# PS-008:
# Network failure classification model using network digital twin

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# Background

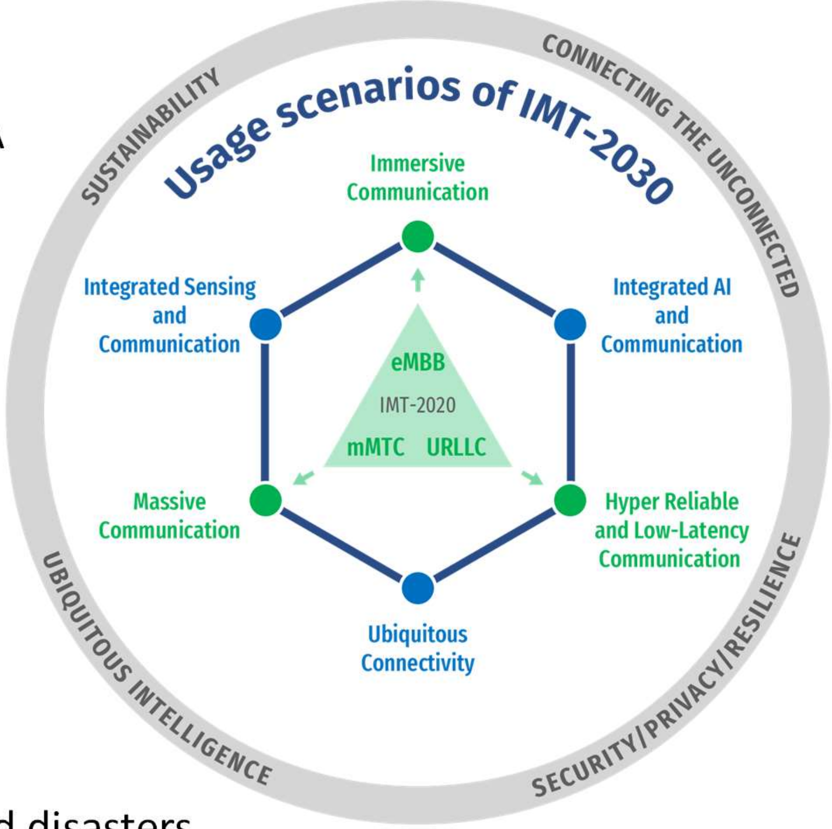
KDDI Research

## ■ Challenge in 5G and Beyond 5G (B5G)

- 5G
  - eMBB, URLLC, mMTC
  - Network Slicing for integrating these features according to SLA
  - Virtualization (VNF, CNF)

- Challenge
  - A greater number of components in networks
  - Increase in operational workloads

- IMT-2030
  - Extended features of eMBB, URLLC, mMTC
  - New aspect: Sensing, AI, Ubiquitous
  - Combination of features for respective scenario
  - Same challenge would remain in B5G
  - How to establish resilient networks against such as failures and disasters

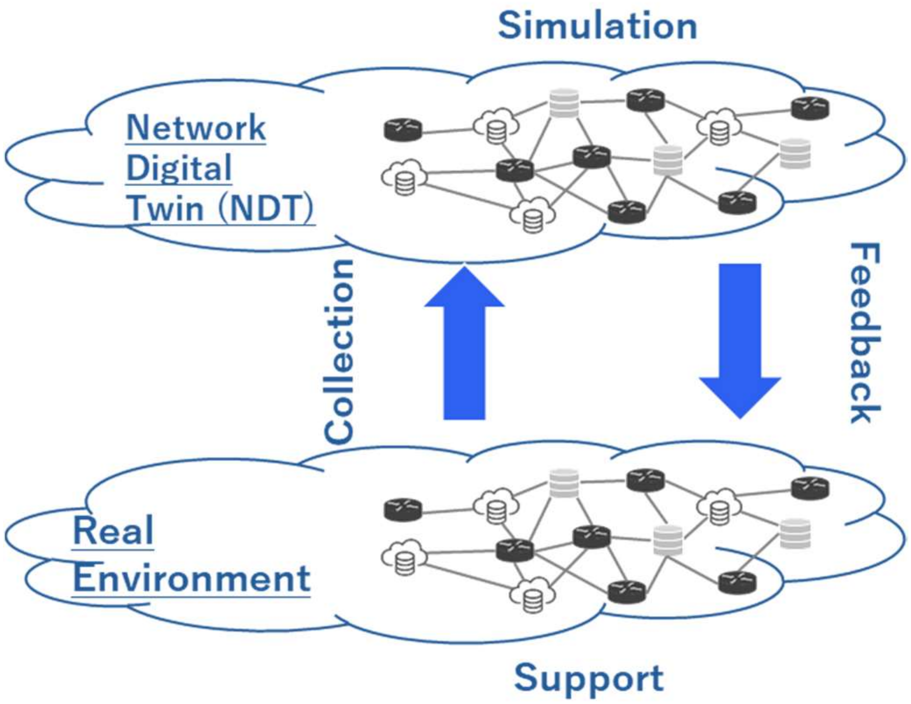

Usage scenarios of IMT-2030
SUSTAINABILITY
CONNECTING THE UNCONNECTED
UBIQUITOUS INTELLIGENCE
SECURITY/PRIVACY/RESILIENCE
Immersive Communication
Integrated Sensing and Communication
Integrated AI and Communication
eMBB
IMT-2020
mMTC
URLLC
Massive Communication
Hyper Reliable and Low-Latency Communication
Ubiquitous Connectivity

