

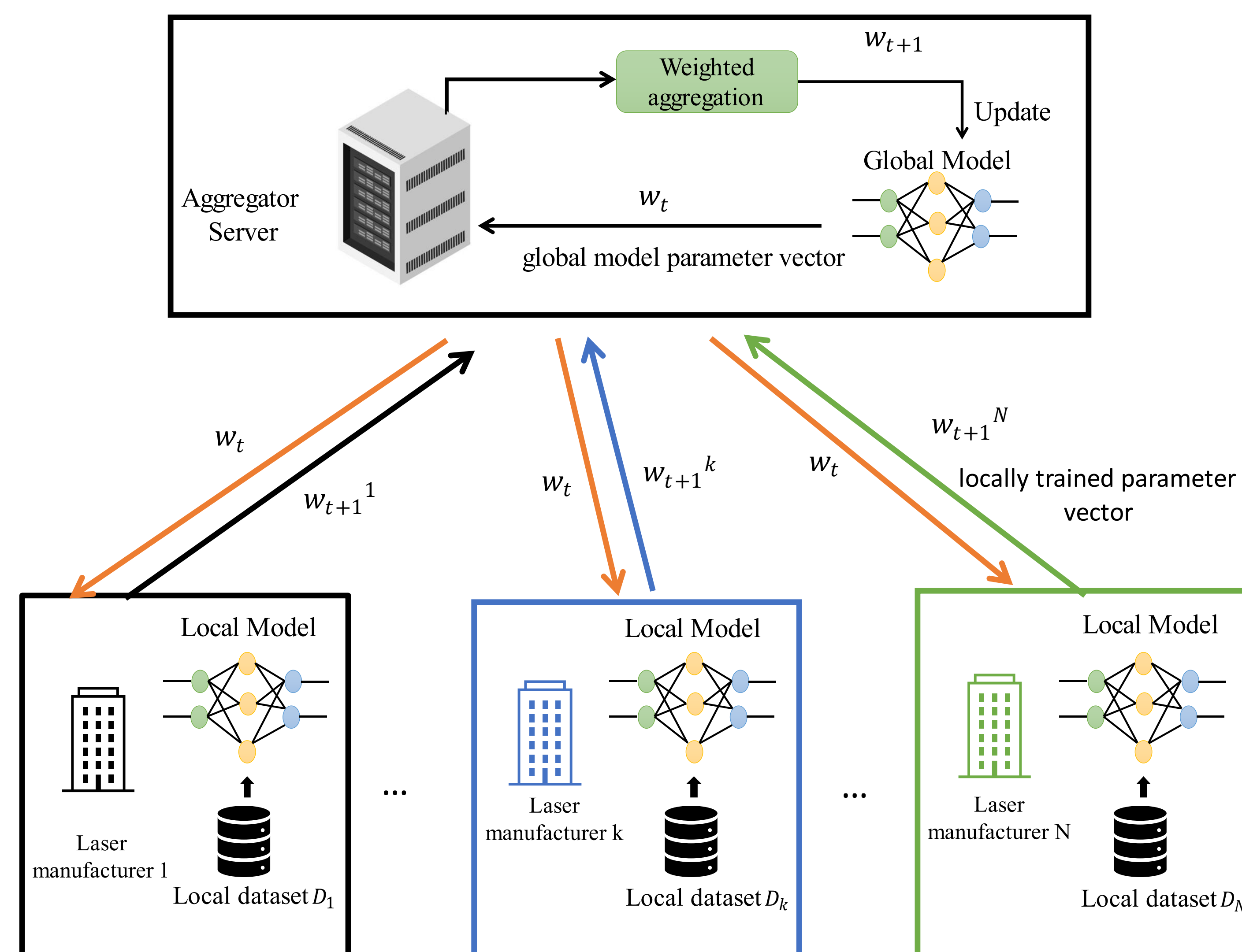
Motivation

- Inaccuracy of the conventional laser lifetime prediction approaches based on extrapolation of accelerated aging test results.
- Emergence of machine learning (ML) as a powerful tool for solving prognostic problems for semiconductor lasers:
 - Reducing maintenance costs and unexpected downtime
 - Improving operational efficiency and productivity
 - Better prediction accuracy
- Lack of sufficient data for building an accurate and reliable prognostic ML model for semiconductor laser lifetime prediction:
 - Aging tests conducted for few devices due to the high effort and costs
- Federated learning (FL) as enabler for the development of a common ML model using datasets owned by many vendors without revealing their business-confidential data

