Threat Intelligence for 5G IoT

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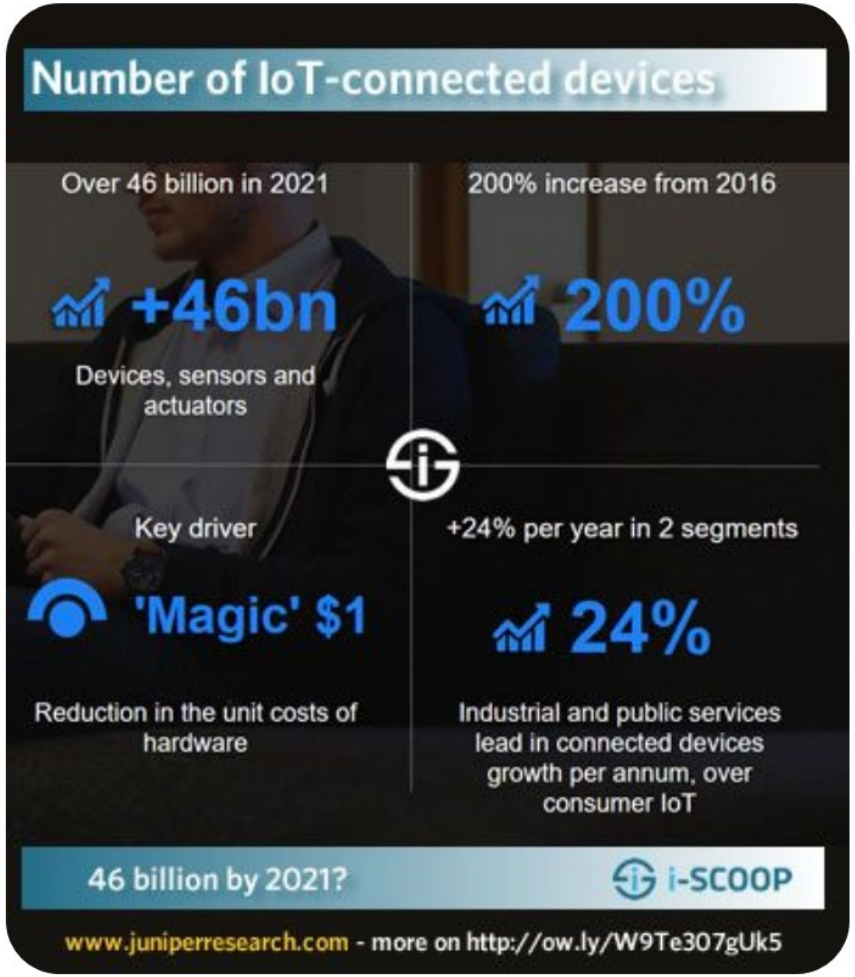
Introduction

- As 5G strives to accomplishing its mission of supporting a multitude of IoT verticals it will be exposed to a big threat:

  Flooding/DDOS attacks by IoT devices that could lead to network breakdown and total service disruption
- Unfortunately, there is currently no adequate defense measure to protect the mobile network against Flooding attacks
- We present here a Flooding prevention solution proposed by Telenor, Wolffia and OsloMet experimented at the 5G4IoT Lab at OsloMet in the scope of the H2020 Concordia Project
- The solution will be able to detect Flooding attacks even before they are launched by using Threat Intelligence with Machine Learning