ITU-R, IMT.FRAMEWORK FOR 2030 AND BEYOND

# Background

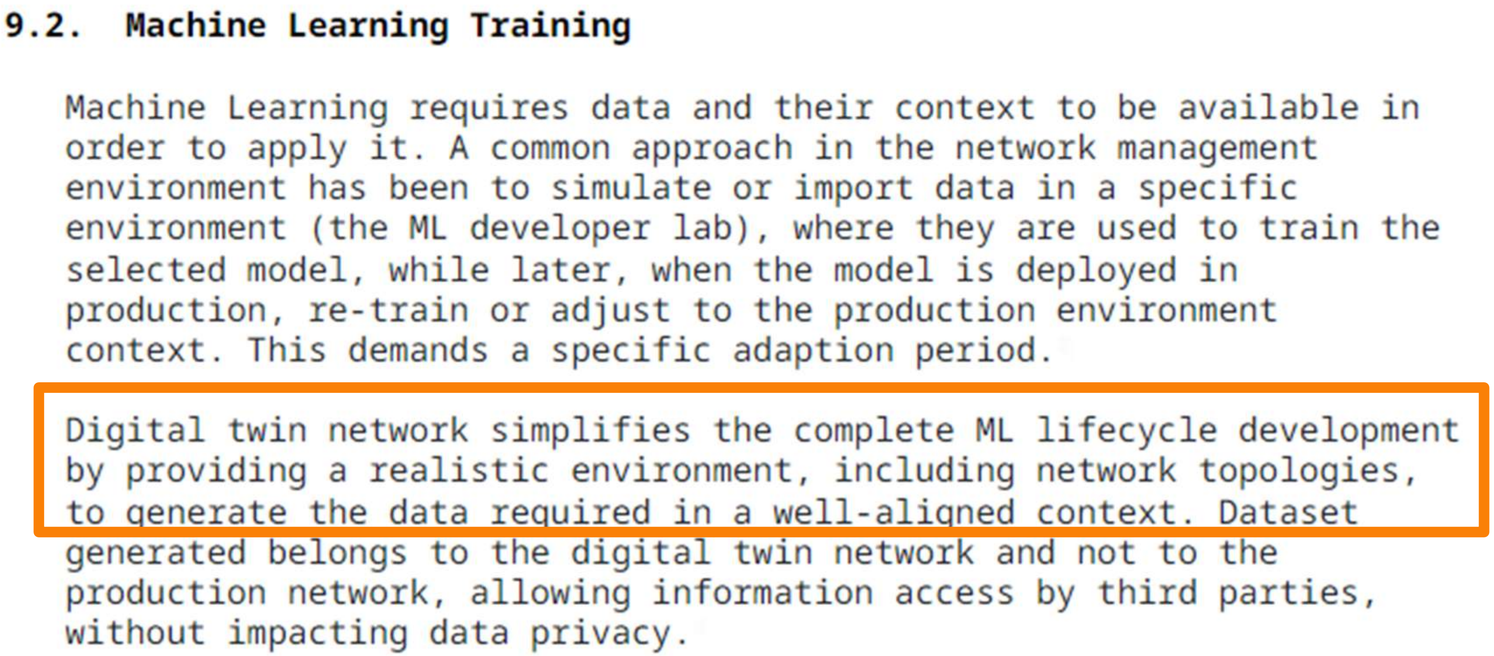
## ■ Network Digital Twin

- Network Digital Twin (NDT) is a mirror network for a real network for supporting actual operations in a real environment.
- Step in using NDT
  1. Collect network information from a real environment
  2. Perform a variety of practical simulations on NDT
  3. Feedback to support operational tasks on a real environment
- Use Case in IRFT document(*)
  - Human Training
  - Machine Learning Training
  - DevOps-Oriented Certification
  - Network Fuzzing
  - Network Inventory Management



