CAN Network Anomaly Detection

정보보호 R&D 데이터 챌린지

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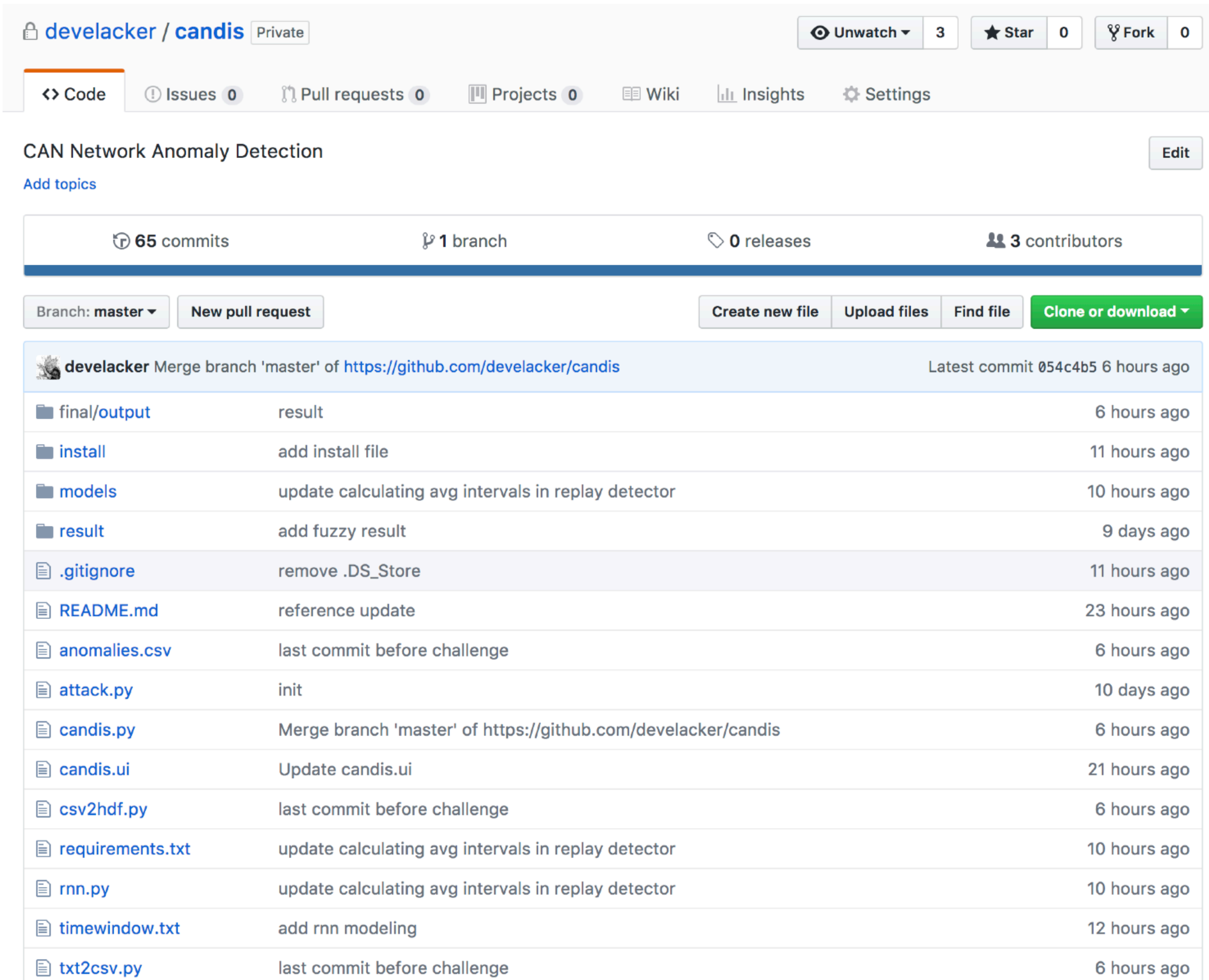
Agenda

- Our Research
- CAN Network Attack Framework
- Attacks on CAN
- Anomaly Detection Methods
- Visualization
- Conclusion and Future Work

Our Research

- CoWork! by using github
- There are three researchers in our team
- The things that we developed is the following
  - CAN anomaly detection for DoS/Fuzzy/Replay Attack
  - Data sequence modeling based on RNN(LSTM) algorithm
  - Realtime visualization by using PyQt

Our Research



Attack Framework

- Frequency effects
  - Insertions: extra packets
  - Erasures: missing packets
- Data: Altering packet data contents
  - Data replay
  - Data field modifications

