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FLScalize: Federated Learning Lifecycle Management Platform

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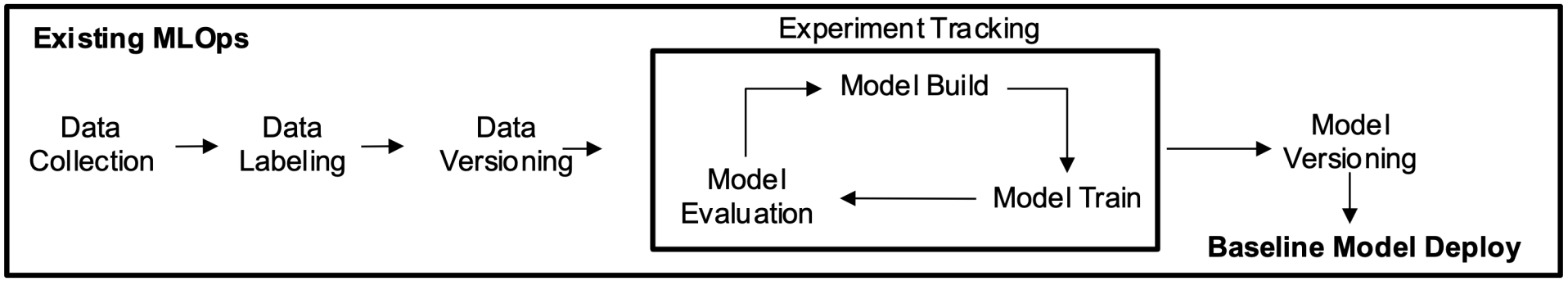
목차

Introduction

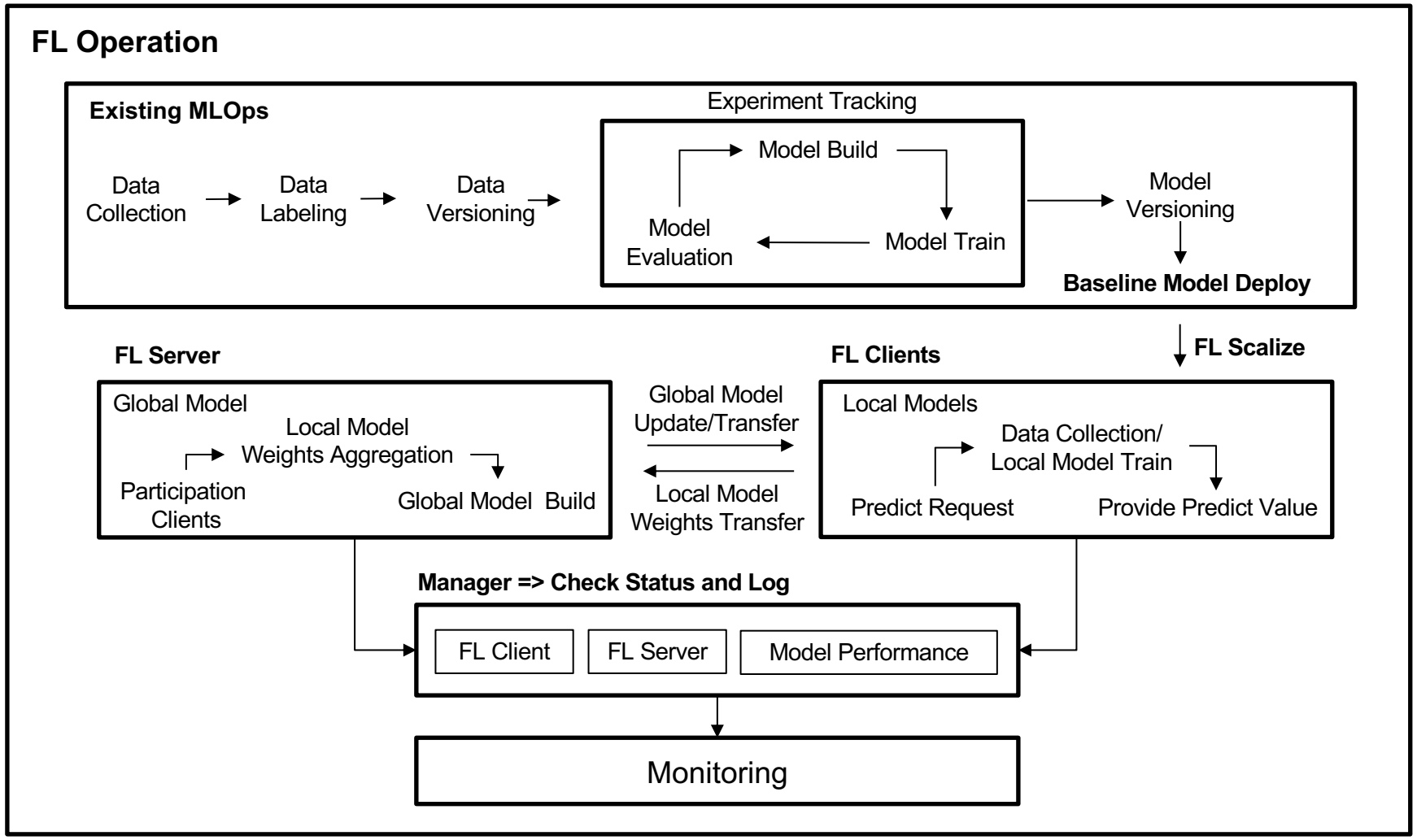
- 연합학습 수명주기 관리와 운영
  - 연합학습 구현을 위해 다양한 연합학습 프레임워크 등장
  - 많은 연구에서 연합학습 성능 향상을 위한 알고리즘 연구 수행
  - Real-World Project에 연합학습을 적용하여 수명주기 관리 및 운영할 수 있는 환경 필요
  - 현재, AI 연구 분야에서는 MLOps를 활용하여 데이터 파이프라인, 모델 설계/학습, 배포 기능 제공