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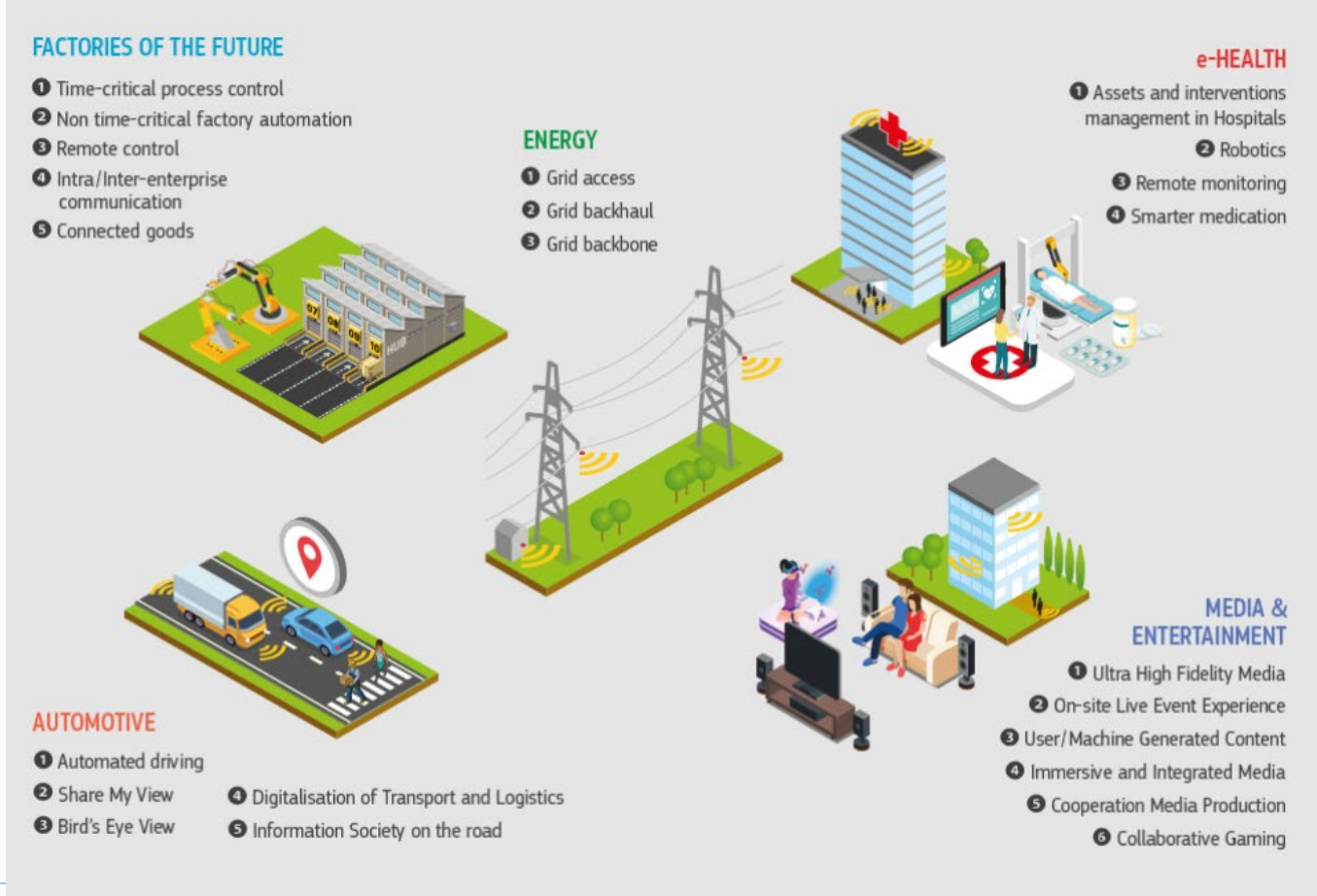
Why preventing Flooding Attacks

- The 5G network is a critical infrastructure for a variety of IoT verticals:
  - Emergency network and services
  - Smart city
  - eHealth
  - Intelligent transport
  - Defence/Army network
  - etc.
- A disruption in the 5G network will have severe consequences for the society