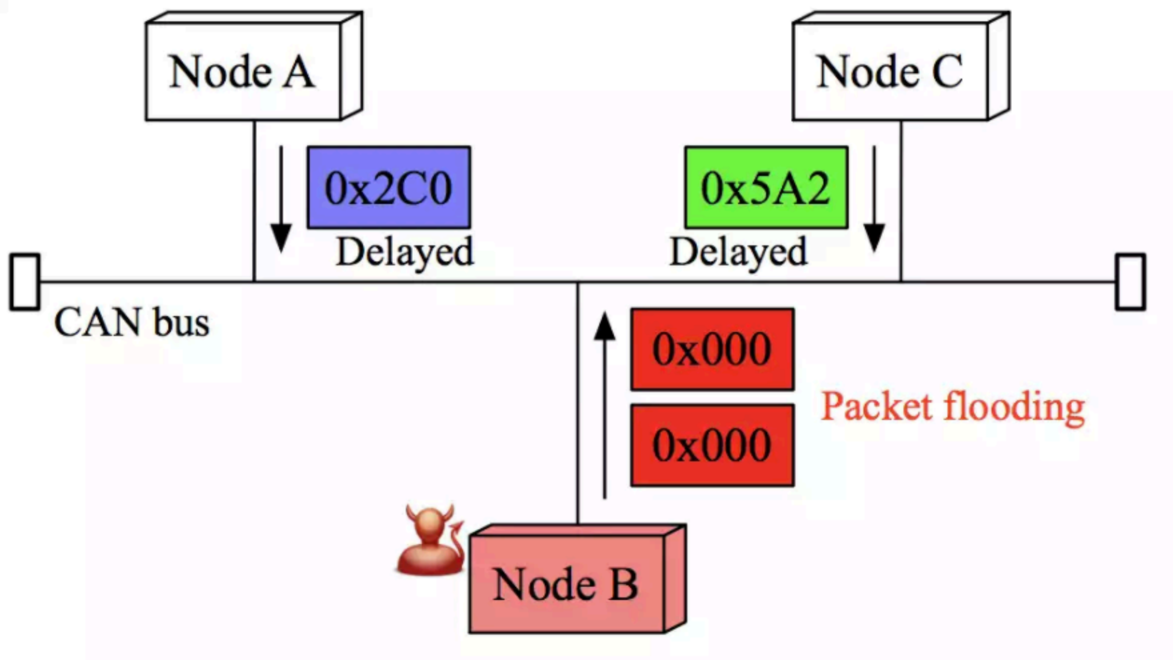
Frequency effects

- Each ID has a **fixed frequency of occurrence** on the bus
- The frequencies of normal packets are very **consistent**
- **Anomalies** in terms of frequencies will involve additional packets, or missing packets that were expected
- The majority of attacks involve inserted packets with specific IDs and data
- Some attacks can manifest as the absence of packets that should arrive at regular intervals

Altering packet data contents

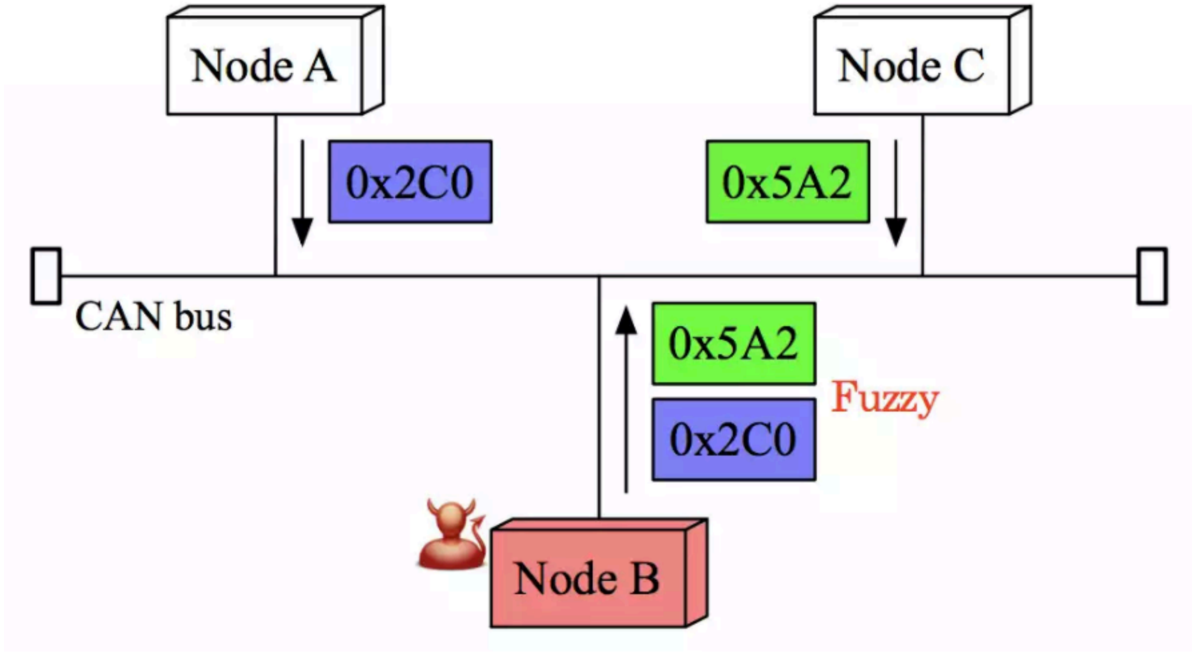
- Many bits in each **data sequence** are **constant**
- The second main signature of attacks is a **change** in the **data sequence** of some ID
- The **only indication of *replay attack*** is that the **data sequence of the ID** being replayed **has changed** from one context to another
- The replaced data is a legitimate subsequence, but **incongruous with preceding data sequence**