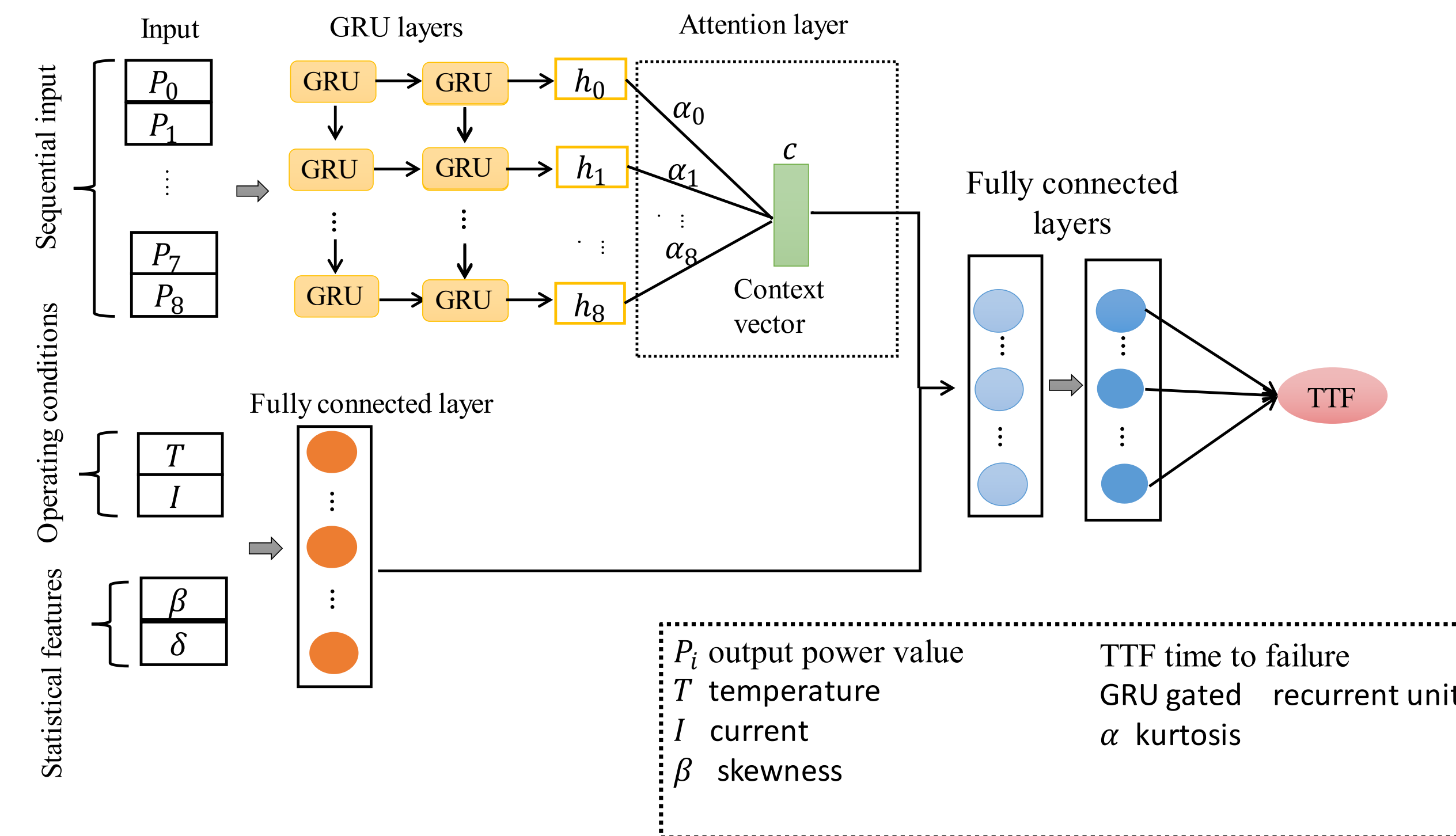
Objective

Implementing an **FL framework**, which allows many **semiconductor laser manufacturers** to collaborate in order to develop a **robust common ML model for semiconductor laser lifetime prediction** before the deployment in optical networks **without sharing local private data with others**.