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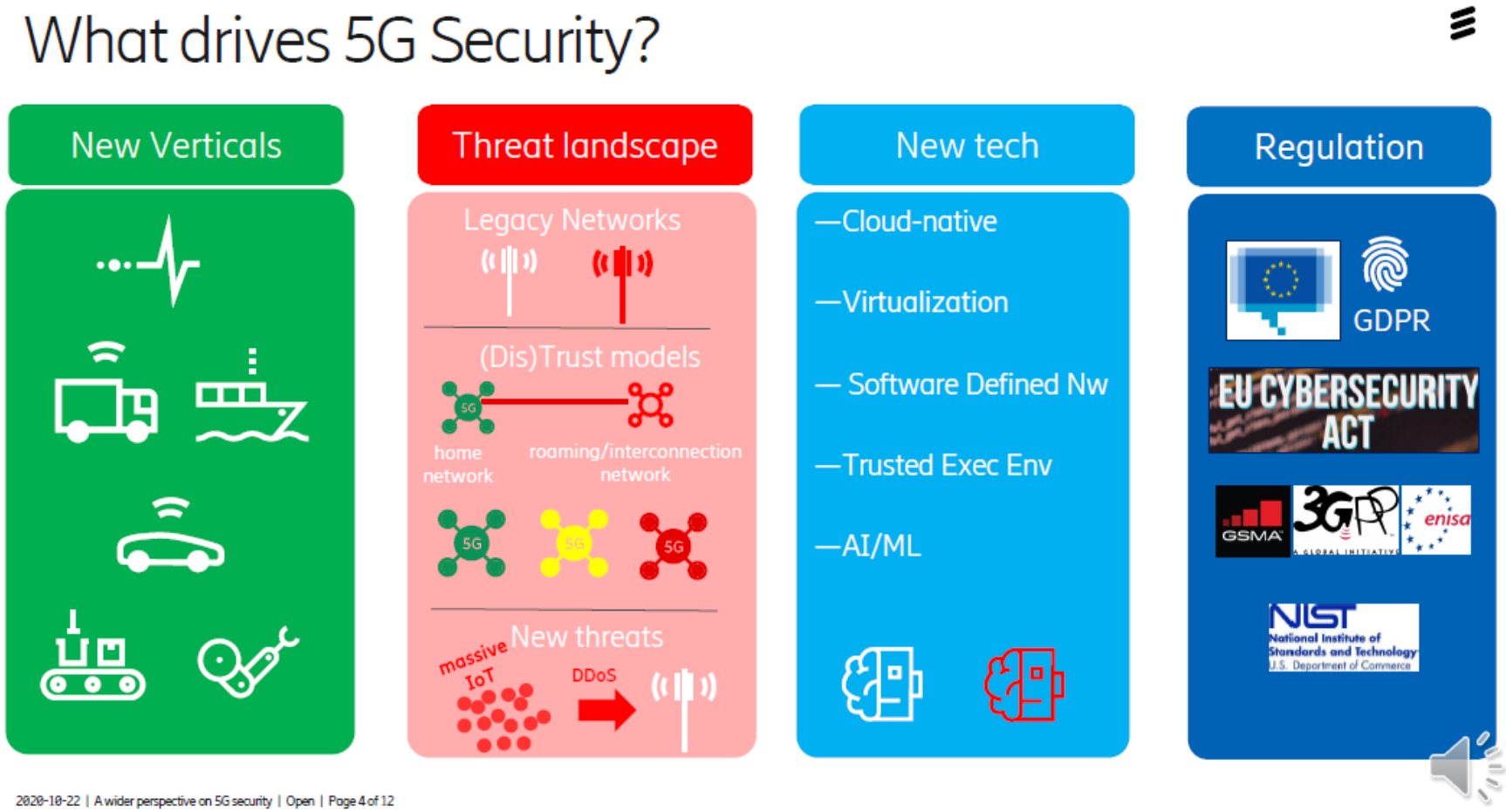
Is Flooding a real threat?

- Not yet happening but will happen if nothing is done



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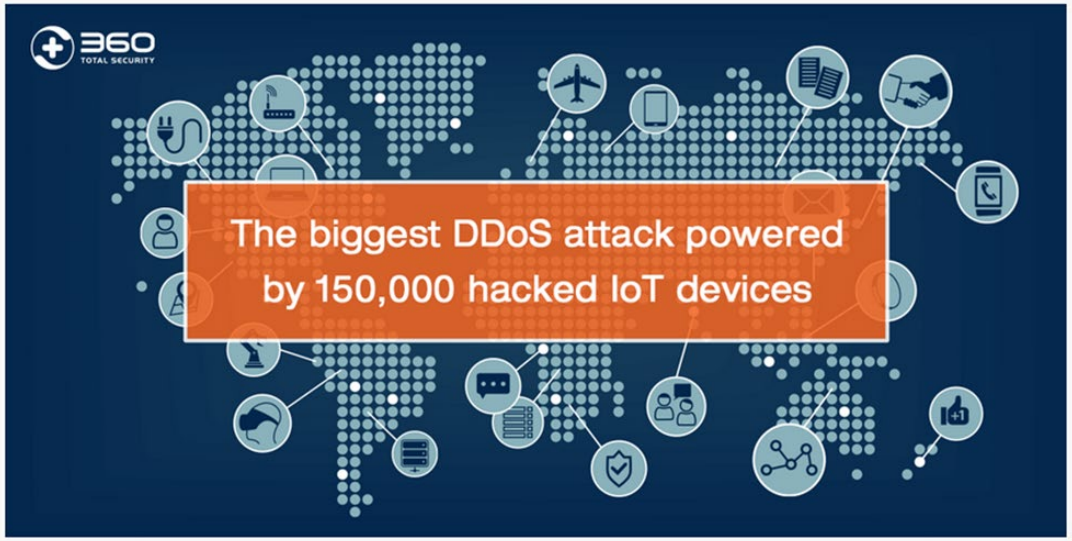
Huge threat from billion IoT devices

