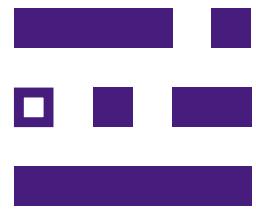
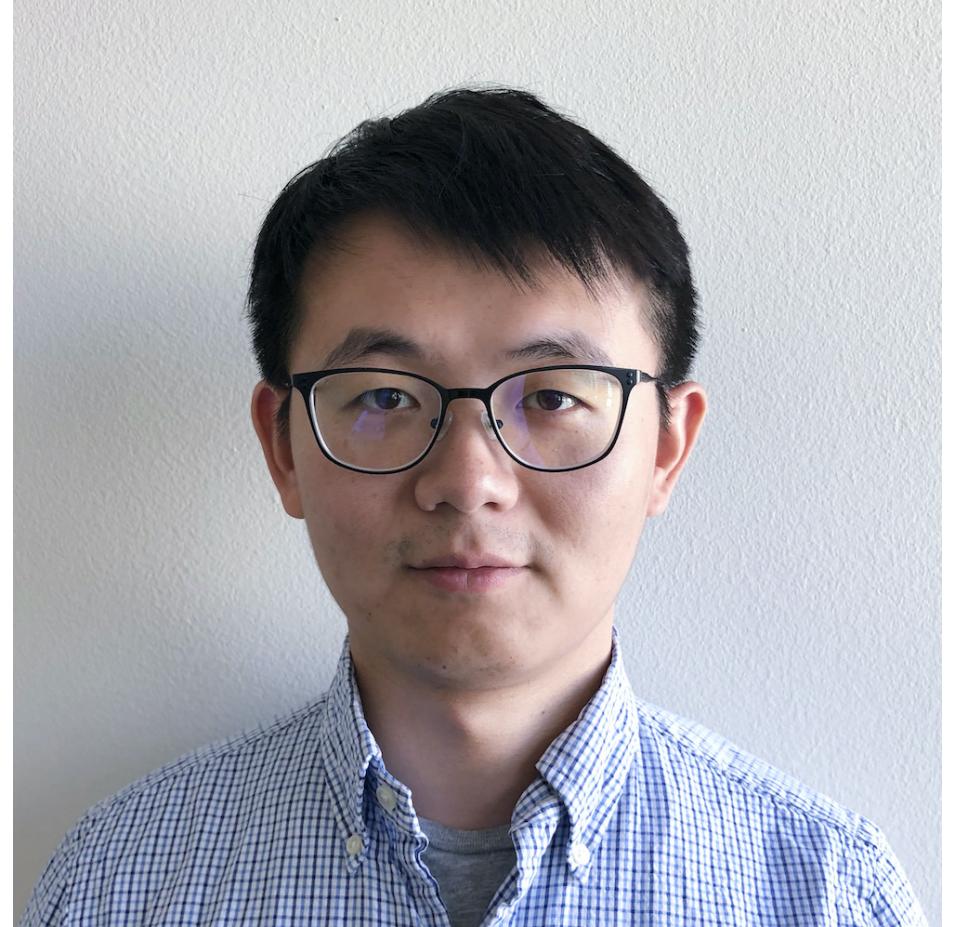


AI + Distributed System

Hao Wang



IntelliSys Lab



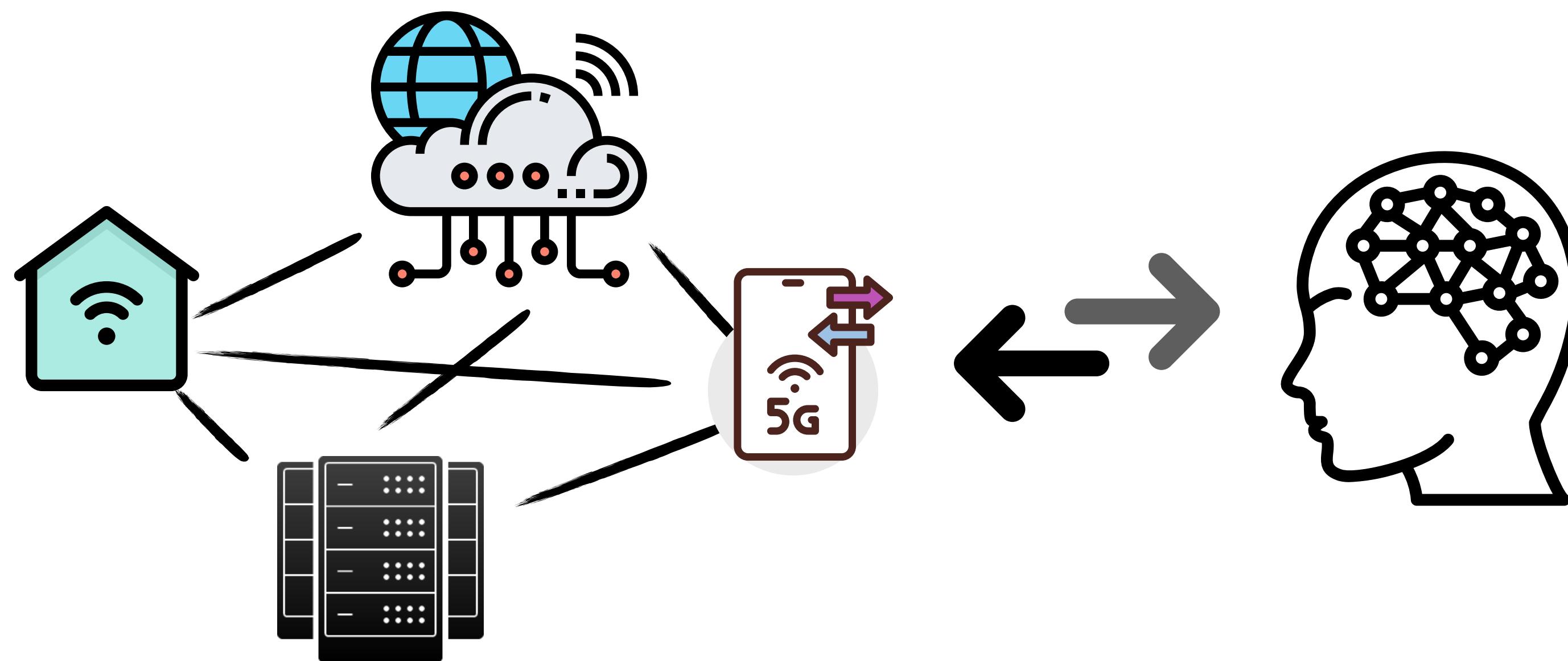
- 09/2015-08/2020
- 01/2021-present



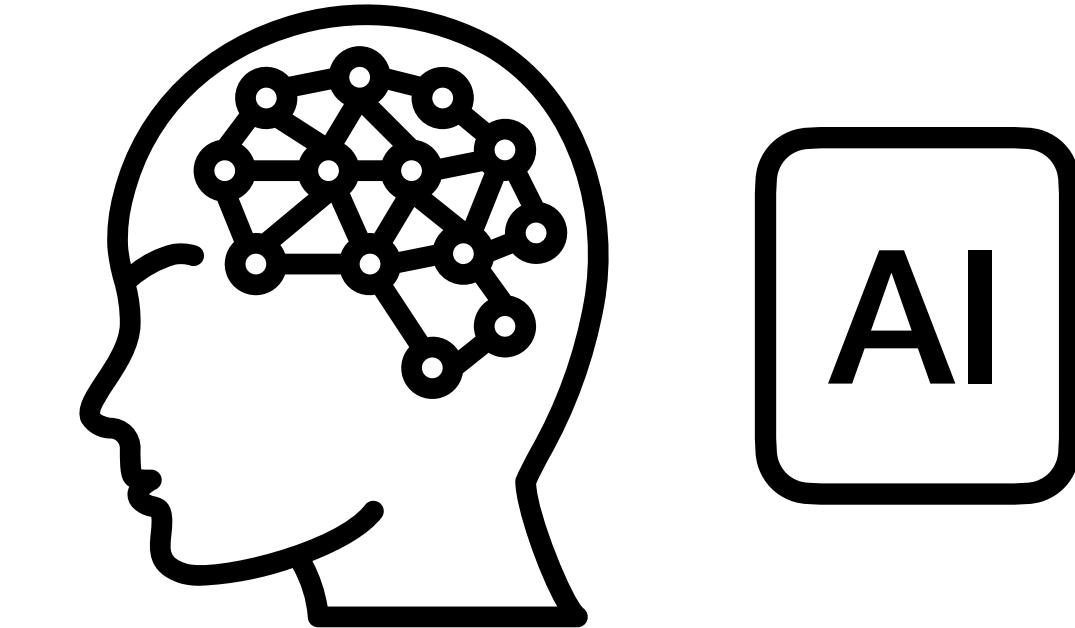
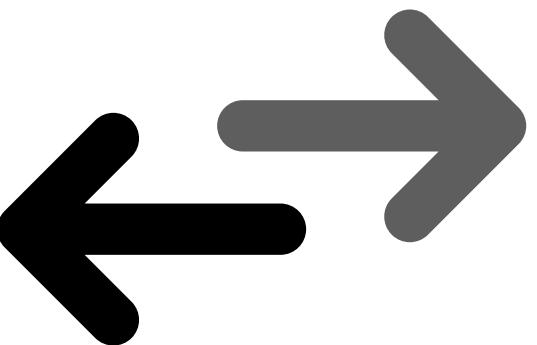
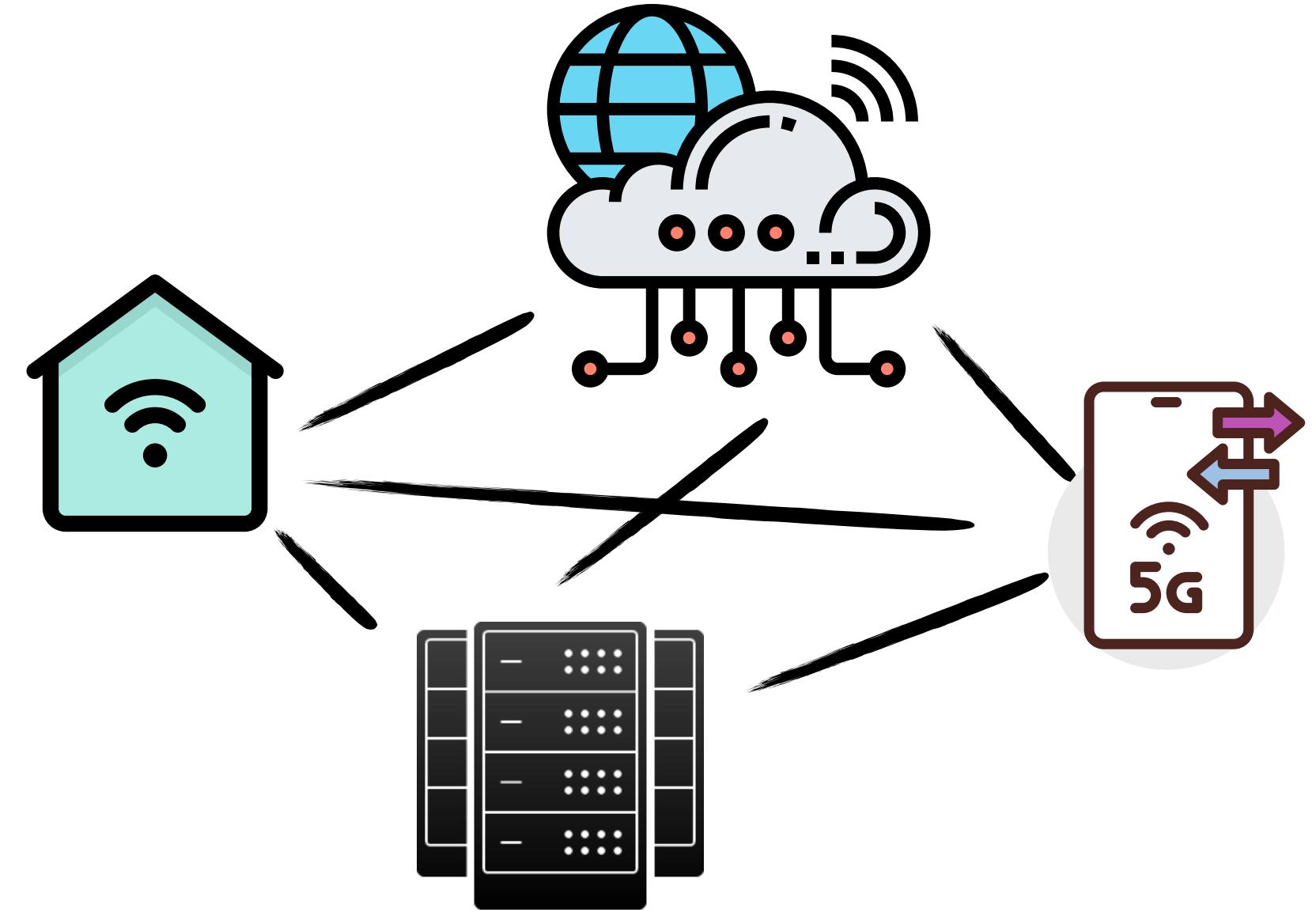
UNIVERSITY OF
TORONTO



LSU | IntelliSys Lab



- **AI + Distributed System**
- 17 published papers
- 624 citations
- Projects sponsored by
 - NSERC, Huawei Canada, Orbis Investment...



