Flexibility Interoperability Platform

July 2019

EcoGrid 2.0 is a research and demonstration project funded by EUDP (Energiteknologisk Udviklings- og Demonstrationsprogram). The 9 partners in the project are:

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1.1 Introduction

Executive summary

To provide interoperability for incompatible home energy management systems in EcoGrid 2.0, a Flexibility Interoperability Platform was built. The evaluation of the platforms performance found that the FIP could perform activations within acceptable time frames and with success rates higher than those of the downstream HEMSs, but also showed that using a centralized service for this task carries the risk of introducing new failure scenarios unrelated to the HEMSs themselves.

Throughout heating season 3, the Flexibility Interoperability Platform (FIP) was to be used by the aggregators to facilitate their communication with home energy management systems (HEMSs) in the EcoGrid 2.0 households.

The need for the FIP was identified previously in the project. It acts as a translation layer between the EcoGrid 2.0 interoperability protocol (described in deliverable D4.5.2) and the native protocols of the HEMSs. Such functionality will always be required as long as the HEMSs does not implement the interoperability protocol themselves, and while the scope of EcoGrid 2.0 is limited to control of HEMSs, the functionality can be extended to the broader spectrum of distributed energy resources (DERs).

The point of this evaluation is to answer research questions 1 and 2 (RQ1 and RQ2):

1. What are the principles and pitfalls when building an interoperability platform to enable DER/Aggregator interoperability without protocol adoption at the DER level?
2. How can such an interoperability platform be implemented in the EcoGrid 2.0 project, and what are the control characteristics that aggregators experience when activating their portfolio?

From the period January 15th to April 5th the entire EcoGrid 2.0 setup was running in autonomous mode. During this period, the FIP was a central facilitator in all demonstrations involving HEMSs. The evaluation of RQ1 is based on experience and data gathered during autonomous operation in heating season 3, rather than specific demonstrations. In-depth description of this is contained in deliverable D5.4, while some points will be summarized below.

In addition to autonomous operations of the FIP, specific tests were conducted against the FIP to gather data to evaluate the portfolio control characteristics (RQ2). These tests are described below.

1.2 Demonstrations

Autonomous operation

As described in D5.4, an important principle in the FIP architecture is the Virtual DER, and isolation between Virtual DERs. While this was achieved in the FIP by implementing the Virtual DERs as lightweight processes with preemptive scheduling and isolated memory space, common error cases were caused by reliance on shared, external systems. The most prevalent examples of these have been:

- Log file rotations inadvertently destroying the logging pipe, rendering the FIP unable to log and filling up the log buffer until running out of memory.
- Queries accessing database tables with transaction auditing and data collection slowed to a crawl due to improper utilization of indexes or indexes growing too large to fit in memory.
- Downstream HEMS vendor cloud systems being overwhelmed due to sudden and large spikes in the number of requests.

Portfolio control characteristics

To discern portfolio control characteristics, the FIP is tested by a load controller, which plays the part of an aggregator. It makes a selection of households, which it then subjects to a sequence of control signals through the FIP. The control signals throttle the heating equipment of the selected households, checks that the change has been effectuated and then unthrottles the heating equipment. The message flow is recorded in order to calculate response times and error rates. The tests were carried out against varied portfolio sizes.

The response times from two such tests are plotted in Figure 1 and Figure 2. As can be seen from the plots, the response times vary dramatically depending on the number of households being activated simultaneously – the median response time for successful control is 11 seconds for 249 households and 52 seconds for 602 households, and the maximum response times are 15 and 66 seconds respectively.

The main reason for the large difference in response times is that the downstream HEMS vendor cloud systems struggle to handle the additional load. This means response times from the downstream systems increase, and fail relatively more often, meaning the FIP must perform more retries.

This difference in response times should not have a large impact on the aggregators ability to activate flexibility due to the time constants involved in household heating. But it should influence the aggregators control algorithm, as they must be prepared to wait for up to a minute before concluding on the success of an activation.

It is notable that the median response times in case of errors is lower than for successful control, and that the minimum and maximum error response times are respectively lower and higher than those for successful control.

The reason for lower median response times in case of errors is that errors are usually discovered early in the communication chain. Either the FIP or the HEMS cloud control system may error out early if it is aware of communication issues with a HEMS that cannot be solved by retries. In contrast, successful control attempts always have to reach the HEMS, and possibly peripheral equipment connected by low quality connections with high latency. Thus, if the FIP knows that a given HEMS is offline it can return an error with sub-second response times, while the fastest successful control actions will always take a few seconds.