- Indeed, if billion of IoT devices get «mad» and bombard with messages the 5G network may collapse
- IoT devices are quite exposed
  - Could be tampered or hijacked without the knowledge of the owner
  - Simple and not capable of strong encryption and authentication
  - Unsecure communication
- Also, it is uncertain «who»/ «what» is behind an IoT device
  - It could be a simple primitive device
  - It could be a «monster» super computer
- The biggest challenge is that once detected a Flooding attack is almost unstoppable and the network may have already collapsed



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A simple but genius solution

- If it is too late to wait until a Flooding attack is launched
- Then let's detect and block it before
- **The big question is: HOW?**
- OUR SOLUTION is quite simple and assuming the following:
  - IoT devices used in a Flooding attack are compromised prior to an attack
  - They should have abnormal behaviour and activities
    - Communicating with allien parties
    - Have more activities than normal
  - On a fixed IP network it is not possible for the IoT platform and IoT owner to monitor and detect such anomalies
    - Because infected devices do not communicate with the IoT platform
  - On mobile networks, by collecting and analyzing data on the network layer both user and control data abnormal behaviours can be captured

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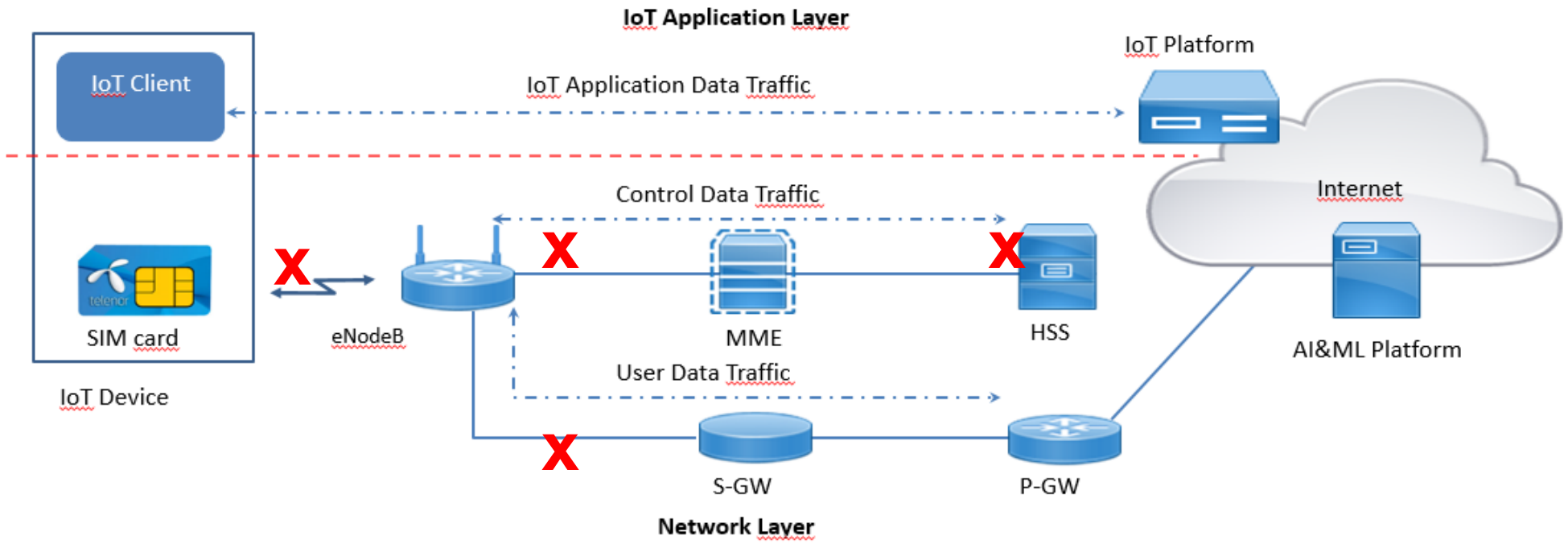
Flooding vs DDoS attacks

- **DDoS (Distributed Denial-of-Service)**
  - Attempt to make it impossible for a service to be delivered to its intended users.
  - By preventing access to virtually anything: servers, devices, services, networks, applications, and even specific transactions within applications
  - Targeting a specific service provider or web site
  - Detection can be done by analysis of traffic destined to a specific destination
- **Flooding**
  - Attempt to tear down the entire network blocking every service on the network
  - Send a massive amount of traffic onto a specific network segment with the goal of creating so much network congestion that legitimate traffic cannot reach the target server or service.
  - This type of attack is not specific to any Web site as the traffic sent onto the network could really be of any type
  - Detection