ML Training / Inference

Performance

Reinforcement Learning

Big Data Analytics

Adaptivity

Federated Learning

Video Processing

Robustness

Transfer Learning

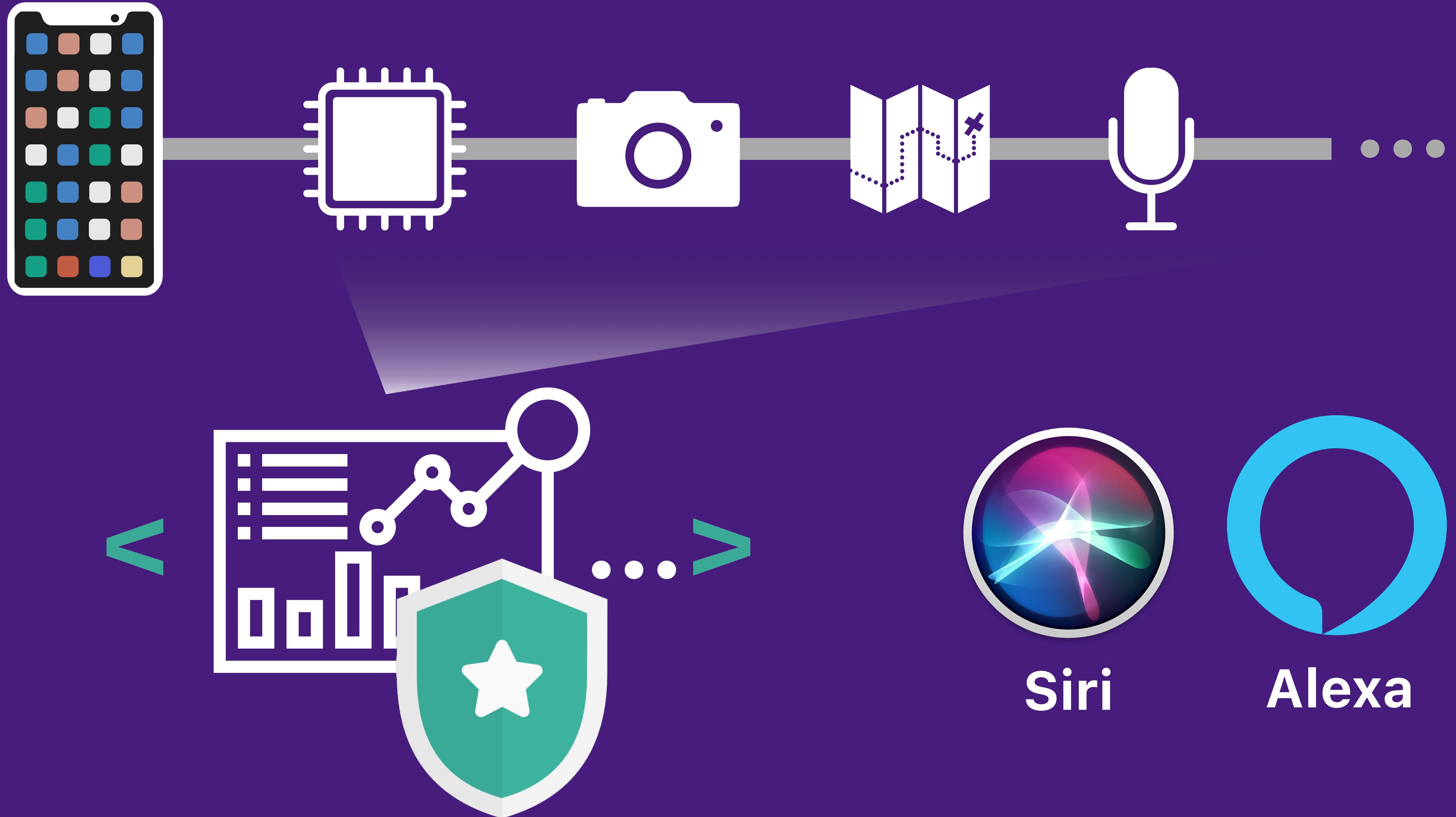
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Topic #1

Federated Learning



Sure. Umami burger?

Yeah. Know the address?

738 E. 3rd St.



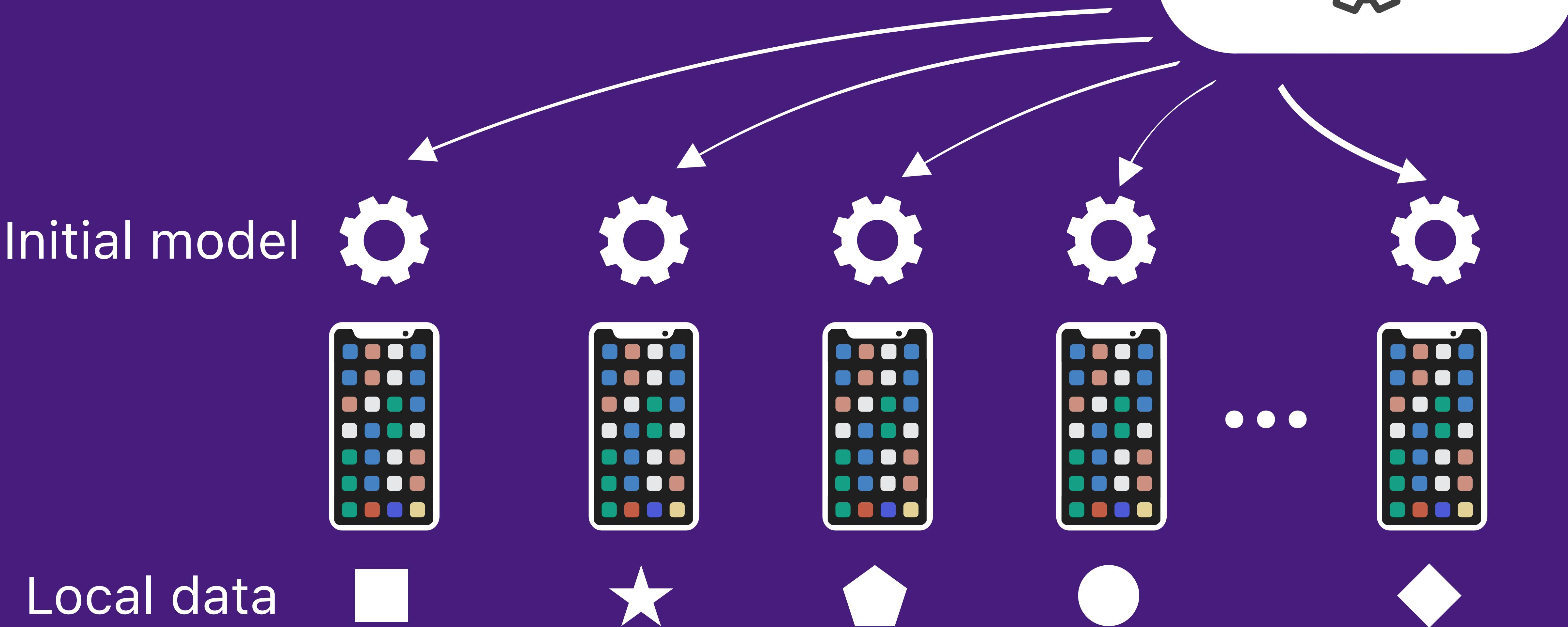
The

Hi



1 2 3 4 5 6 7 8 9 0
q w e r t y u i o p
a s d f g h j k l
z x c v b n m x

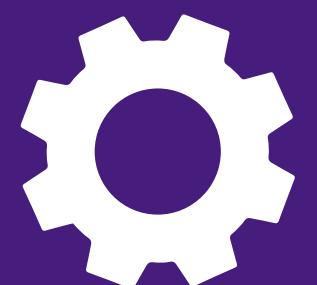
Federated Averaging Algorithm (FedAvg)



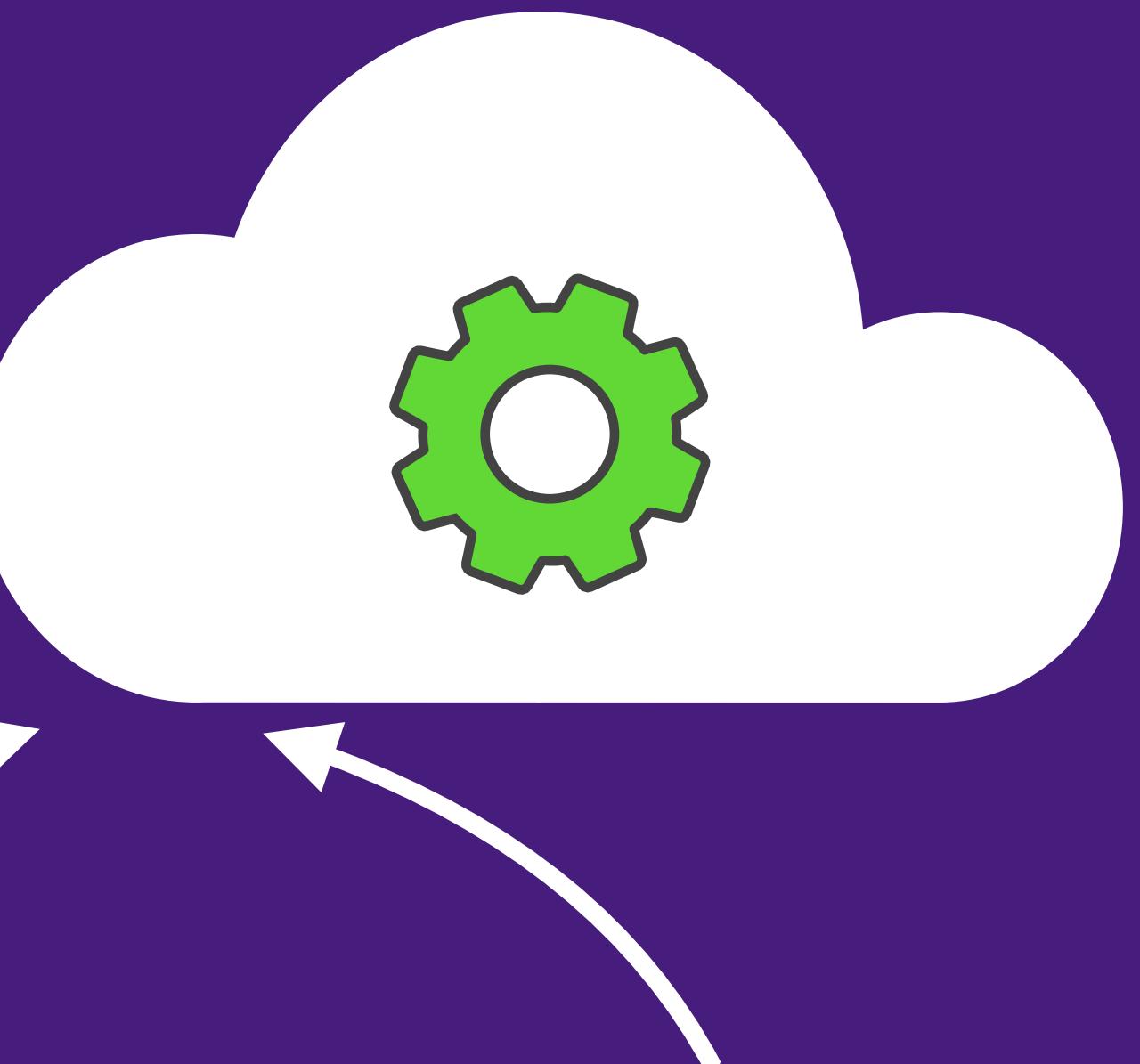
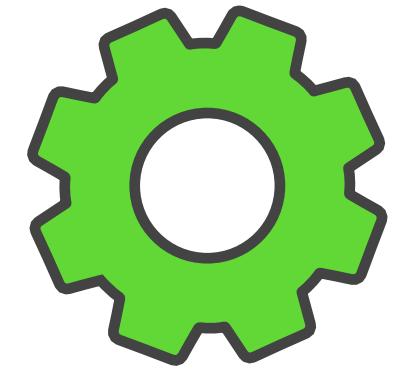
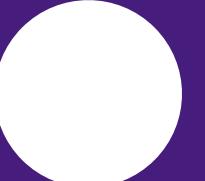
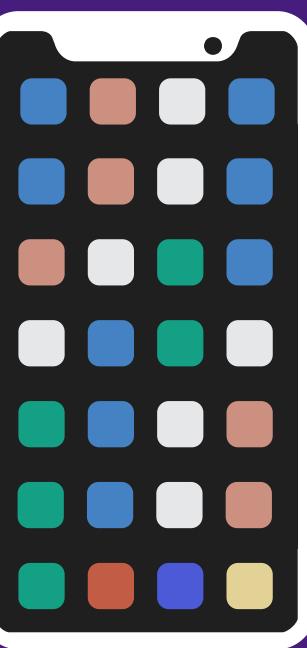
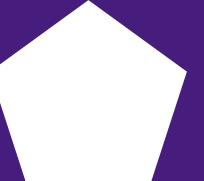
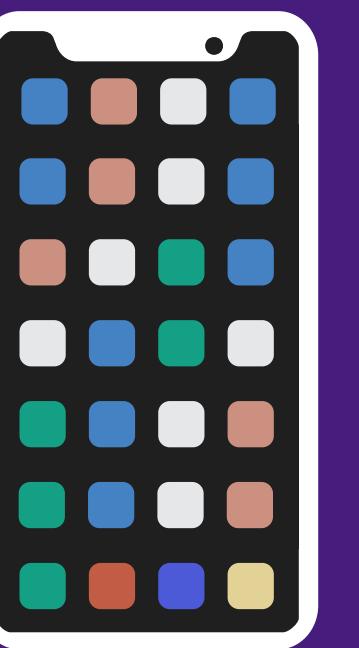
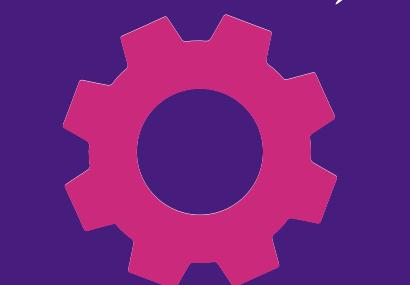
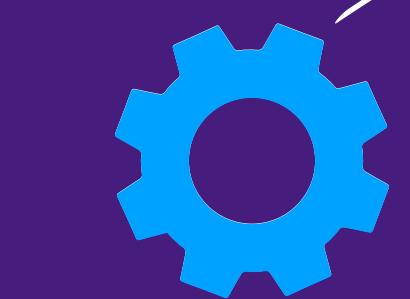
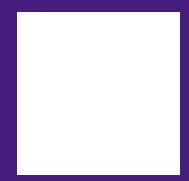
Random selection

