Federated Learning

Idea, Applications, and

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Terminology

Distributed Learning

Classical parallelization, advantages:

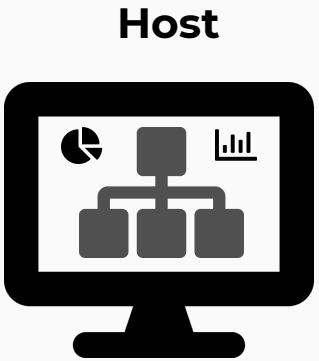
- Speed up fitting process
- Train model on much more data
- Idea behind Spark, Hadoop, ...
- Assumption that we already have a database which we want to distribute, hence data of the splits should follow the same distribution

Federated/Decentralized Learning

Federated Learning as learning on decentralized data with the following properties:

- **Non-IID** The training data on a given client is typically based on the usage of the mobile device by a particular user, and hence any particular user's local dataset will not be representative of the population distribution.
- **Unbalanced** Similarly, some users will make much heavier use of the service or app than others, leading to varying amounts of local training data.
- **Massively distributed** We expect the number of clients participating in an optimization to be much larger than the average number of examples per client.
- **Limited communication** Mobile devices are frequently offline or on slow or expensive connections.

What is it About?



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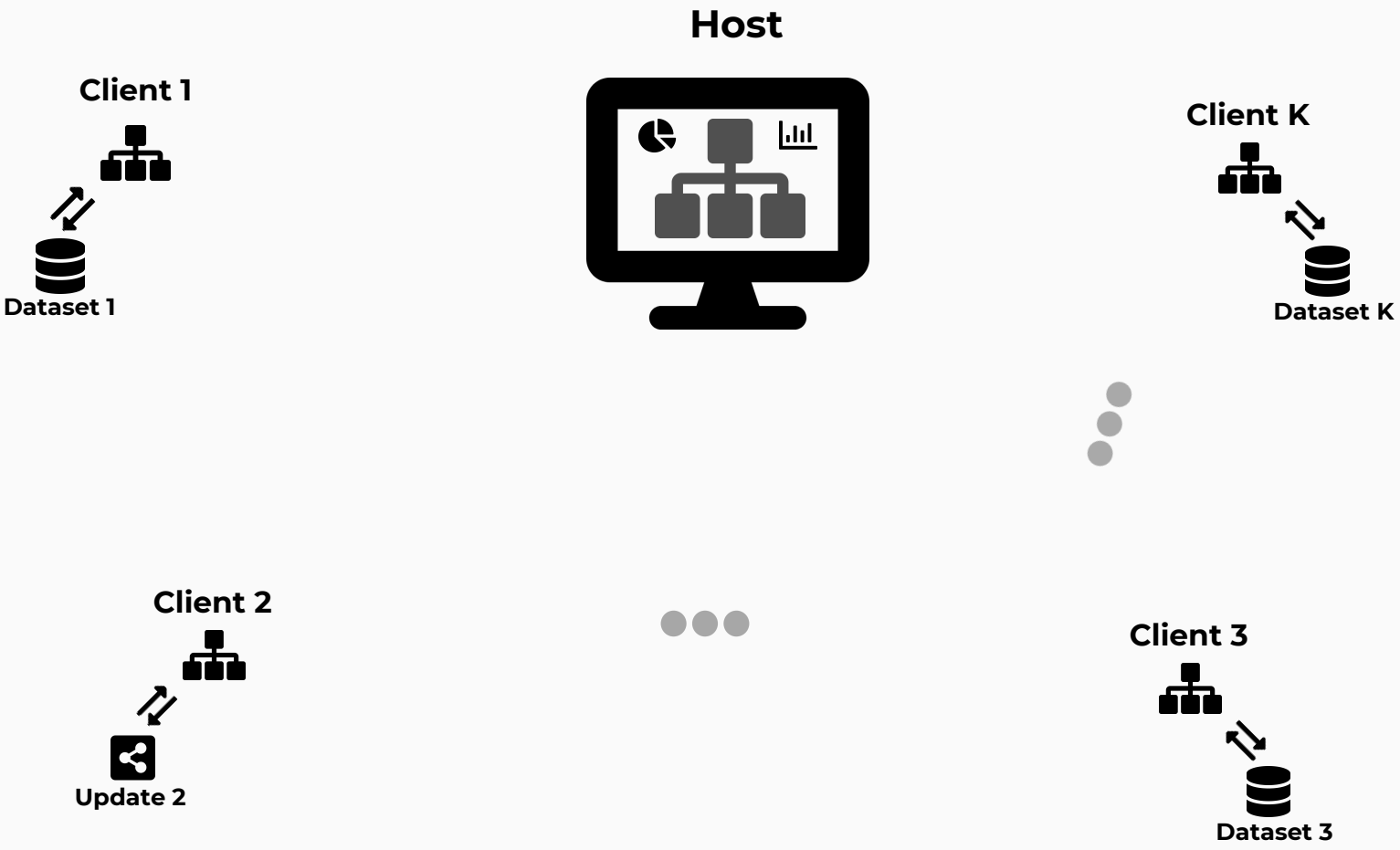