Proposed Framework



Local ML Model's Architecture



Experiments

Experimental data

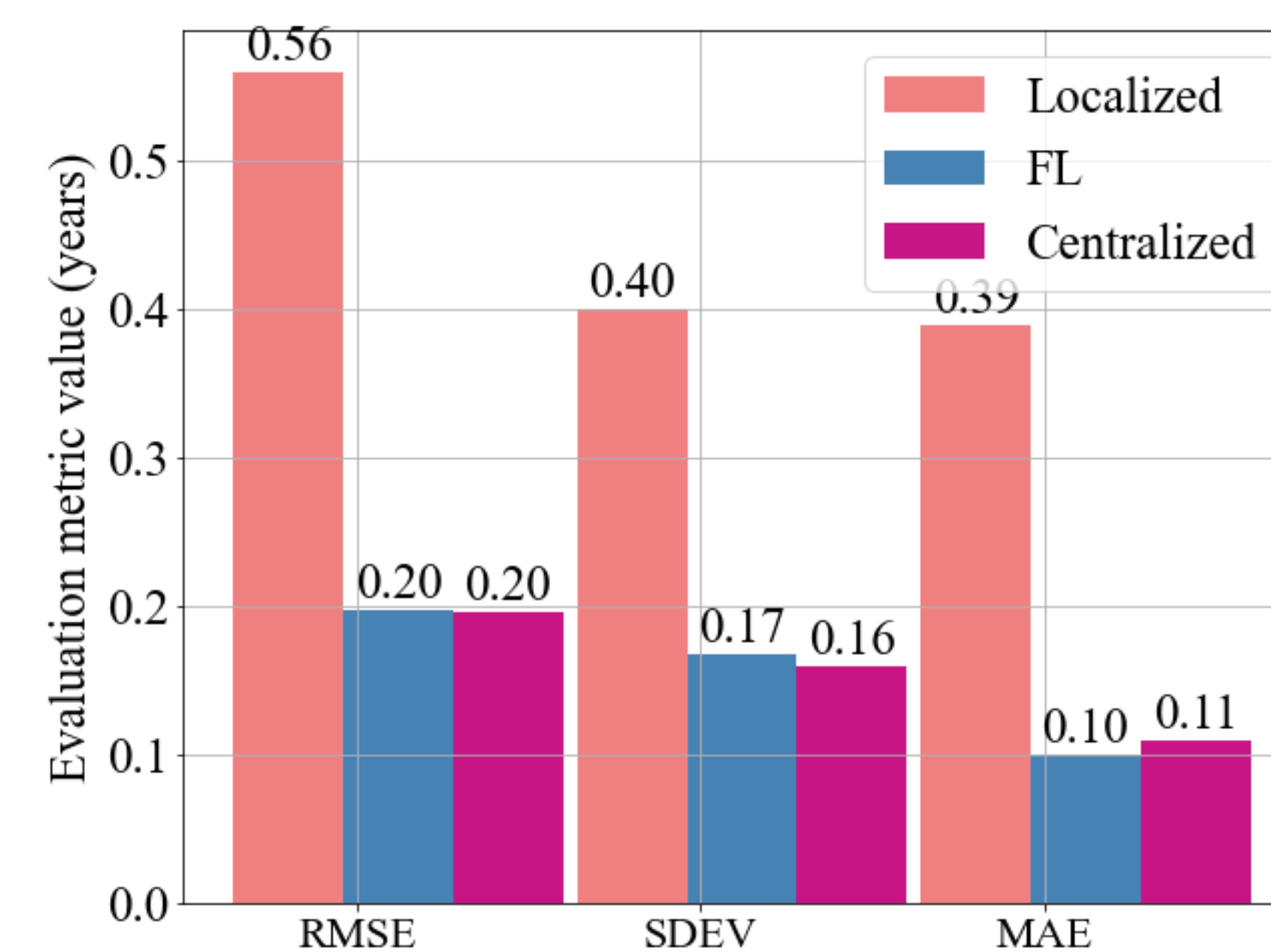
- Reliability data derived from several accelerated aging tests performed for vertical-cavity surface-emitting lasers (VCSEL)
 - Different operating conditions
 - Output power measurements monitored under constant operating current
 - TTF defined as the time at which the output power has decreased by 1 dB (20%) of its initial value.
 - 3,397 samples incorporating the sequences of monitored output power measurements combined with β , δ , T and I .

