Lucerne University of
Applied Sciences and Arts

HOCHSCHULE
LUZERN

Technik & Architektur
FH Zentralschweiz

MSE | MASTER OF SCIENCE IN ENGINEERING

Master-Thesis Engineering, Information and Communication Technologies

Federated Learning for Load Curve Prediction

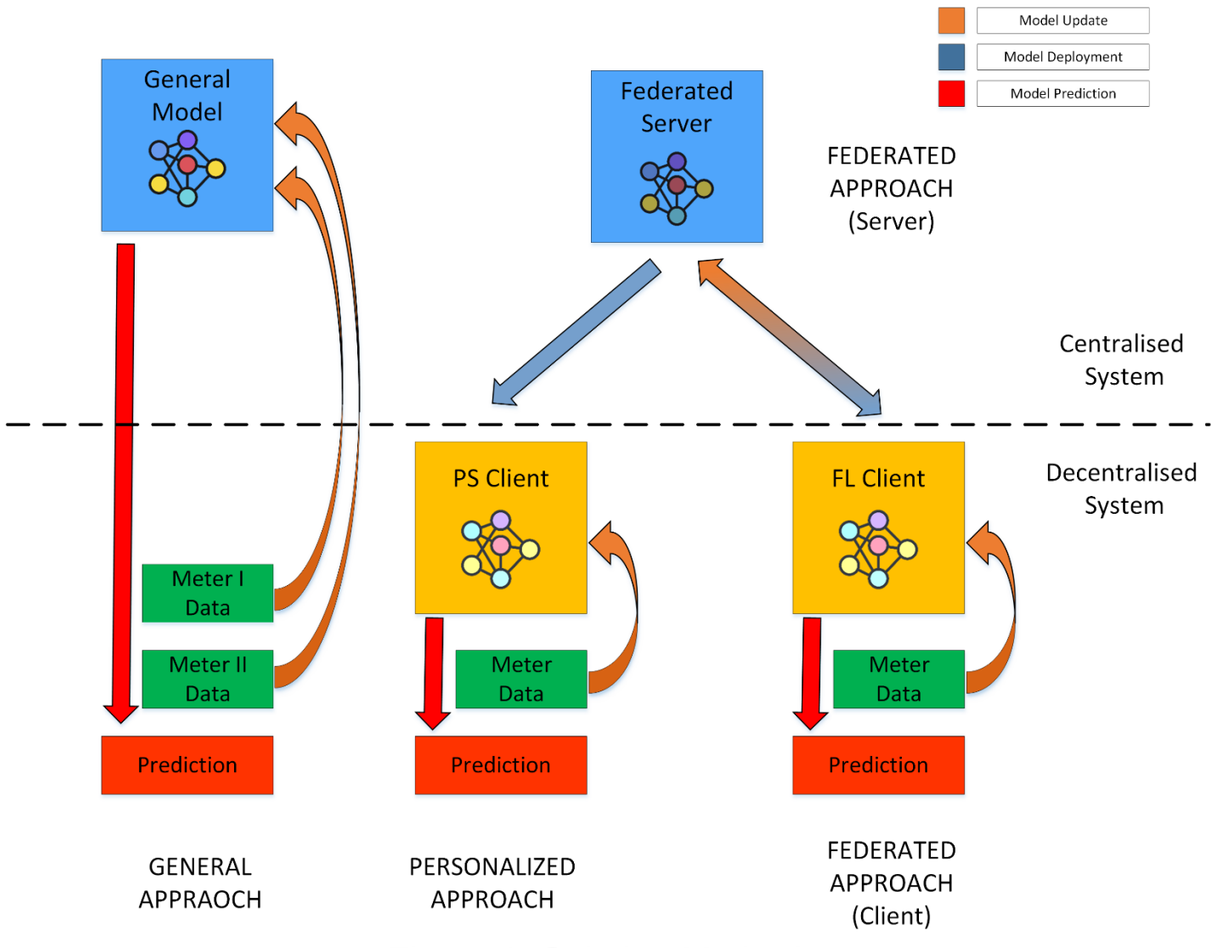

Figure 1: Solution Methods

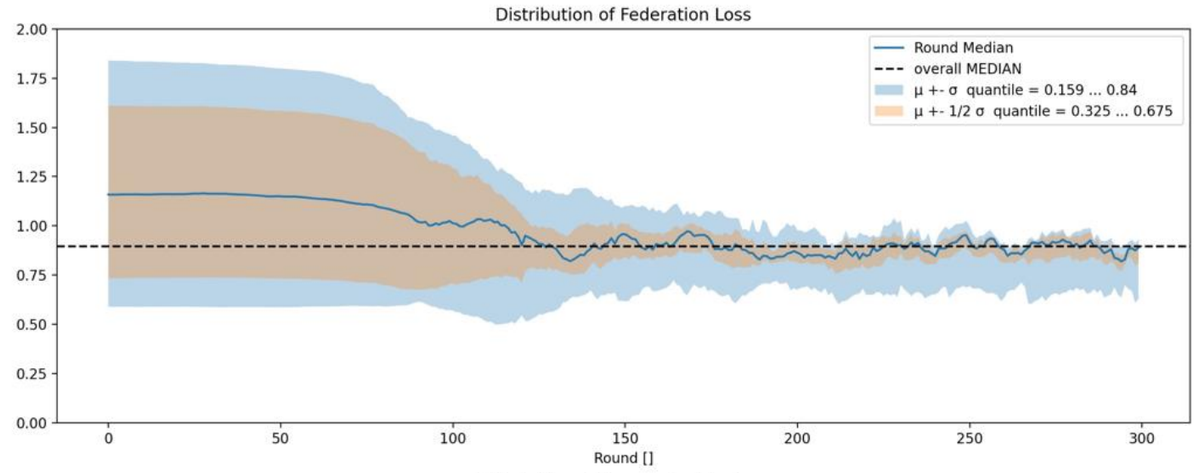

Figure 2: Convergence of Personalized and Federated Client

Loss Diff [x - y]	FL Client	PS Client	General	FL Server
FL Client	0	0.0217	-0.1167	-0.0200
PS	-0.0217	0	-0.1667	-0.0633
General	0.1167	0.1667	0	-0.0406
FL Server	0.0200	0.0633	0.0406	0
Sum of Differences	0.1150	0.2517	-0.2427	-0.1240
Rank	**2**	**1**	**3**	**4**
Hypothesis	3*	1	2*	4

Figure 3: Summary of Performance Comparisons

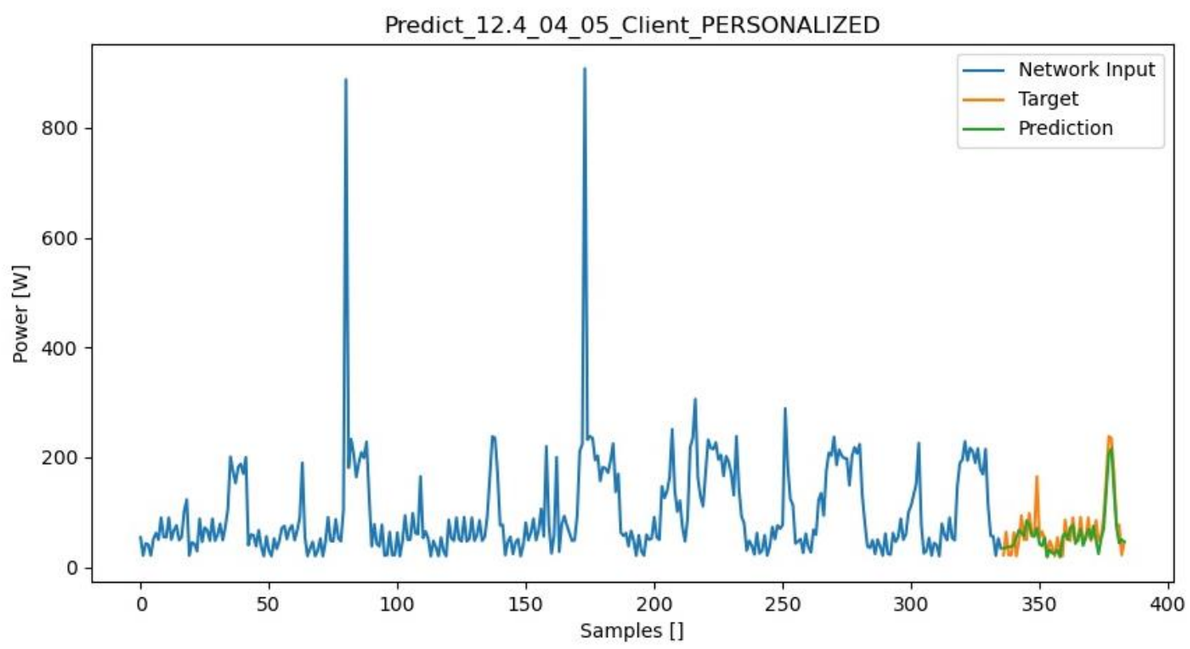

Figure 4: Prediction of Personalized Client

Problem description

Smart meters are becoming more and more wide spread among residential and industrial customers. This creates new opportunities for DSOs to use machine learning and other data science to optimize cost, performance and resilience of the electrical grid. Previous work on the VM2 revealed that it is possible to predict the load curves, using only past load curves. However, this infers the problem that the load curve prediction can not be used on new customers which have no previously known load profiles. This Problem is called the "New Customer Problem". The goal of this thesis is to analyse and compare the different solution methods for the New Customer Problem.

Solution method

Four different solution methods were analyzed. They are the General Approach, the Personalized Approach, the Federated Learning Client and Server Approach.

The General Approach describes the training of a centralized neural network with the decentralized data from the new clients. Swiss Data Privacy Laws prohibit the transmission of private user data, thus this General Approach was implemented only as a means of comparison. For the Personalized Approach a neural network is deployed onto an edge device. There it is optimized on the local data from the new customer. This allows the network to learn the structure of the previously unknown user. The last solution method, the federated learning, can be split into two approaches, the client and the server. The client also uses local optimization to train a neural network. However, the partially optimized networks of all federated clients are sent back to a centralized system, where they are averaged to build a new and improved version of the centralized network. This is the federated server model. Lastly, this new model is redeployed onto all clients. These solution methods were compared in a simulation approach. It allowed for a statistical comparison of the different solution methods.

Results

The results of the simulation showed that the Personalized Approach had both the best convergence and the best performance. It is thus the solution method of choice. This can also be seen in its good predictive qualities in figure 4.

Fabian Widmer

Advisor:
Prof Dr. Markus Thalmann

Industrial Partner:
Romande Energy