



# Gotta Detect'Em All: Fake Base Station and Multi-Step Attack Detection in Cellular Networks

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# Fake Base Stations

Lack of authentication in initial broadcast messages

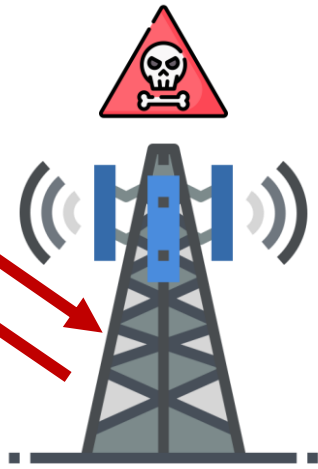


Legitimate Base Station



Are we connecting to a Fake Base Station?

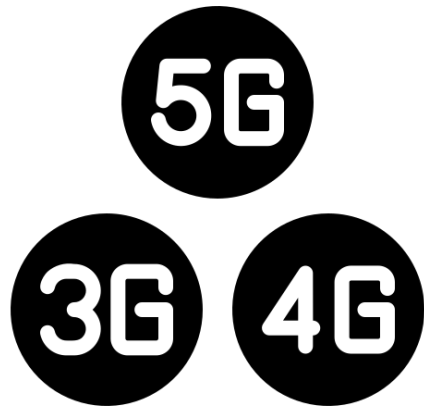
Connects naively to the strongest signal



Fake Base Station



# Motivation



A Persistent Problem



Billions of unprotected device



Impracticality and high cost of existing detection mechanisms

# Motivation

## DHS confirms it has detected evidence of mobile snooping devices around DC

By Tal Kopan, CNN  
2 minute read · Updated 9:11 AM EDT, Wed April 4, 2018



Technology

## Gang Of Drivers Caught Using Stingrays To Send Fake Links And Steal Cash

May 25, 2023 TNR Staff Comments(3)

OHRUV MEHROTRA SECURITY JAN 18, 2025 10:21 AM

## Secret Phone Surveillance Tech Was Likely Deployed at 2024 DNC

Data WIRED collected during the 2024 Democratic National Convention strongly suggests the use of a cell-site simulator, a controversial spy device that intercepts sensitive data from every phone in its range.



## Apple and Google Are Introducing New Ways to Defeat Cell Site Simulators, But Is it Enough?

BY COOPER QUINTIN | SEPTEMBER 13, 2023

BY COOPER QUINTIN | SEPTEMBER 13, 2023

BY COOPER QUINTIN | SEPTEMBER 13, 2023

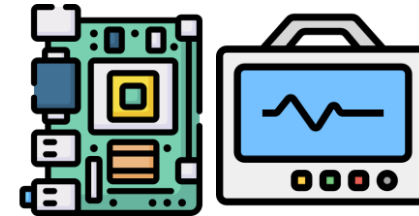
# Solution – Machine Learning?