*draft-irtf-nmrg-network-digital-twin-arch

# Use Case: Machine Learning Training

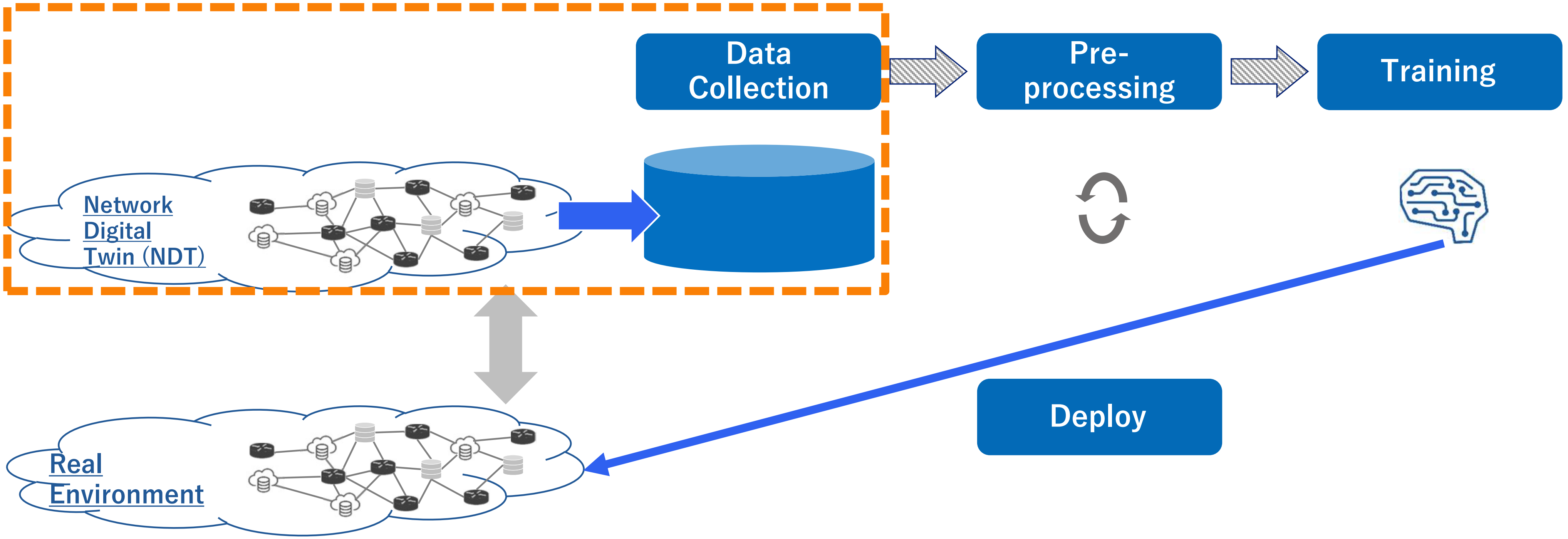


### 9.2. Machine Learning Training

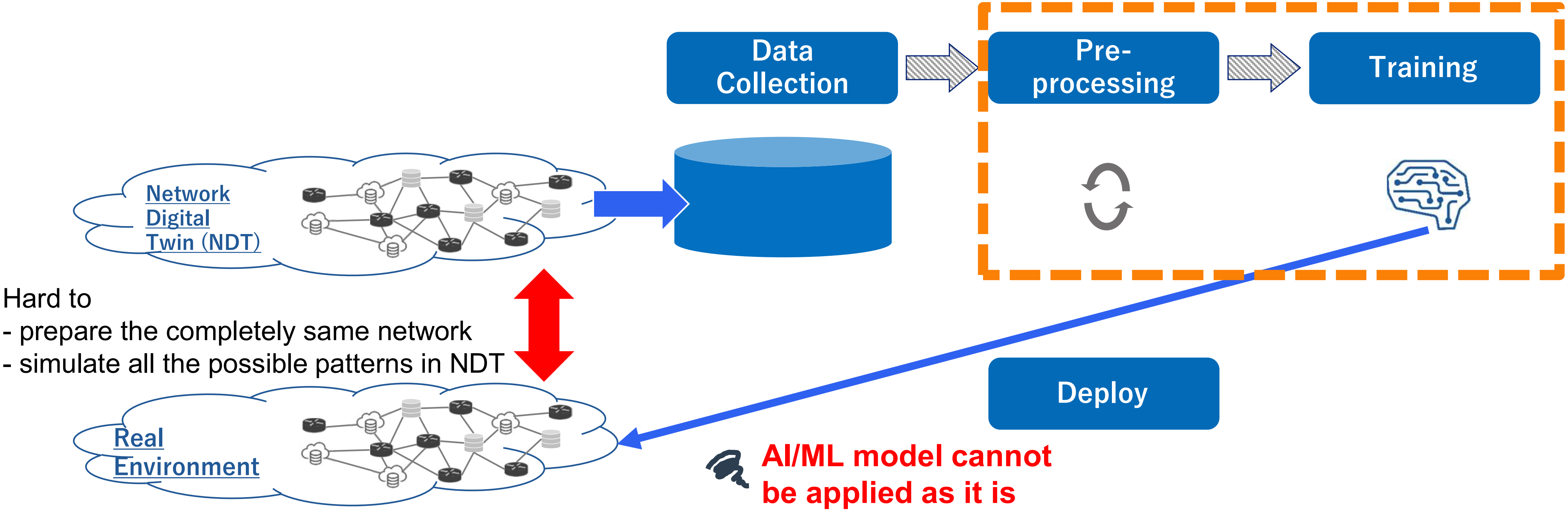
Machine Learning requires data and their context to be available in order to apply it. A common approach in the network management environment has been to simulate or import data in a specific environment (the ML developer lab), where they are used to train the selected model, while later, when the model is deployed in production, re-train or adjust to the production environment context. This demands a specific adaption period.