Flooding attacks on mobile networks



- Aims at taking down the entire mobile network:
  - No phone call
  - No SMS
  - No emergency call

- Blocking Radio Access Network (RAN)
- Blocking Control Plane
- Blocking Data Plane

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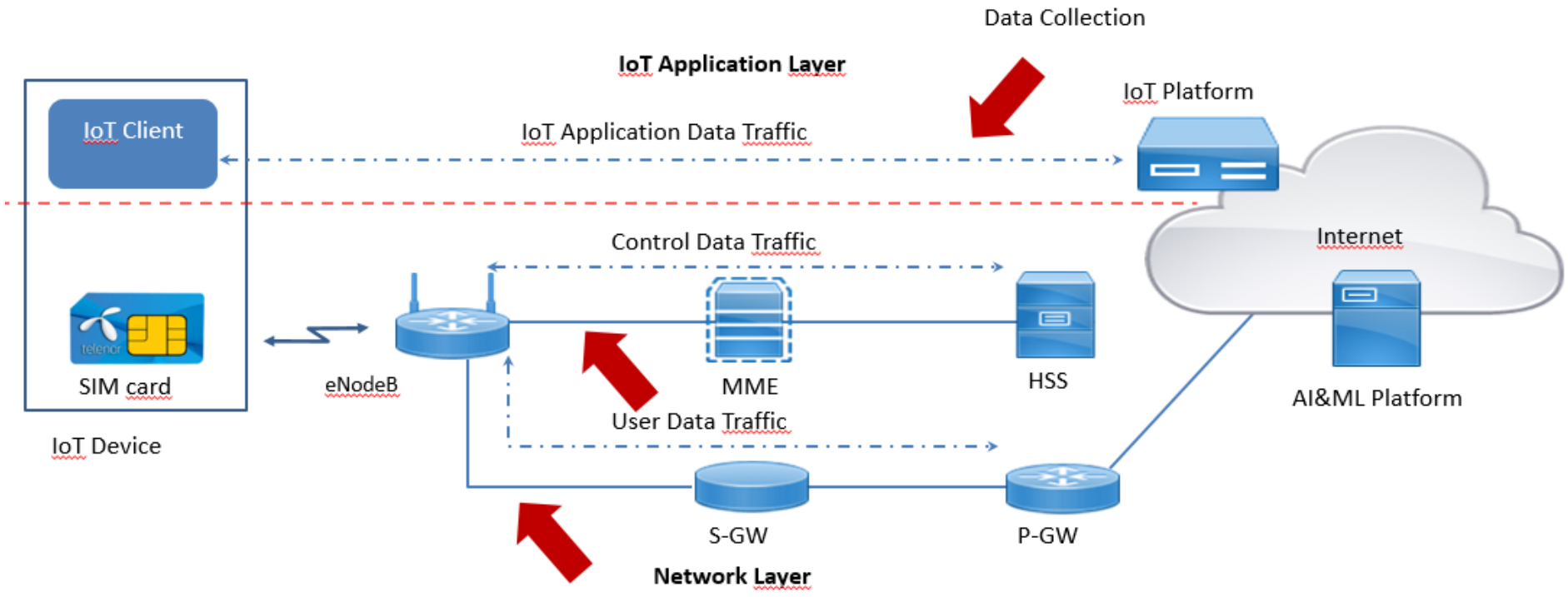
The Detection of Flooding Attacks solution

- Collection and analyse of data at three locations:
- On the application layer
- On the Network layer:
  - User plane
  - Control plane