Protect all the existing  
and new devices



No change  
in protocol



No additional hardware



Minimal Overhead

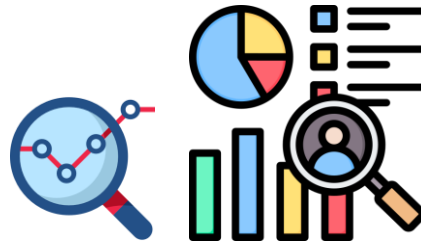


Supports Roaming

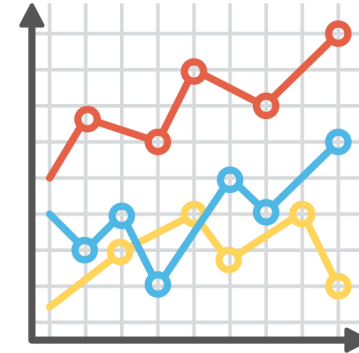
# Challenges



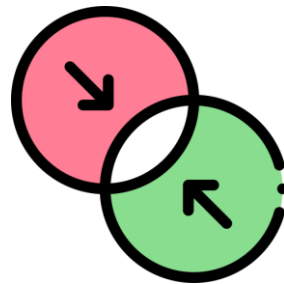
Dataset availability and quality



Incorporating surrounding context



Learning MSA Characteristics



Combining Predictions

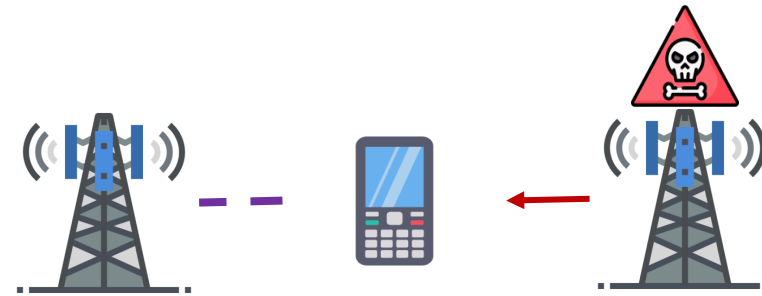


Real Time Detection

# FBSDetector-Dataset Generation



Mobility



Legitimate Base Station

Fake Base Station

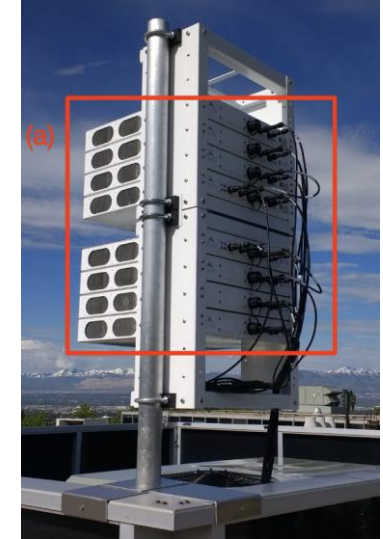
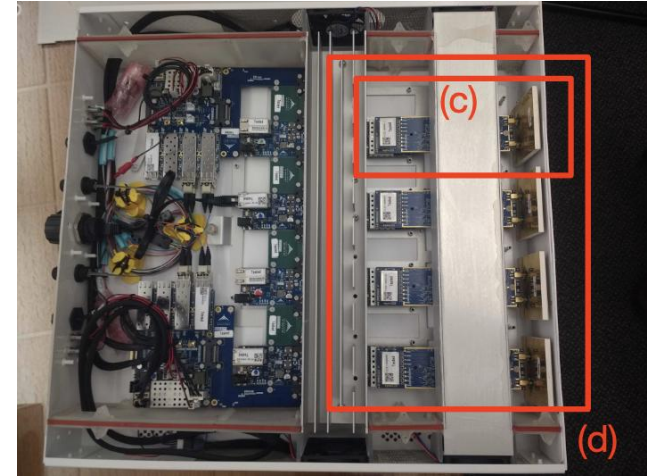
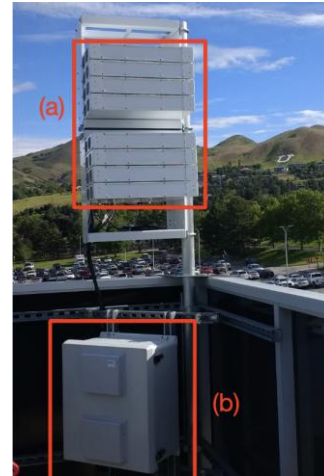
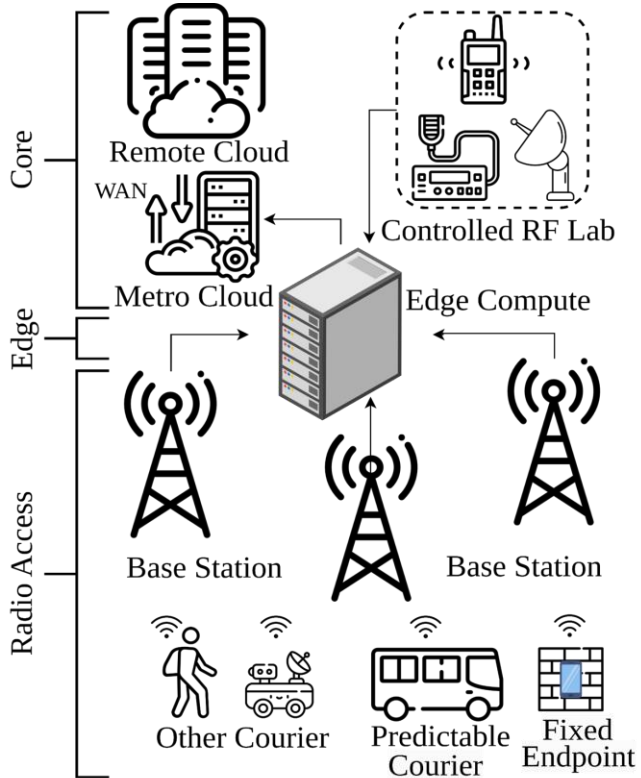