Attacks on CAN



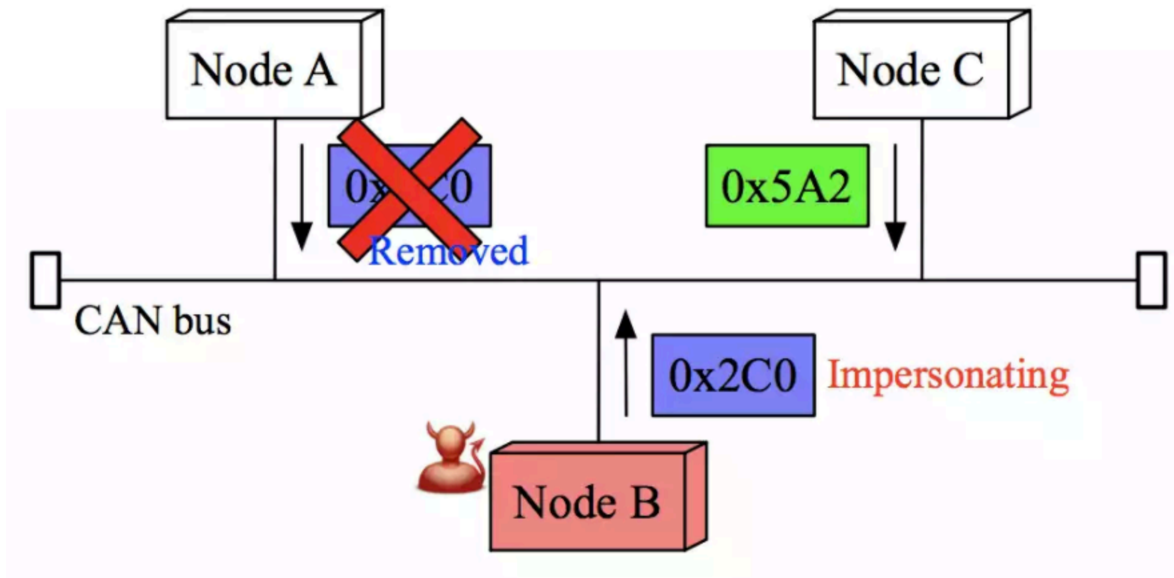
DoS Attack

Attacks on CAN



Fuzzy Attack

Attacks on CAN

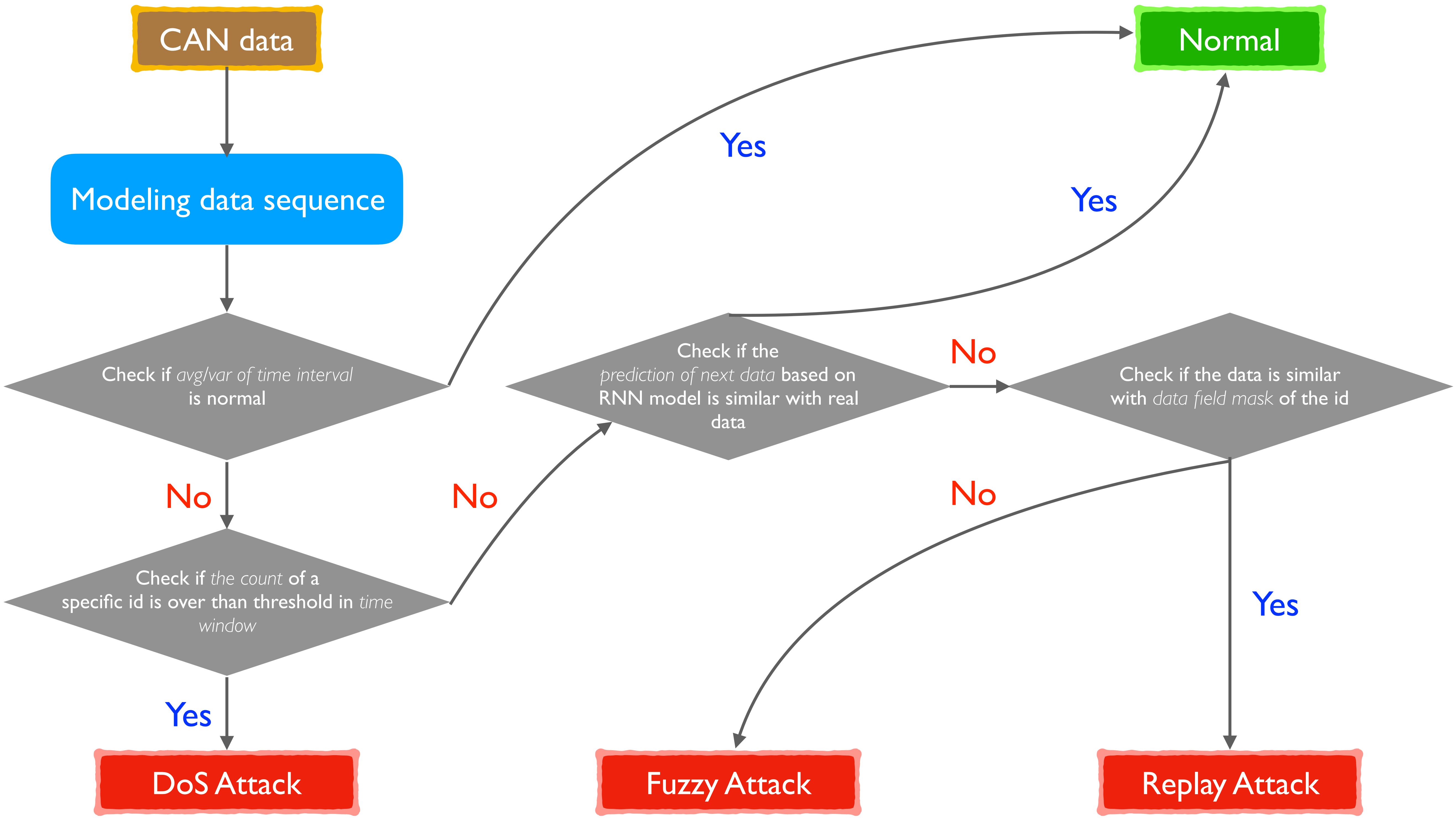


Impersonation Attack

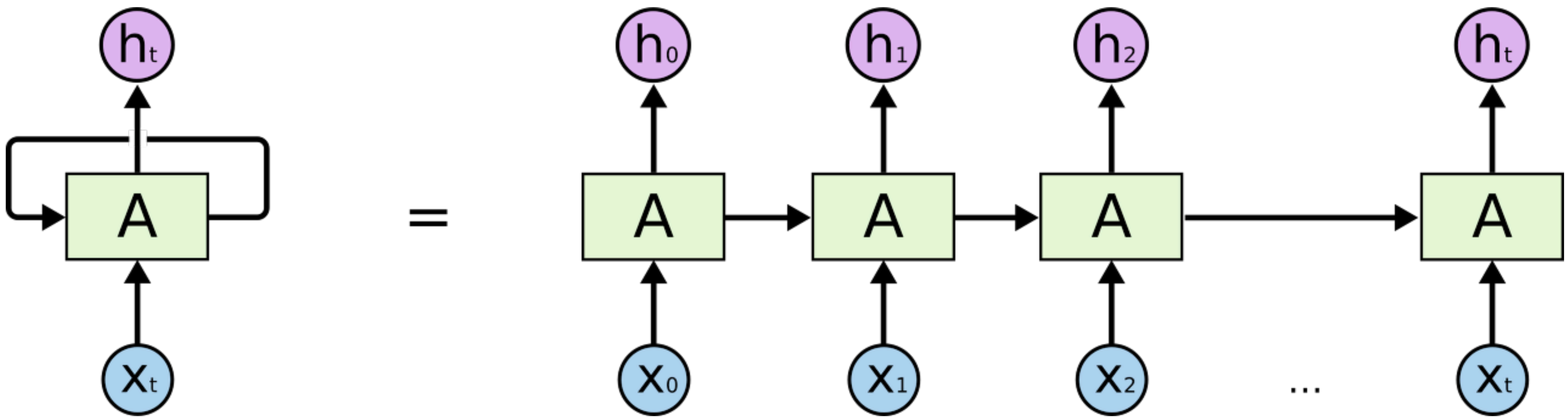
Anomaly Detection Methods

- **Frequency** anomaly detection
  - Average/Deviation of *Time Interval*
- **Data sequence** anomaly detection
  - RNN(Recurrent Neural Network) - *LSTM(Long Short Term Memory)*
  - *Data field mask* by ANDing all data sequence of each ID