Update global model

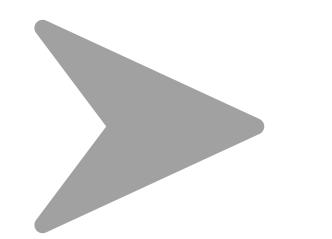
Local model



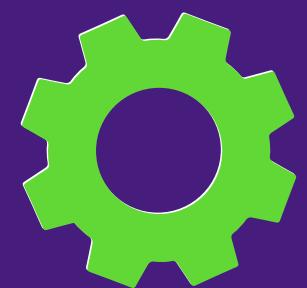
Local data



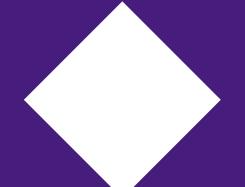
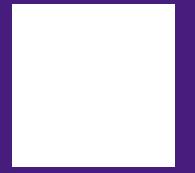
Thank you for the ~~f~~eedback



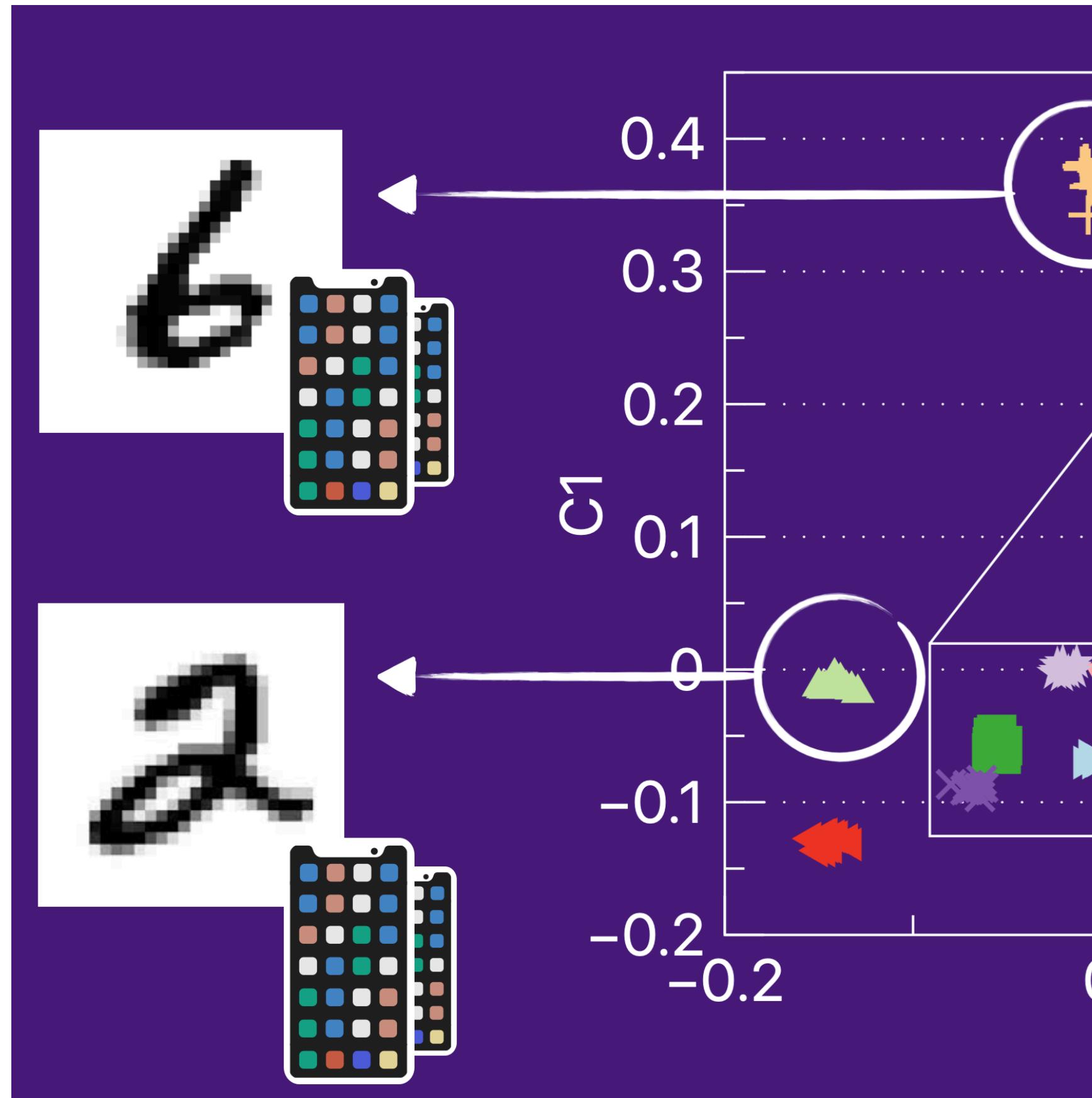
Local model



Local data



Projects Done

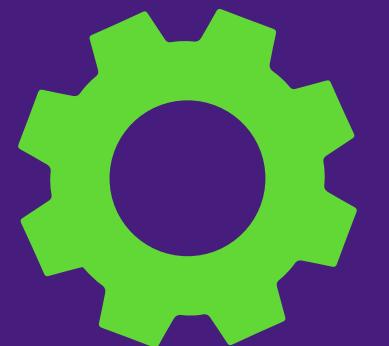
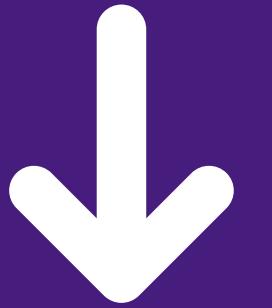
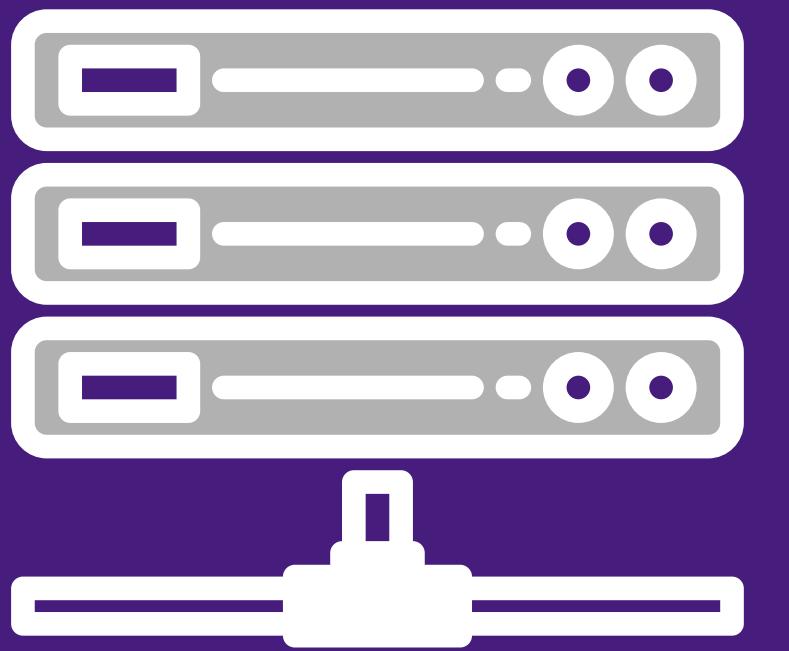


- Optimizing Federated Learning on Non-IID Data with Reinforcement Learning
- [INFOCOM'20]
 - Federated learning
 - Client selection
 - Reinforcement learning

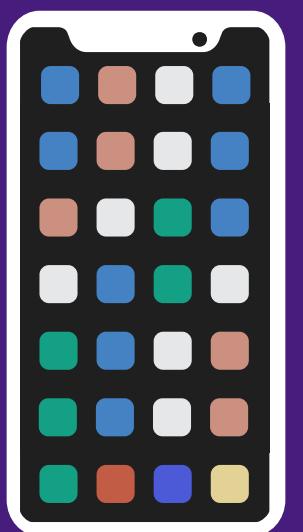
**ML algorithms assume the training data is
independent and identically distributed (IID)**

Federated Learning reuses the existing ML
algorithms but on **non-IID** data

< ◊ ★ ... ♦ >



◊ ★ ... ♦



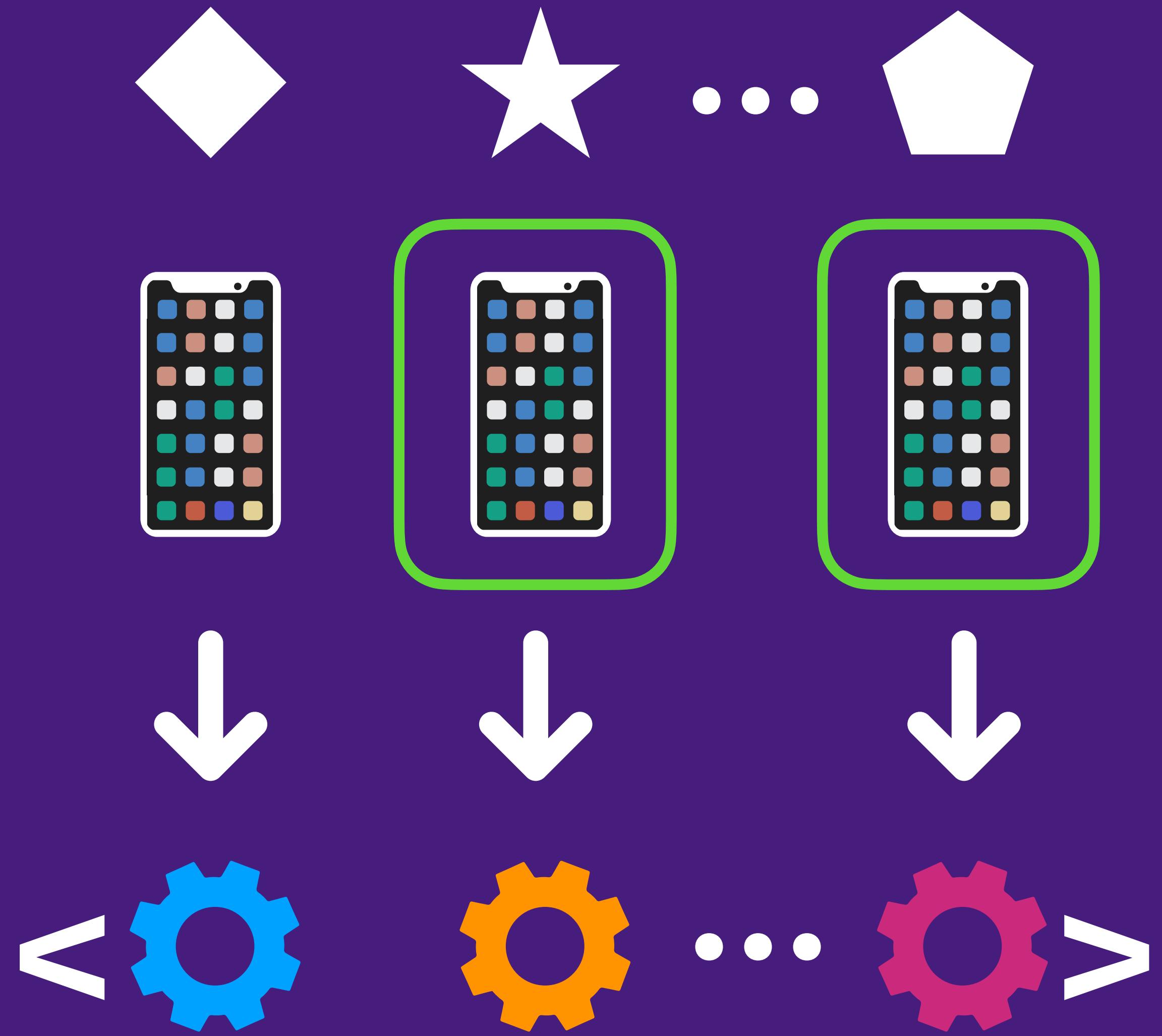
< ⚛ ⚛ ... ⚛ >

Build IID training data? **No**



Peeking into the data distribution
on each device without violating
data privacy

Probing the bias of non-IID data



Carefully **select devices**
to **balance** the bias
introduced by **non-IID**
data



