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Federal Department of the Environment, Transport, Energy and Communications DETEC
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Division

REEL Demo – Romande Energie ELectric network in local balance Demonstrator

Deliverable: 2b1 Successful communication and control of one DSM device with the use of Commelec agent in 1 feeder

Demo site: Chapelle

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[Lausanne, 20.11.2018]

1. Description of deliverable and goal

1.1. Executive summary

We have successfully developed and tested a shadow agent. The shadow agent periodically (every 1 second) pings the GridEye server and gets power measurements corresponding to four different nodes in the grid at Chappelle-sur-Moudon. Based on these measurements, it computes the Commelec advertisement. This advertisement would be sent to the Commelec grid agent once we will run the grid agent to control other flexible resources in the grid. The second part, i.e., control of DSM device, is not yet done. In this part, the resource agent will need to implement the power setpoints (received from the grid agent) in the resource that it is managing. For example, a battery resource agent will need to communicate the power setpoints it received from the grid agent to the battery converter or the battery management system (BMS). The battery converter and/or BMS then eventually will implement the corresponding power setpoints in the battery.

1.2. Research question

We have designed a central controller that considers the safe operation of the grid under its control. To compute the power setpoints for the next time interval, it periodically receives the advertisements from the controllable resources. These advertisements consist of the power flexibility, willingness of a resource to do a particular power setpoint, and the associated uncertainty to implement a particular power setpoint asked by the central controller. As the central controller accounts for the safe operation of the grid, it also needs to know the possible region of power setpoints that an uncontrollable resource or node in the grid can do. We have designed a resource agent for such uncontrollable resources or nodes in the grid. The research question in designing such a resource agent is the prediction of the range of power setpoints that the resource can do in the next time interval. We have designed and implemented an algorithm that, for a given confidence, can predict the range of power setpoints (both for active and reactive power) the power values from this resource will lie in.

1.3. Novelty of the proposed solutions compared to the state-of-art

We have designed the new algorithm for predicting the range of power values for short time intervals. We have tested it for the period of one second and ten seconds. We found that the algorithm predicts well for this time interval and has very low performance overhead in terms of CPU and memory usage. The proposed solution is better than most state-of-the-art methods and a publication is under-way.

1.4. Description

Background:

Commelec control framework consists of two types of agents: resource agent and grid agent. Resource agent senses the state of the resource, and based on this state and characteristics of the resource, it creates and periodically sends the advertisements to the grid agent. The advertisement consists of the power flexibility, willingness, and uncertainty of a resource. Based on the information in the advertisements and other objectives set by the user, the grid agent computes optimal power setpoints each resource should implement. These optimal setpoints are then communicated back to the corresponding resource agents, which implement these power setpoints in the resource they manage. For the resources that are not controllable, e.g., an uncontrollable load or PV panels, this last step does not really make sense. In the Commelec language, such resource agents are called shadow agents. The job of the shadow agent is to periodically compute and send the Commelec advertisement to the grid agent.

Details of work done: Our shadow agent (written in C++) periodically pings the GridEye server over HTTPS. The GridEye server replies with the measurements that are received from four GridEye devices that are placed in the grid of Chappelle-sur-Moudon (Figure 1).