Digital twin network simplifies the complete ML lifecycle development by providing a realistic environment, including network topologies, to generate the data required in a well-aligned context. Dataset generated belongs to the digital twin network and not to the production network, allowing information access by third parties, without impacting data privacy.

# Challenge for ML Training on NDT



# Challenge for ML Training on NDT



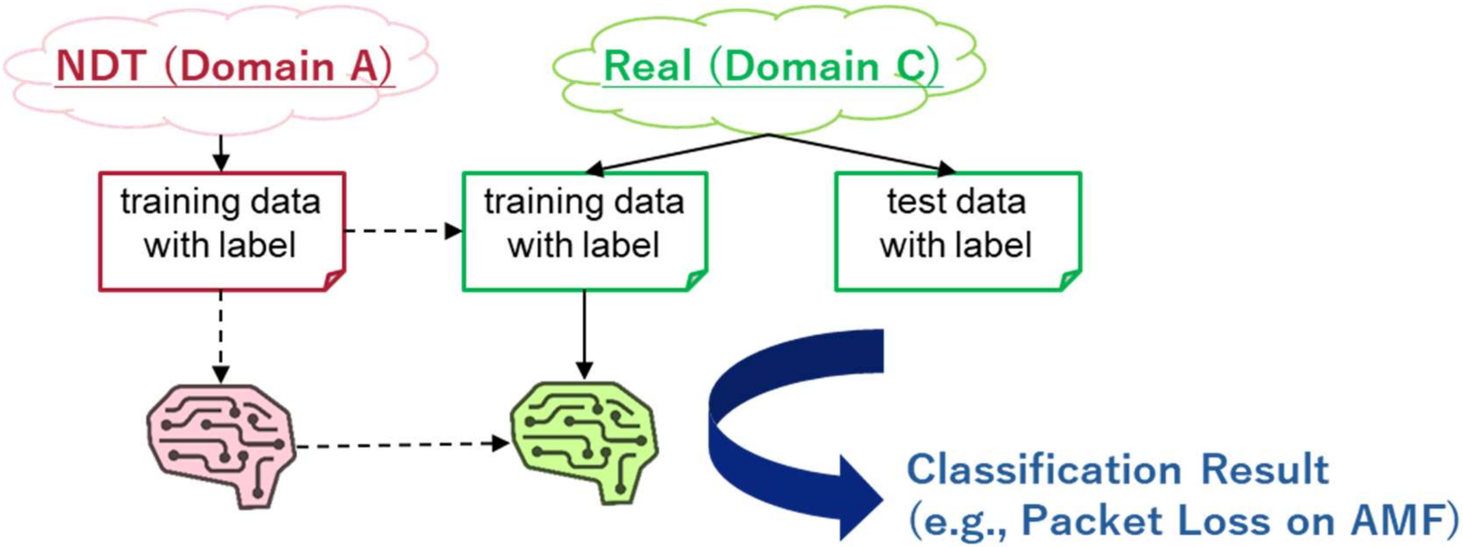
Hard to
- prepare the completely same network
- simulate all the possible patterns in NDT

AI/ML model cannot be applied as it is

**The approach to create ML models from NDT data should be somehow refined to obtain good models for supporting the actual network operation.**