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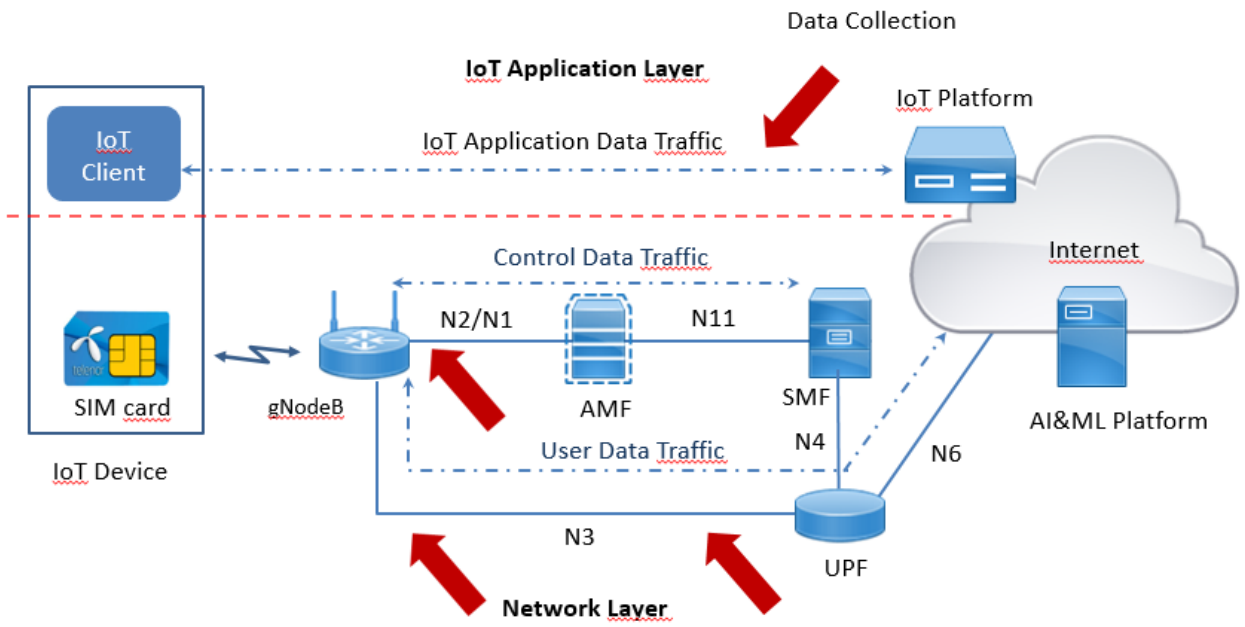
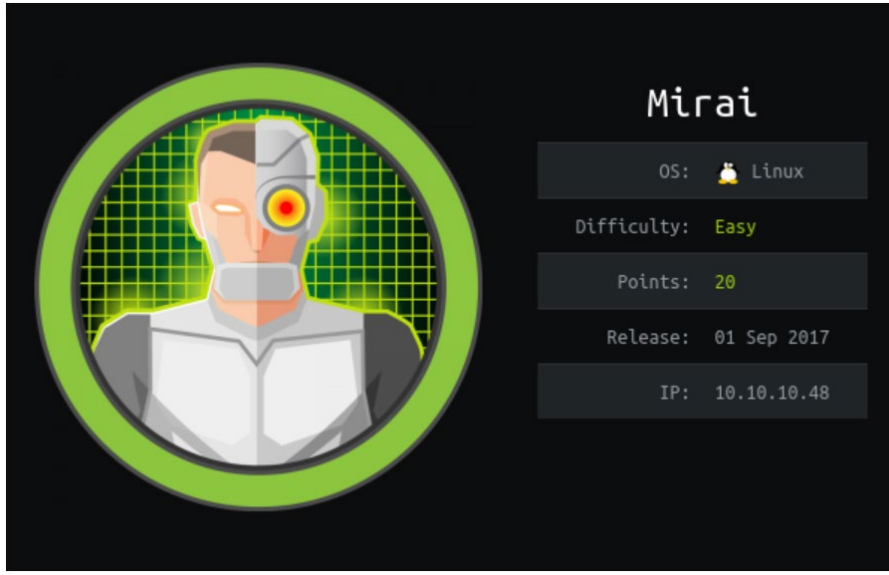
The 5G4IoT Machine Learning Platform

- Making use of Machine Learning
  - Semi-supervise
  - Both labelled and unlabelled data
  - Benign (normal) data are used to build a profile of the normal situation
  - Any deviation is interpreted as an anomaly that will be analysed by security experts
- **A big challenge:** The lack of malicious data
  - Solutions:
    - Simulated attacks with purposely infected devices
      - Simulated Mobile phones
      - Raspberry PI infected with Mirai
    - Generation of traffic based collected traffic



Achievements

- A 5G IoT testbed is established at the 5G4IoT lab:
  - A small lab 5G network is built with:
    - Commodity computers combined with OsloMet cloud
    - Using USRP (Universal Software defined Radio Peripheral)
    - Running OpenAirInterface and Open5GS
  - A variety of devices:
    - Mobile phones
    - Digital locks
    - Cameras
    - Raspberry Pis
    - Sensors
  - A ML platform based on commodity computers and open source software
- Profiles for normal situation have been built
- **Next step:** Introduce anomalies:
  - Particular app on mobile phones
  - Simulated infected Raspberry PI