  - 기존 MLOps는 수많은 Client를 보유하고 있는 연합학습 환경에 적합하지 않음
    => 기존 MLOps를 확장시킨 Federated Learning Operation (FedOps) 필요

Introduction

- 연합학습 수명주기 관리와 운영



Introduction

- FLScalize Contribution
  - Easily application of data and models to the FL environment
  - Manager component that checks the state of FL client and server
  - Continuous integration/deployment/training
  - Providing simulation environments for two categories of FL that occur in the real world (System/Data Heterogeneity)
  - FL lifecycle management applicable to real projects

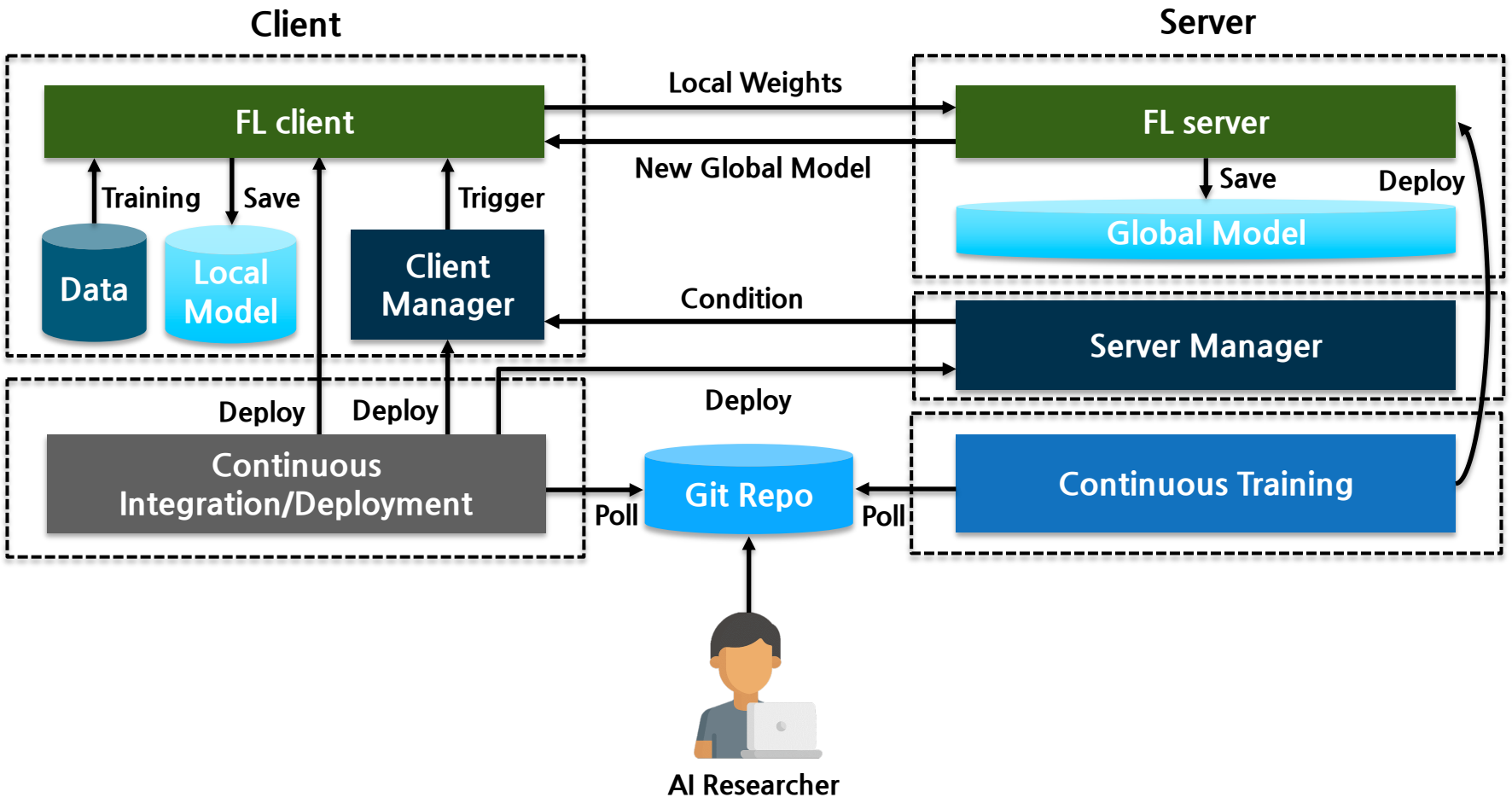
Related Research

- Comparision of FLScalize with Existing FL Frameworks

	TFF	FATE	FedScale	EasyFL	FLScalize
Simple application of data and model	○	○	○	○	✓
FL client/server management	X	X	X	X	✓
Heterogeneous system and data	○	○	○	✓	✓
Multi-client CI/CD/CT	X	○	X	X	✓
FL lifecycle management	X	○	X	○	✓