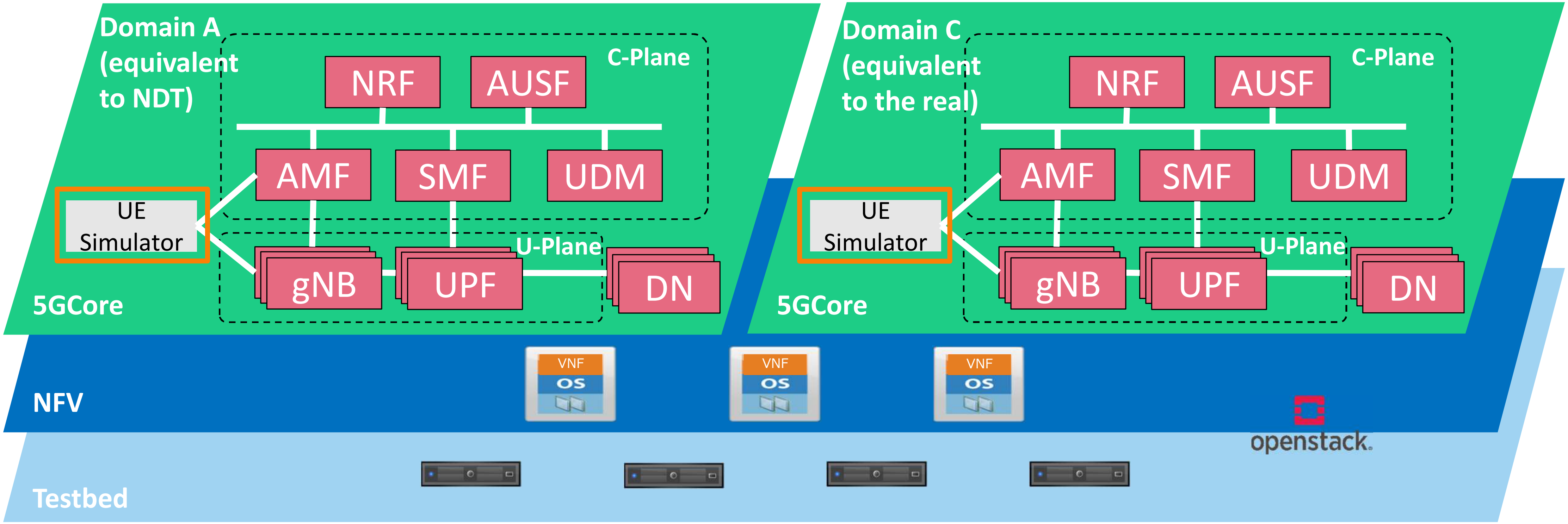
# Purpose of our problem

- To create a good ML model using the dataset generated in network digital twin
  - Network failure classification model, i.e., Root Cause Analysis (RCA) model
  - Train models on training data collected from NDT (Domain A, large volume) and training data from Real (Domain C, small volume)
  - Evaluate the trained models with test data from Real (Domain C)
  - The goal is to develop a good failure classification model in terms of F1-score



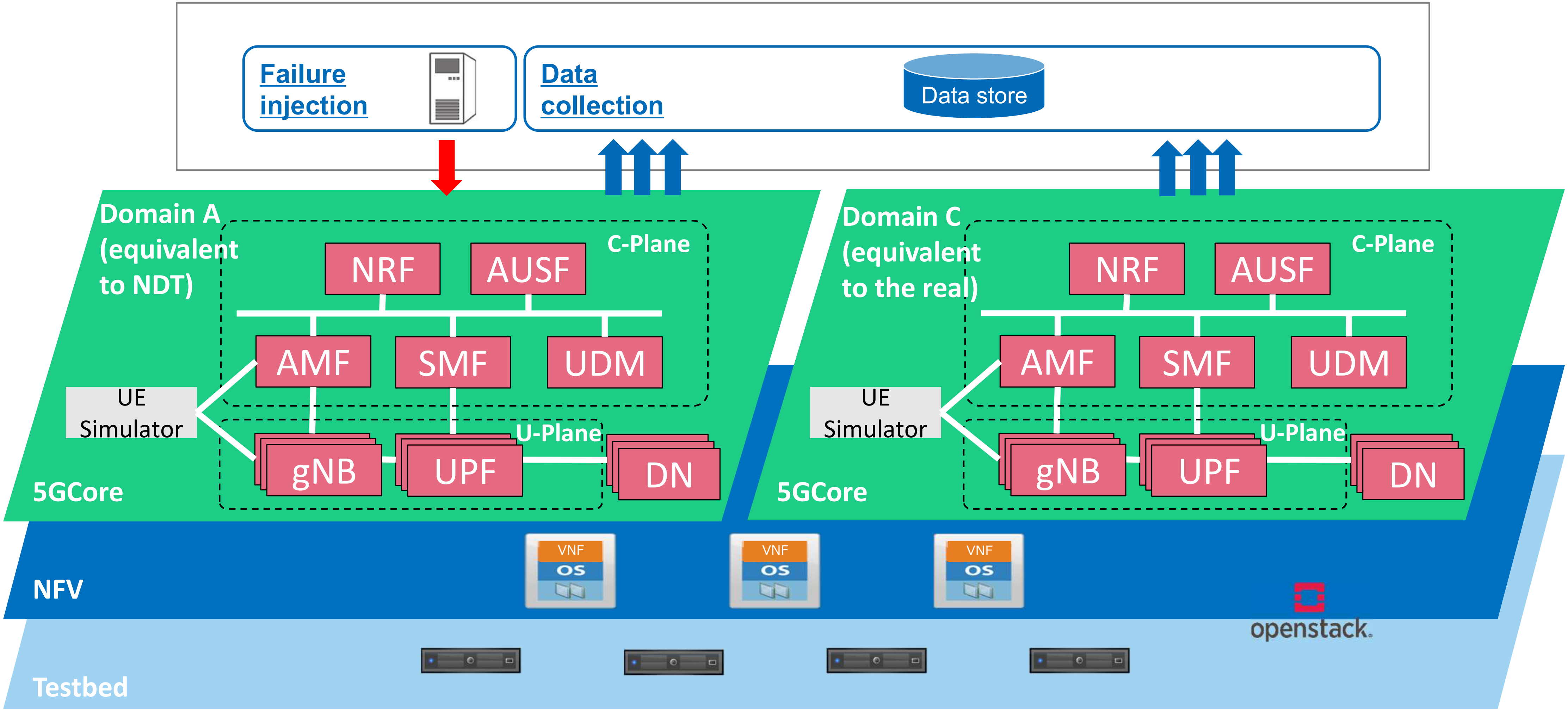
# Environment

We set two VNF-based 5G mobile core networks (same topology)