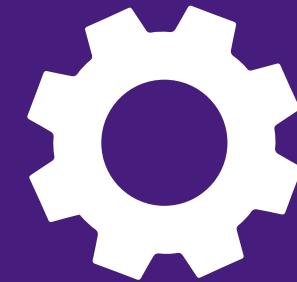
100 devices, each has 600 samples

Non-IID data



80% data has the same label, e.g, "6"

Initial model



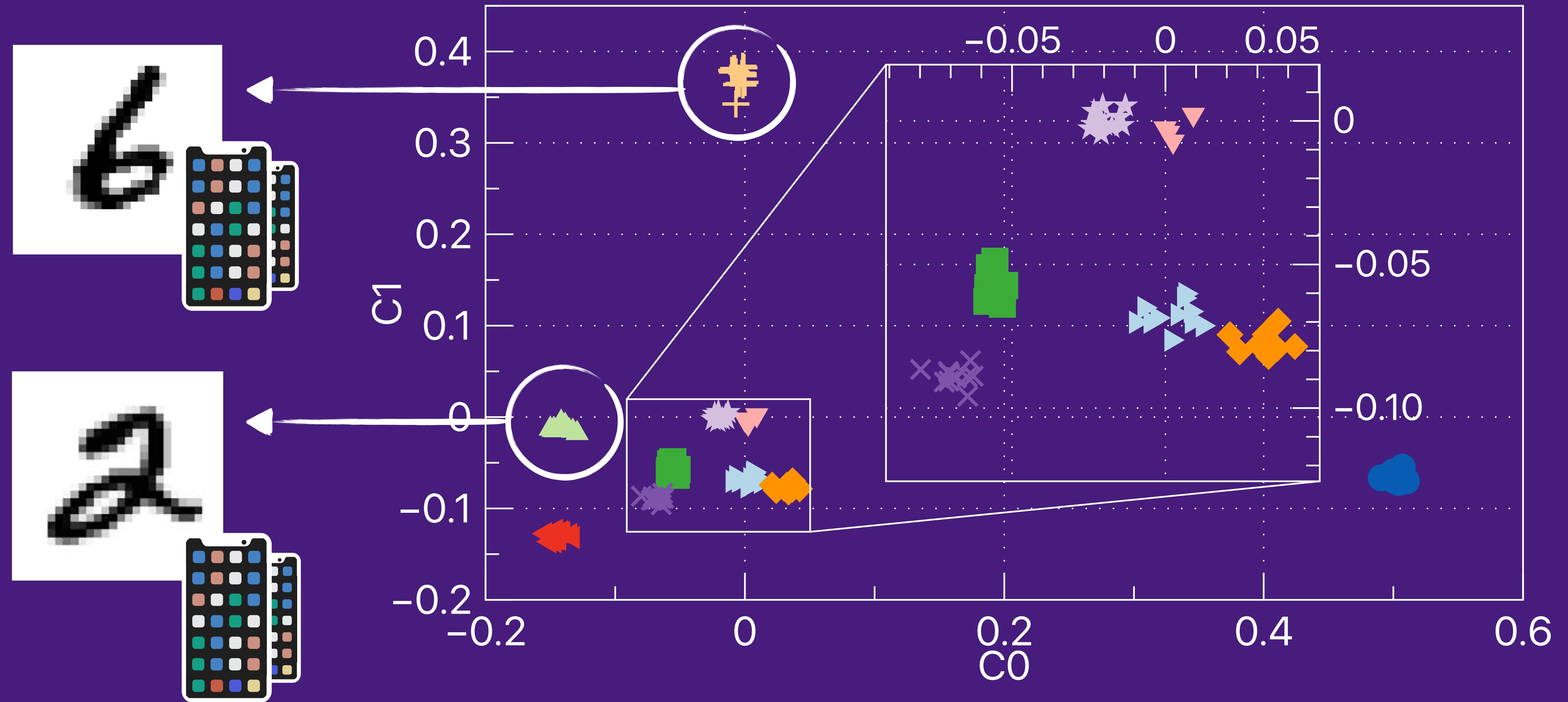
A two-layer CNN model with
431,080 parameters

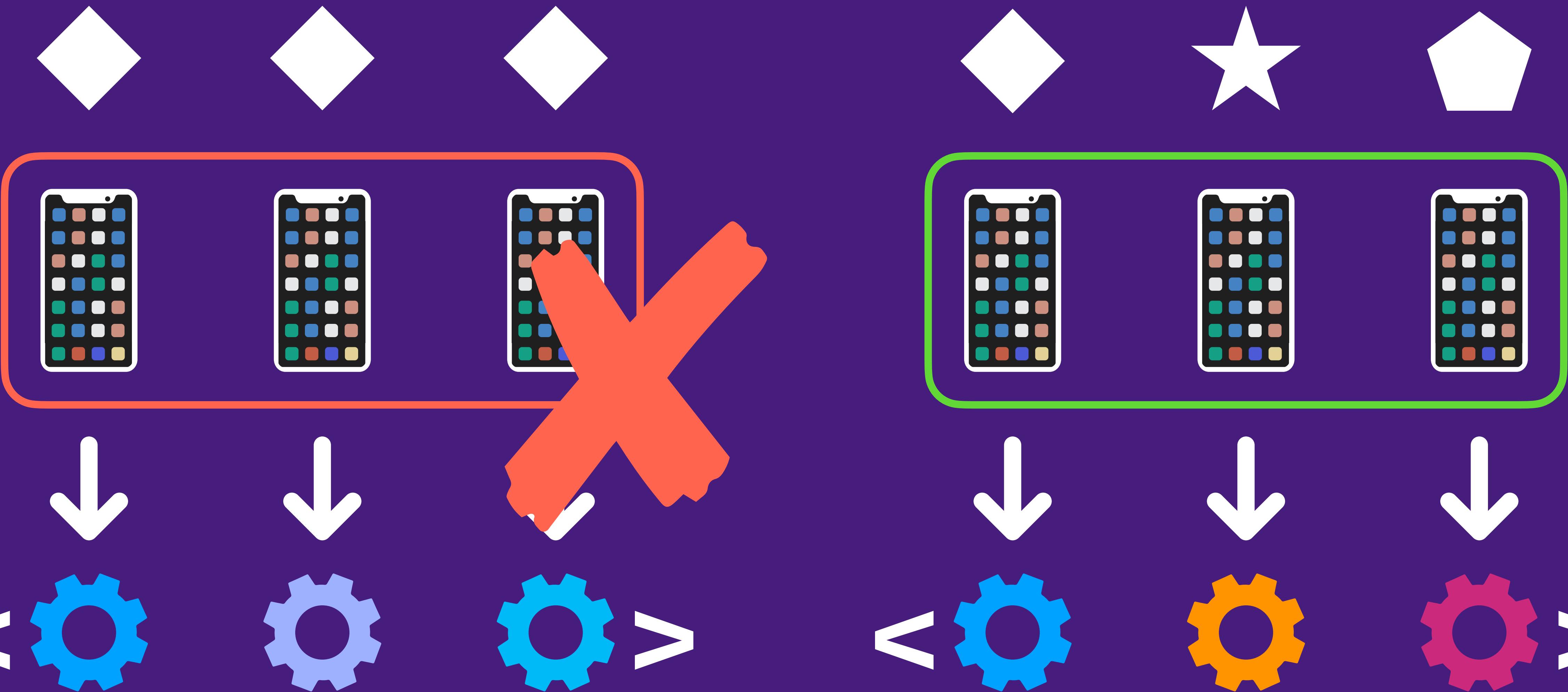
Local model



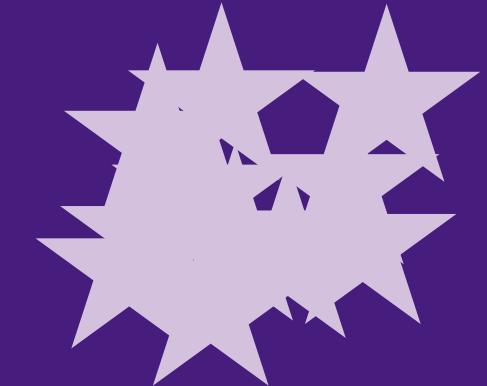
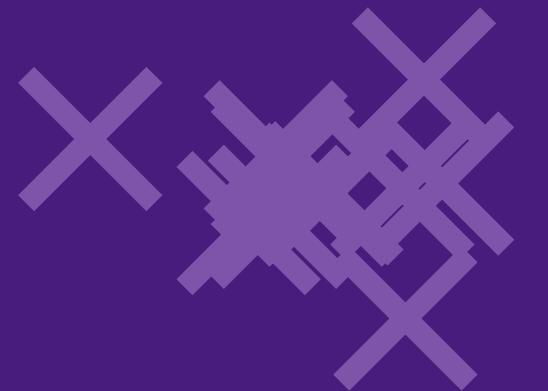
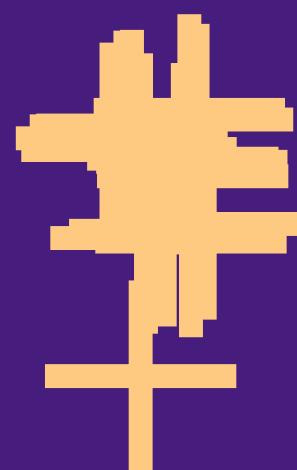
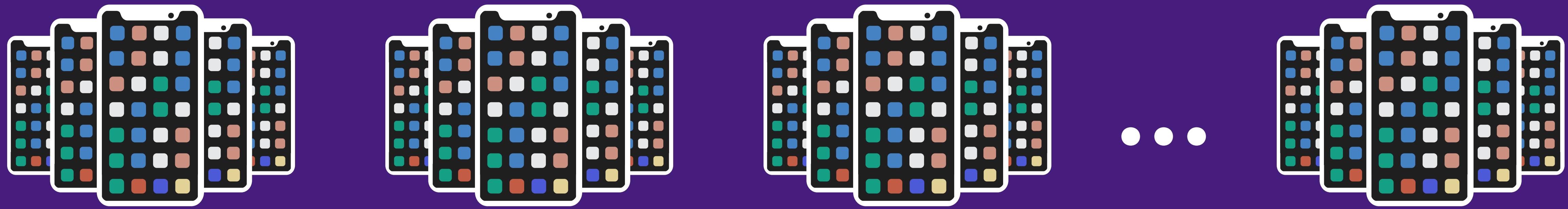
We apply Principle Component Analysis
(PCA) to reduce dimensionality