Anomaly Detection Methods

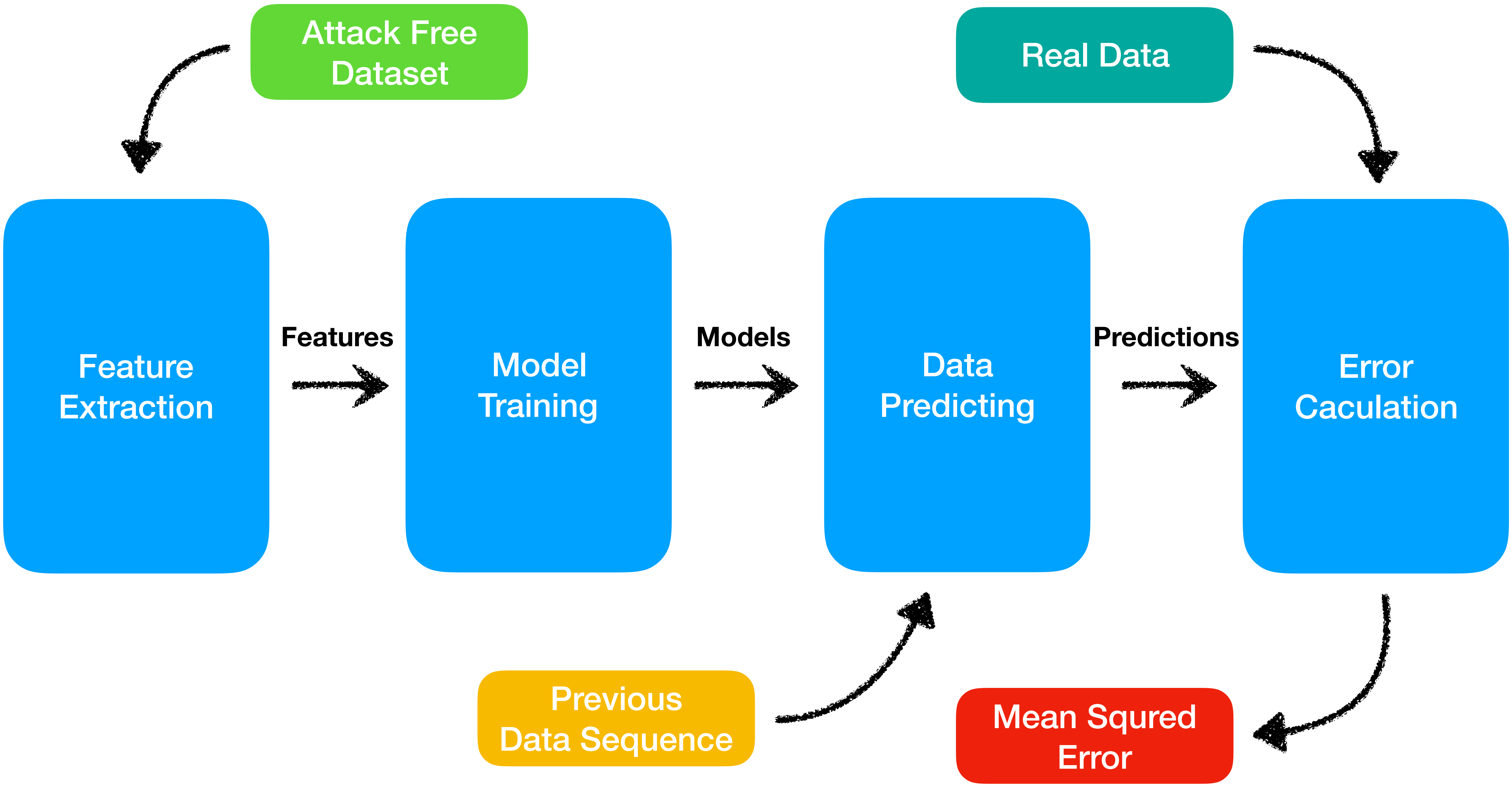


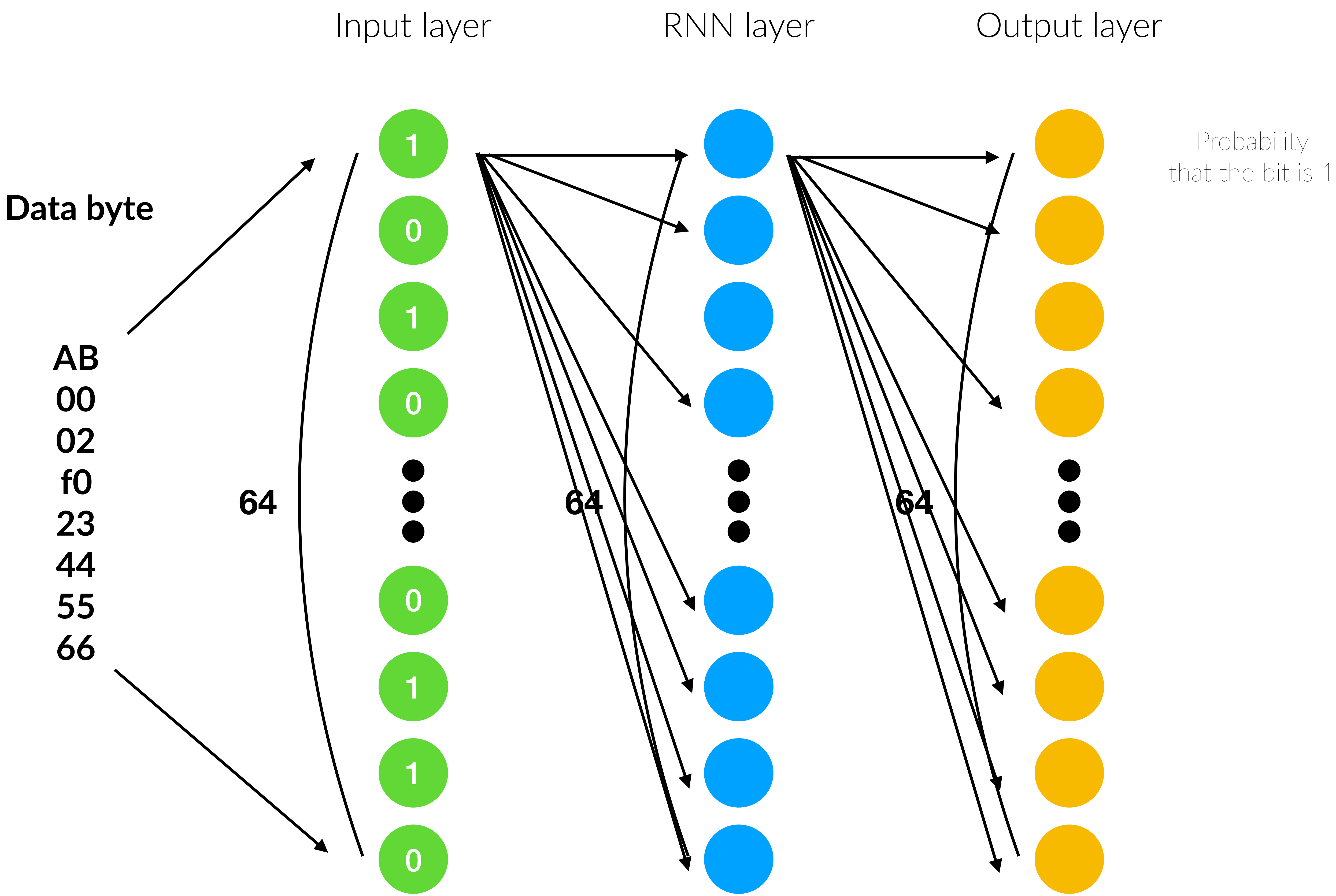
Recurrent Neural Network



- Save previous input data in network
- Predict next sequence from previous data
- In our case, predict next data bytes in real can packets

Recurrent Neural Network





Fully Connected Network

Recurrent Neural Network

RNN modeling by using Keras

```
model = Sequential()
model.add(SimpleRNN(64, input_shape = (steps, 64)))
model.add(Dense(64))

model.compile(loss='mse', optimizer='rmsprop', metrics=["accuracy"])

x_train = feature[:,:-1,:]
y_train = feature[:,-1,:]

history = model.fit(x_train, y_train,  epochs=epochs, verbose=1)

model.save("./models/rnn_model_" + key + ".h5")
```