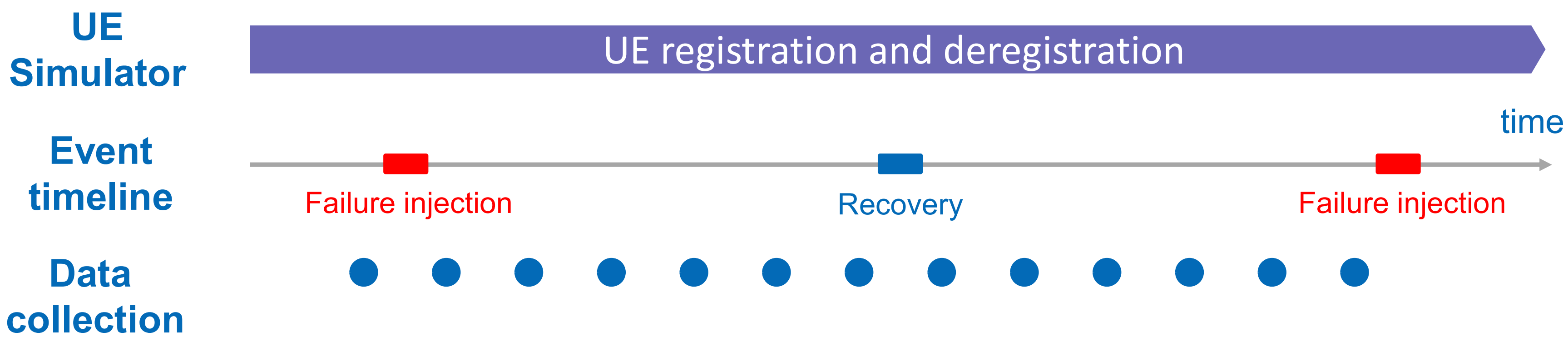


UE Simulator generates different trend of calls

# Environment



# Test scenario



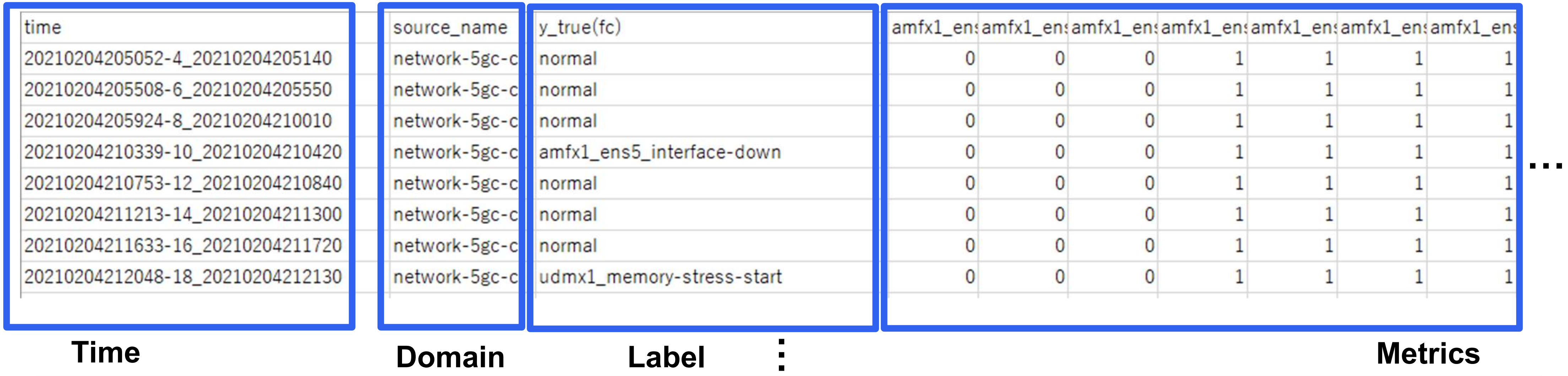
## ■ Failure Event Type

- Failure Type
  - Bridge down (bridge-delif)
  - Interface down (interface-down)
  - Packet loss (interface-loss-start-70)
  - Memory stress (memory-stress-start)
  - CPU overload (vcpu-overload-start)
- Failure Pont
  - AMF (amfx1)
  - AUSF (ausfx1)
  - UDM (udmx1)

- Scenario for domain A and scenario for domain C includes the same failure event type with the same occurrence rate, but total number of failure injections in domain C scenario is smaller than that in domain A scenario.