The reason why the slowest errors have higher response times than the slowest successful control attempts is that some error conditions can only be determined when HEMS interactions time out, which obviously takes longer than successful HEMS interactions.

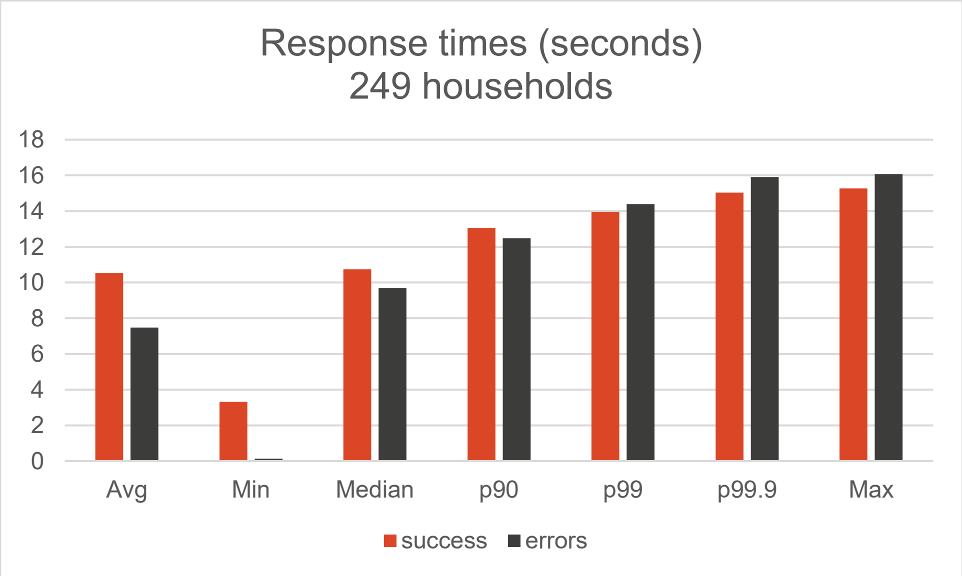

Figure 1 - Response times in test with 249 households

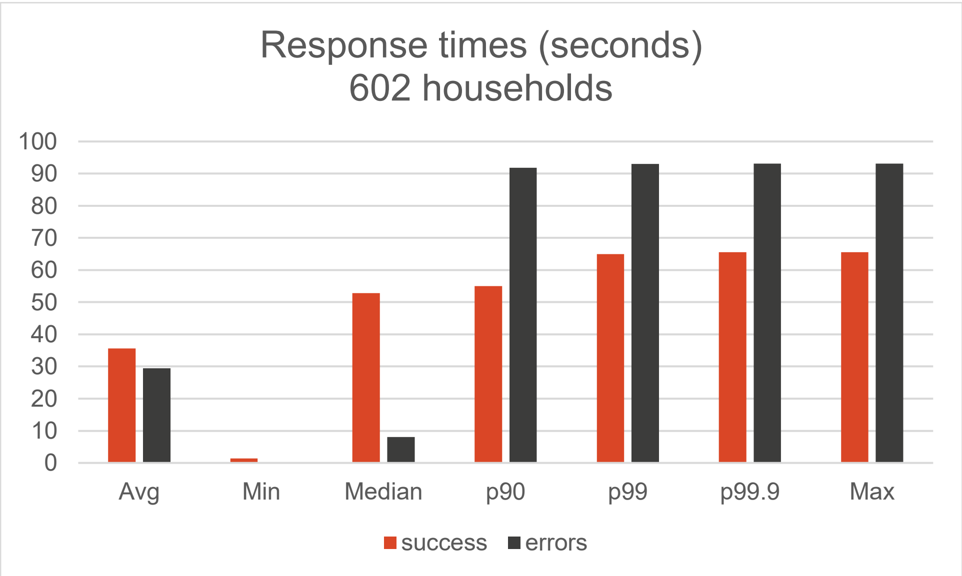

Figure 2 - Response times in test with 602 households

Another important aspect of the control characteristics is the number of successful HEMS responses during activation. For tests including more than 50% of the portfolio, the success rate was consistently between 70 – 80% of the activated portfolio. Individual HEMSs were much more error prone than others, ostensibly due to connectivity or configuration issues, which skewered the results from tests on smaller parts of the portfolio.

The success rates during autonomous operation were higher than those seen during synthetic load tests. During the period of autonomous operation, the aggregators performed more than 100.000 control actions through the FIP, with a success rate of 90%. These control actions led to almost 300.000 interactions with the HEMSs, which had a success rate of 67%. The reason for the greater success rate of FIP control actions was that many HEMS interactions would succeed when retried.