Conclusion

- IoT will play a central role in the digitalization of the society
  - More and more devices and sensors will be used
  - More security will be needed to ensure that these IoT devices are functioning as intended
- 5G will be the dominant connectivity and communication infrastructure which has the critical mission to support and provide adequate security to IoT applications and devices
- With the rise of AI/ML it is natural that AI/ML should be used to provide improved security for IoT but the main challenge is the data sets:
  - What are the relevant data?
  - Where/How to collect them?
  - How to store and consume them?
- Another challenge is how to share the lessons learnt between mobile networks:
  - Due to differences in size, distribution, number of users, configuration, etc.
- We will continue researching to bring clarity to these issues

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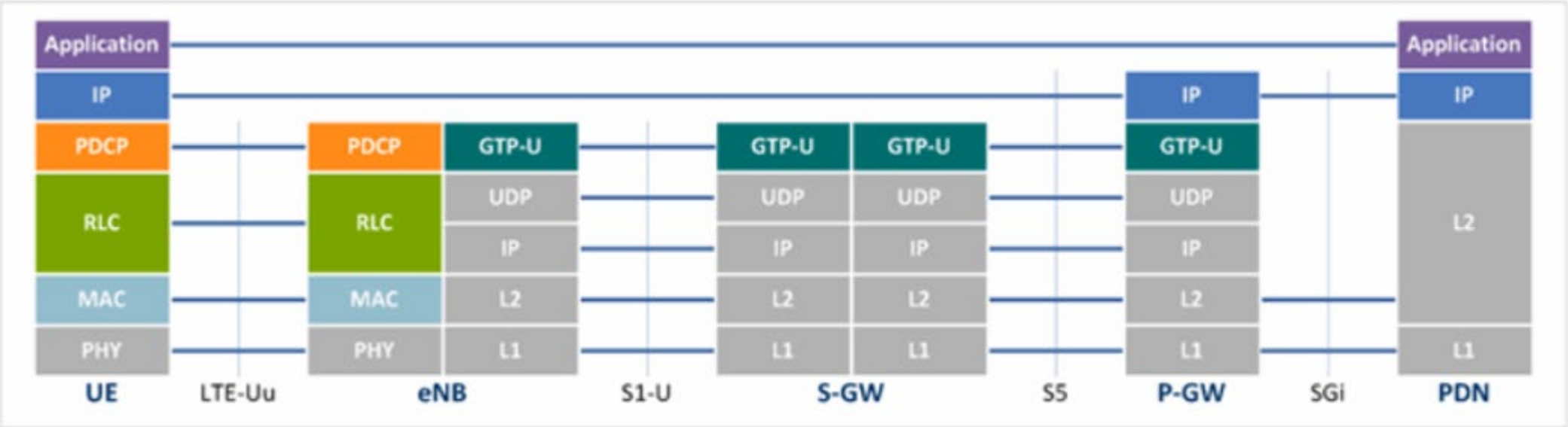
Thank you

5G4IOT

Differences with DDoS attacks on fixed networks

- Attacks can be launched on the application layer, on the network user plane or control plane or on the RAN
- Attacks can happen before the devices get allocated an IP address:
  - Other mobile identities must be used:
    - **SUPI** - Subscription Permanent Identifier
      - **IMSI** – International Mobile Subscriber Identity
    - **SUCI** - Subscription Concealed Identifier
    - **GUTI** – Global Unique Temporary Identifier
      - **TMSI** – Temporary Mobile Subscriber Identity
    - **PEI** – Permanent Equipment Identifier
    - **DNN** - Data Network Name
    - **NSSAI** - Network Slice Selection Assistance Information
- Mobility of devices
  - Change in device location and concentration
  - Registration Area/Tracking Area is a relevant attribute
- Unknown an uncontrolled number of devices connected to the mobile network
  - Roaming devices from other mobile networks
- Protocols and collected data sets are different