431,080-dimension model weight → 2-dimension space

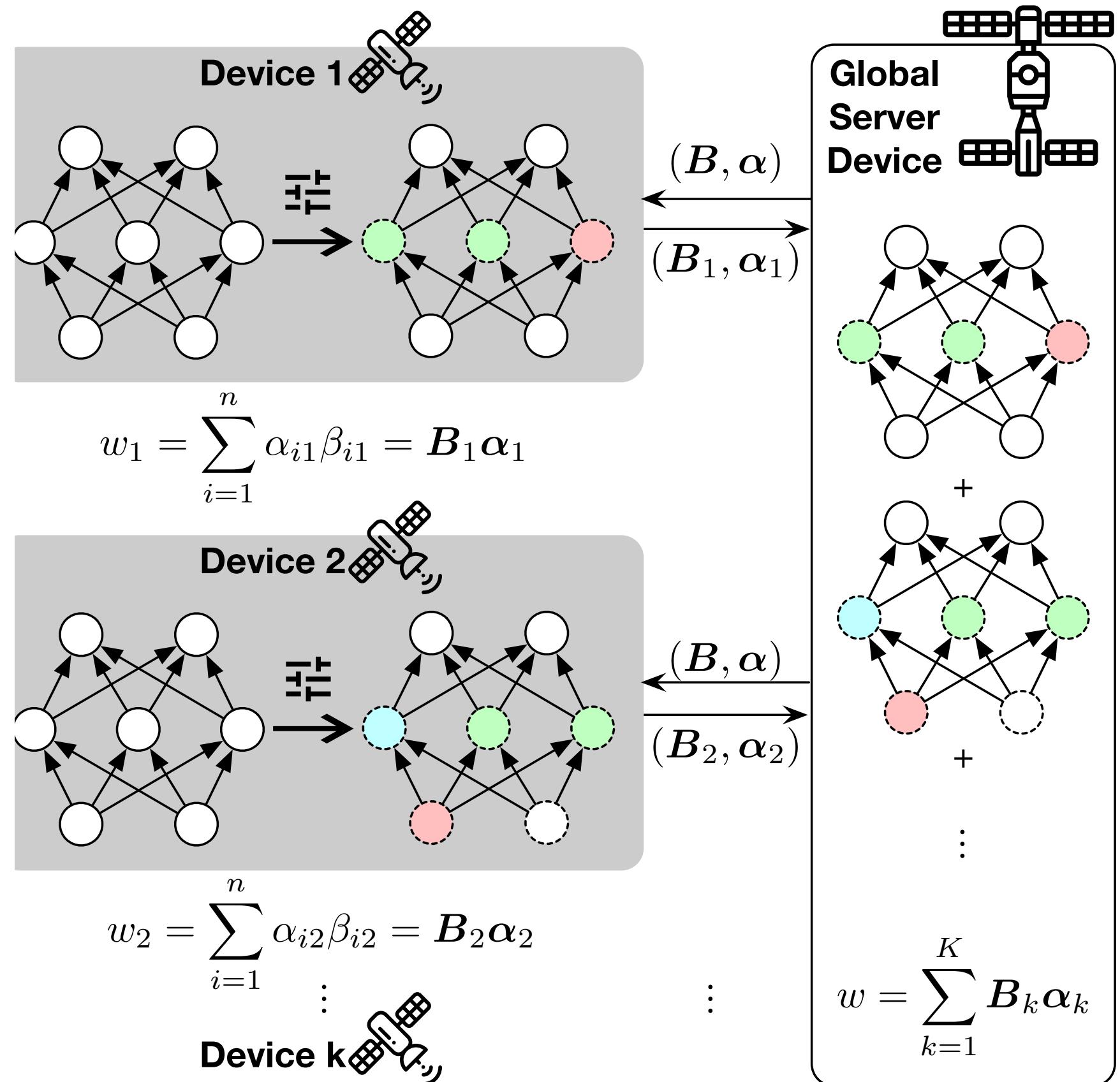




How to select participating clients?

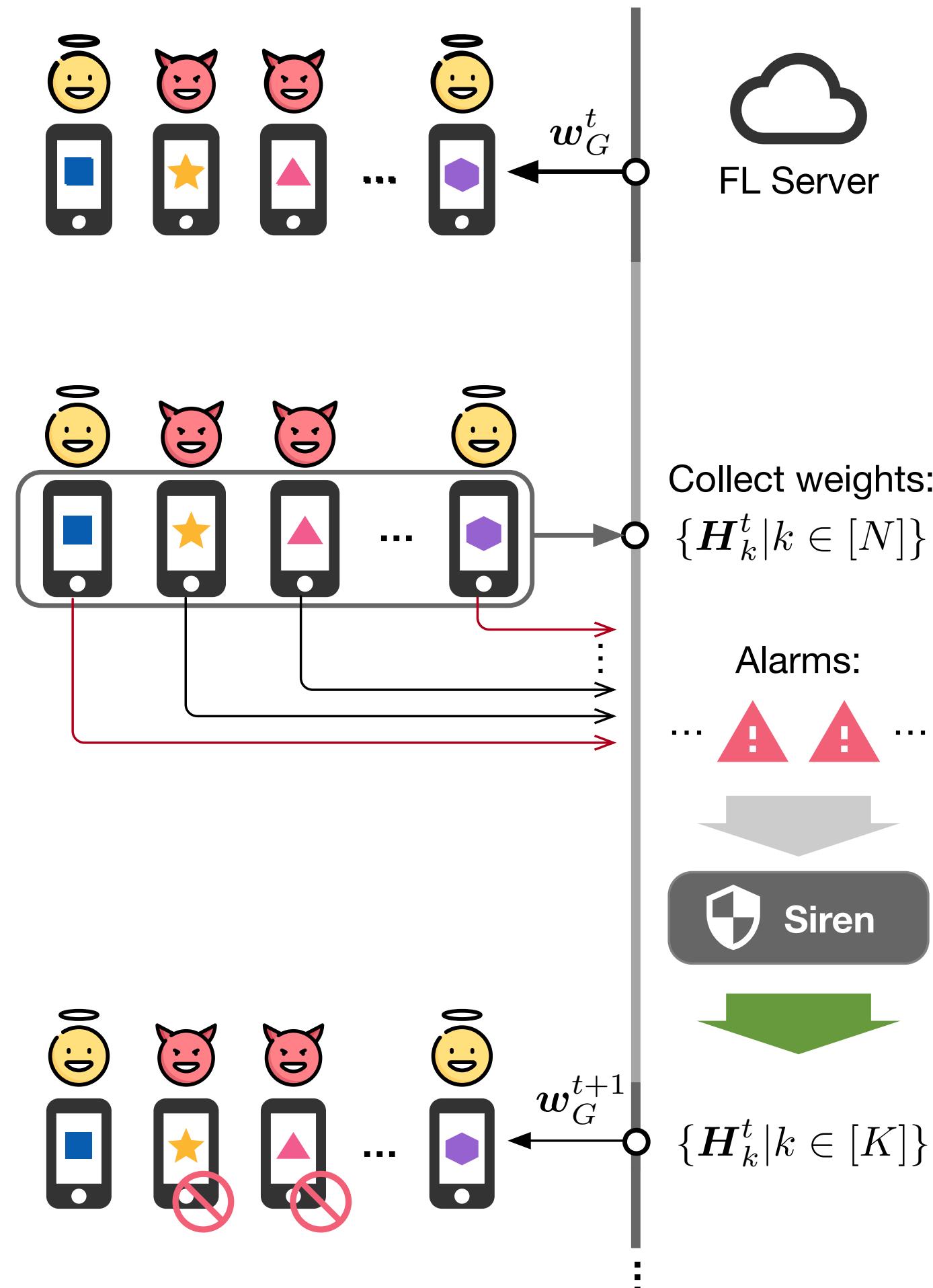


Projects Done

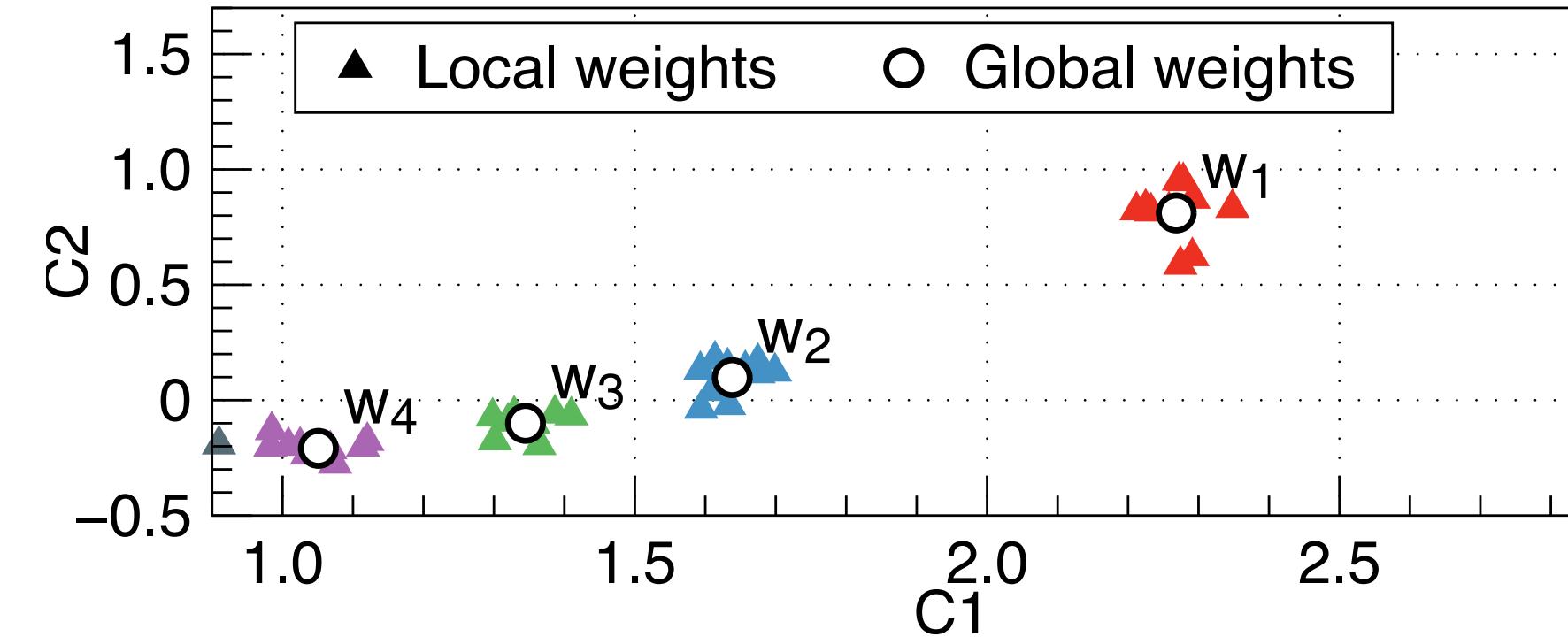
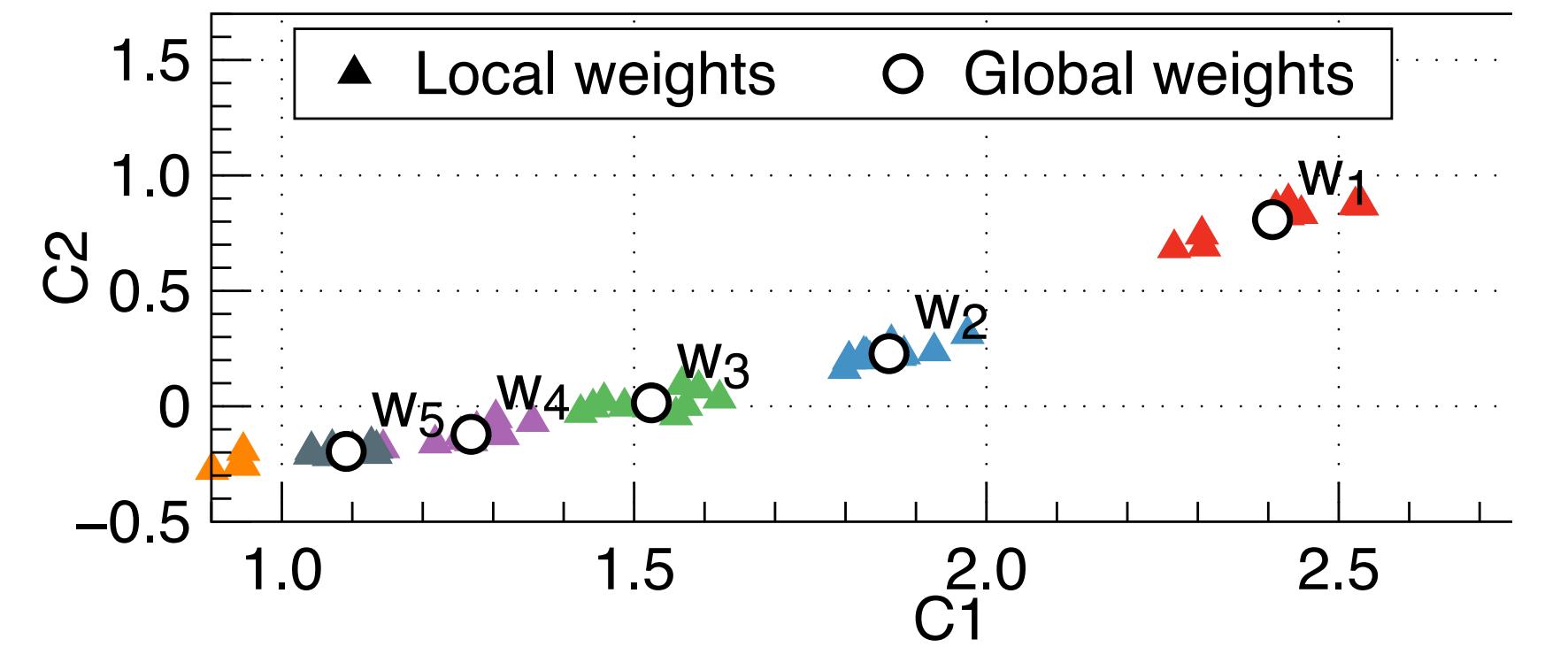


- SpaceDML: Enabling Distributed Machine Learning in Space Information Networks
- [IEEE Network]
 - Federated learning
 - Model compression
 - Space information network

Projects Ongoing



- Byzantine-robust Federated Learning
 - Federated learning
 - Byzantine attacks
 - Security & privacy



- Debugging Federated Learning
 - Mitigating stragglers
 - Model tuning & testing
 - Personalized federated learning