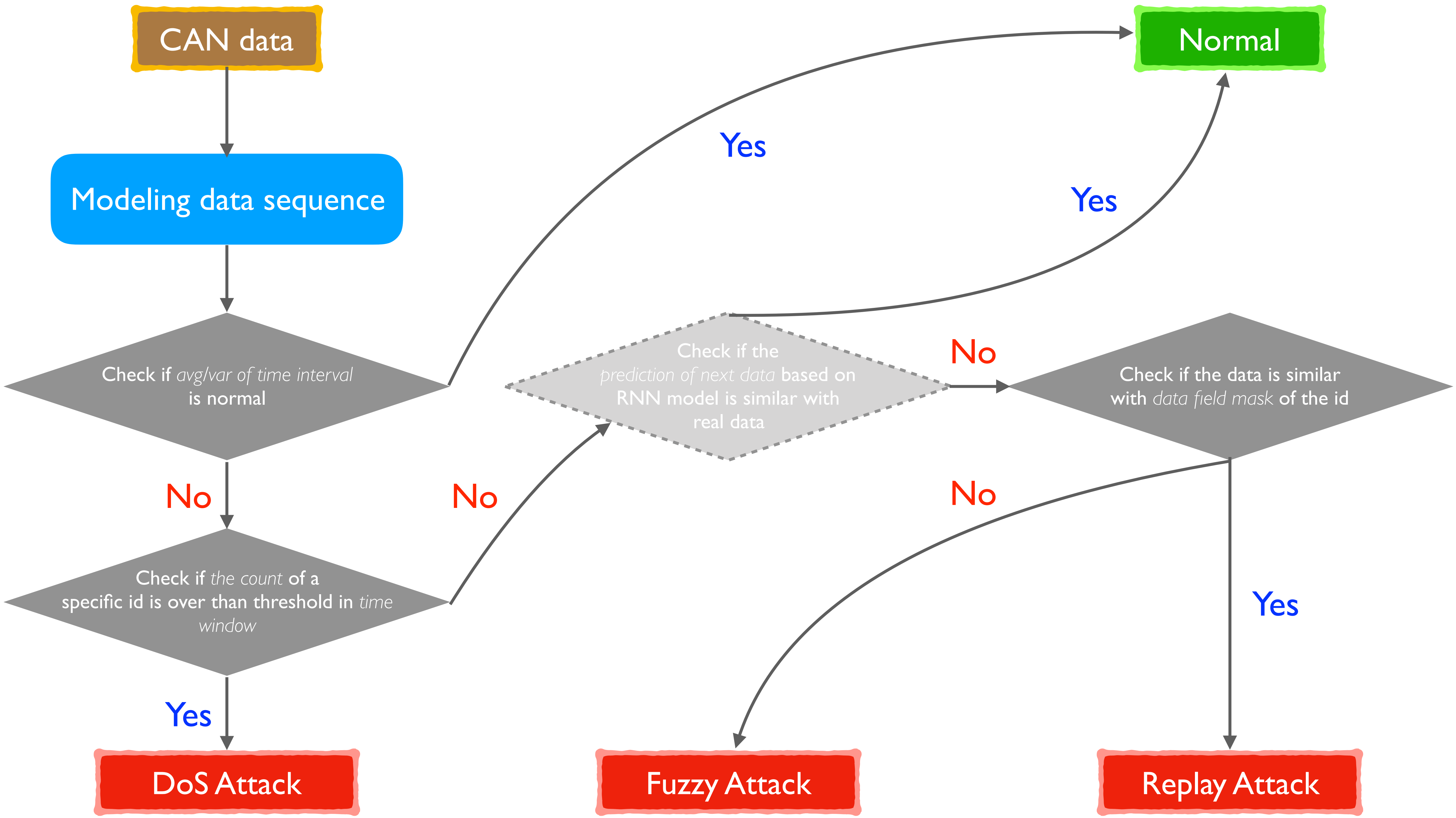
Weakness

- Too slow for real time detecting
  - Use only in warning state
- Vehicle model is changed
  - Train new model with new datasets… but not enough time :(

Actually...