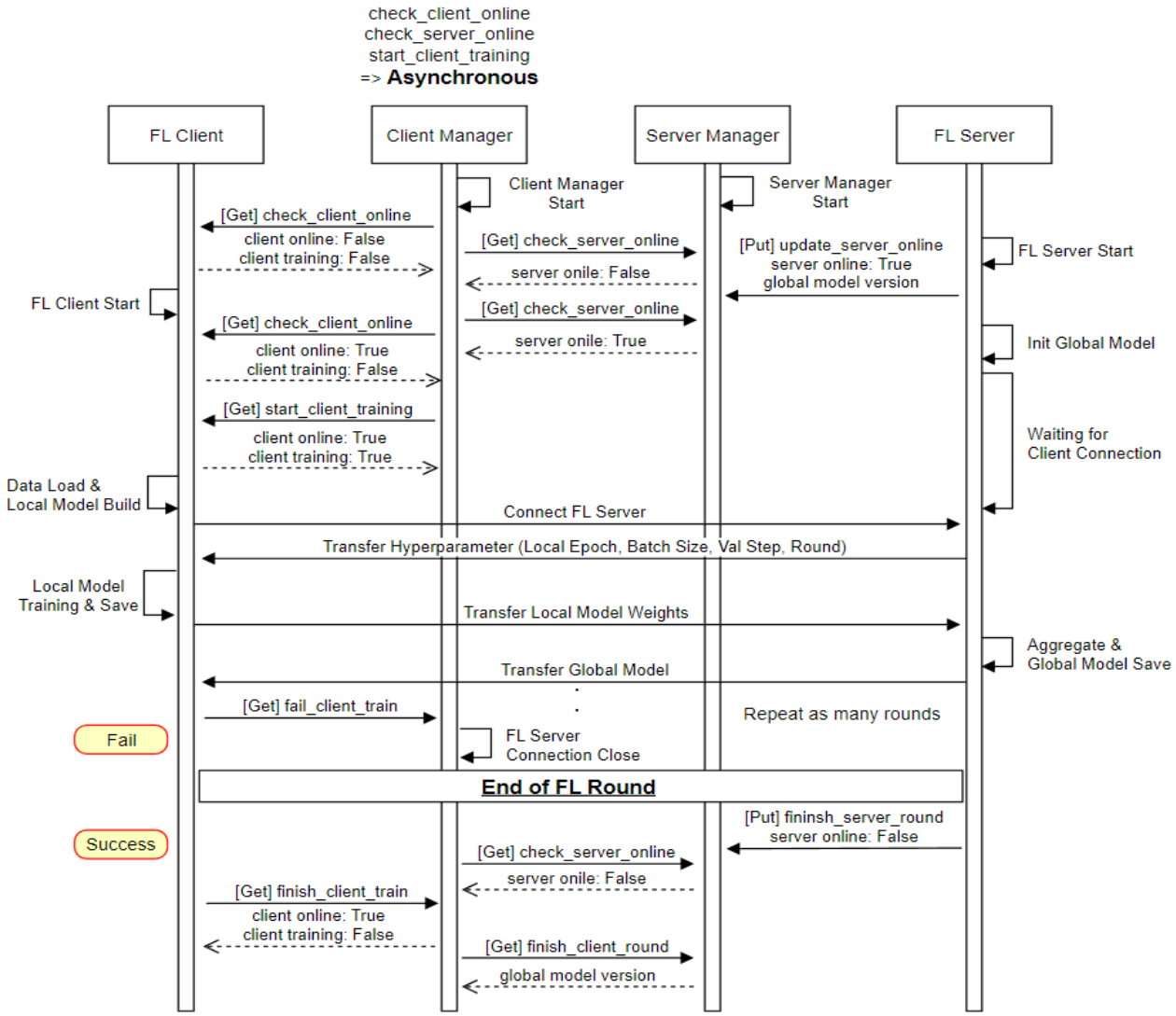
FLScalize System Design & Architecture

- FL Lifecycle Management



FLScalize System Design & Architecture

- FL Lifecycle Process



Experimental Environment Setup

- FLScalize Environment

Server Name	CPU	GPU
D Server	Intel i9-9900KF (8core)	NVIDIA®2080Ti (2)
E Server	Intel Xeon Silver 4214R (12core)	NVIDIA®3090Ti (2)
X Server	Intel i9-10980XE (18core)	NVIDIA®3070Ti (2)

microk8s cluster

Dataset	Model	Sample
CIFAR-10	CNN	60,000
MNIST	ResNet50	70,000
FASHION MNIST	VGG16	70,000