The success rate for activations has much greater impact on the aggregators ability to utilize the flexibility of its portfolio than the response times. With success rates of about 90%, the aggregators will have to account for this in extra uncertainty when calculating the flexibility of their portfolio. As some HEMSs failed much more than others, aggregators may want to exclude such HEMSs from their portfolio.

1.3 Conclusion

The FIP was able to perform activations within acceptable time frames and with success rates higher than those of the downstream HEMS systems. That said, while it is possible to provide a centralized interoperability platform to include non-compatible DERs in aggregator portfolios, the act of doing so carries the risk of introducing new failure scenarios. This means a DER may be fully functioning, but the aggregator is unable to control it due to issues within the interoperability platform. Principles such as isolation and fault tolerance lowers this risk, but do not remove it. Especially reliance on shared, external systems must be treated with care, to avoid that these become single-point of failures. Ultimately, scalability concerns can be only addressed by building it as a distributed systems, but building distributed systems which act as a single entity is not easily done.

2 Customers Can Freely Choose Their Aggregator

2.1 Introduction

Executive summary

The evaluation "Customers Can Freely Choose Their Aggregator" shows that interoperability made it possible for customers to make a free choice of aggregator regardless of their households heating equipment type. It was further demonstrated that it is possible to nudge customers toward choosing products which increase the flexibility available to aggregators, and that customers were mostly interested in products focused on economic savings.

In heating season 3, partners in EcoGrid 2.0 provided a web portal to test out different ideas for aggregator products to customers. Three different products were available: Basis, Economy and Environment. Both aggregators offered the Basis product, while the Economy product was offered by Insero and the Environment product was offered by IBM.

Similar products were also available during heating season 2, but in HS2, the customers could only choose between products offered by one of the two aggregators. In HS3, customers were able to choose their product freely between both aggregators. In order to avoid company bias in their selection, customers were never informed which aggregator offered which products.

Prior to HS3, customers were assigned to an aggregator based on their home energy management system (HEMS) type. EcoGrid 2.0 used two different types of HEMS – Greenwave and Siemens – which were not interoperable. As such, aggregators only supported one type of HEMS. In order to enable customers to choose their aggregator freely, it was required to establish interoperability among the HEMSs. This was done through the Flexibility Interoperability Platform, as described in D4.5.2 and D5.4.

In the beginning of the heating season, the customers were assigned to the new products. This assignment was made based on their choice in HS2, as well as their type of HEMS. This ensured that both aggregators had a mixed portfolio of households with both Greenwave and Siemens heating control equipment, and was the basis for demonstrating interoperability between aggregators and equipment types, as described in the evaluation of the Flexibility Interoperability Platform.

In order to demonstrate handoff of customers between aggregators, customers were able to change their product selection at any time during HS3. In the **Aggregator handover** demonstration, customers were nudged towards making a choice that would result in such a handoff.

2.2 Demonstrations

Aggregator handover

The initial distribution of customers among aggregators in HS3 are shown in Table 1. As shown, most customers started with the Basis product. The Basis product was described as a safe choice, as the aggregator would only perform the minimal control necessary to provide flexibility. The Economy and Environmental products would see more control by aggregators, as these would attempt to optimize consumption patterns for economic or environmental benefits respectively. Thus, these products could be seen as more risky, but would provide more flexibility to the aggregator. The products are described in detail in D6.1.5.

Product	**Customers**
Basis (Insero)	204
Basis (IBM)	357
Economy (Insero)	148
Environment (IBM)	38

Table 1 –Distribution of customers (households) among aggregator products at the beginning of HS3 (2018-10-01).

Two times during HS3, customers with the Basis product were nudged towards choosing either the Economy and Environment product. Those who were represented by the IBM aggregator were nudged towards the Economy product (Insero), while those who were represented by the Insero aggregator were nudged towards the Environment product.

Nudging was done by way of product recommendations in emails from the EcoGrid 2.0 project to customers. To change their product, customers had to go browse to the web portal, log in and enter their choice. The number of customers who made this change is listed in Table 1.

Product change	**Number of customers**
Basis (Insero) => Environment (IBM)	27
Basis (IBM) => Economy (Insero)	50

Table 2 - Number of aggregator handovers based on product changes.

2.3 Conclusion

A precondition for allowing customers to freely choose their aggregator, no matter their HEMS type, is the establishment of interoperability among HEMSs. Once this is achieved, customers can be presented with a choice between the available aggregator products. With the appropriate aggregator handover procedures in place, it is then possible for customers to freely choose their own aggregator.

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