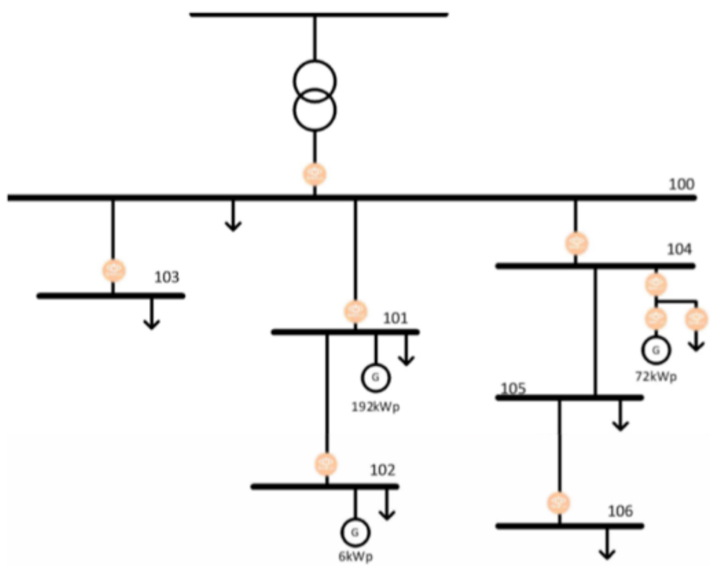
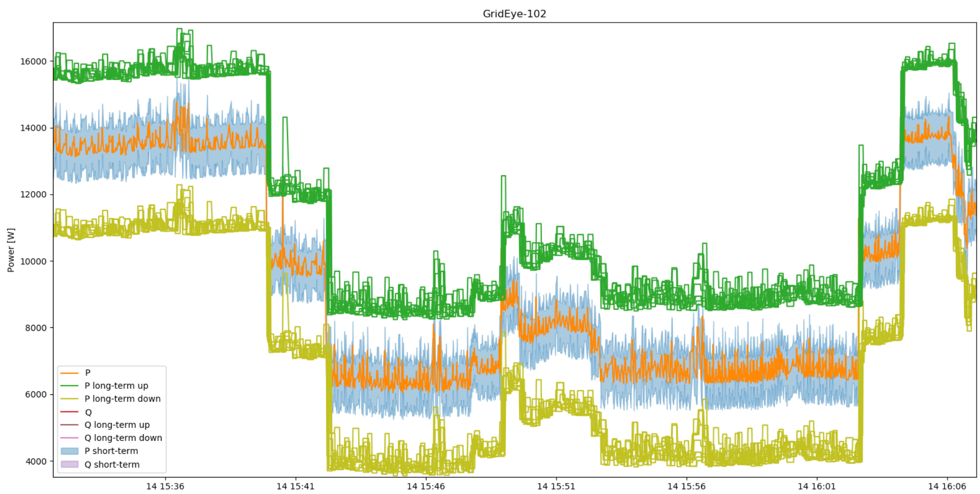


Figure 1: Topology of Grid at Chappelle-sur-Moudon. GridEye devices are located at 101, 102, 104, and transformer.

These measurements are received in JSON format and then, parsed to compute the apparent power injected/absorbed at each node. Currently, we do not receive the information to compute the power factor and therefore, assume a power factor of 1. Thus, currently, apparent power (S) represents fully the active power (P) and we take the reactive power (Q) as zero for the advertisement creation process in the shadow agent.

To compute the commelec advertisement, we need three quantities: flexibility (PQ profile), willingness (virtual cost), and uncertainty (belief function). In case of shadow agent, it is trivial to compute the first two quantities: as the resource is uncontrollable, we say that the resource is uncontrollable and therefore, does not have any flexibility. In the PQ profile, this corresponds to a point in the PQ plane. Also, as the resource is uncontrollable, the virtual cost or willingness does not make any sense and therefore, is put to zero. To compute the uncertainty (belief function), we mainly use historical data and then, predict the interval in which the power in the next time step will fall for a particular confidence. The algorithm for computing the power setpoint is not yet published.

Figure 2 depicts the results obtained from our forecasting algorithm for the data received from the GridEye device at node 101, 102, 104, and transformer. The short-term forecasting interval is 1 second whereas the long-term one is 10 seconds.