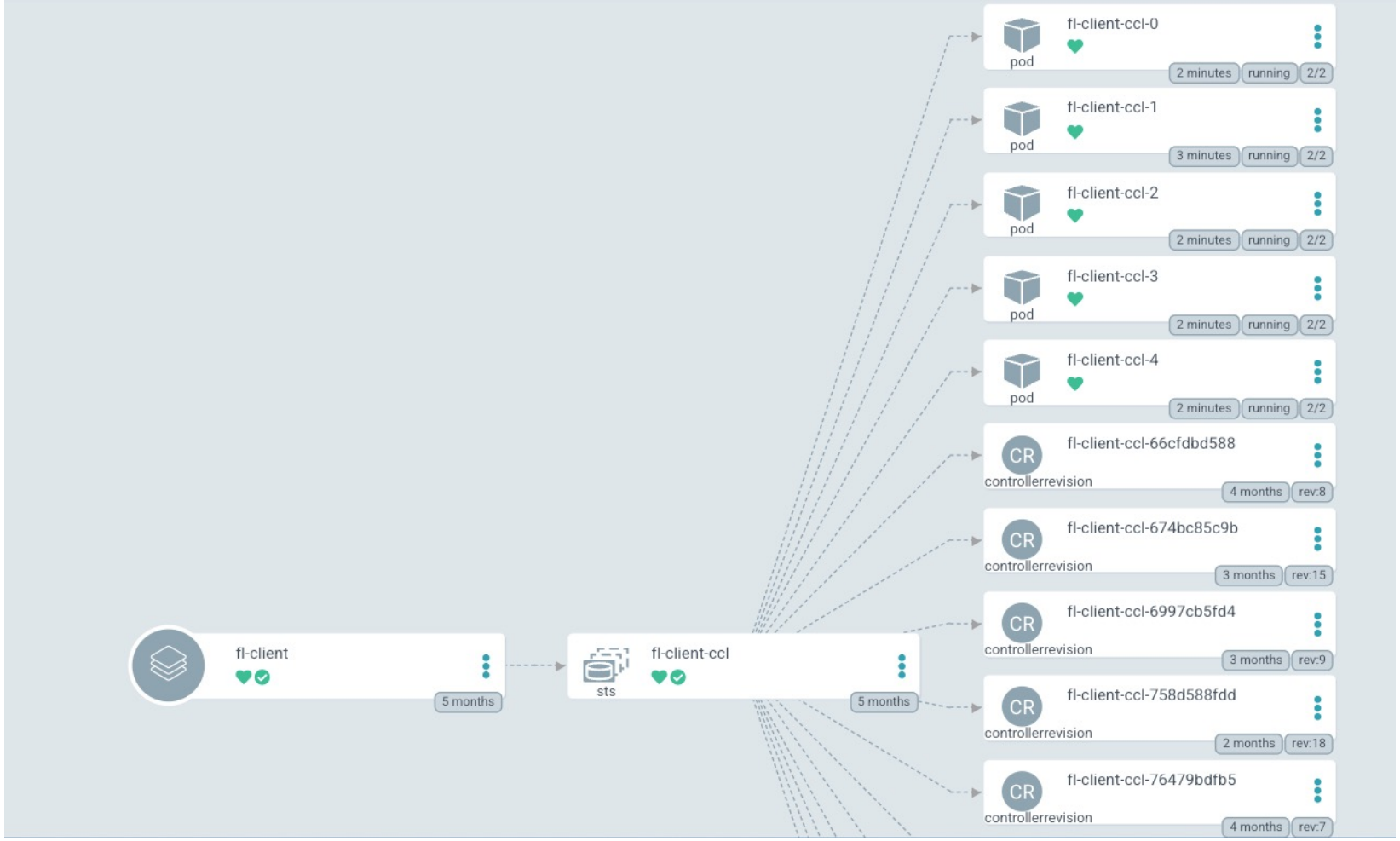
data/model

Non-IID	Description
Imbalanced Data	Each client is randomly distributed in different sizes
Skewed Data	Each client has only one class (or two/three classes)
Imbalanced /Skewed Data	Each client has only one class and is distributed in different sizes

data partition

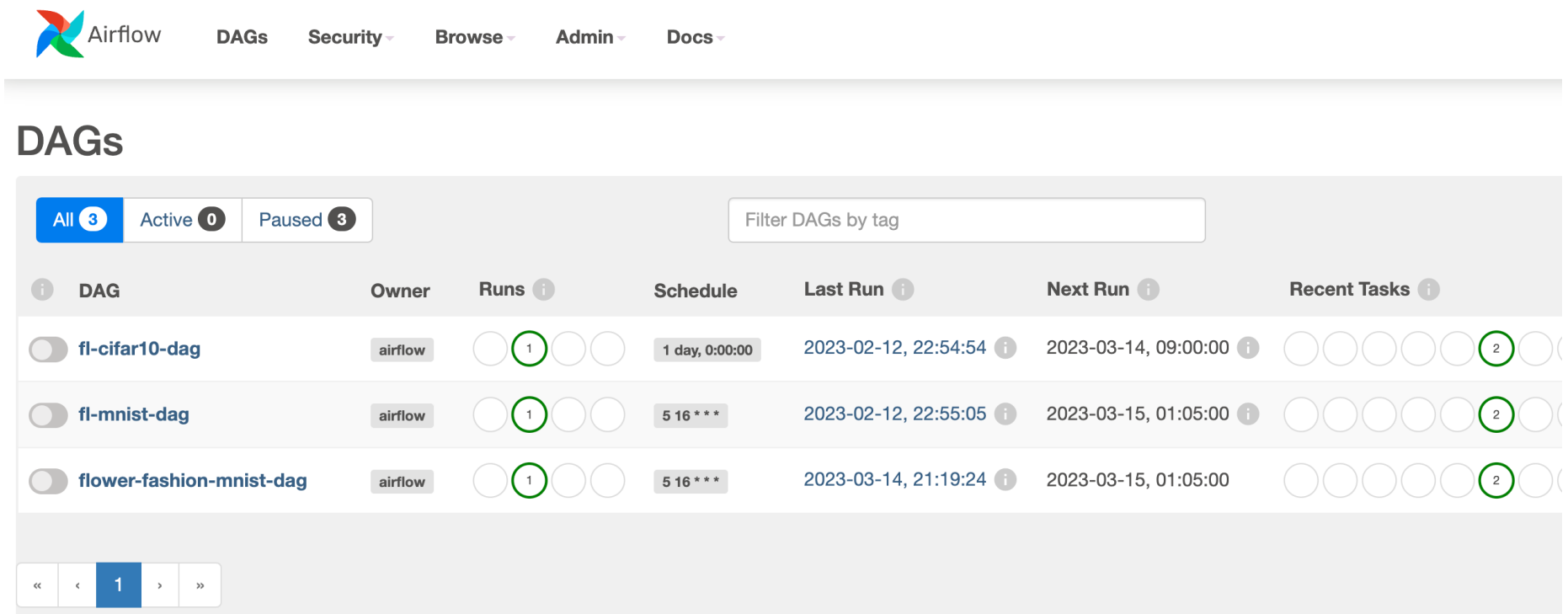
Implementation and Result

- Deploying and running five client pods using ArgoCD



Implementation and Result

- Creating three FL tasks (CIFAR-10, MNIST, and FASHION MNIST) to support a workflow that creates an FL round



Implementation and Result

- System/Data Heterogeneity Result

Client Group	System	Each Round Time	Local Training Time	Total Time
Group 1	CPU 1, Memory 2 GB	66.7 s	48.2 s	1,346.4 s
Group 2	CPU 3, Memory 4 GB	60.5 s	44.3 s	1,224.1 s
Group 3	CPU 1, GPU 1, Memory 2 GB	61.1 s	44.7 s	1,243.4 s

