EFFICIENT INFRASTRUCTURE FOR AGGREGATION AND MARKETING OF DISTRIBUTED SMALL-SCALE ENERGY RESOURCES

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ABSTRACT

Within the German E-Energy initiative the project E-DeMa is funded by the Federal Ministry of Economics and Technology (reference number 01ME08013A). In a consortium (with RWE, Miele, Prosyst and the universities Bochum, Dortmund and Duisburg-Essen) Stadtwerke Krefeld (SWK) and Siemens gained experiences during the trial run in 2012 reflected in this article. In the E-DeMa project CHP (combined heat and power) sites and home appliances are controlled by an aggregator power control system. Thus communication must be based on standard protocols and has to be vendor independent to support seamless installation and maintenance. The volume and rate of data will increase dramatically as information will increasingly be exchanged between the market place and all participating decentralized power producers, prosumers, aggregators and related control systems. Different approaches to handle these challenges are discussed. The paper reports on the experience gained in the E-DeMa project particularly considering the interfaces of the aggregator system. Based on this, recommendations for necessary standardization are highlighted - covering these interfaces as well as overall system architecture in order to be well prepared for large scale and long-term implementations far beyond the scope of a research project.

INTRODUCTION

This article reflects knowledge and experiences gained during the German research project „E-DeMa“, subsidized by the Federal Ministry of Economics and Technology in the frame of the „E-Energy“ program. In the E-DeMa project CHP (combined heat and power) sites and home appliances are controlled by an aggregator power control system. This system also communicates with a B2B system implemented and integrated within the E-DeMa market platform.

The different systems, i.e. for DSO (Distribution System Operator) grid control, aggregator control, meter data management, grid operational planning and trading interact smartly with each other to provide an energy marketplace enabling automated transactions between power producers and prosumers.

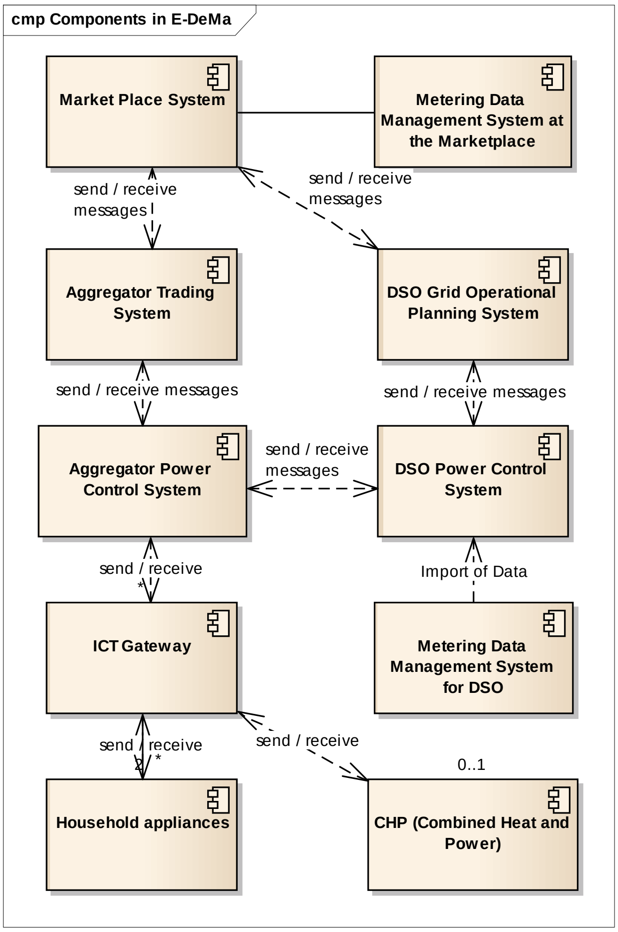

Figure 1: Components in E-DeMa

In future two aspects become very important for the power control architecture:

- The communication between control centers and distributed energy resources has to be standardized to keep the software affordable and maintainable. The same is true for linking the diverse software systems.
- The volume and rate of data will increase dramatically. This has to be handled by the software architecture of the future system landscape while at the same time still dealing with legacy installations.