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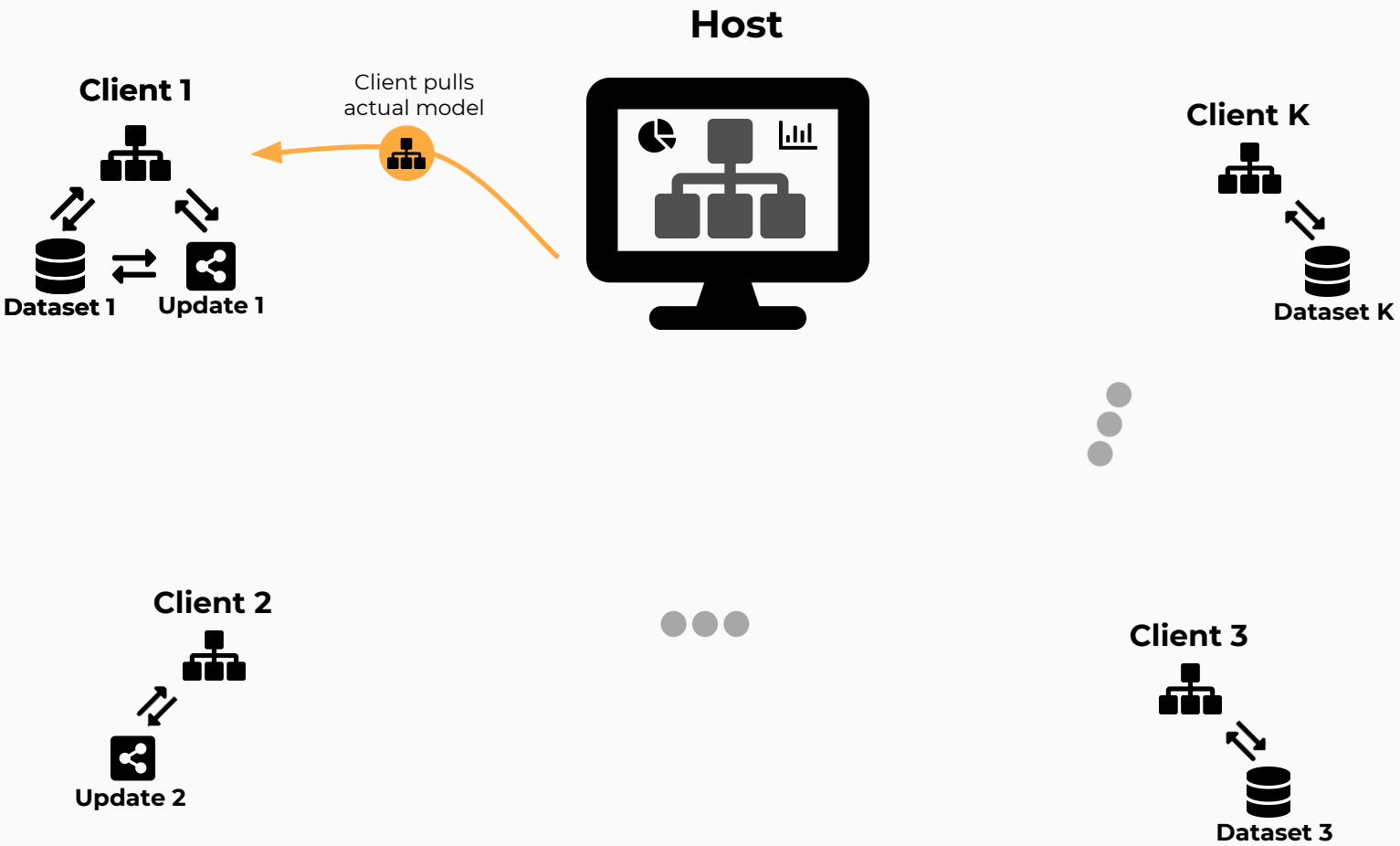