Time Cost

Data Heterogeneity	CIFAR-10		FASHION MNIST		MNIST	
	Local Model	Global Model	Local Model	Global Model	Local Model	Global Model
IID	91.8%	91.4%	96.6%	89.8%	95.6%	91.7%
Imbalanced	91.3%	91.1%	84.2%	80.6%	94.9%	91.5%
Skewed One Class	84.2%	81.9%	14.7%	32.1%	26.8%	13.4%
Skewed Two Class	88.6%	88.3%	25.2%	12.7%	25.9%	25.2%
Skewed Three Class	90.4%	89.7%	59.3%	55.9%	38.9%	33.6%
Imbalanced/ Skewed Three Class	89.3%	88.5%	49.1%	47.3%	29.9%	25.7%

Accuracy

Conclusion and Future work

- FLScalize
  - data와 model을 연합학습 환경에 간편하게 적용하고 다양한 FL Task 생성
  - client/server 상태를 지속적으로 확인하고 관리하는 Manager Component와 Multi-Client의 Resource 구성 환경
  - 지속적인 통합/배포 및 학습할 수 있는 Federated Learning Lifecycle Management
  - 자신의 FL Task 실험을 위해 System/Data Heterogeneity Simulation 환경 제공

- FLScalize of the Future => FedOps
  - microk8s 서버환경이 아닌 실제 여러 Client와 Server를 분리한 환경에서의 FL Lifecycle Management 지원
  - 실제 디바이스(Mobile/IoT/PC)를 Client로 적용하여 Real Multi FL Client 관리/모니터링/운영 서비스 제공
    => FedOps Platform으로 확장

FLScalize 실습

- docker 설치 (https://www.docker.com/)
- anaconda prompt 실행

- FedOps Git clone

-mac: git clone https://github.com/Kwangkee/Gachon.git && mv Gachon/pratice/FedOps . && rm -rf Gachon

-window: git clone https://github.com/Kwangkee/Gachon.git && move Gachon\\practice\\FedOps . && del Gachon

- conda create –n fedops python=3.9
- conda activate fedops
- git clone해서 받은 폴더로 이동 => cd FedOps
- pip install –r requirements.txt
- conda install tensorflow==2.10.0 keras==2.10.0
- pip install numpy –-upgrade