Attacker Level



Multi-step attacks

# FBSDetector-POWDER

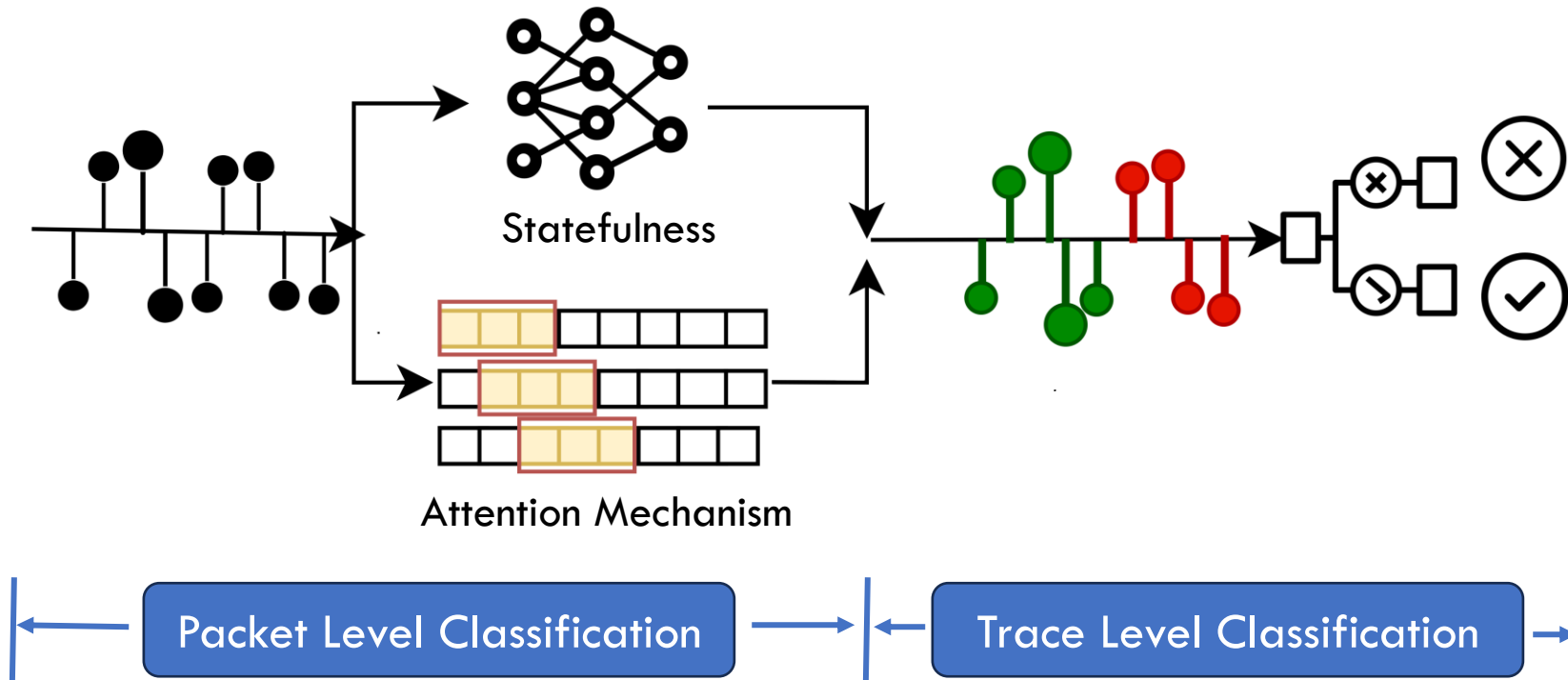


(a) Radio and antenna array; (b) Hub; (c) 2x2 Transceiver and antenna; (d) Transceiver chain

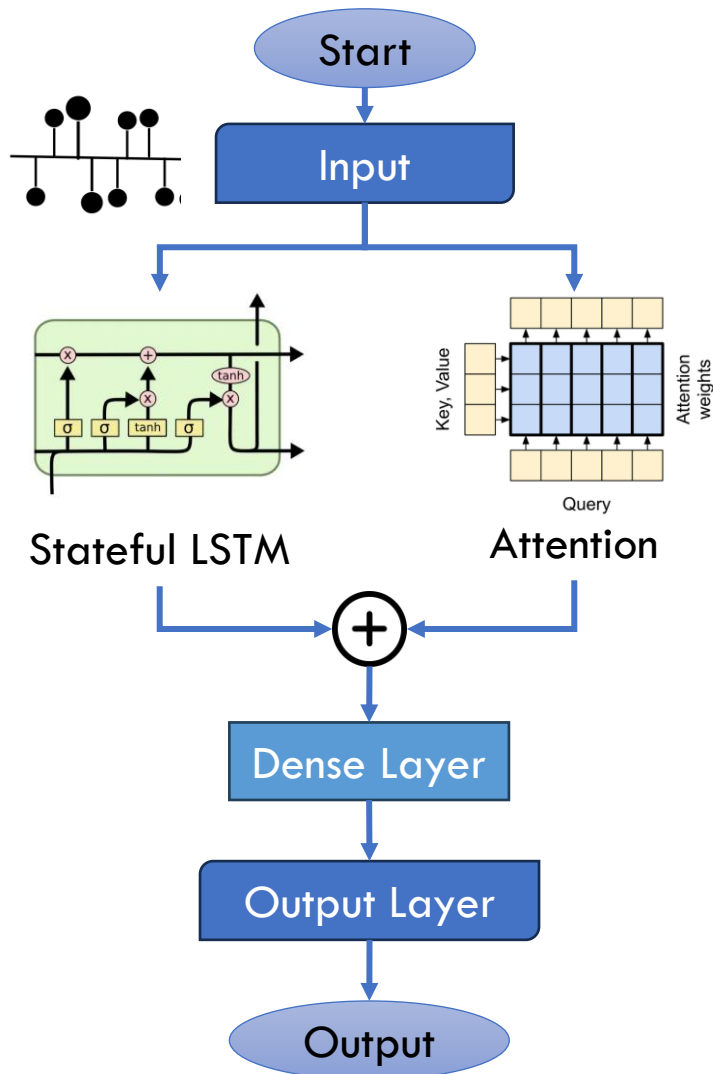
## Capabilities leveraged:

- Platform for **Open Wireless Data-drive Experimental Research (POWDER)**
- City-scale remote accessible large testbed by NSF
- Provides the capability to deploy FBS and attacks in real devices with actual packets following ethical guidelines
- Provides the capability to test mobility and signal overlapping

# FBSDetector-FBS Detection



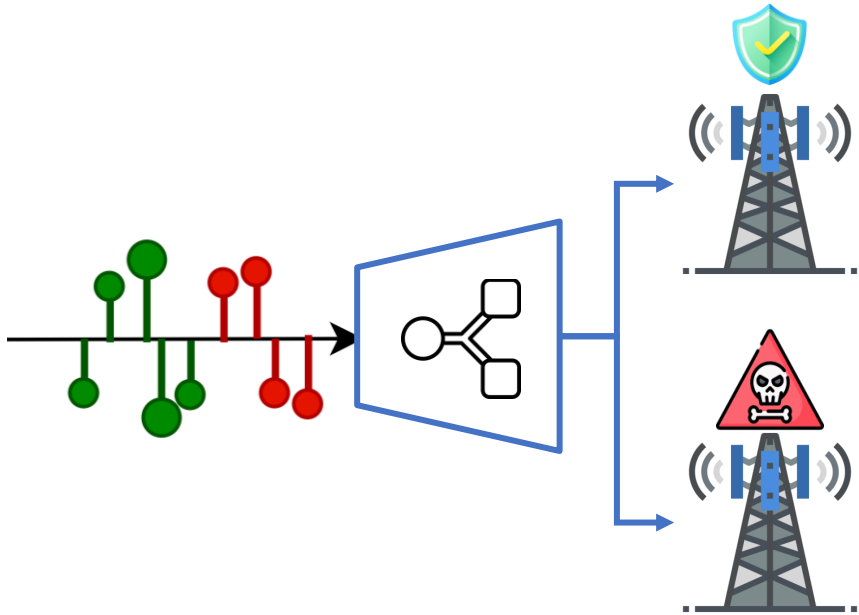
# FBS Detection – Packet Level Classification



## Advantages/ Strength:

- **Classifies each packet individually**
  - Taking the context it was sent into consideration
- **Statefulness models long-term dependencies**
  - that span across sequences
- **Attention mechanism focuses on the parts of each sequence**
  - that affect the classification outcome the most