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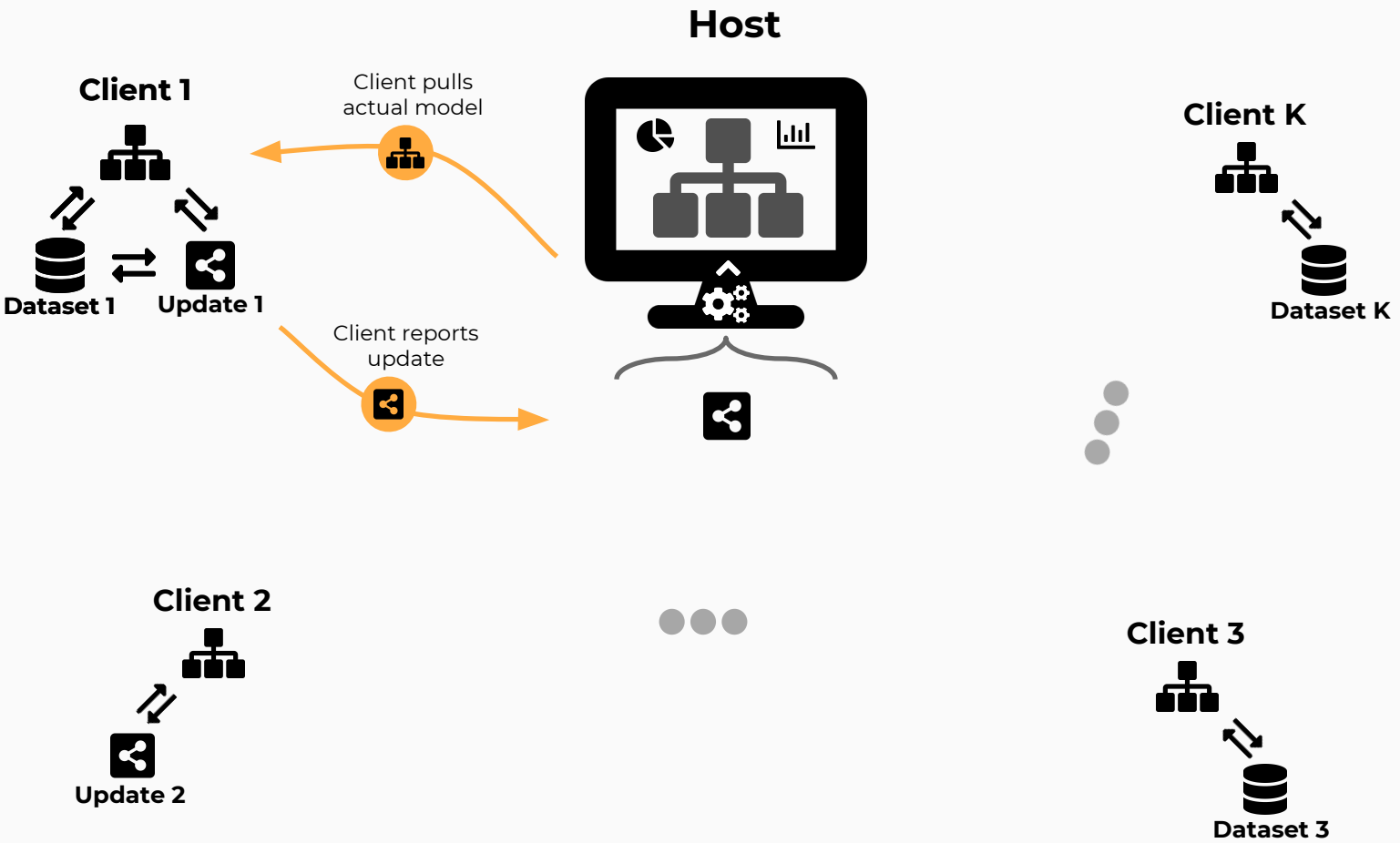

