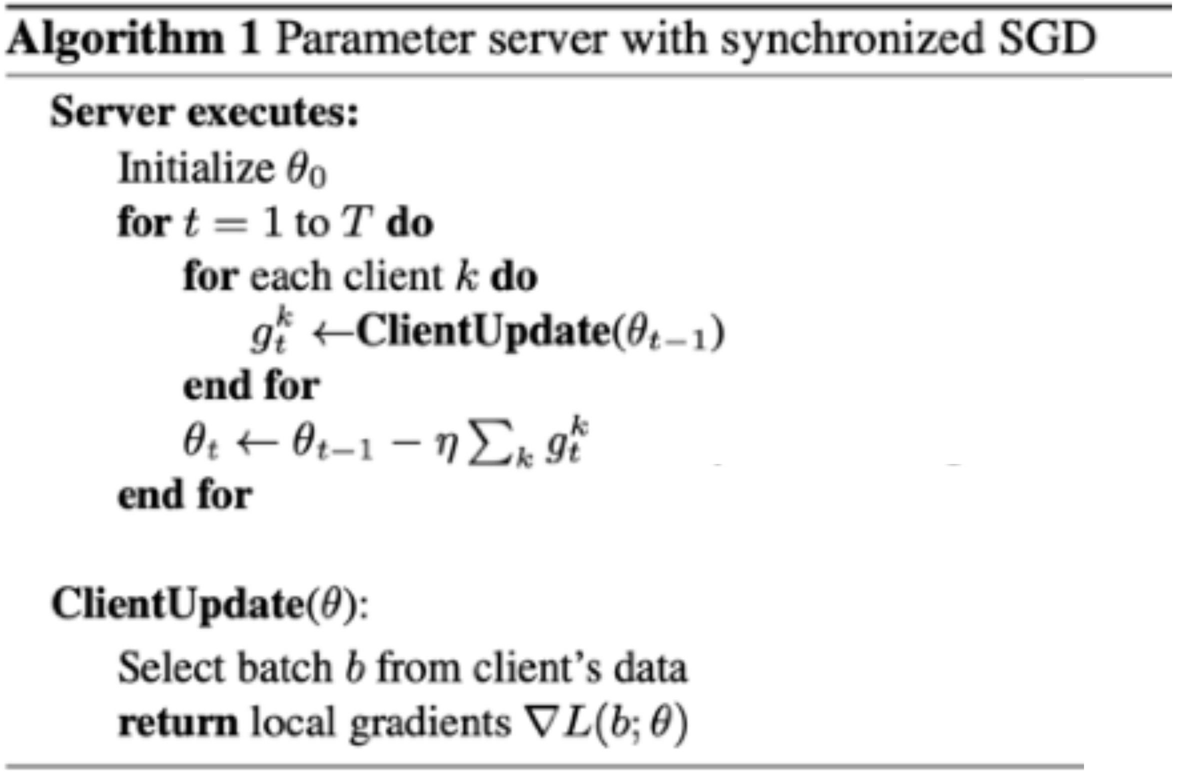
Collaborative

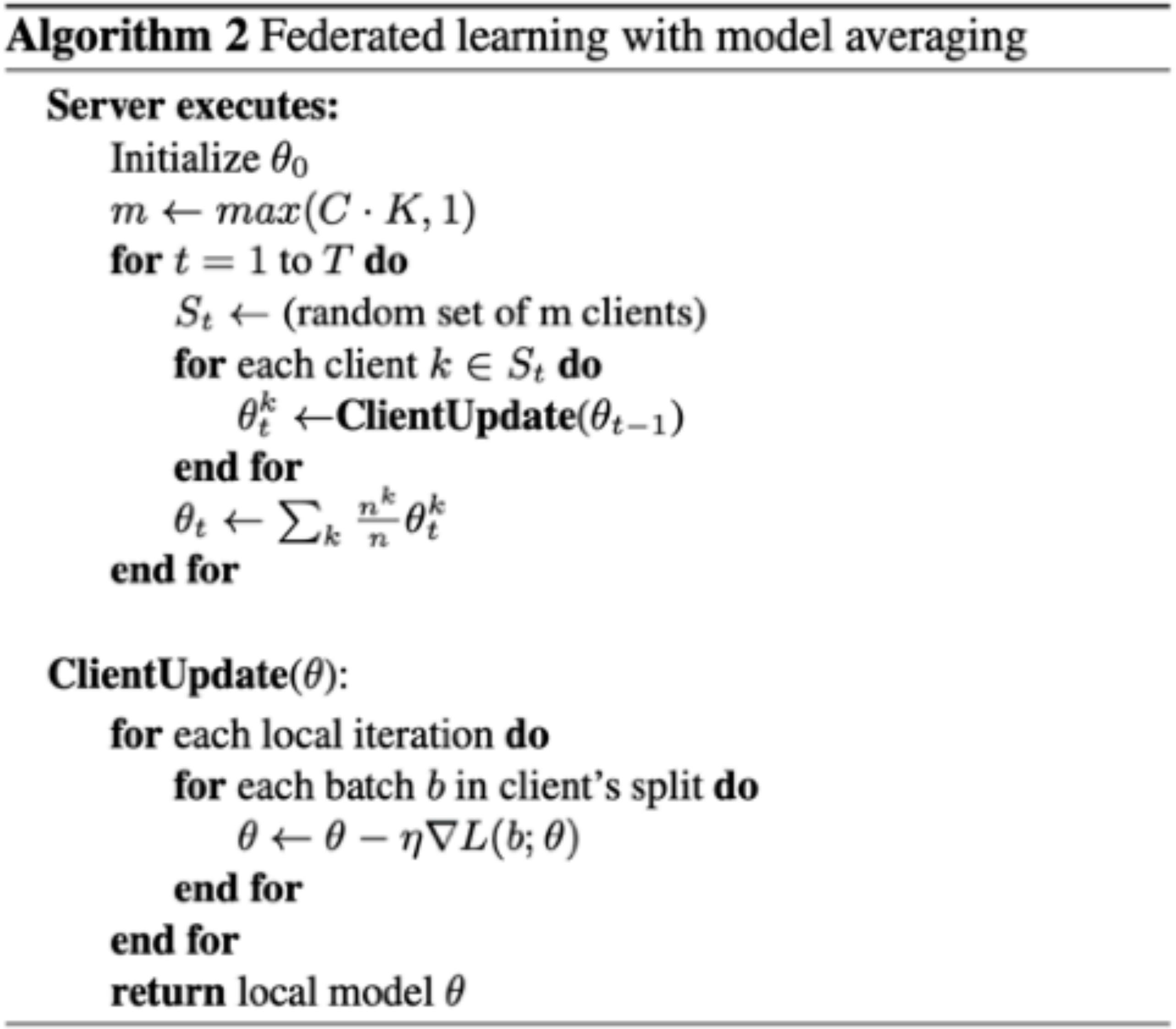


Algorithm 1 Parameter server with synchronized SGD

```
Server executes:
    Initialize $\theta_0$
    for $t = 1$ to $T$ do
        for each client $k$ do
            $g_t^k \leftarrow$ClientUpdate($\theta_{t-1}$)
        end for
        $\theta_t \leftarrow \theta_{t-1} - \eta \sum_k g_t^k$
    end for

ClientUpdate($\theta$):
    Select batch $b$ from client's data
    return local gradients $\nabla L(b; \theta)$
```