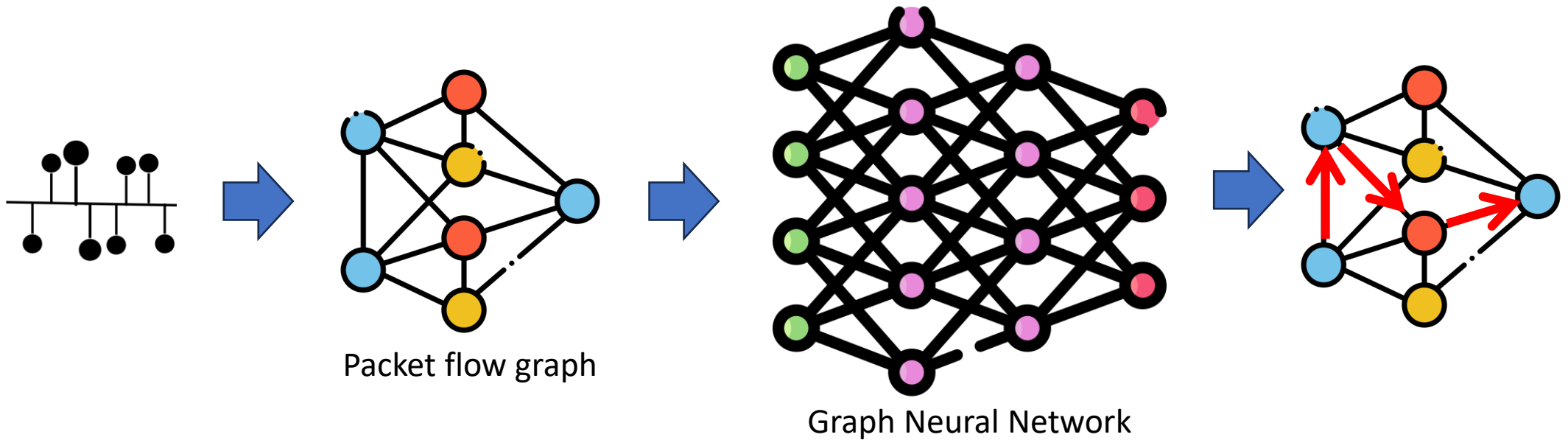
# FBS Detection – Trace Level Classification