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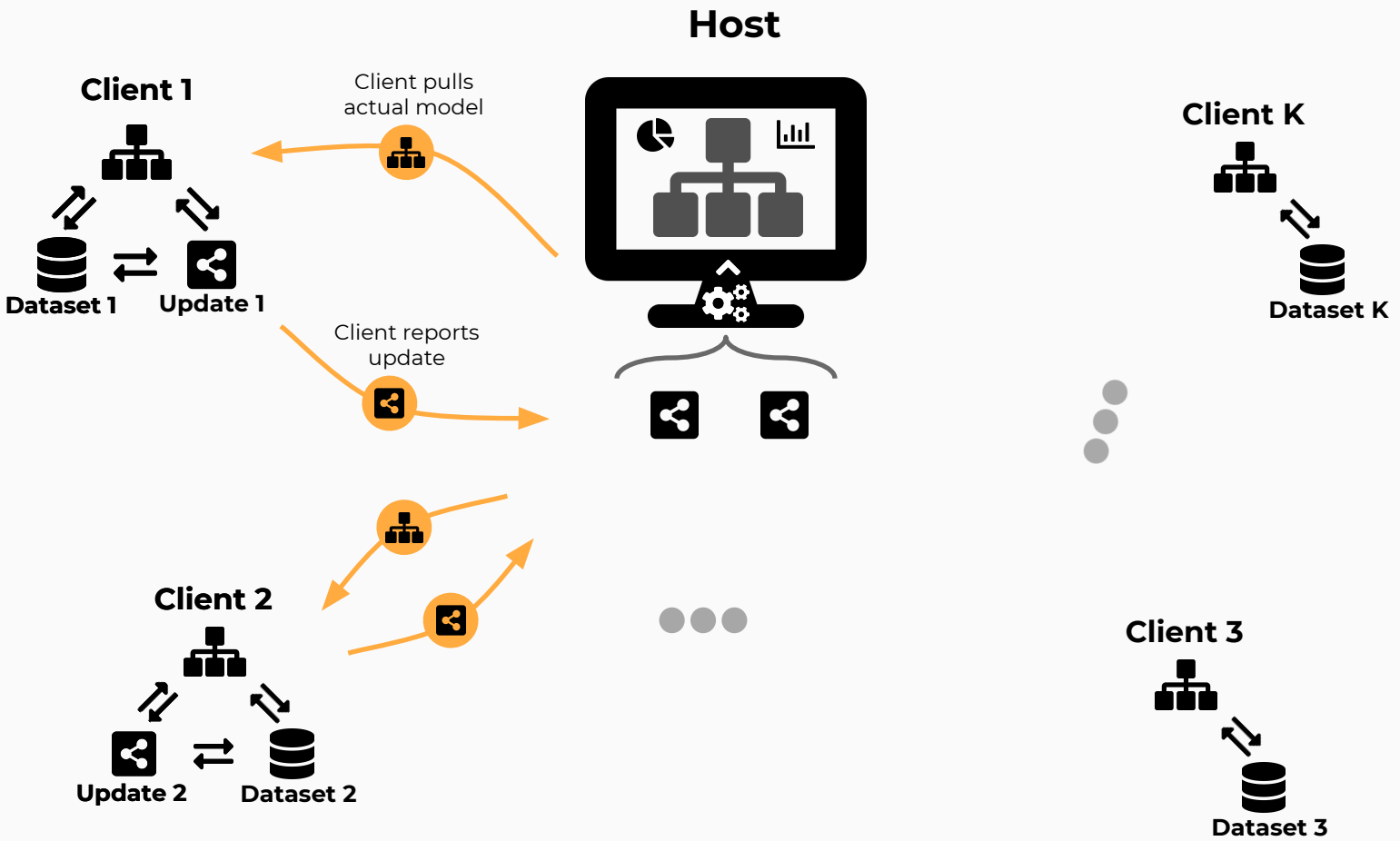