COMMUNICATION WITH DISTRIBUTED ENERGY RESOURCES

Communication with household appliances

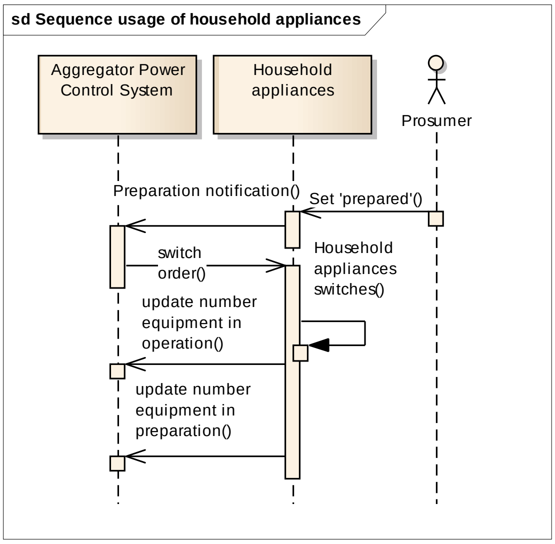

Figure 2: Sequence usage household appliances

The communication between the aggregator control center and the households in case of switching of an appliance via the ICT gateway worked according to the following schema:

- The owner of a household appliance sets it into the state ‘prepared for usage by the aggregator’.
- The aggregator receives a notification of this event.
- Then the aggregator can send the switching command.
- The appliance responds with an acknowledgement sent to the ICT gateway.
- This device communicates the number of already switched household appliances and of the ones, which are prepared for further usage by the aggregator

Communication with CHP sites

The CHP sites were handled in different modes: schedule prognosis mode, availability forecast mode and request without acknowledgement mode.

The schedule prognosis mode worked according to the following schema:

- With sufficient lead time the aggregator system triggers the CHP to provide a prognosis schedule for the behavior of the CHP upon a given aggregator request (direction ‘up’ or ‘down’, time ‘from’ and time ‘to’)
- The CHP responds by sending a schedule.
- The aggregator system performs planning with this CHP data and confirms the schedule (or only a part of it).
- The CHP follows this confirmed schedule.

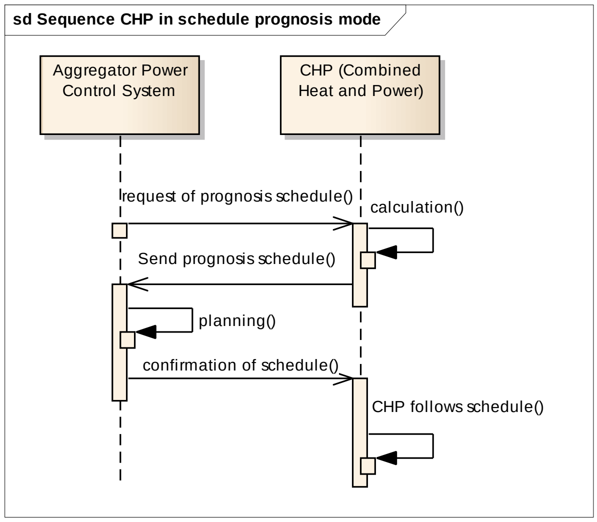

Figure 3: Sequence CHP in schedule prognosis mode

The availability forecast mode worked according to the following schema:

- With sufficient lead time the aggregator system triggers the CHP to provide an availability forecast for the behavior of the CHP upon a given aggregator request (direction ‘up’ or ‘down’, time ‘from’ and time ‘to’)
- The CHP responds with either ‘ready’, ’later within required time interval’ or ‘not ready’.
- The aggregator system performs planning with this CHP data and confirms a potential usage in the next interval,