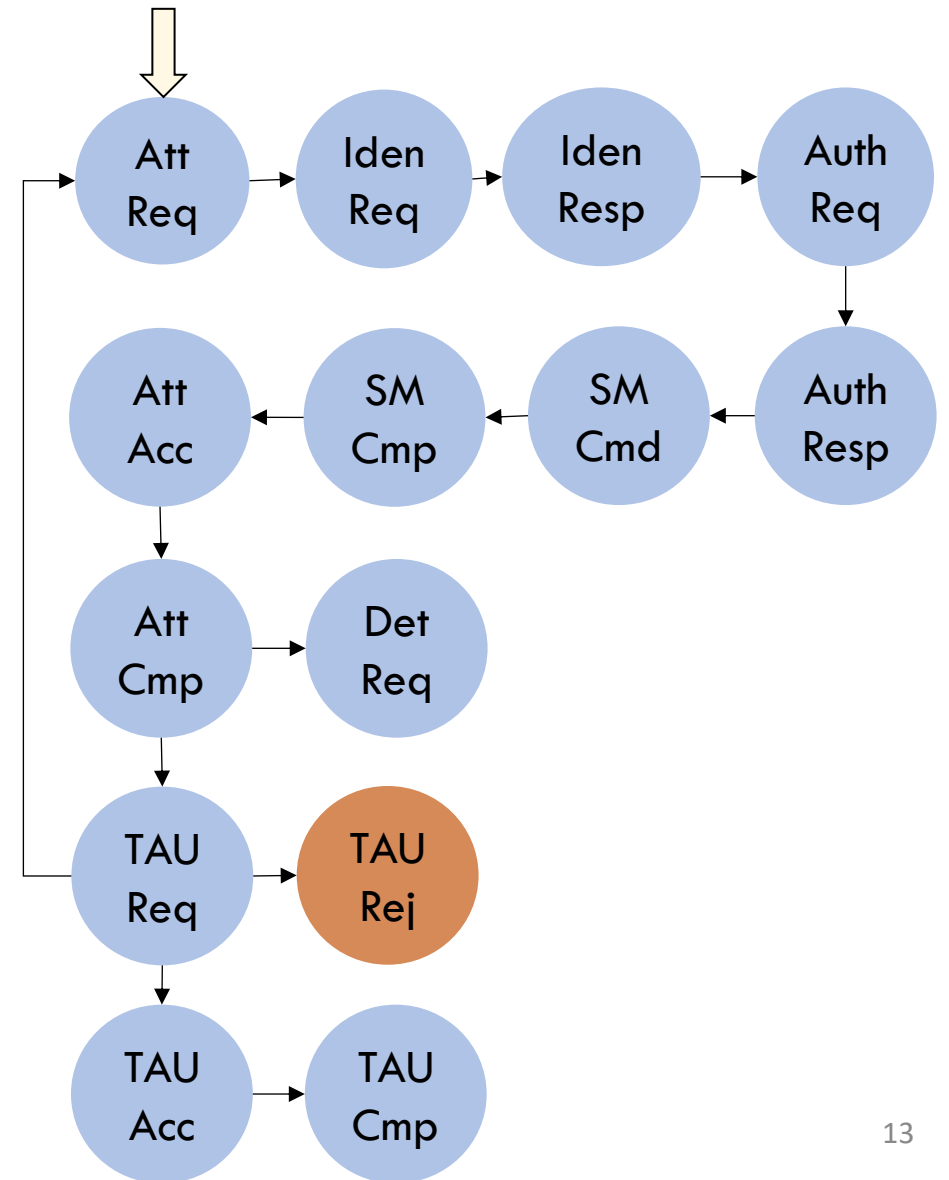
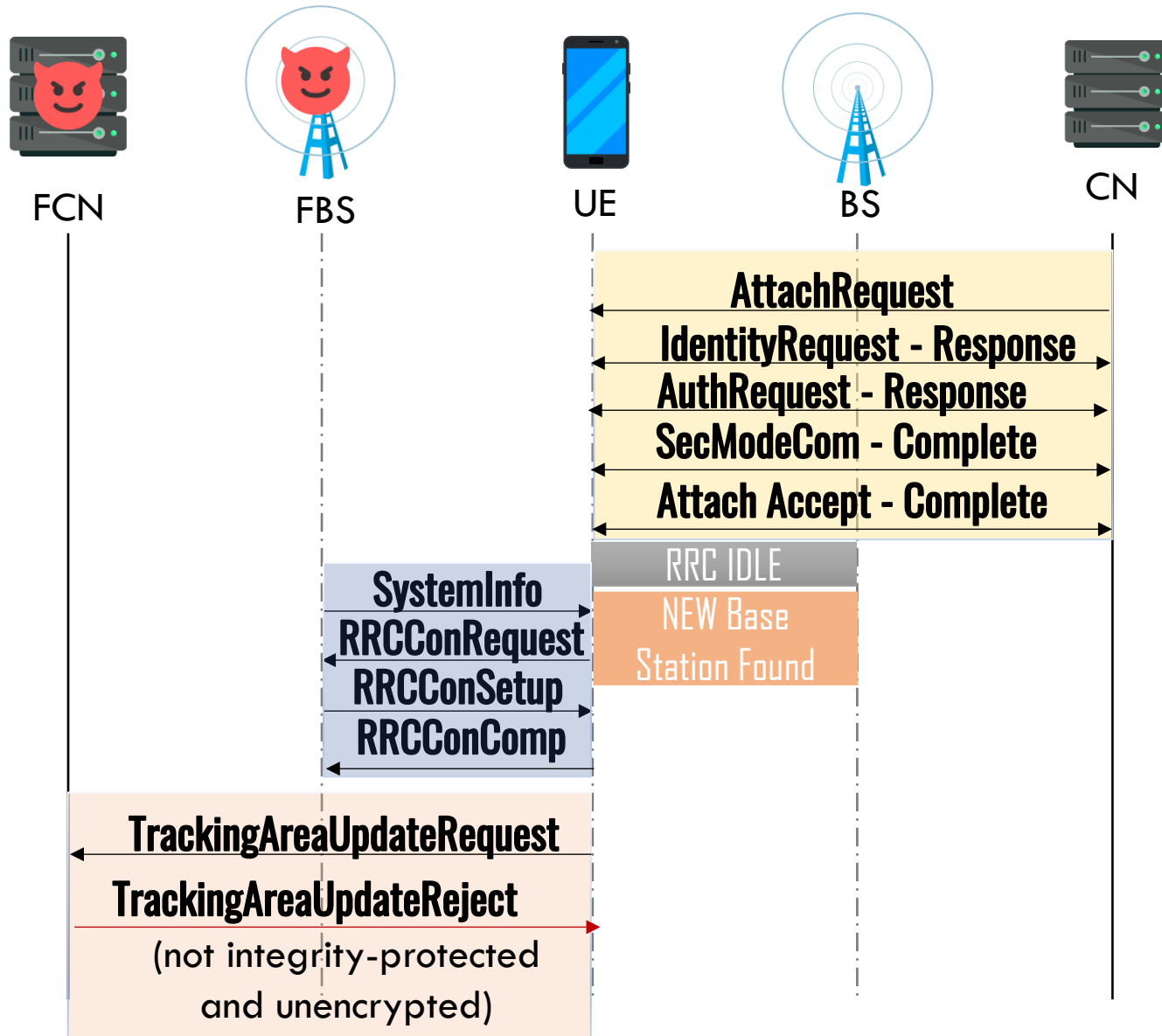
## Advantages/ Strength:

- Classifies the whole labeled trace from packet level classification
- Examines the order of packets and
  - sequence patterns
  - to discern characteristics indicative of FBS