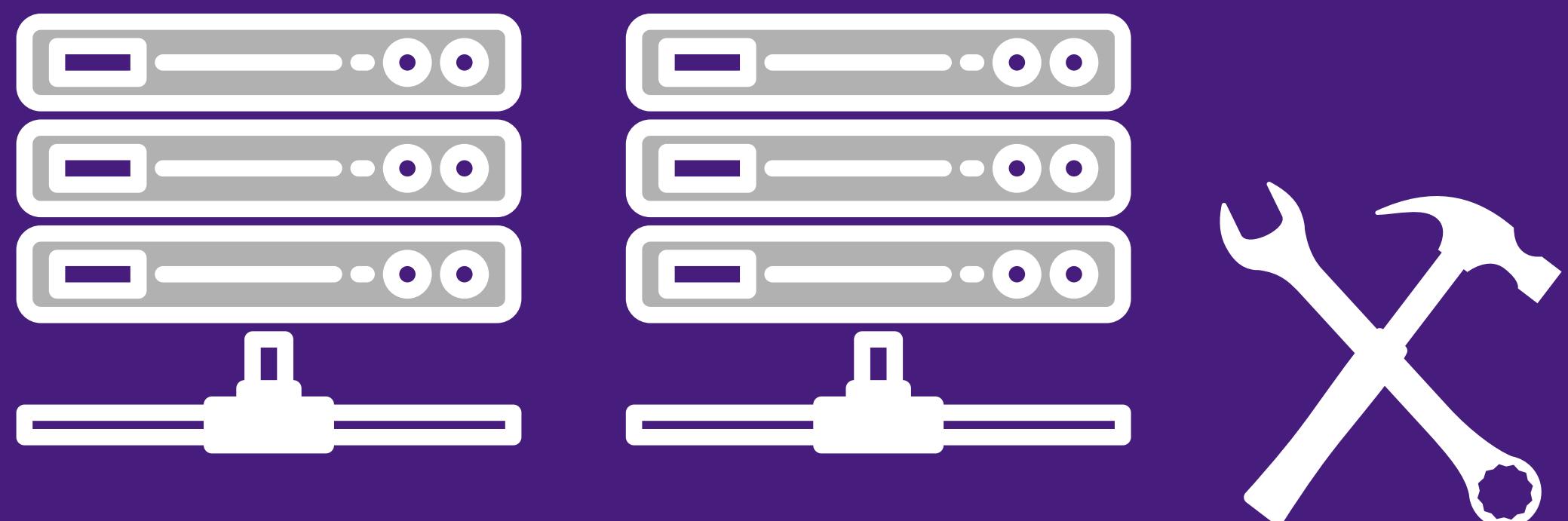
Topic #2

Serverless Computing

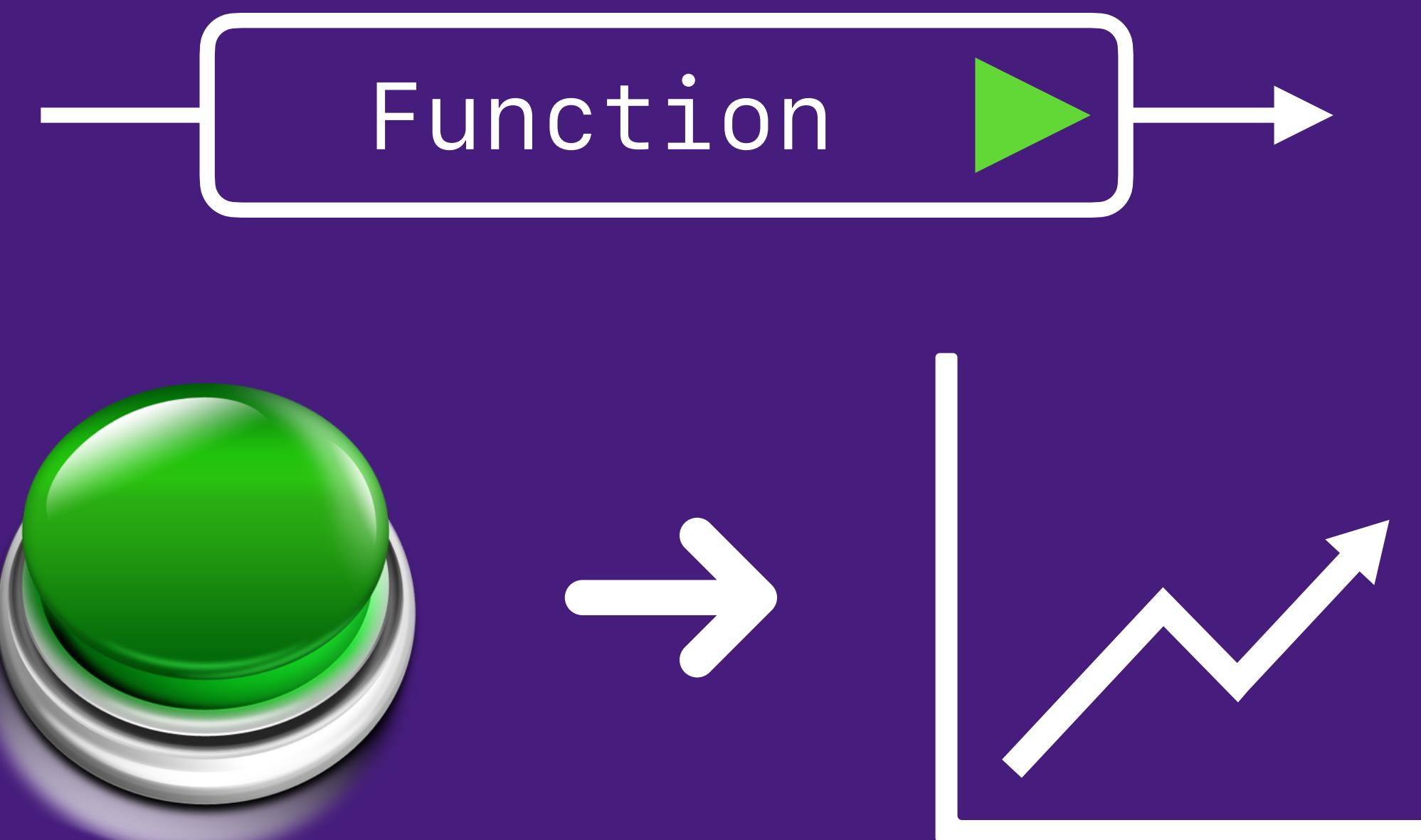
What is Serverless?

	IaaS	Serverless
Pricing	Per hour	Per call
Resources	Virtual Server	Functions
Maintanance	By users	By providers
Examples	AWS EC2	AWS Lambda