Heterogeneous federated setting: 8 vendors owning different local data with different degradation trends

Results

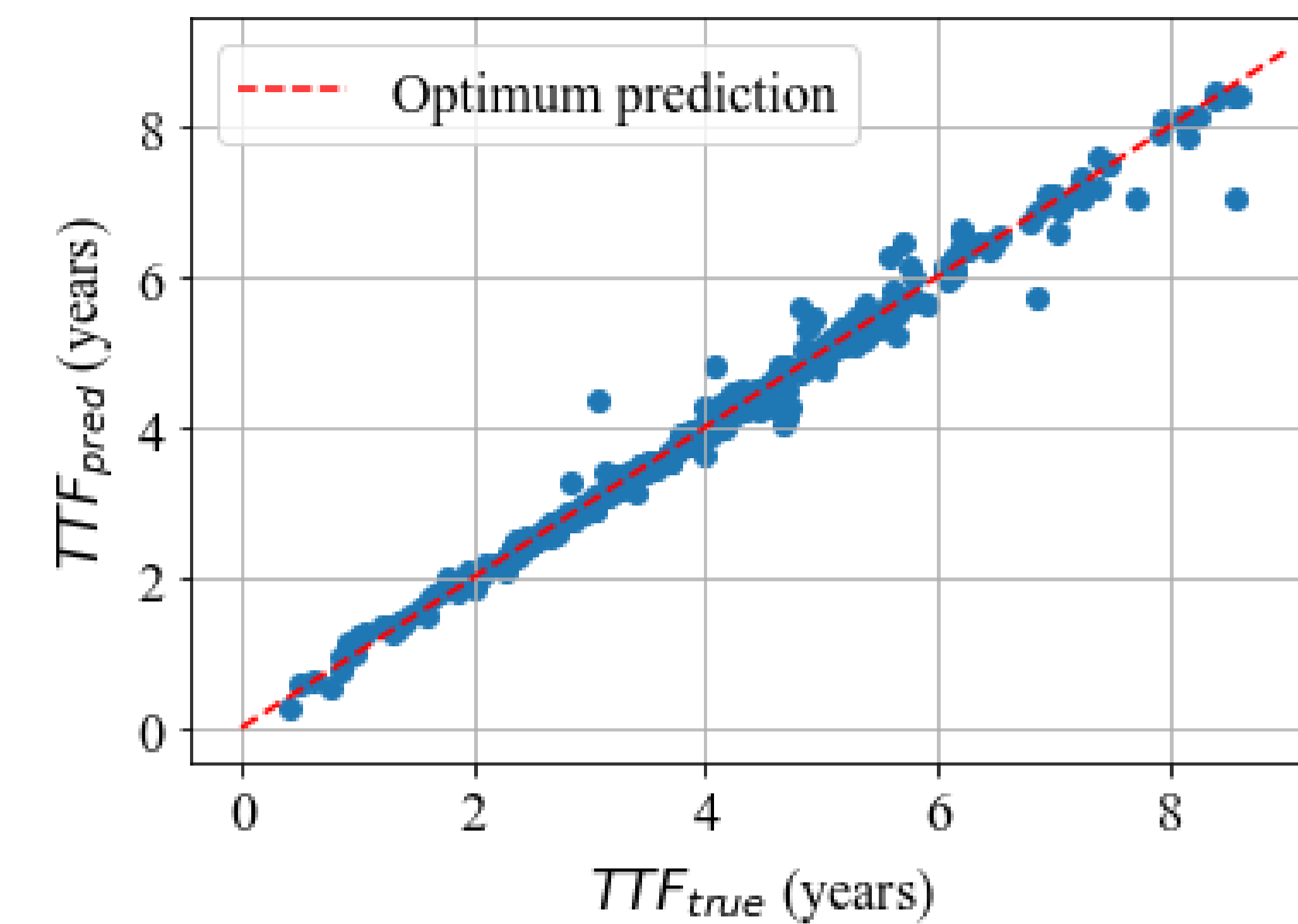
Comparison of the proposed framework with baseline approaches

Evaluation metrics: root mean square error (RMSE), standard deviation (SDEV), and mean absolute error (MAE).