# FBSDetector-MSA Recognition

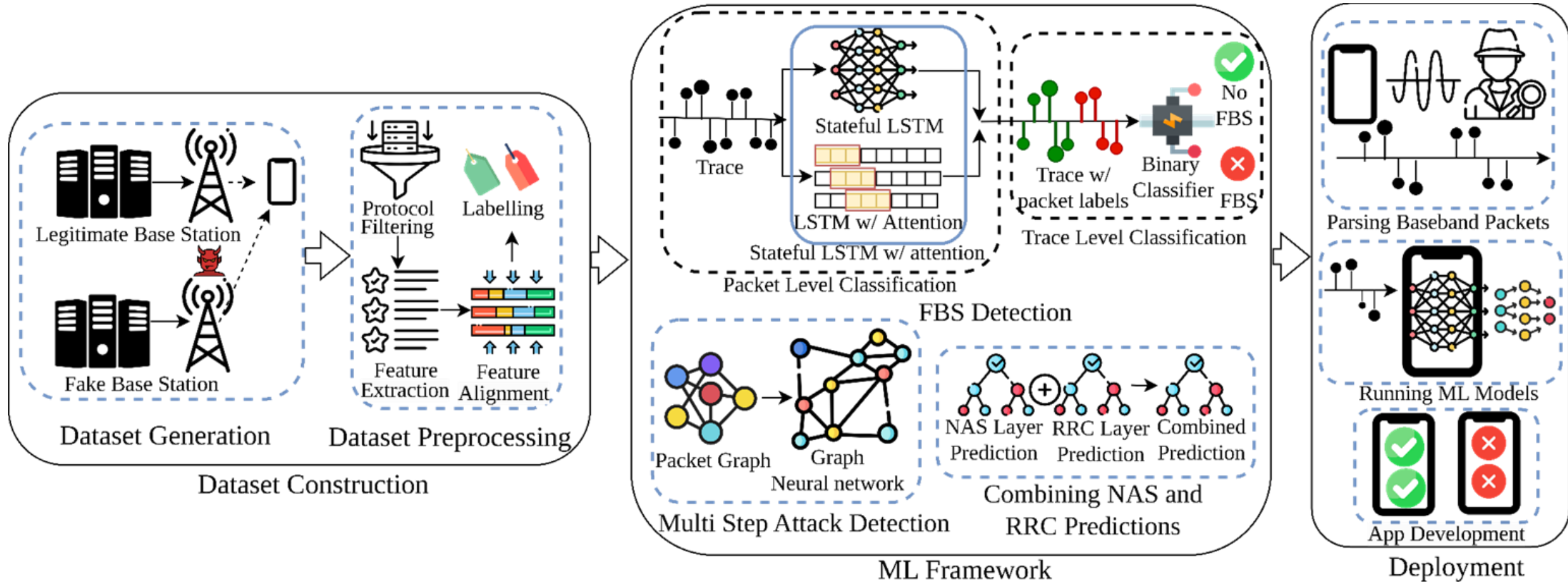


# FBSDetector-MSA Recognition Example

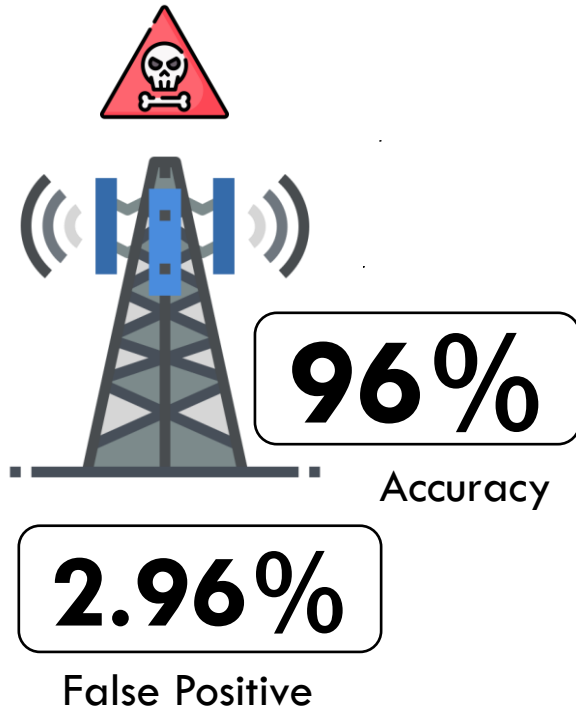


# FBSDetector-Overall Solution

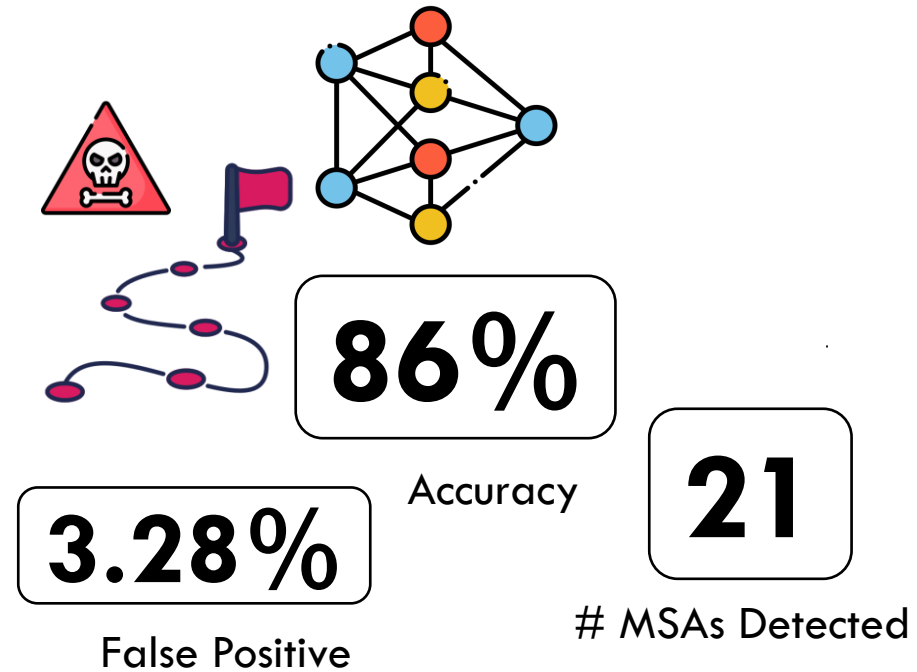
Overview of our end to end solution to detect FBSes and MSAs



