UNICORN: URLLC Network Traffic Classification and OOD Detection for O-RAN

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Problem

Optimized resource allocation requires careful traffic identification.

Existing literature study classifying 5G traffic as 3 classes of:
- Enhanced Mobile Broadband (eMBB)
- Massive Machine Type Communications (mMTC)
- Ultra-Reliable Low Latency Communication (uRLLC)

Challenges

- ML methods should not access user data.
- The solution must be O-RAN compliant, with standardized interfaces.
- ML methods should be able to identify new traffic types (out of distribution i.e., OOD) that are not previously trained on.
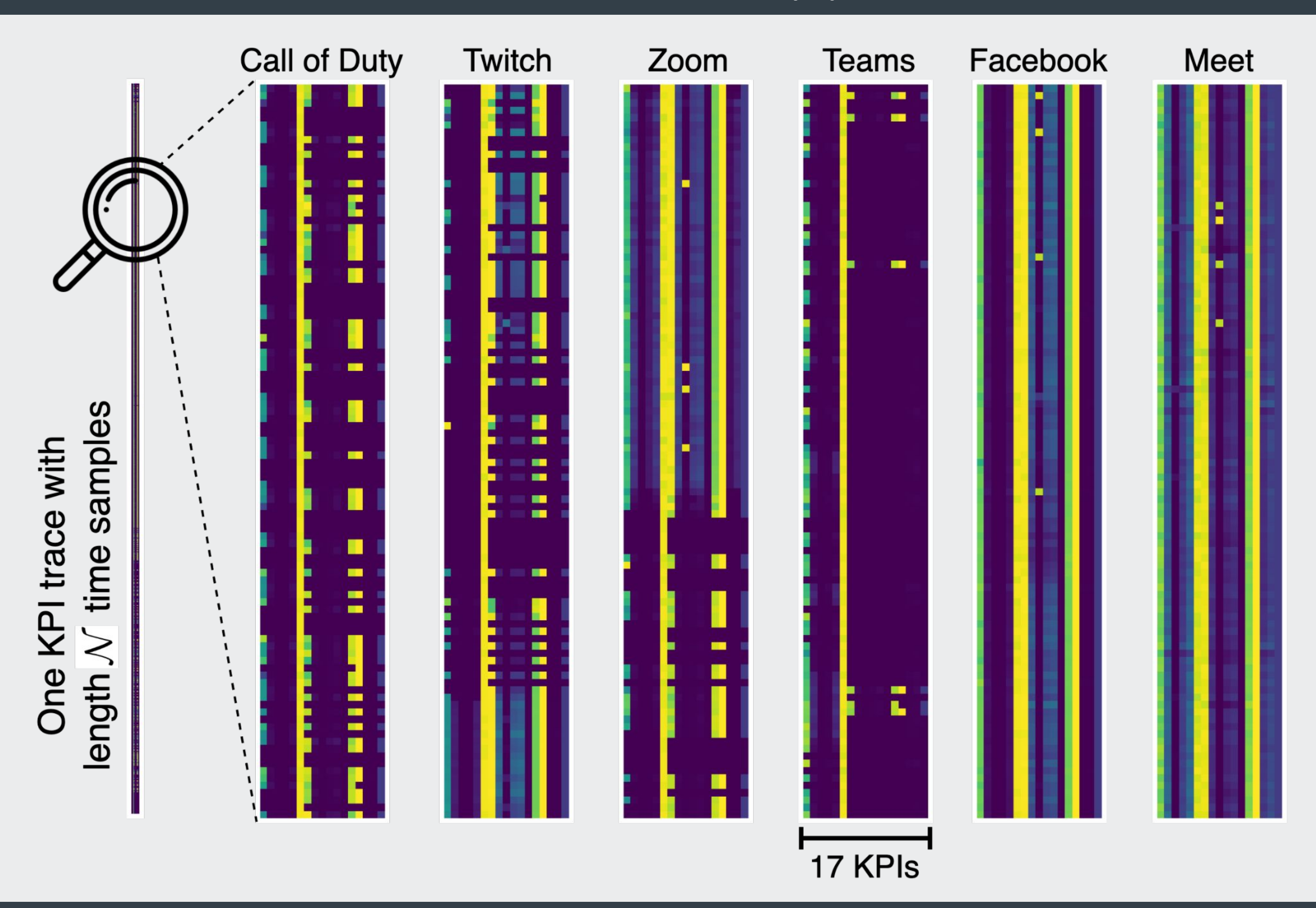
Proposed Solution
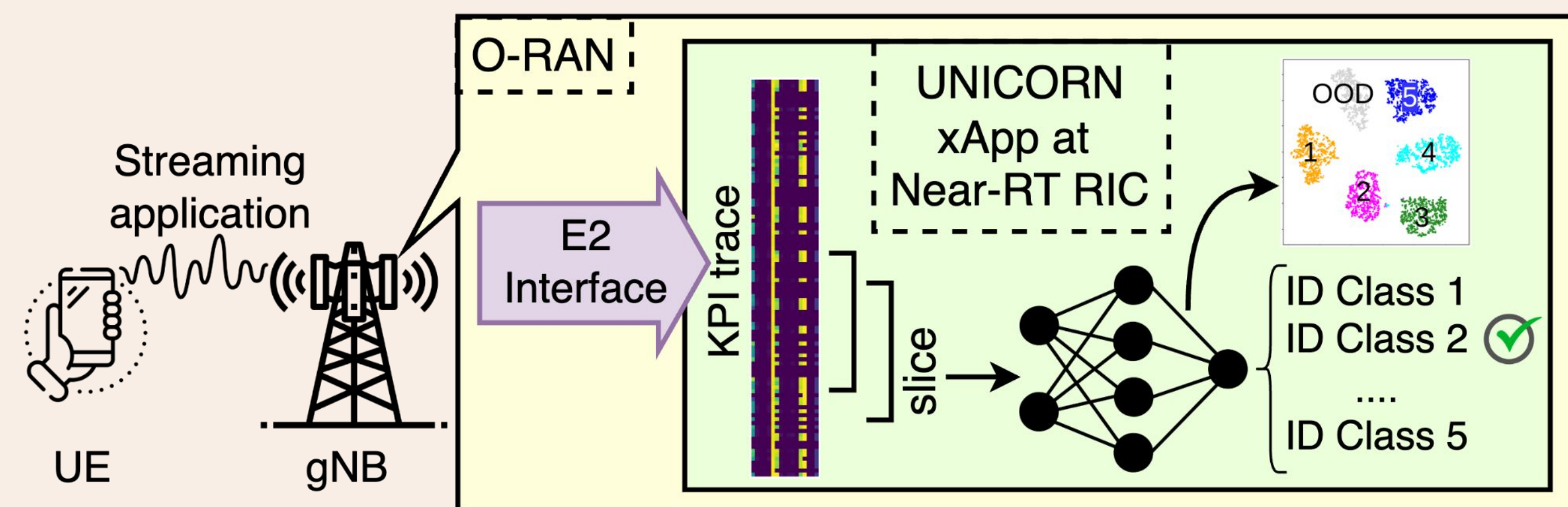
Dataset Collection