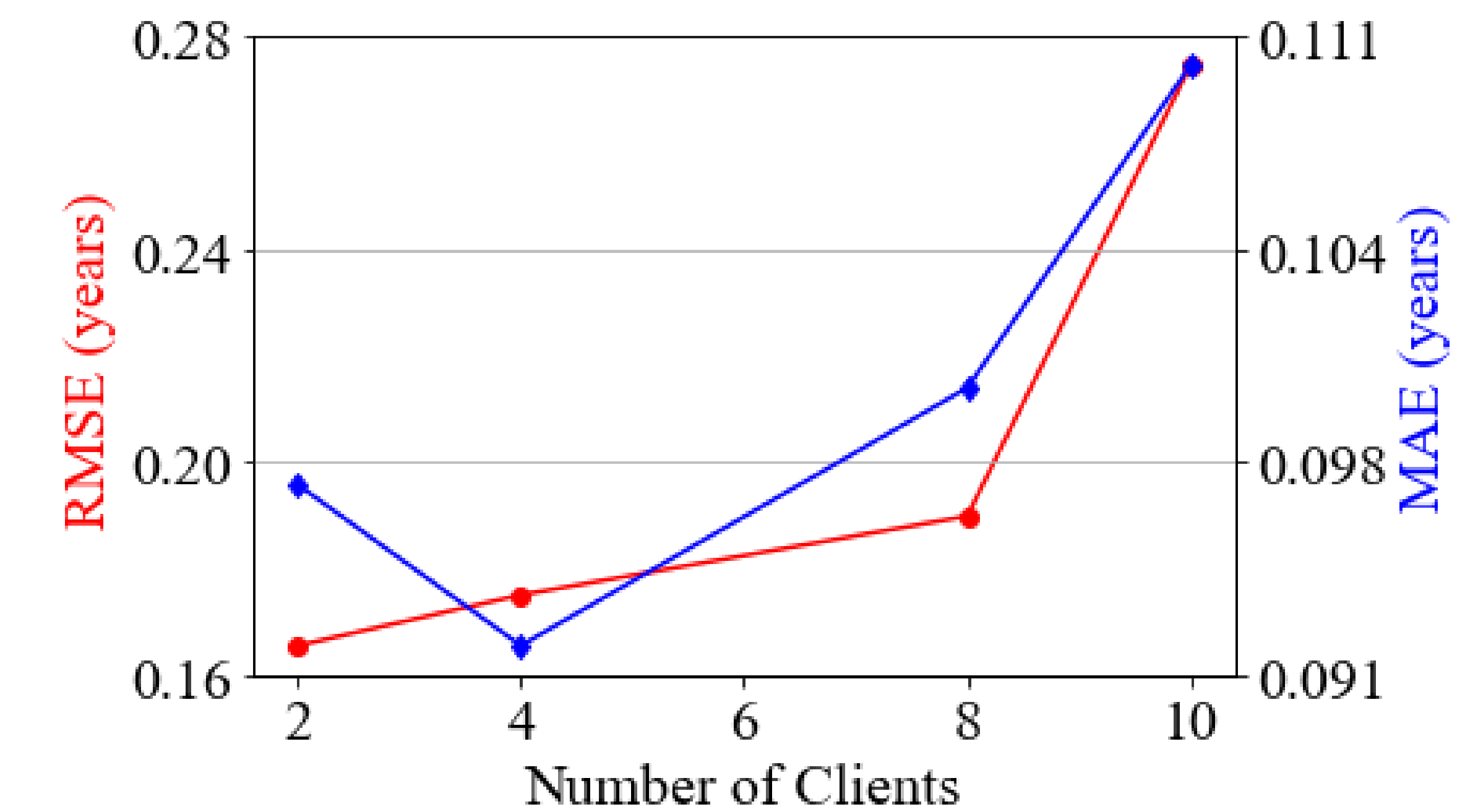
The proposed FL model outperforms the localized approach and achieves similar performance as the centralized approach while **ensuring data privacy**.

Prediction capability of the proposed approach



The proposed FL approach achieves **accurate prediction**.

Impact of the number of clients on FL model performance



An increase of the number of clients (semiconductor manufacturers) leads to a decrease of the performance of the FL model.

Conclusion and future work

- ✓ An accurate and reliable FL approach for semiconductor laser lifetime prediction has been presented, achieving a good prediction capability (a MAE of 0.1 years) while ensuring data privacy.
- Security assessment of the proposed framework will be a future research item, e.g. privacy threat analysis, and investigation of vulnerability to model poisoning attacks.