# FBS and MSA Detection Performance

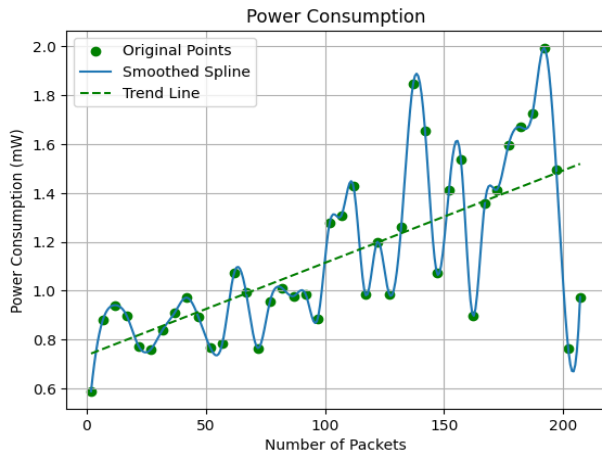


FBS Detection

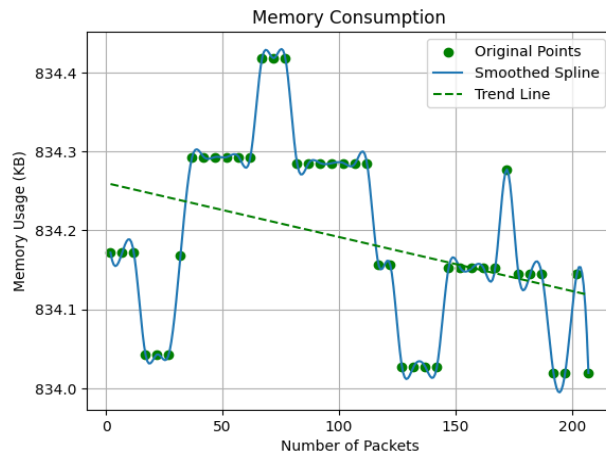


MSA Recognition

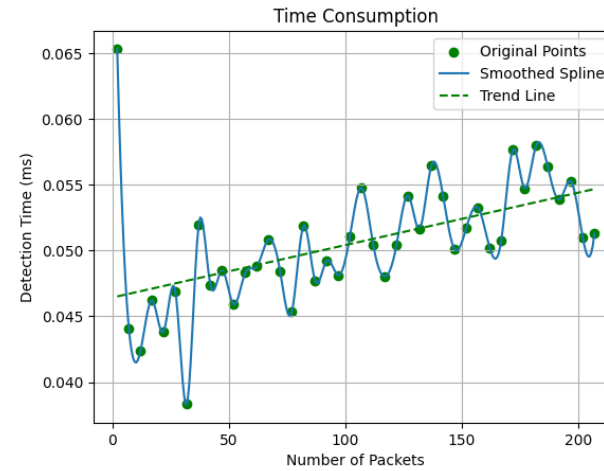
# Overhead Analysis



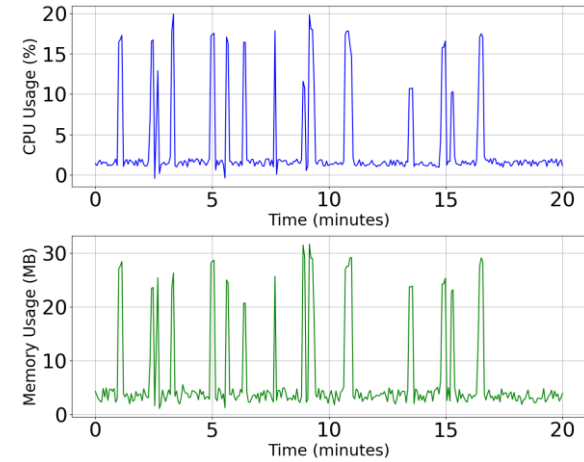
Power Consumption



Memory Consumption



Time Consumption

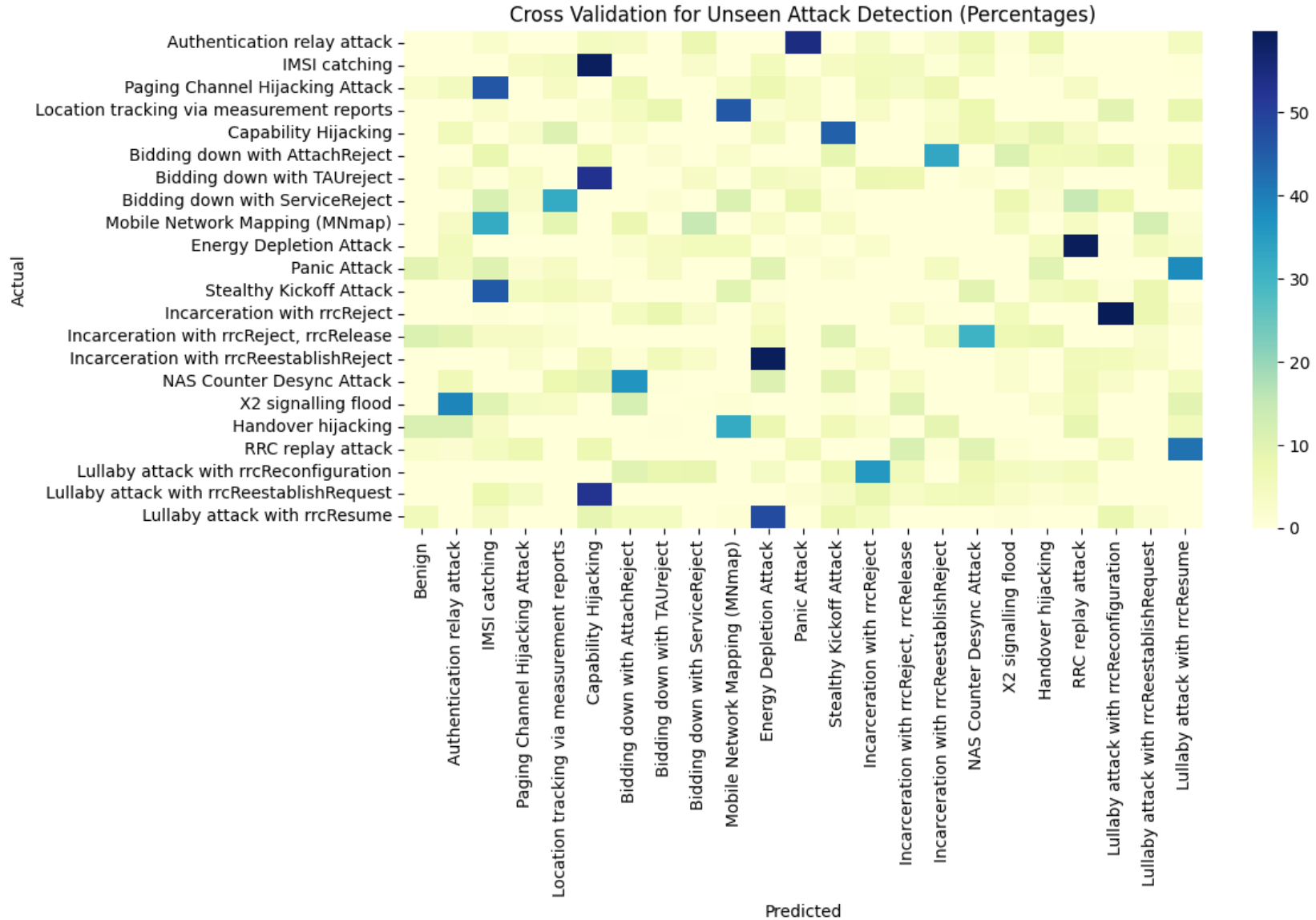


Memory and CPU usage by the mobile app