Dataset Generation Steps:
- 5G Traffic Capture
- Traffic Emulation in Colosseum
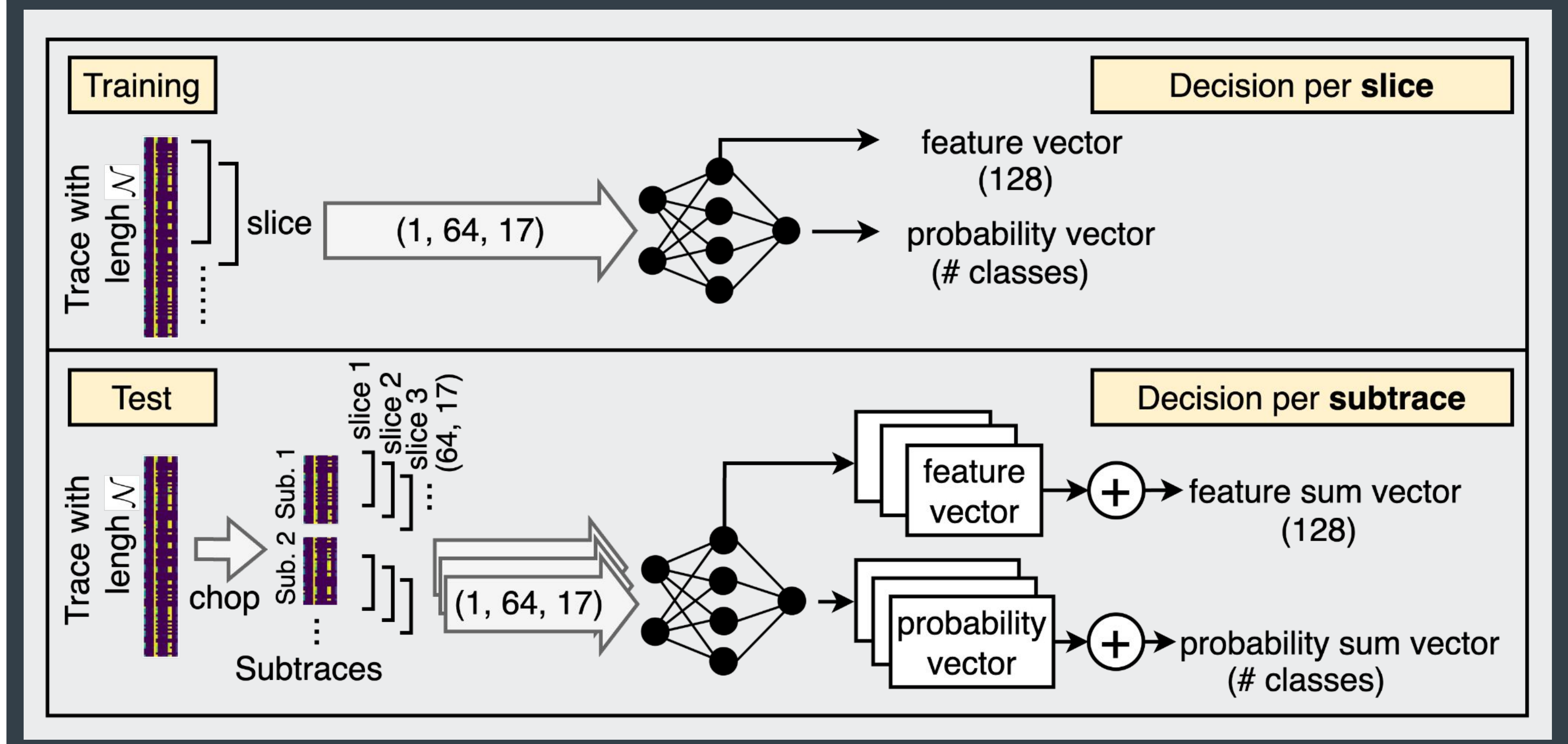- Key Performance Indicator (KPI) Capture