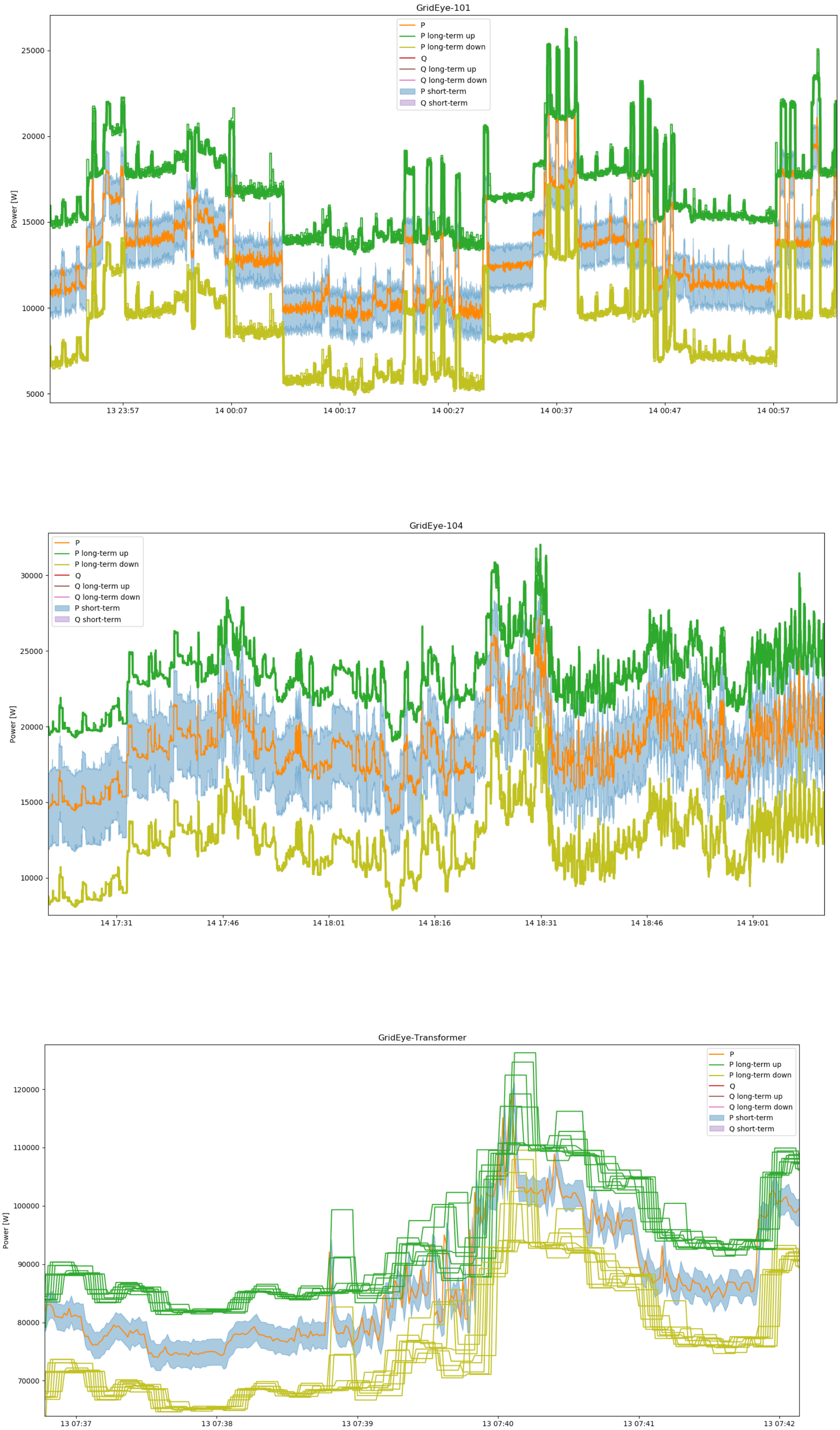
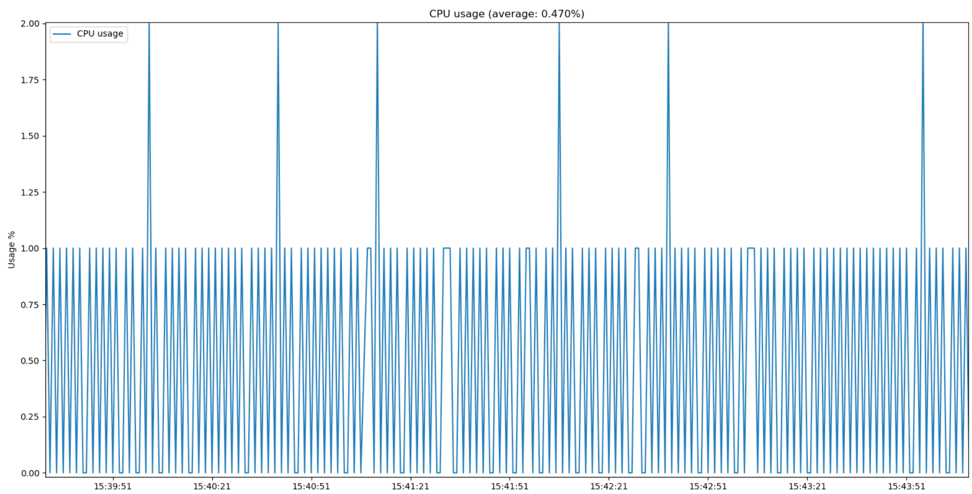


Figure 2: Short- and long-term prediction intervals for the measurements corresponding to GridEye device at node 101, 102, 104, and transformer.