# Dataset

- For training
  - training-data_a.csv
    - Collected in domain A
    - 80 samples per failure label
  - training-data_c.csv
    - Collected in domain C
    - 10 samples per failure label
- For test
  - test-data_c.csv
    - Collected in domain C
- Dataset Example

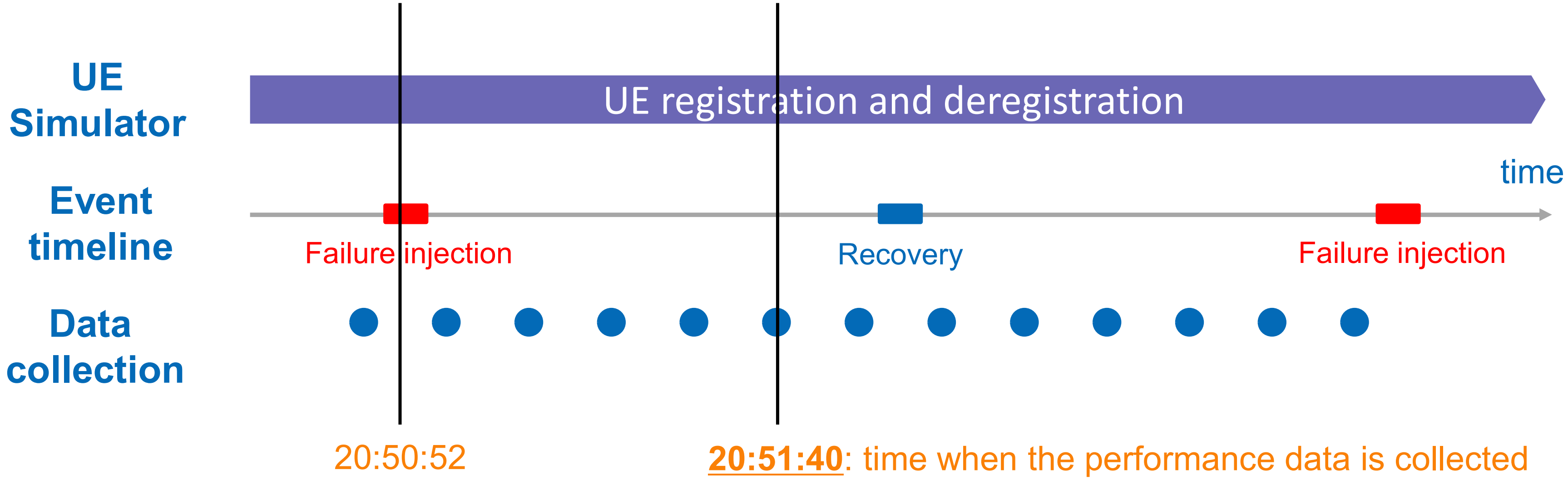


| time | source_name | y_true(fc) | amfx1_ens | amfx1_ens | amfx1_ens | amfx1_ens | amfx1_ens | amfx1_ens | amfx1_ens |
|---|---|---|---|---|---|---|---|---|---|
| 20210204205052-4_20210204205140 | network-5gc-c | normal | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204205508-6_20210204205550 | network-5gc-c | normal | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204205924-8_20210204210010 | network-5gc-c | normal | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204210339-10_20210204210420 | network-5gc-c | amfx1_ens5_interface-down | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204210753-12_20210204210840 | network-5gc-c | normal | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204211213-14_20210204211300 | network-5gc-c | normal | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204211633-16_20210204211720 | network-5gc-c | normal | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 20210204212048-18_20210204212130 | network-5gc-c | udmx1_memory-stress-start | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

# Dataset: Time

## ■ Time

- {start time of event}-{number}_{data collection time}
- Example: “*20210204205052-4_20210204205140*”



# Dataset: Label

- ■ Label for failure classification
  - ■ normal case
    - ●*“normal”*
  - ■ Failure case
    - ●combination of failure point and type
    - ●{failure-point}_{failure-type}
    - ●Example: *“amfx1_ens5_interface-down”*<br>*“udmx1_vcpu-overload-start”*
  - ● Total 16 labels are contained in all datasets.