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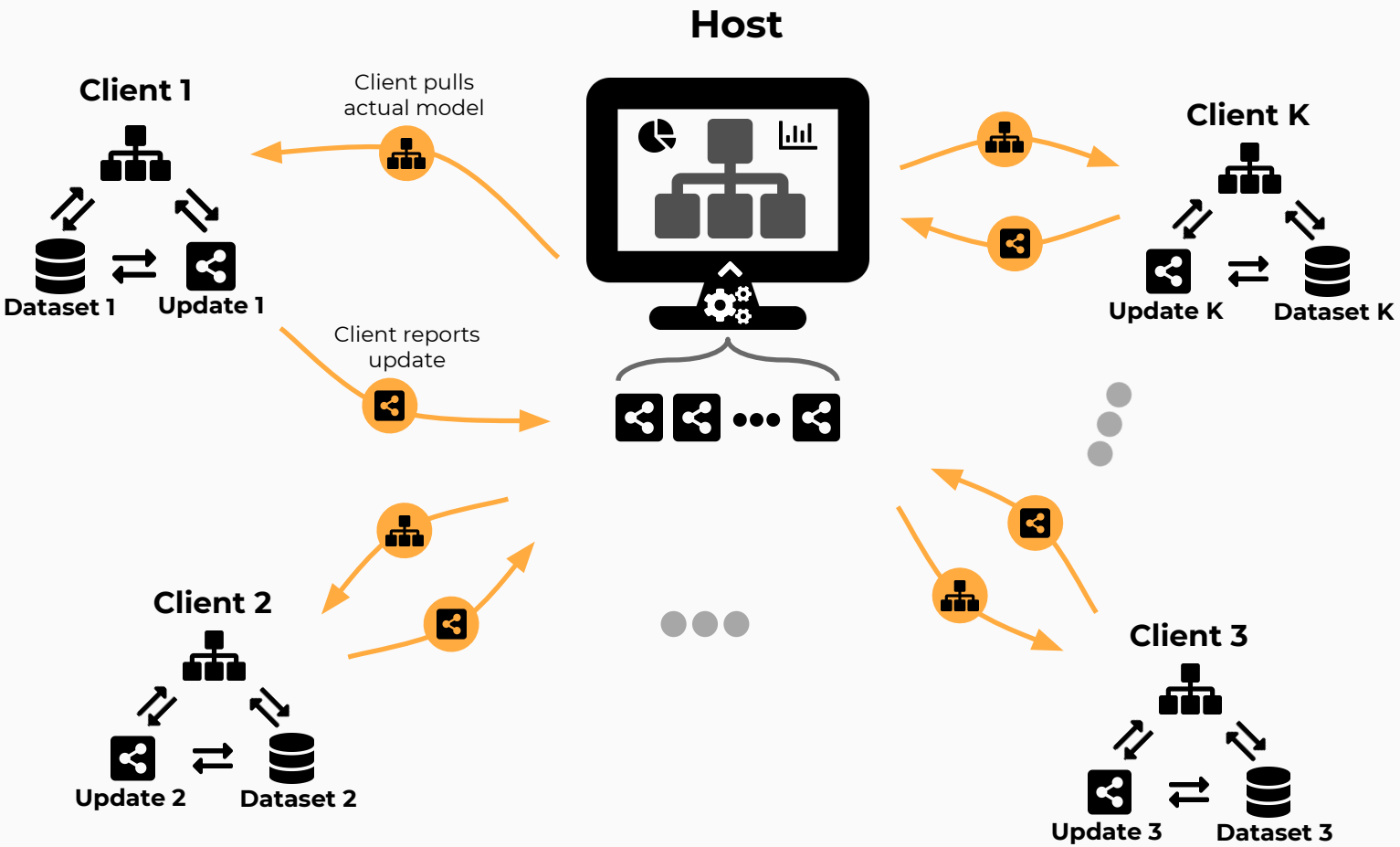

Federated Learning/Decentralized Learning

- Model comes to the data, not data to the model
- Privacy concerning method
- ...

Federated Learning of Gradient-Based Methods

Google Paper

- Problems

Federated Averaging

- Mention problems and how we can tackle them (more steps in one iteration . . .)

Challenges

Communication Costs vs. Training Costs

Evaluation of Federated Learning Systems

Example with Logistic Regression

Setup

- **Loss Function/Negative Log-Likelihood**

$$L\left(y, f(x,\theta)\right) = -y \log\left(f(x,\theta)\right) - (1-y) \log\left(1 - f(x,\theta)\right)$$

- **Response Function**

$$f(x) = \left(1 + \exp\left(-x^T\theta\right)\right)^{-1}$$

- **Score Function**

$$\frac{\delta}{\delta\theta} L(y, f\left(x,\theta\right)) = x\left(y - f(x,\theta)\right)$$

Boosting and Federated Learning