- **There are some tricky issues to detect anomalies like**
  - Too many resources are needed to adjust deep learning to CAN network packet
  - There are some ambiguous concepts on CAN attack types
  - Very hard to speed up the rate of next data predictions based on RNN (LSTM) and very hard to understand the algorithm :(
  - Maybe there is no perfect algorithm which detects all the attack vectors at a time

Anomaly Detection Methods



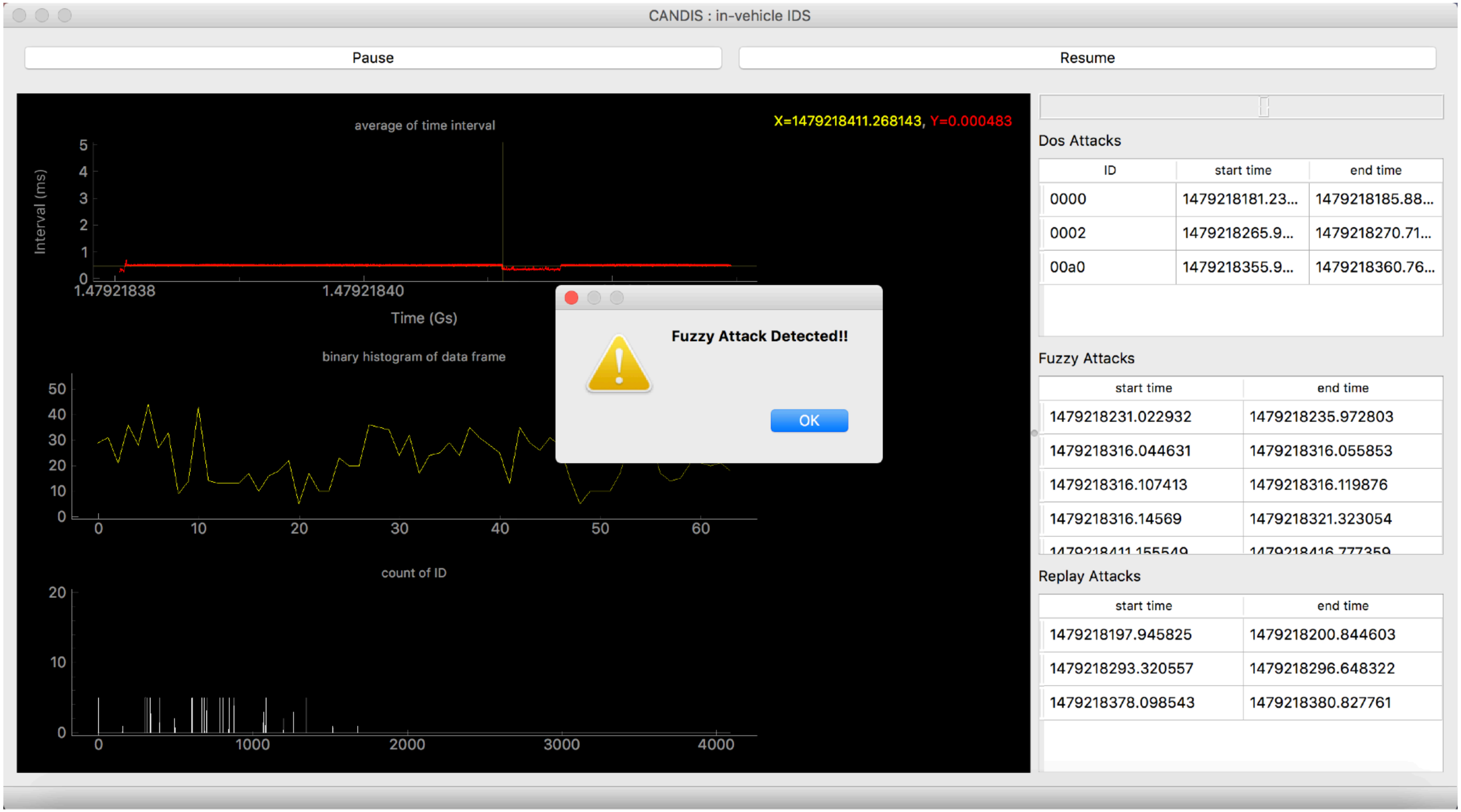
Visualization

- Environment
  - Python 3
  - Numpy
  - PyQt5, PyQtGraph
- Focusing on real time plotting
- Cross checking whether the detection is correct

Visualization

Before

Visualization



After

Demo

Conclusion and Future Work

- There are many types of attack vector on CAN network
- Realtime and precision are the most important elements in anomaly detection
- More faster data sequence predictions
- User friendly visualization tool
- Improve the speed of detection
- Make it more easy to adopt in new vehicles

Reference

- Adrian Taylor, "Anomaly-based detection of malicious activity in in-vehicle networks", 2017
- Mohammad Raashid Ansari, "Low-Cost Approaches to Detect Masquerade and Replay Attacks on Automotive Controller Area Network", 2016
- Hyunsung Lee, Seong Hoon Jeong, Huy Kang Kim, "OTIDS: A Novel Intrusion Detection System for In-vehicle Network by using Remote Frame", 2016

Thank you!