We note that our shadow agents are able to correctly forecast the interval in which the next measurements (for the period of 1 second or 10 seconds respectively) would fall. Most of the time the actual measurements fell inside the predicted interval that was predicted by our shadow agent one or ten seconds before. As post-processing step, we are now developing the scripts to compute the exact matrices that would tell us how good the performance of our prediction interval is.

Figure 3 presents the CPU and memory usage of these four shadow agents. As we can see in the figure of the CPU usage, the maximum CPU usage is 2% whereas its average value over the period of 10 days is 0.47%. The maximum memory usage is 60 MB after running the shadow agents for a period of 10 days. The rise in memory usage is due to the algorithm that predicts the power forecast for the next time intervals. Depending on the type of the day (week-day, week-end, holidays, power values), it creates new classes and therefore, needs to allocate new memory. However, once we see all the cases, we expect the memory usage to saturate at a specific value and we believe that this value will be less than 75MB.



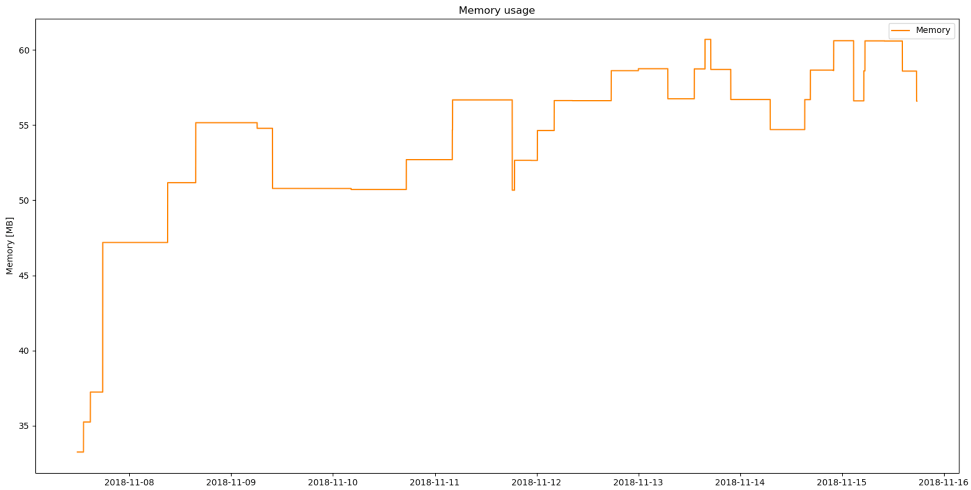


Figure 3: CPU and Memory usage of four shadow agents running on an Intel(R) Xeon(R) Bronze 3104 CPU @ 1.70GHz with 6 cores.

Conclusion: This work permits us to collect the power injections at different buses in the grid of Chappelle-sur-Moudon. This information is useful for two tasks: the estimation of the state of the grid and predictions of the variations in the power at different nodes in the next control time step. The first task is done by a state estimator whereas the second task is done by the shadow agent. Output of both the state estimator and shadow agent is fed to the grid agent. Having equipped with this information, grid agent can make decisions that are more robust in terms of the safe operation of the grid. As we have previously mentioned, the GridEye server does not send us the information to calculate the power factor at injections/absorptions at different nodes and therefore, we cannot split the apparent power at each node in the active and reactive power. This is the immediate next step to do for this activity.

2. Achievement of deliverable:

2.1. Date

20 November 2018

2.2. Demonstration of the deliverable

This deliverable has been achieved through the successful collection of information from the GridEye device on the demo site in Chappelle-sur-Moudon and the prediction of the measurements.

3. Impact

The deliverable is built for the successful test of Commelec control framework with one DSM device.