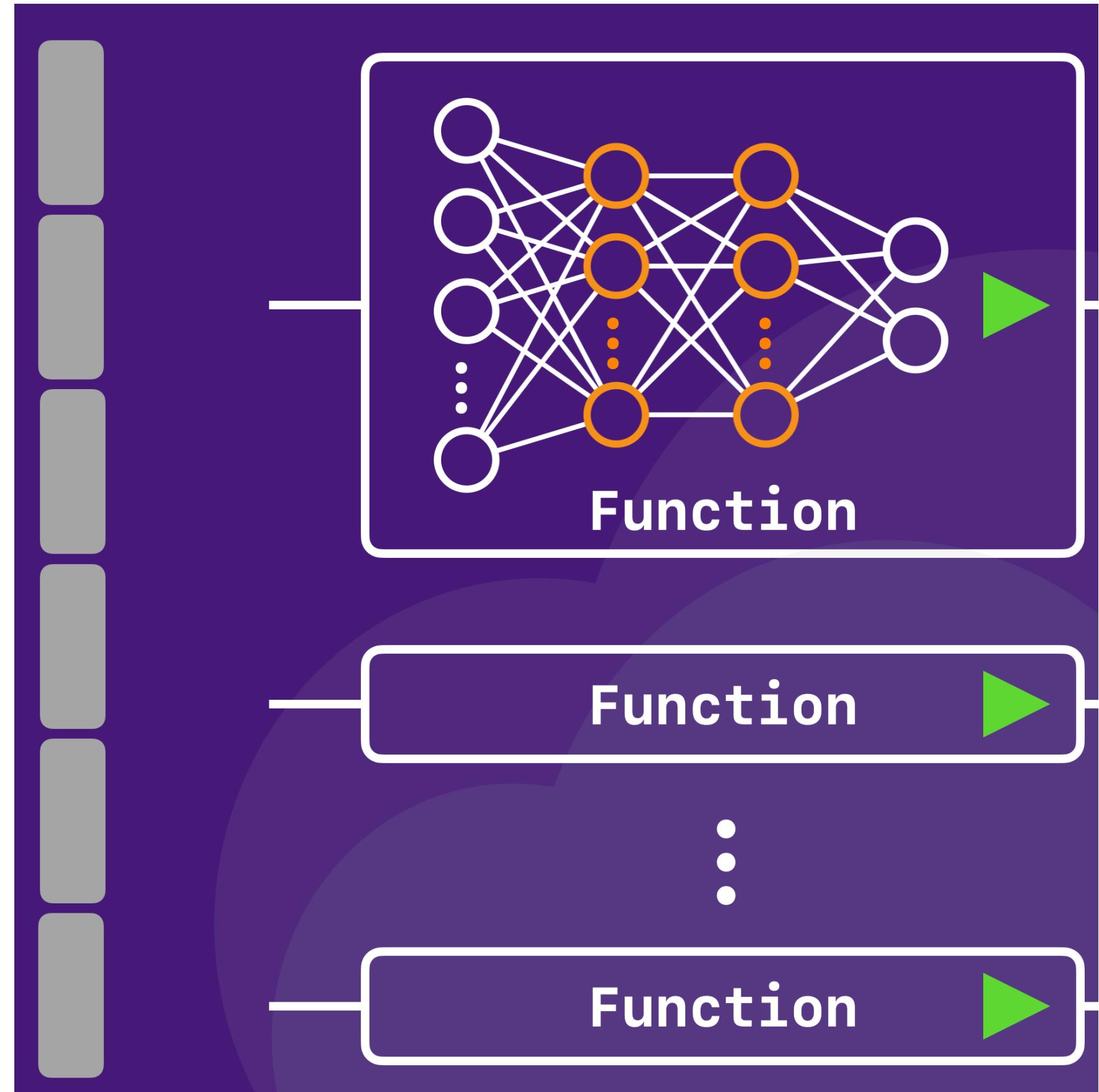
Traditional Cloud



Serverless Cloud

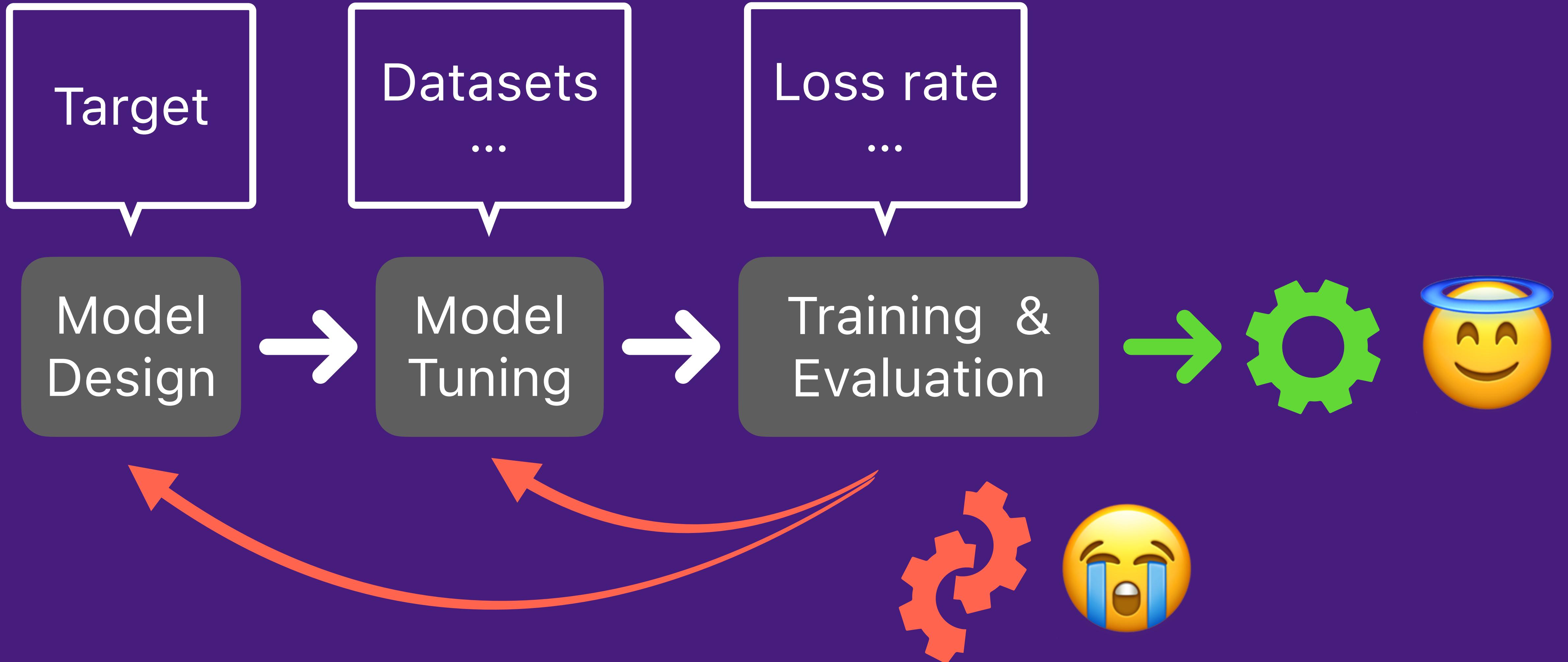


Projects Done

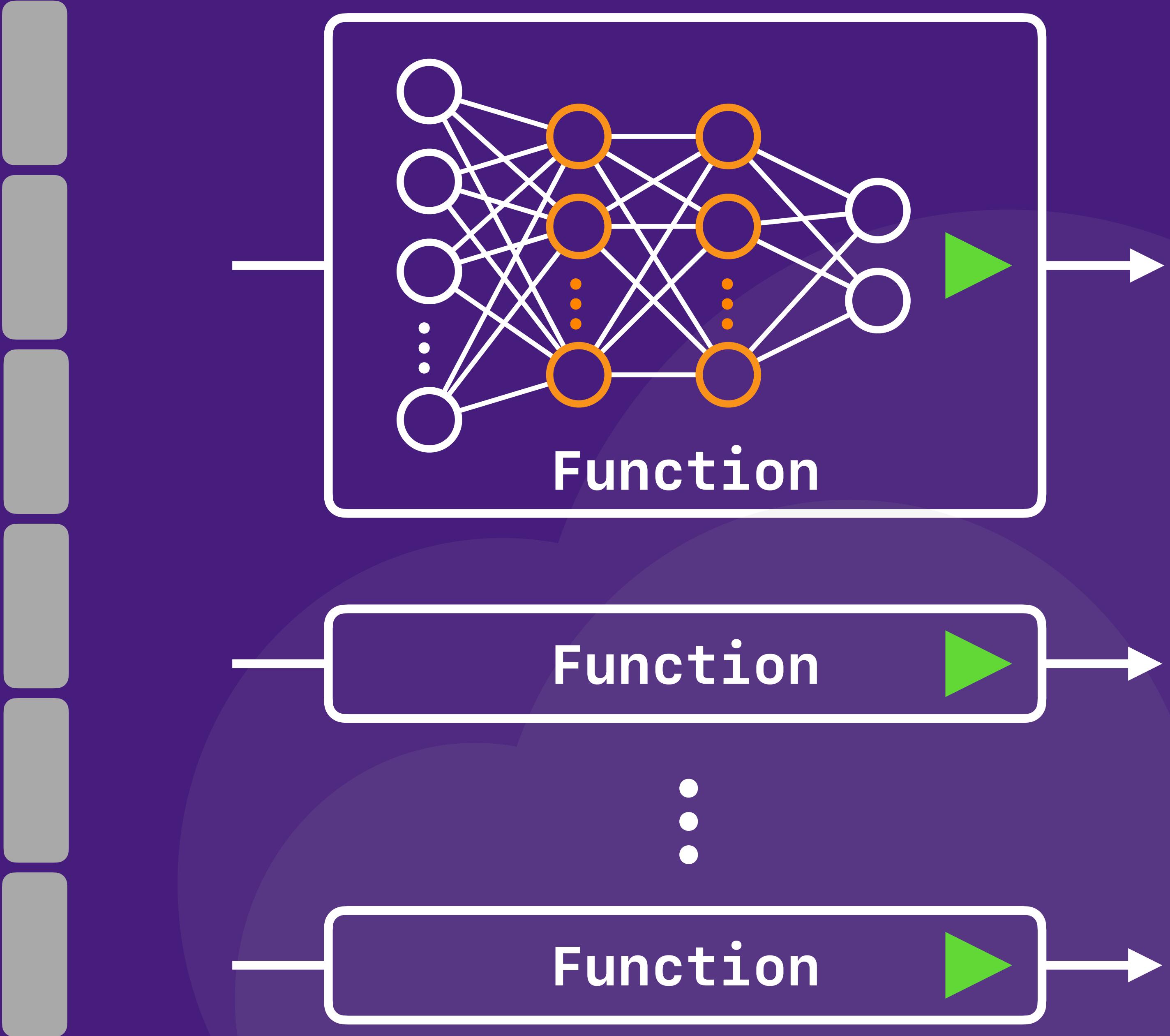


- Distributed Machine Learning with a Serverless Architecture
- [INFOCOM'19]
 - Serverless ML system
 - Resource provisioning