Federated

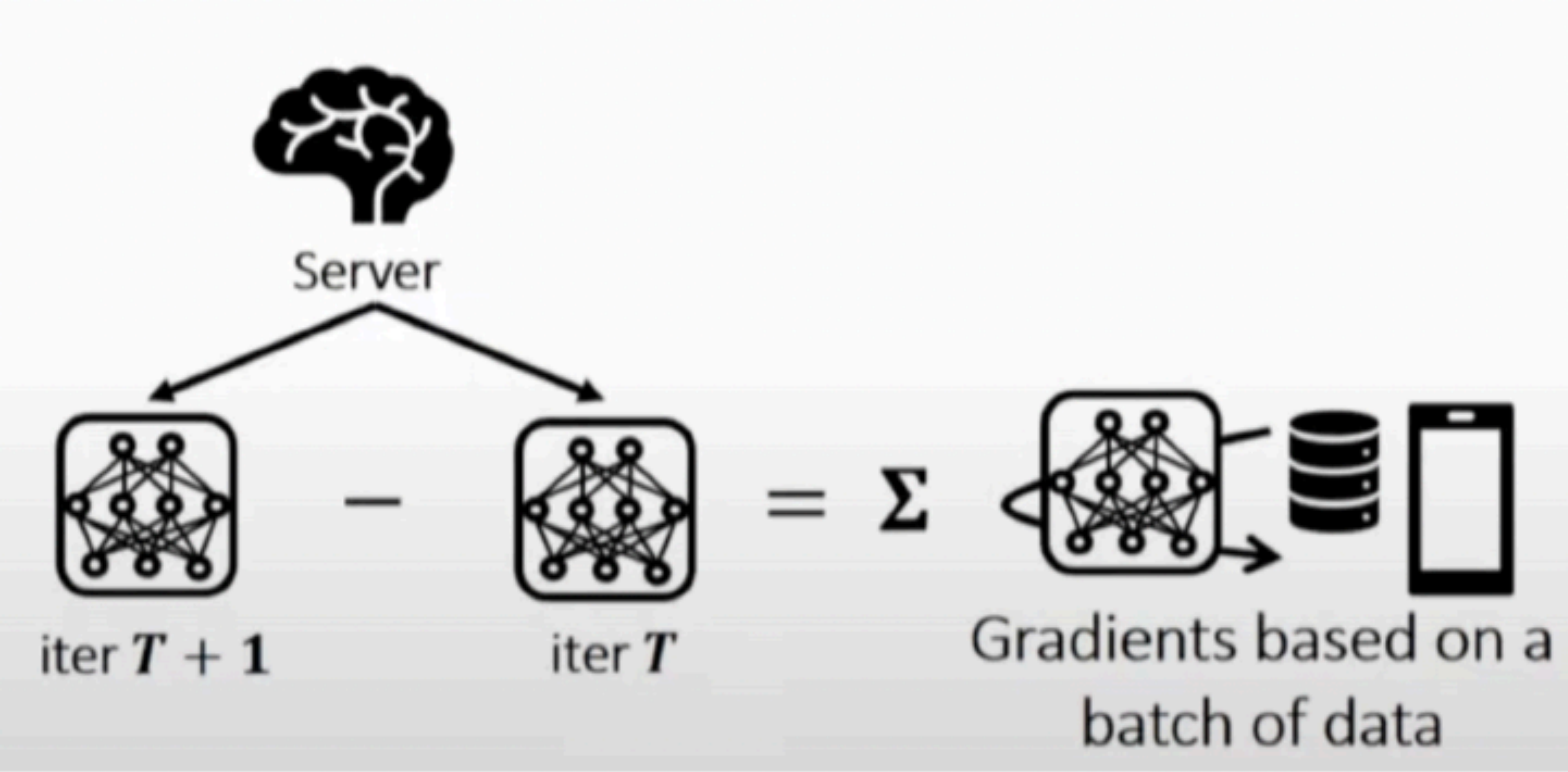


Algorithm 2 Federated learning with model averaging

```
Server executes:
    Initialize $\theta_0$
    $m \leftarrow max(C \cdot K, 1)$
    for $t = 1$ to $T$ do
        $S_t \leftarrow$ (random set of m clients)
        for each client $k \in S_t$ do
            $\theta_t^k \leftarrow$ClientUpdate($\theta_{t-1}$)
        end for
        $\theta_t \leftarrow \sum_k \frac{n^k}{n} \theta_t^k$
    end for

ClientUpdate($\theta$):
    for each local iteration do
        for each batch $b$ in client's split do
            $\theta \leftarrow \theta - \eta \nabla L(b; \theta)$
        end for
    end for
    return local model $\theta$
```

Threat Model


Server
iter $T + 1$
$-$
iter T
$= \Sigma$
Gradients based on a batch of data