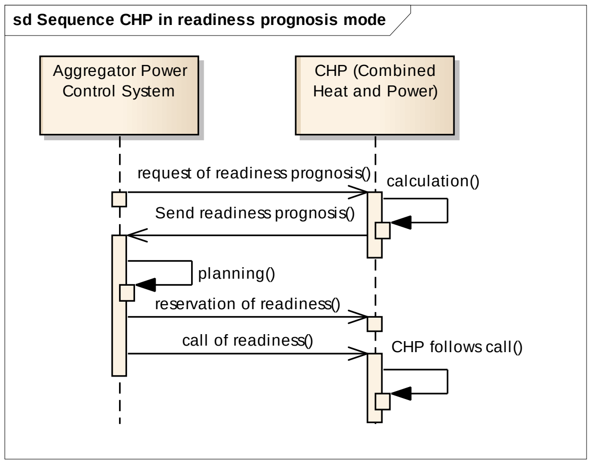

Figure 4: CHP in availability forecast mode

The request without acknowledgement mode worked according to the following schema:

- With sufficient lead time the aggregator system triggers the CHP to follow a given request (direction ‘up’ or ‘down’, time ‘from’ and time ‘to’)

- No handshaking is required. The aggregator system monitors the measurements of the CHP's active power and global overall heat index.

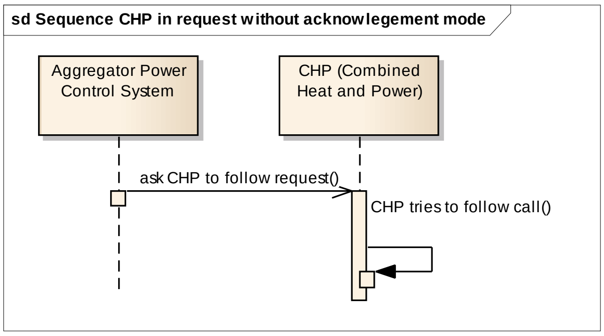

Figure 5: CHP in request w/o acknowledgement mode

Future communication with distributed energy resources

In the E-DeMa project dishwashers, washing machines and tumble dryers from one single vendor were used, also only one type of CHP was deployed. So there was no real need to consider a variety of manufacturers, different kind of equipment from one vendor or different firmware versions.

This will be completely different in the future. In such instance, standardization of communication based on IEC61850 (and BacNet for appliances) becomes an absolute necessity to support seamless installation and maintenance. Both vendors of decentralized energy resources and of control center systems need to apply the standardized interface.

Such a protocol has to define based on IEC 61850:

- Messages between control center system and each type of decentralized energy resources.
- Order of these messages within a communication session.
- Maximum response times.

In the E-DeMa project the aggregator control system provided pre-billing information for further processing on the market platform.

The following picture indicates the related data exchange. It becomes evident that different (legacy) systems from various vendors have to interact.

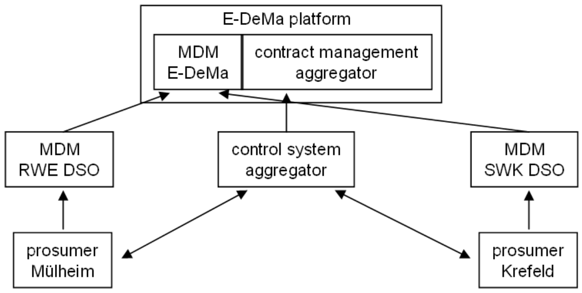

Figure 6: E-DeMa system landscape reflecting data flow for aggregator – prosumer pre-billing

For further processing like billing an architecture based on e.g. SOA messages is required for the integration and communication between the diverse IT systems involved.

POWER CONTROL SYSTEM ARCHITECTURE

The volume and rate of data will grow dramatically as dynamic information will increasingly be exchanged between the market place and all participating decentralized power producers, prosumers, aggregators and related control systems. There are different possibilities to handle this challenge beside the 'classical' faster hardware/multithreading approach:

- Multiple power control systems will share workload and interchange a minimum set of data.
- More and distributed intelligence is needed. Some tasks of control center systems are moved to peripheral devices.

Case 'More power control systems manage significantly higher data volume'

This can be further divided into two sub cases.

