Digital intelligent and scalable control for renewables in heating networks

Deliverable D3.3

Report on the Model Predictive Control algorithm hardware implementation, validation and debugging procedure

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Executive summary

The deliverable D3.3 focuses on the technical implementation of the model predictive control (MPC) algorithm, with reference to the hardware installation, validation, and debugging procedure. Indeed, hardware installation and configuration was carried out by Siram with the help of the local system integrator, which is responsible for any modification on the BMS side. Then, after all the hardware has been installed, the communication software was configured and real-time communication between the MPC and BMS was validated. Finally, Siram and the University of Parma configured the MPC and defined a debugging procedure in order to adjust and correct MPC parameters during operations. This has been done by analyzing the output of the MPC and, concurrently, the energy consumptions data of the plant.

1. Introduction

This report is the Deliverable D3.3 of Work Package WP3 of the DISTRHEAT project, led by Siram Veolia. The work package "WP3 - Prototyping and demonstration for small DHC" aims to implement and demonstrate the novel control algorithm developed in WP2 in a real test site.

2. Hardware Implementation

The hardware implementation has the primary objective of setting up the real-time communication between the BMS and the MPC, which must run in parallel with the standard control logics of the energy plant of the Hospital Cona. In this respect, it has been chosen to run the MPC separately from the BMS, in order to guarantee continuity of service by keeping physical disaggregation between the two systems. Moreover, in order to be able to access the MPC from remote locations (e.g. for maintenance and supervision purposes), a connection to the Siram network was implemented through private APN and double network cards to keep the networks separated.

As far as local data transfer is concerned, a standard industrial protocol has been selected in order to allow real-time data to be shared between BMS and MPC. Considering the technical specifications of the BMS software installed and the amount of data necessary to set up the exchange interface, the Modbus TCP protocol has been chosen. In detail, the BMS is configured as a Modbus TCP server, sharing variables with read and write access to external clients. The only client in the network with authorized access is the MPC, which runs on a PC in the same LAN of the BMS. For completion, the diagram of the whole IT architecture is reported as Figure 1.

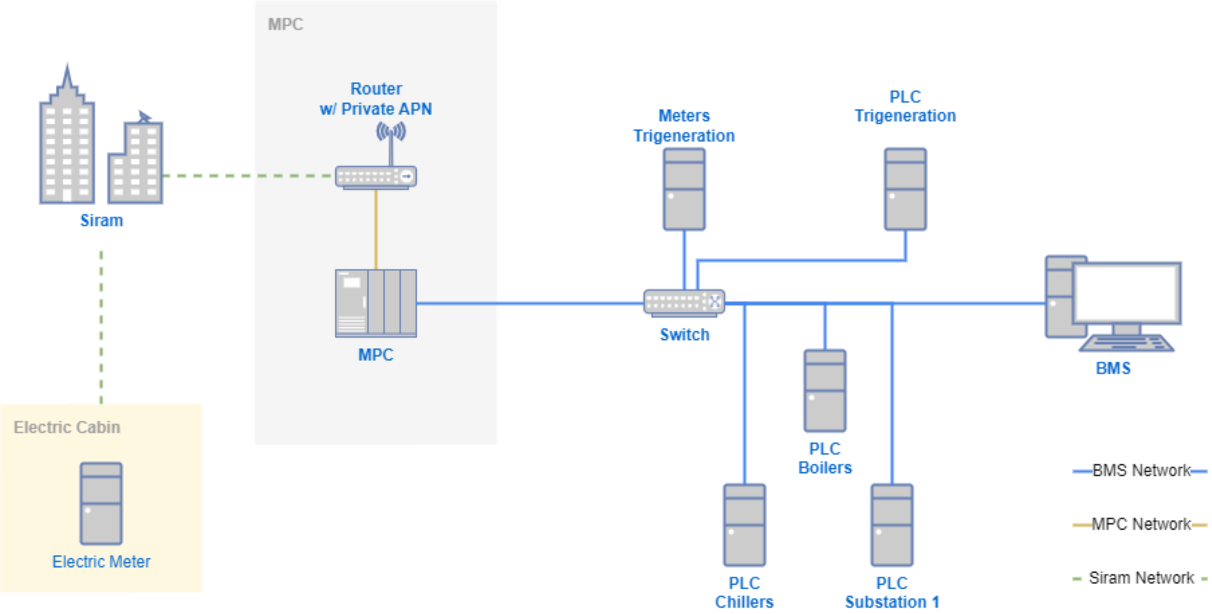

Figure 1. A graphical representation of the IT network.

3. Validation and debugging procedure

The hardware implementation of the MPC and the set up of the communication has been carried out with the help of the local system integrator, responsible for the implementation of the Modbus TCP server. On the other hand, Siram has installed the PC with the client software for real-time data exchange and optimization.

Eventually, the validation of the architecture and data exchange has been verified during the commissioning phase by Siram and the system integrator. In this phase, data exchange between BMS and MPC was verified to ensure that all the variables were correctly configured, and writing access was guaranteed for the setpoints identified. In particular, to maintain a high level of safety thus guaranteeing service continuity, the writing procedure was firstly tested offline (i.e. with the equipment locally disconnected from the BMS control), and then online with real-time control on the equipment. The positive results in these final tests concluded the validation procedure.

Then, in collaboration with the University of Parma, the MPC controller was set up in order to carry out the real-time optimization based on the data exchanged with the BMS. After the first implementation, a debugging procedure was implemented in order to monitor the system and occasionally tune some parameters related to the physical models adopted during the optimization process. This has been implemented through the analysis of the data produced by the MPC, which one the one hand has been logged to local files and, on the other hand, it has been sent to a centralized database of Siram for data analysis. The main issues encountered are reported below in Table 1.

Issue	**Causes**	**Action**
Absence of data in the remote database	Issues with the remote database	Contact IT Support
	Gateway offline	Contact the local plant operators to check connection and reset the gateway
	PC offline	Contact the local plant operators to check the PC status and reset it
	No modbus communication	Contact the local plant operators to check the ethernet cables. Eventually reset the PC remotely.
No optimization results produced	Error in the data exchange	Correction on the data exchange format
	MPC scheduler is stopped	Identification of the bug in the MPC code and restart of the scheduler
Optimization results not correct	MPC algorithm not correctly tunted	Analysis of the results and identification of the incorrect parameter to be changed

Table 1. Most frequent operating issues with the MPC controller.

4. Conclusions

Overall, by monitoring the MPC output and, concurrently, the real-time setpoints and energy consumptions of the plant, it has been possible to monitor, adjust and correct the MPC parameters during the operational phase of the DISTRHEAT project.