# Dataset: Metric

## ■ Metric

- {instance name}(_{interface name})_{metric name}_value
  - {interface name} is used only for interface-related metrics

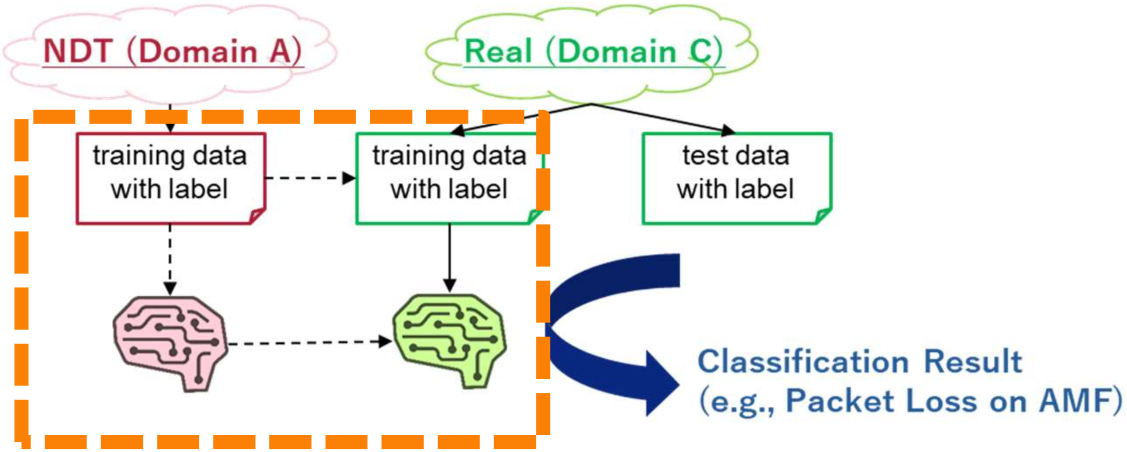
- Interface
  - Example: “*amfx1_ens3_statistics.in-octets_value*”
    - The incoming octets on the network interface “ens3” of instance “amfx1”

- Memory, CPU
  - Example: “*amfx1_memory-stats.used-percent_value*”
    - The percentage of memory usage on the instance “amfx1”

# Task

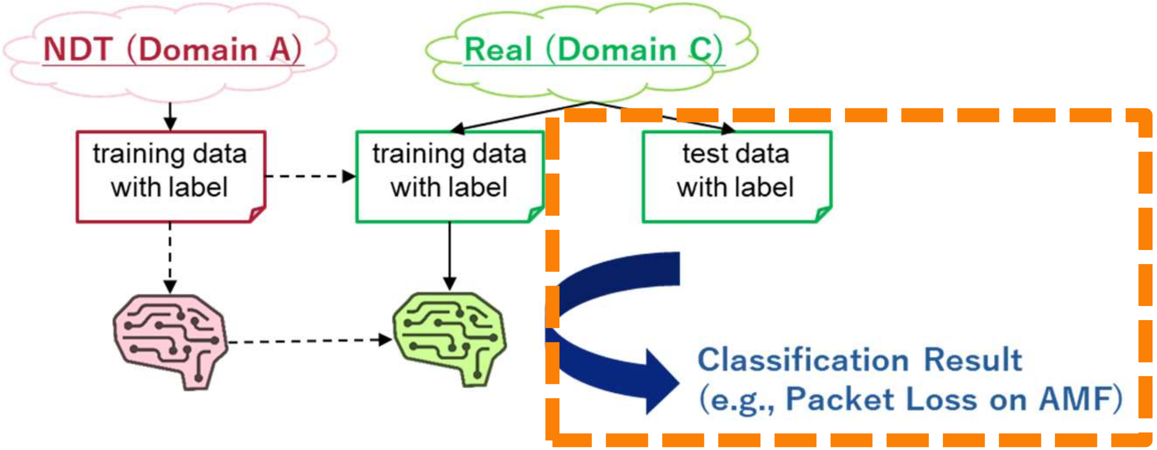
■Create a network failure classification model using the dataset generated in network digital twin

- <u>Training</u>
  - Participants will train a failure classification model for domain C utilizing the training data from domain A and the training data from domain C with label.



# Task

- Create a network failure classification model using the dataset generated in network digital twin
  - Evaluation
    - Participants will evaluate the failure classification result with the test data with label based on the created model.
      1. Create a confusion matrix using the test data
      2. Calculate F1-score for each label



# Task

## ■ Advanced task

- Participants can try advanced task by decreasing the volume of training data from domain C (training-data_c.csv)
- Participants try to develop a good failure classification model for domain C utilizing the training data from domain A and part of the training data from domain C with label.
- This case provides limited training data from the target domain (domain C), therefore more challenging task.

- Training
  1. Participants decrease the training data from domain C.
     Possible number of samples per failure label: 1-9
  2. Participants will train a failure classification model for domain C utilizing the training data from domain A and part of the training data from domain C with label.
- Evaluation
  - Participants will evaluate the failure classification result with the test data with label based on the created model.
  1. Create a confusion matrix using the test data
  2. Calculate F1-score for each label

# Submission

- ■Please submit presentation file containing
  - ●your solution (type of ML model, originality in pre-processing/training method etc.)
  - ●evaluation result including confusion matrix and F1-score of all 16 labels
- ■Participants can include multiple results that are obtained with different volume of domain C training data.

Contact information

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