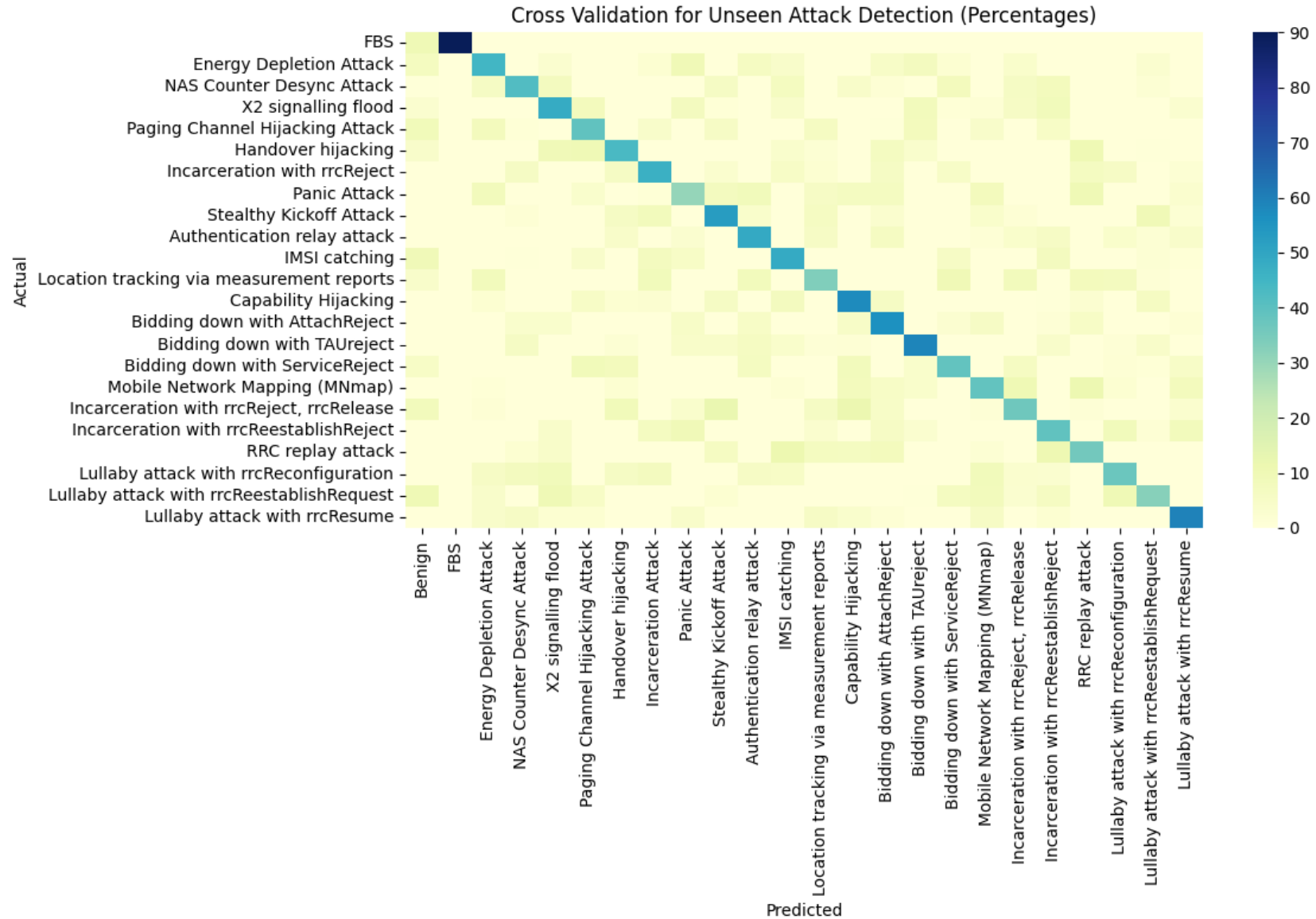
# Real world Validation and Comparison



# Unseen Attack Evaluation



# Reshaped Attack Evaluation

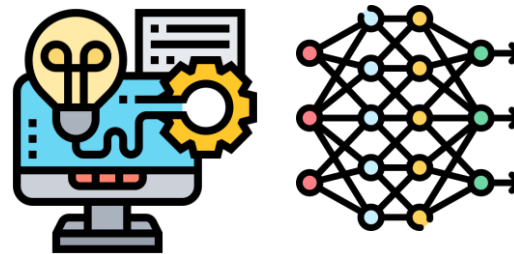




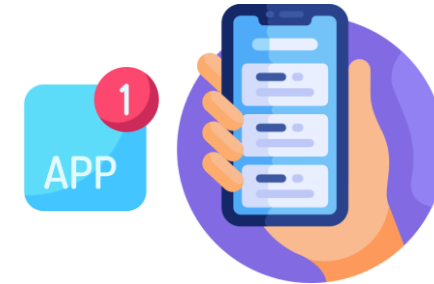
# Conclusion and Takeaway



First ever-large scale  
attack dataset for FBS Detection



Novel ML model combining  
stateful models with attention



End-user-deployed  
solution for FBS Detection