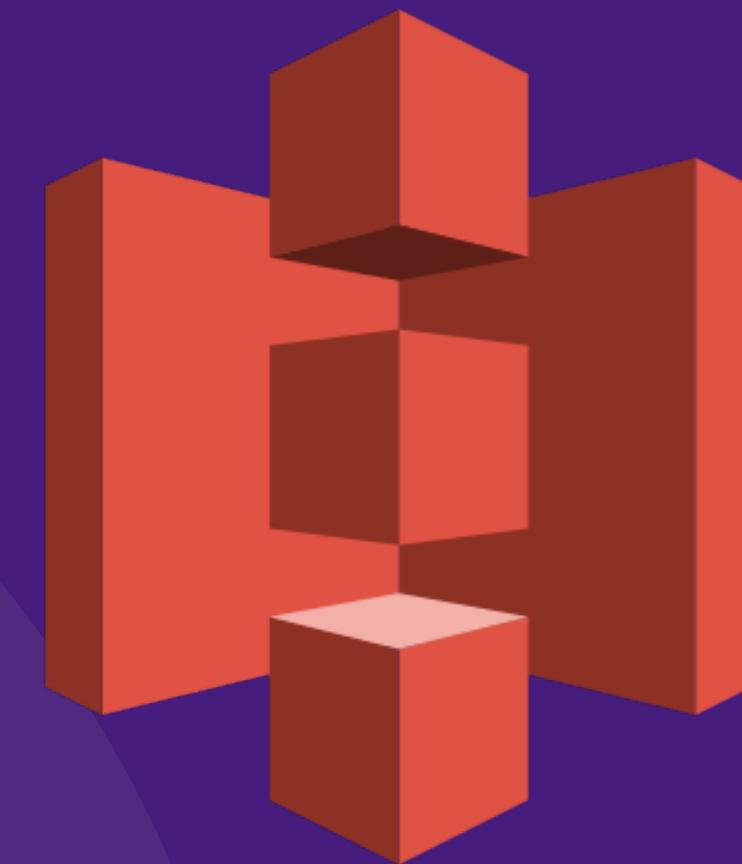
A General ML Workflow



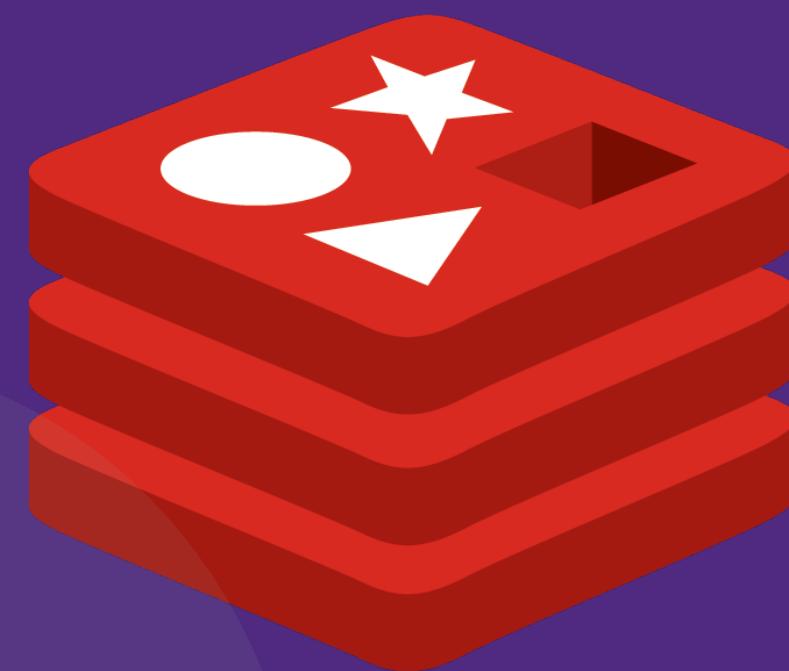
Input samples



KV Storage

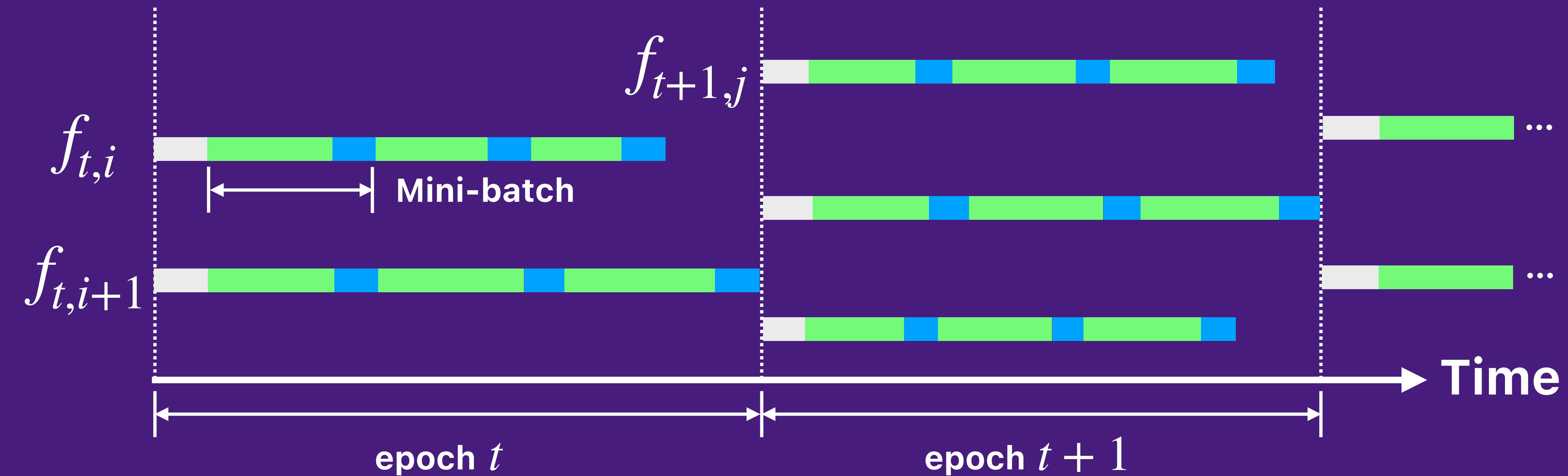


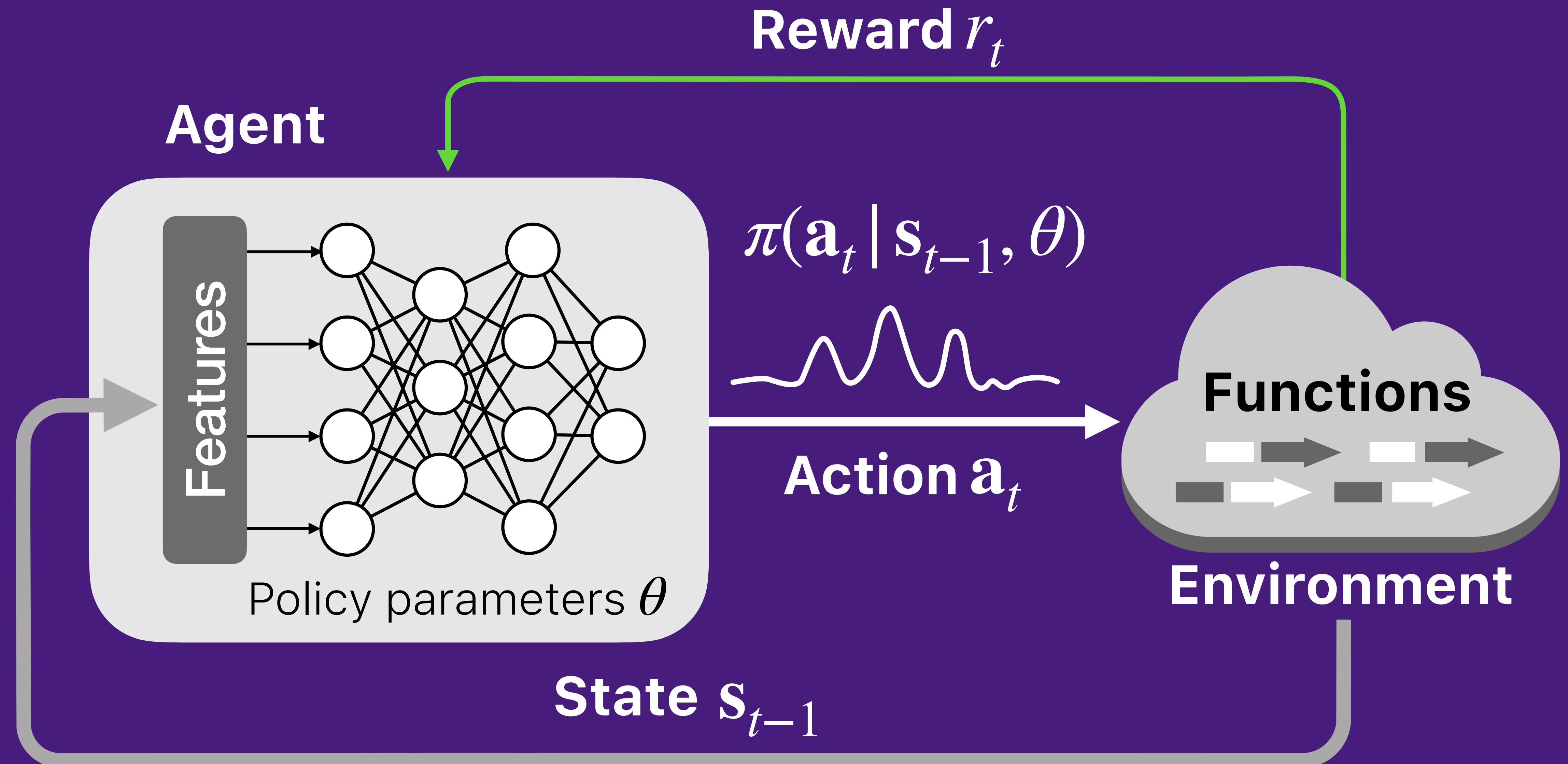
AWS S3

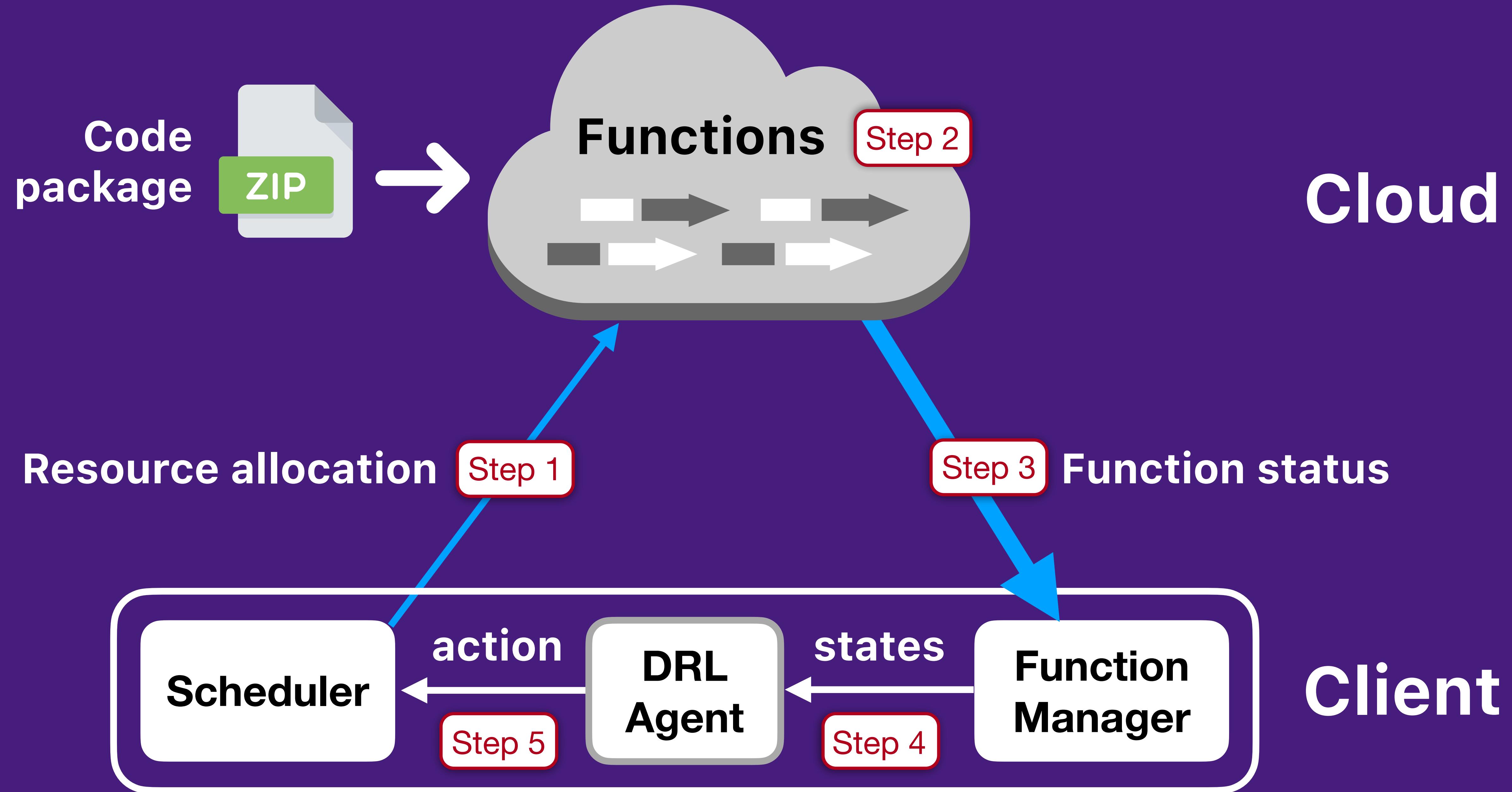


Redis

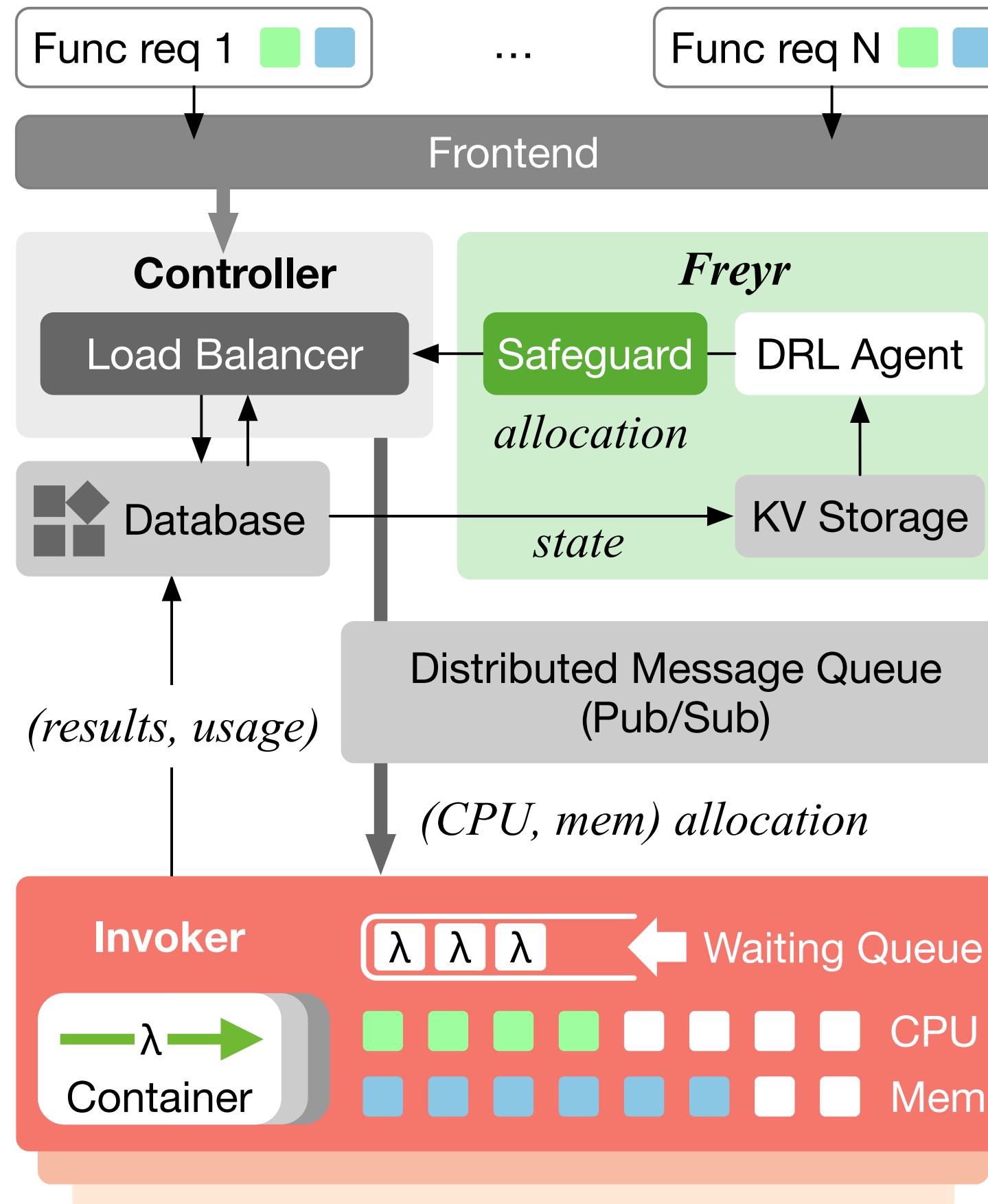
■ Fetching data ■ Computing ■ Updating Parameters





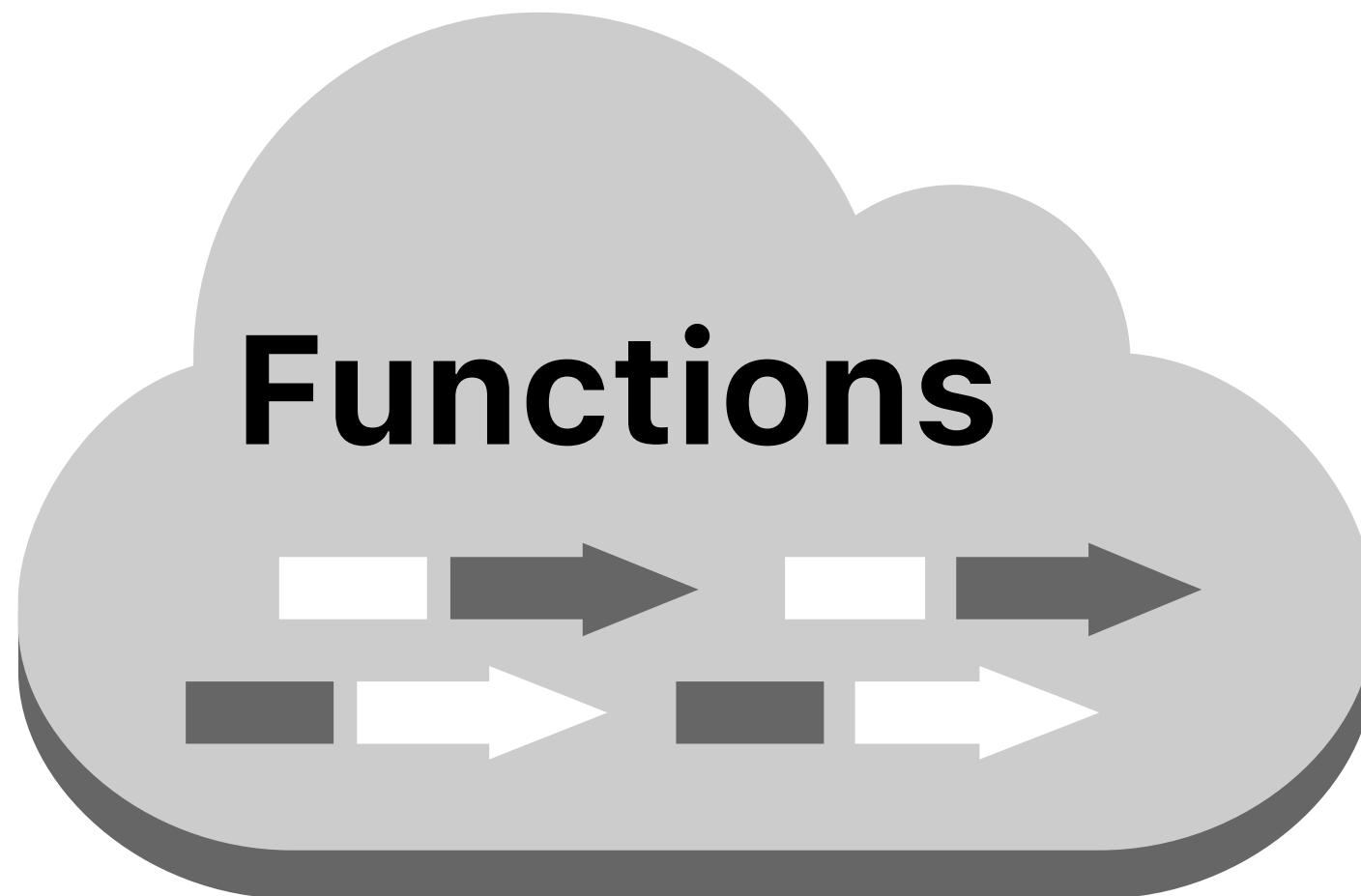


Projects Ongoing



- Resource Provisioning for Serverless
 - Resource rebalancing
 - Function acceleration

Projects Ongoing



- Optimizing Serverless
 - Function cold start
 - Resource provisioning
- New Serverless Applications
 - Serverless scientific computing
 - Serverless high performance computing

Wrap-up

- Federated Learning
 - Performance: stragglers, debugging
 - Security: Byzantine attacks & defense
- Serverless Computing
 - Cold start & other performance issues
 - New serverless applications



LSU

Louisiana State University