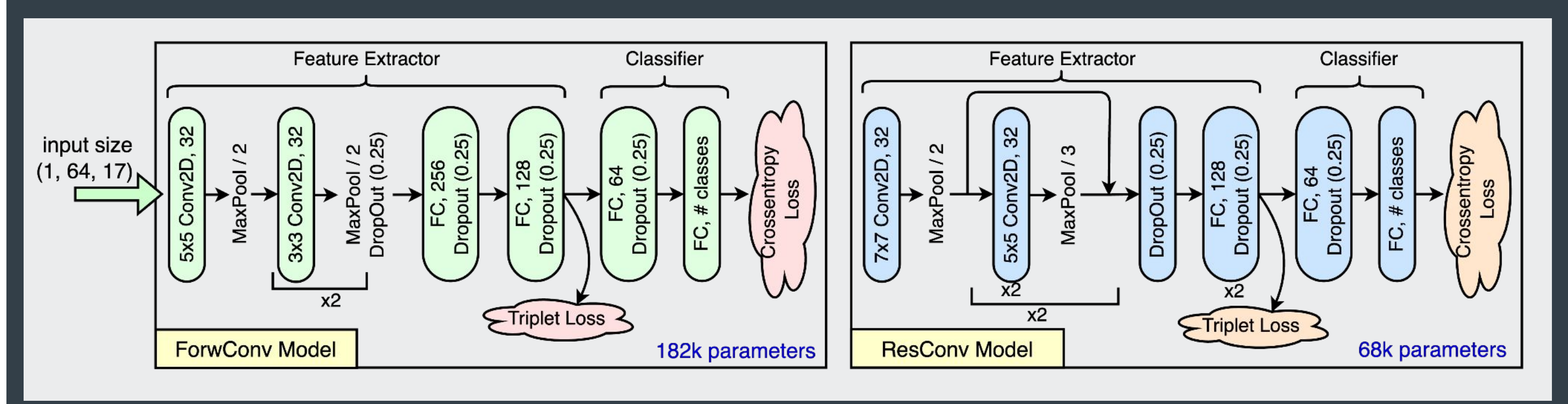5G traffic capture: During 42 hours of interactive data collection:

