

FedGreen: Federated Learning with Fine-Grained Gradient Compression for Green Mobile Edge Computing

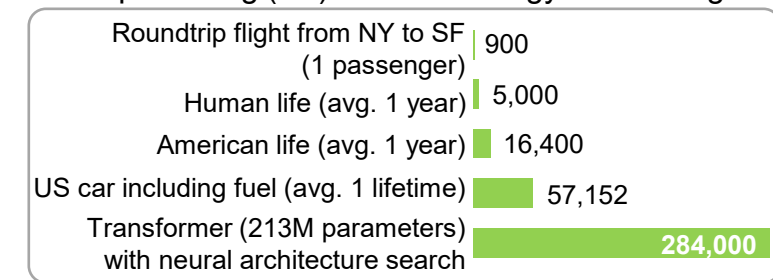
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The Demand for Efficient FL in MEC

- Deep learning (DL) is rather energy-consuming

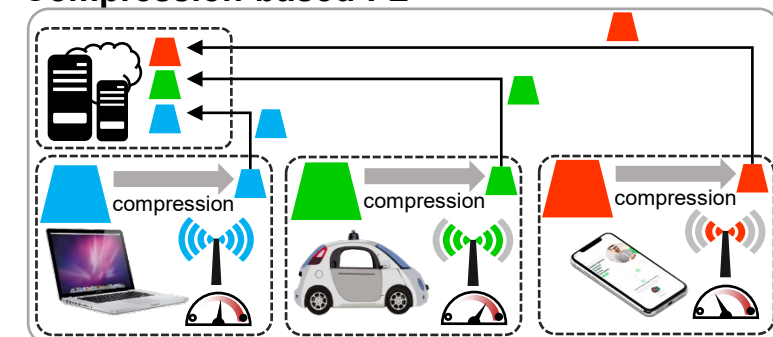


- Federated learning can be more energy-consuming than centralized training

Higher communication cost: many IoT devices connect to the aggregation server via wireless communication, such as 4G/5G, which is highly energy-consuming.

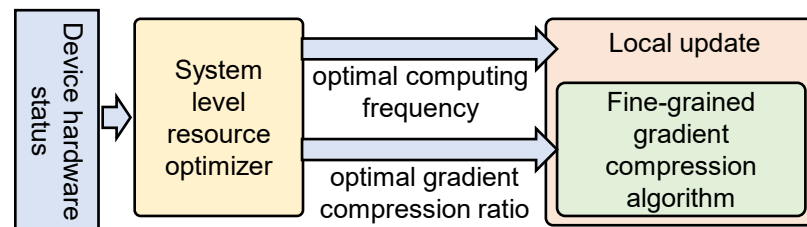
More training iteration step: due to the non-independent and identically data distribution, federated learning requires many iteration steps to converge.

Shortcomings of Existing Gradient-Compression-based FL



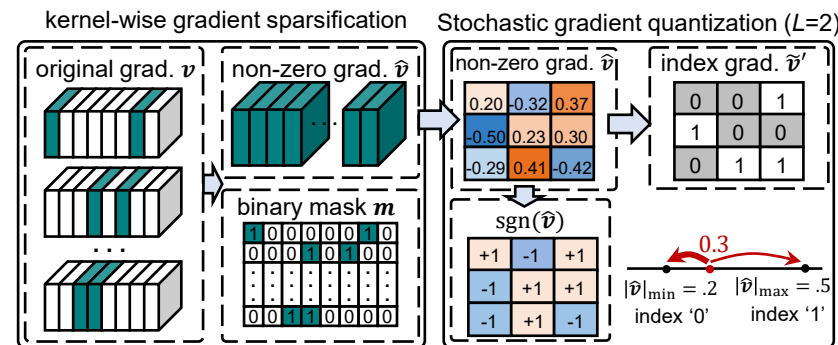
Devices with various communication states and computing capabilities **share a unified gradient compression strategy.**

FedGreen: Algorithm-System Co-design

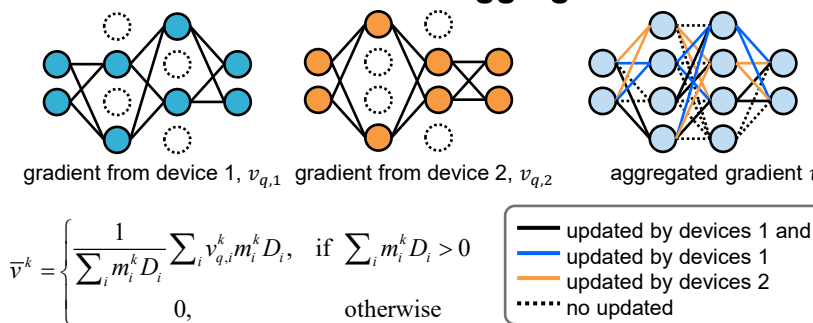


In FL with gradient compression, the computing frequency and compression ratio of each device should be optimized to match the hardware configuration and channel status.

Client-Side Fine-Grained Gradient Compression



Server-Side Element-wise Aggregation



Learning Accuracy-Energy Efficiency Trade-off

learning accuracy energy efficiency

$$\mathcal{G} = F(\{\alpha_i\}_{1 \leq i \leq I}) - \varpi J \sum_{i=1}^I \left(\frac{p_i S}{\alpha_i r_i} + \varepsilon_i f_i^2 n D_i W \right)$$

(P1): $\max \mathcal{G}$ compression ratio ≥ 1

subject to: $\alpha_i \geq 1, \forall i,$ computing frequency

$$0 < f_i \leq f_i^{\max}, \forall i,$$

$$\frac{S}{\alpha_i r_i} + \frac{n D_i W}{f_i} \leq T^{\max}, \forall i, \quad \text{maximum delay per round}$$

variables: $\alpha_i, f_i, \forall i$ This problem can be solved by binary search!

Experiment Results

