Microgrids are ideally suited for distributed control solutions. However, challenges exist when realizing the developed distributed controller under hardware level:

- Sufficient computational capability to support small iterative time step;
- Time synchronization management of concurrency among all the nodes;
- Exchange information in a fast and accurate manner;
- Scalable controller and hardware implementation;
- Device interaction codes development VS Core control codes development;
- Communication failure tolerance.

RIAPS runs on a three-layer structure:

- An **Application** is a distributed control algorithm that is designed for a specific control goal and it is consist of **Actors**;
- An **Actor** realizes an abstract function that is part of the designed algorithm like individual controller in each agent, it is consist of **Components**;
- A **Component** is the building block of RIAPS and realizes the physical functions like measurement sensing or calculation.

**Application Developments**

- Improved energy/power management with adaptive distributed control;
- Stable control for islanded mode, grid synchronization, (un)intentional islanding;
- Voltage/frequency restoration upon re-synchronization;
- Virtual Impedance control for improved dynamic reactive power sharing;
- Utilizes distributed computation and decision making platform.

**Partners**

- ARPA-E

**References**

- [https://riaps.isis.vanderbilt.edu/](https://riaps.isis.vanderbilt.edu/)

**Infrastructure**

1. **Opal-RT real time simulator**
   - Inverter switching model in FPGA solver
   - Power system model in CPU solver
2. **Texas Instruments F28377S MCU**
   - Inverter control using PWM signal
   - Modbus communication with Beaglebone Black
3. **SEL 451 Relay**
   - Providing real-world protection device response
   - Communication with Beaglebone Black using C37 protocol
4. **Beaglebone Black**
   - RIAPS node hardware carrier
   - Distributed control algorithm implementation
   - Communication with DSP via Modbus
5. **Linux machine**
   - Grafana Display

**RIAPS System Architecture Overview**

1. **Real time Simulation**
   - Opal 5031
   - Analog Signals
   - Opal 5607 I/O Board
   - Digital Signals
2. **Hardware in the Loop**
   - SEL 451 Relay
   - C37 protocol
   - DSP Boards
3. **Controller in the Loop**
   - Linux Machine
   - ZeroMQ
   - ModBus Protocol
   - BeagleBone Black

**Microgrid Testbed in FREEDM Systems Center**

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