Indoor Stationary   Outdoor Stationary   Outdoor Walking

KPI Patterns Per Application

Call of Duty   Twitch   Zoom   Teams   Facebook   Meet

One KPI trace with length $\mathcal{N}$ time samples

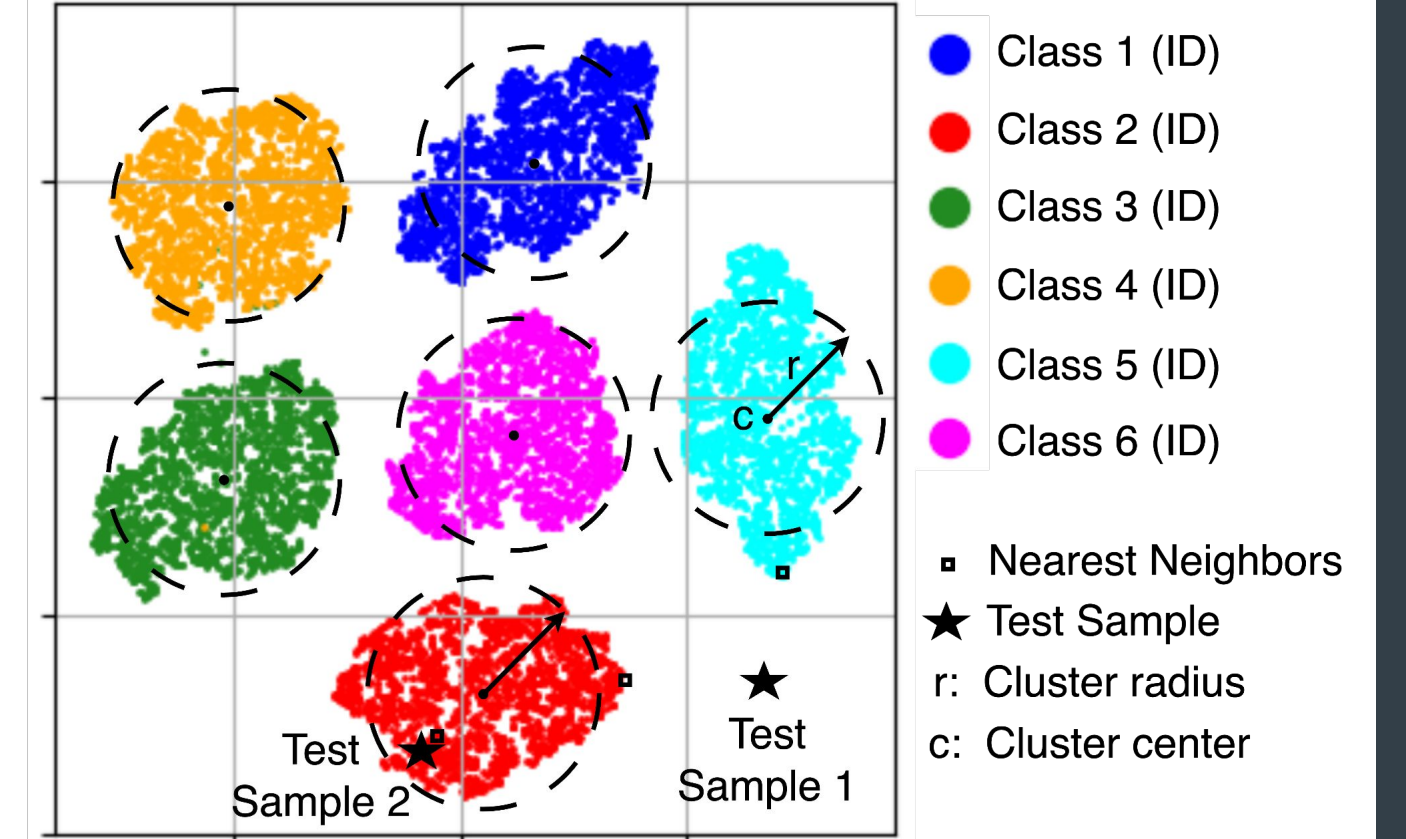17 KPIs

Training and Test Pipelines
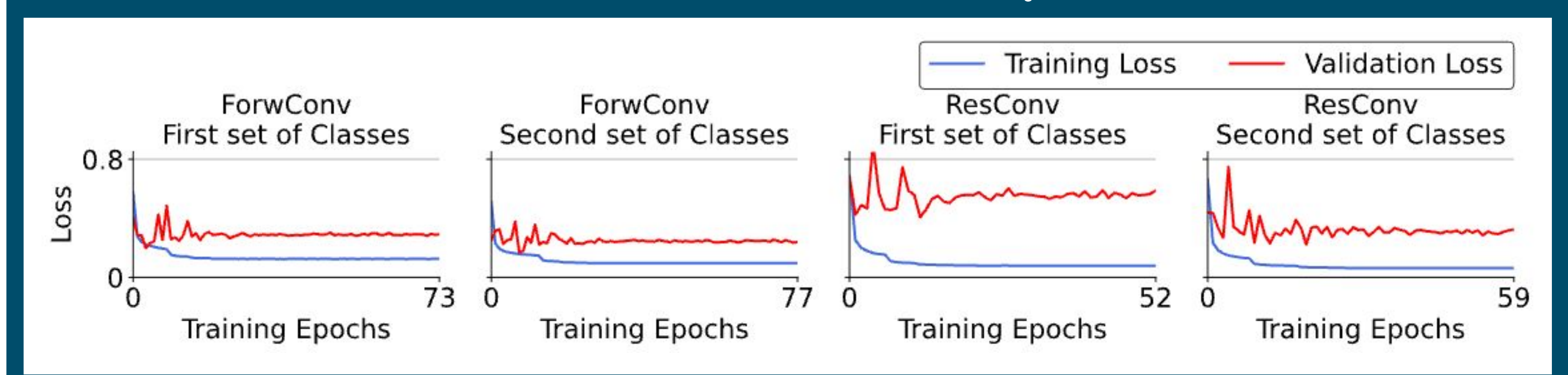

Neural Network Architectures
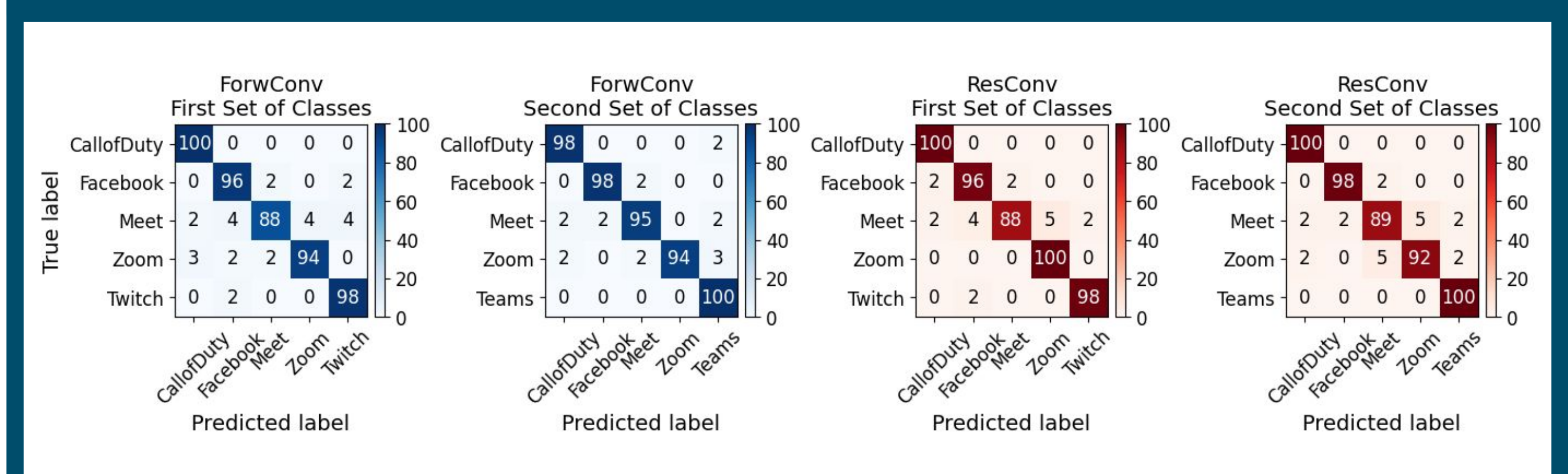

Out-of-Distribution (OOD) Detection

- Post-training - Characterizing ID clusters:
  - Center
  - Radius
- During Deployment:
  - Return K-nearest Neighbors
  - Detect OOD samples.

Class 1 (ID)
Class 2 (ID)
Class 3 (ID)
Class 4 (ID)
Class 5 (ID)
Class 6 (ID)
■ Nearest Neighbors
★ Test Sample
r: Cluster radius
c: Cluster center

Test Sample 2   Test Sample 1

Results: Loss Over Epochs

Results: Confusion Matrices

Results: OOD Detection

- Good cluster separation among the ID and OOD classes.
- True positive as high as 88%.
- False positive as low as 8%.