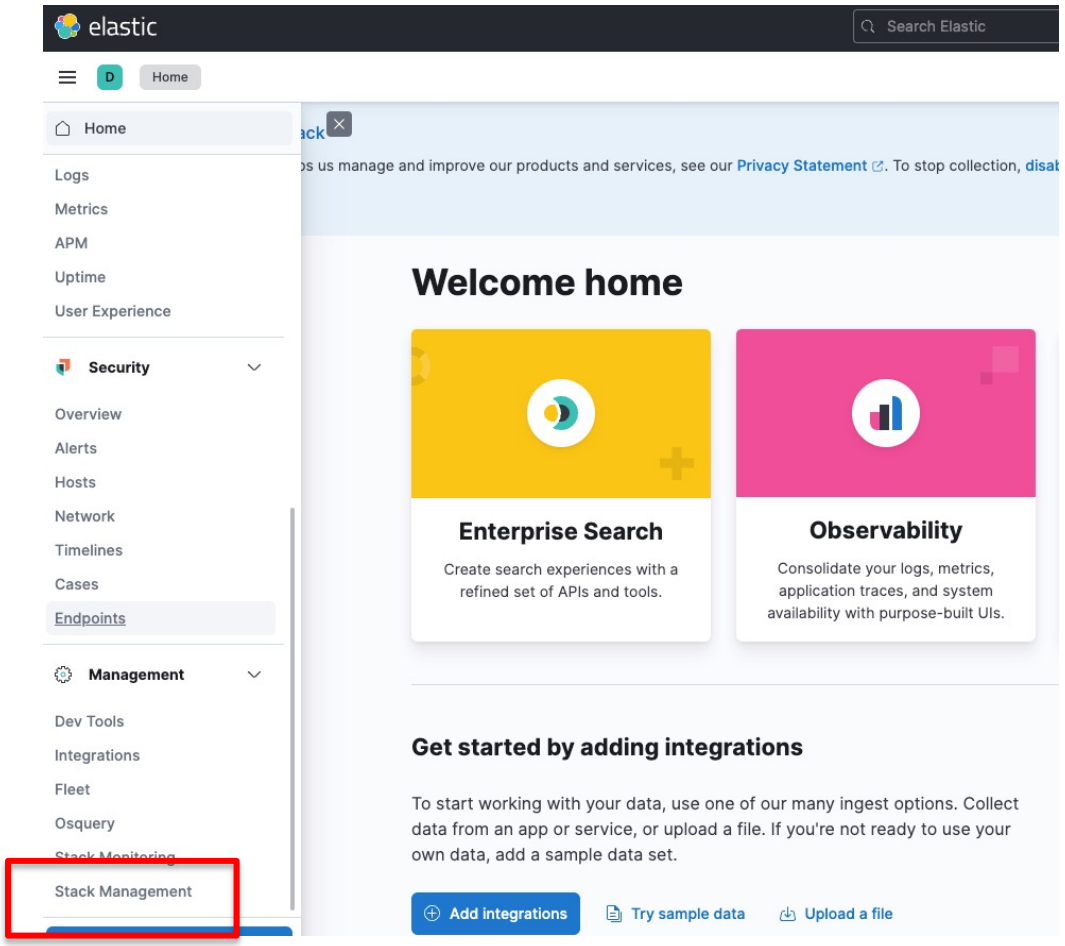
FLScalize 실습

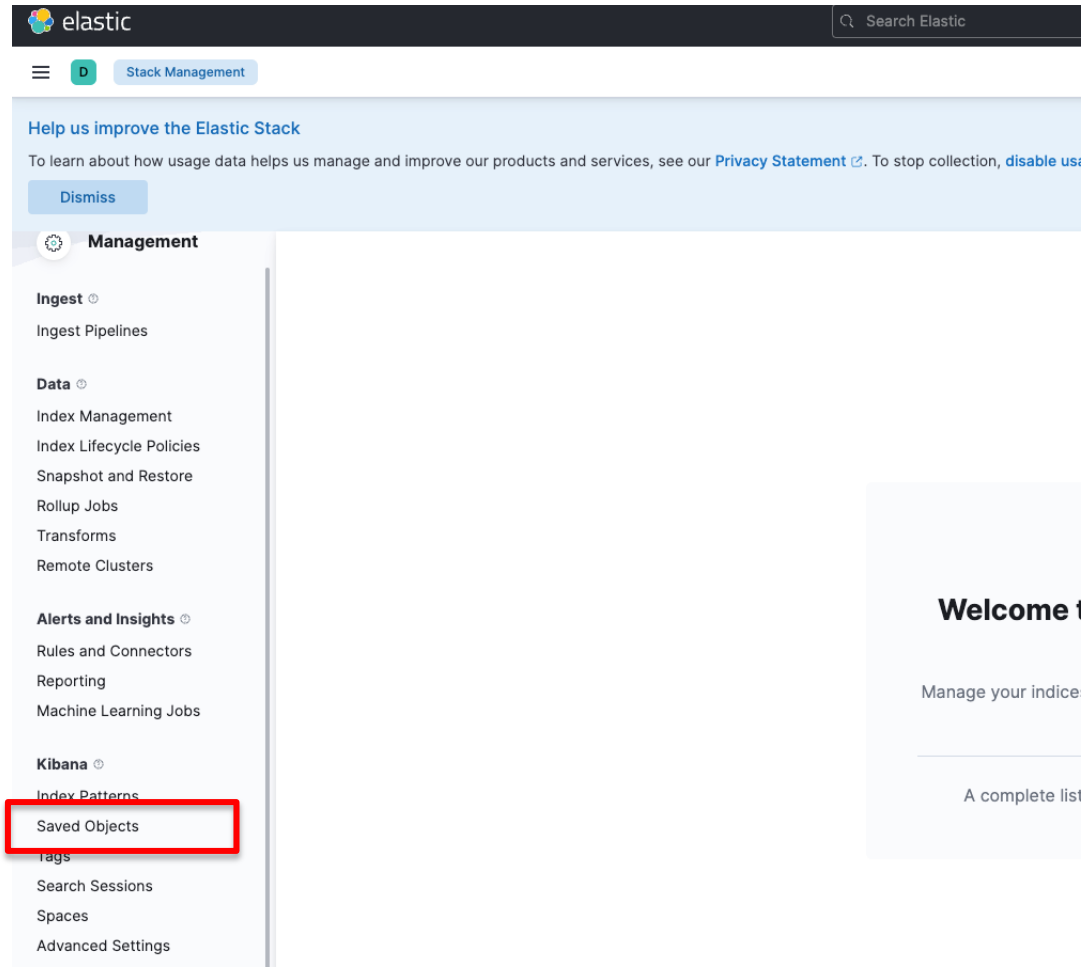
- 1. Server Manager 실행
  - cd FedOps/server_manager
  - conda activate fedops
  - python app.py
- 2. FL Server 실행
  - 또 다른 shell 창 실행
  - cd FedOps/server
  - conda activate fedops
  - python app.py
- 3. Client Docker Compose 실행
  - docker 실행
  - 또 다른 shell 창 실행
  - cd FedOps/server
  - cd git_clone경로/FedOps/cross_silo
  - sh monitoring.sh
    (window는 git bash에서 실행)
    (window는 맨 마지막 커맨드 주석 해제)
  - error 발생 시