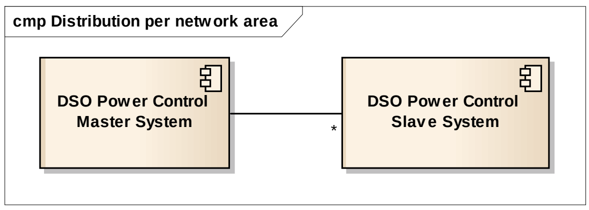

Figure 7: Distribution per network area

The first one is the distribution of the amount of data per network area. One control center is master and the other control centers - each of them handling one area - are subordinated.

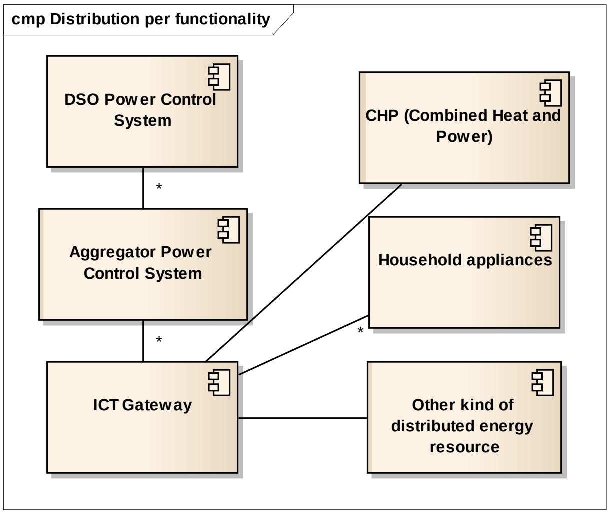

Figure 8: Distribution per functionality

The second approach is the distribution of the amount of data via functionality. The main control center of the DSO operates the grid as such with some information just handled as summaries, e. g. aggregated loads while the single consumers are modelled in another control system. Opposite to the DSO control center this aggregator control centers have no information about the topology. Their 'only' task is to distribute requests concerning the aggregated loads to the real single consumers (the same is valid for the generators).

Case 'Tasks are moved out to the periphery'

Distributed intelligence requires more local instrumentation and control functionalities making peripheral infrastructure more expensive. For example distributed data storage for process variables and configuration information also has to support online data model modifications, upgrade / update of software as well as replacement of hardware. Especially the latter can cause problems when establishing the communication connection to the new equipment for the first time.

Another example is the start-up coordination with the control center system. The most complicated case would be the simultaneous restart of ICT gateway and CHP software after a blackout. The availability monitoring of the distributed intelligent devices by the control center system has to be taken into consideration too.

DSO PERSPECTIVE

Based on the experience gained by SWK Netze GmbH in 2012 in their project trial area the following processes have to be supported to benefit from the additional data available thanks to the ICT coverage described above - irrespective of the future control system architecture of choice:

- Triggering condition based maintenance utilizing measurements to detect equipment loading, transformer losses, temperature trends etc.
- fault prevention by limit violation monitoring
- detailed information of network group loading for planned switching or integration of distributed generation like CHP sites
- tap changer triggering
- fault location and isolation based on earth fault indication
- mapping of GIS data for planning purposes – dimensioning or reduction of line and transformer capacity
- real-time load flow analysis for critical supply or grid congestion situations (e. g. big public events) or studying of particular day type profiles
- simulation of grid expansion and decommissioning based on historical measurements

CONCLUSION

In the E-DeMa project distributed energy resources are controlled very well by the aggregator control system with the currently available software structures. For the control systems of the future we have two big issues to resolve within the next few years.

The first one is the necessity of standardization of the communication between control centers and the peripheral devices. Without such approach for the interface there will be no affordable and maintainable software – neither on the side of control center system vendors nor for manufacturers of distributed energy resource. Also standardized processes will be needed amongst the different kinds of IT systems to allow seamless workflows e. g. for billing.

The second issue is the enormous impact of the dramatically increasing volume and rate of data. The existence of an aggregator control center is the first reflection to this issue. The assignment of the tasks to the different parts of a future control system architecture will play a key role in the next years.

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