IEC 61499 applications can easily be ported between integrated IEC 61131-3, is platform independence. Apart from the ability to design complex control systems, the main advantages of IEC 61499 compared to the current industry standard, IEC 61131, are platform independence. IEC 61499 applications can easily be ported between integrated IEC 61131-3, is platform independence.

Hardware

- PC (Windows/Linux)
- Raspberry Pi (Raspberry Pi SPi, Raspberry Pi SPi SPS)
- Ondax
- Wago PPCs SPS
- iCraft
- mUp 200
- Insteon
- CUB 189
- Any JAVA-based hardware

Routine Environment

- 4diac-RT
- open source
- proprietary
- closed source

Source code

- github.com/MrcJkb/forte_spine_comm/
- github.com/MrcJkb/VCCControllerLib/
- github.com/MrcJkb/PVTControllerLib/

Hardware: converged field tests with a Raspberry Pi

For optimal results, the PVprog algorithm needs to know the PV power production (PV production) and the load separately (above, right). This can be achieved by using smart components that comply with the EEBus “SPINE” protocol.

Exemplary setup:

- Raspberry Pi 2 (Raspberry Pi 2 running Node.js, RT)
- 4.5 kWh PV system
- 5.3 kWh usable battery
- Battery hosts a RESTful server
- Communication via HTTP: RESTful API methods
- Communication protocol: the contract application remains almost completely unchanged
- Monitoring via RESTful server or via controller

The following non-portable additions were made to the application for increased stability:

- Implemented a watchdog timer. If the Raspberry Pi crashes, it will restart itself (development will begin shortly).
- Implemented the ability to send and load internal data on a different RTE than the battery. This way the field test can take up to 16 days to fully initialize, are not lost.

Source code

- PVprog algorithm in Matlab: pysparse2.htw-berlin.de/veroeffentlichungen/daten/pvprog/
- tcpip4diac: Matlab - IEC 61499 communication library
- github.com/MrcJkb/tcpip4diac/
- Polysun4diac: Polysun - IEC 61499 communication plugin
- github.com/MrcJkb/Polysun-4diac-ControllerPlugin/
- IEC 61499 function block library + control application:
  github.com/MrcJkb/PV4diacController/
- HTTP communication layer for 4diac-RT:
  github.com/MrcJkb/forte_http_comm/
- EEBus "SPINE" communication layer for 4diac-RT:
  github.com/MrcJkb/forte_spine_comm/

Summary and conclusion

- Open-source communication libraries enable co-simulation of industry compatible IEC 61499 control applications with Polysun and Matlab.
- Direct development of control applications in an IEC 61499 compliant IDE.
- No prototyping necessary.
- No porting from prototype to final product necessary.
- The Libraries were used to develop an intelligent model-based control application for building energy systems.

For optimal results...

- PVprog operation and PV curtailing should communicate (i.e. in a combined controller).
- DSM controlled load should be treated by PVprog as stored energy that reduces the load at a later time.
- Use of intelligent devices (e.g., SPINE).

Outlook:

- Preliminary field test results prove to be very promising.
- Implementation of SPINE communication protocol for 4diac plug-in development.
- In an ever-growing industry, the potential for further development of this project may never cease to exist.