  => docer-compose-monitoring.yaml 파일에서
  fl-client, client_manager의 cpus 변경
  fl-client -> “1” client_manager -> “0.5”

FLScalize 실습

- Client Monitoring Dashboard 설정





FLScalize 실습

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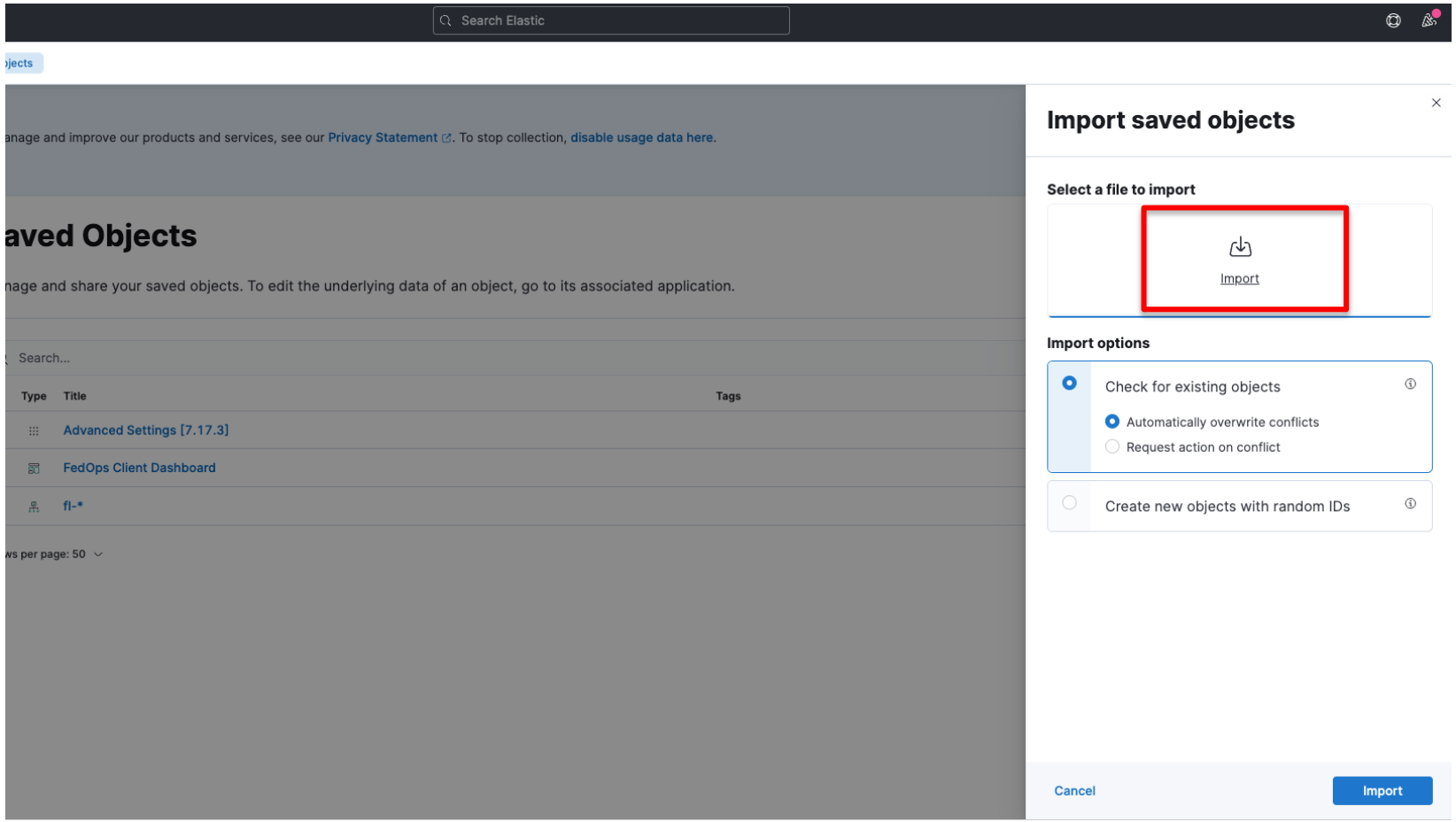

- Fedops/cross_silo 디렉토리에 있는 파일 import

“FedOps_Client_Dashboard_V3.ndjson”

FLScalize 실습

- Client Monitoring Dashboard 설정