5G User Plane Protocol stack



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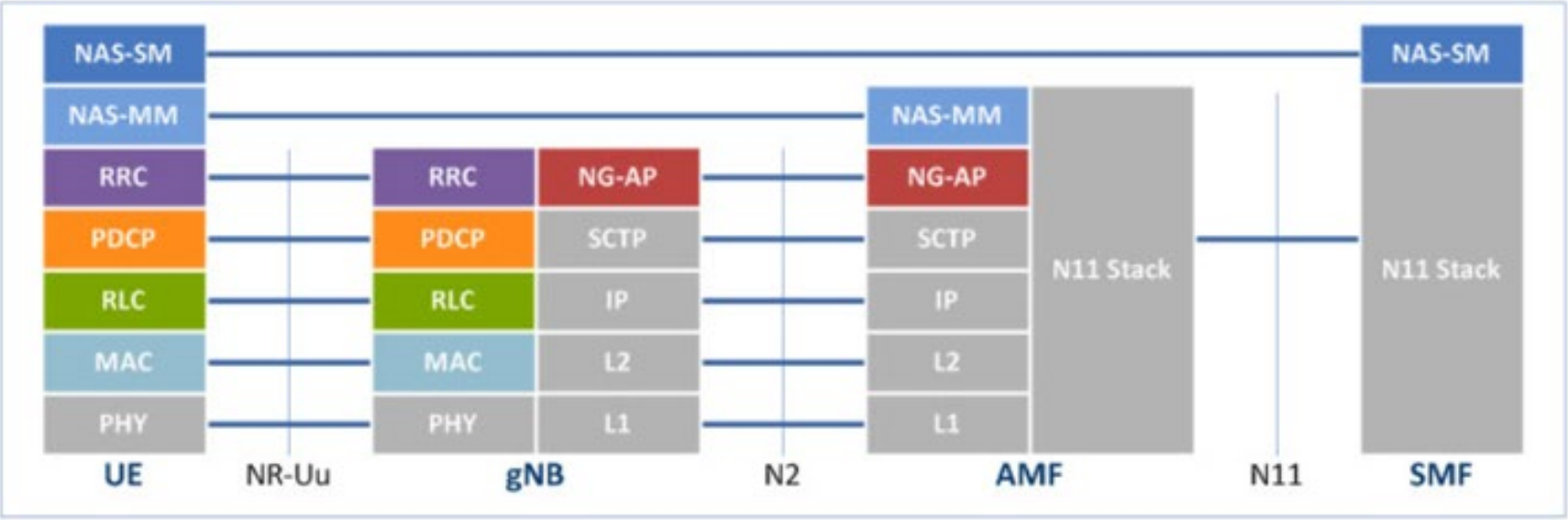
5G Control Plane Protocol Stack



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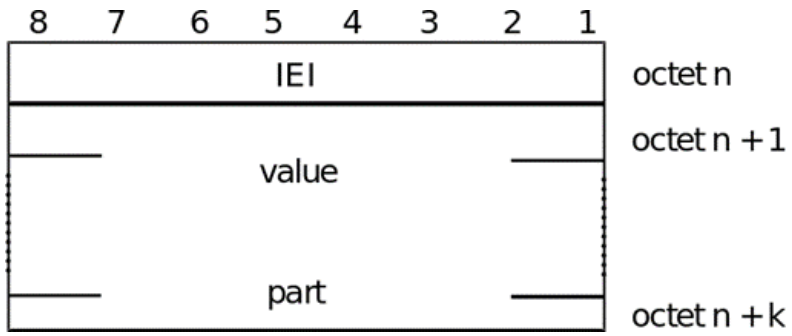
L3 Signalling Message

- A standard L3 message consists of:
  - an imperative part, itself composed of a header and the rest of imperative part
  - followed by a non-imperative part.
  - Both the non-header part of the imperative part and the non-imperative part are **composed of successive parts referred as standard information elements**.
- Totally four categories of standard **information** elements (IE) are defined:
  - information elements of format V or TV with value part consisting of 1/2 octet (**type 1**);
  - information elements of format T with value part consisting of 0 octets (**type 2**);
  - information elements of format V or TV with value part that has fixed length of at least one octet (**type 3**);
  - information elements of format LV or TLV with value part consisting of zero, one or more octets (**type 4**)



Type 3 IE of format TV (k = 1, 2, …)

Non-Access-Stratum (NAS) message for 5G System

- Every 5GS NAS message is a standard L3 message
- NAS message categories:
  - Registration
  - Call Control
  - Call independent Supplementary Services
  - Short Message Service
  - Session Management Service
  - Location services

8	7	6	5	4	3	2	1	
Extended protocol discriminator								octet 1
Security header type associated with a spare half octet; or PDU session identity								octet 2
Procedure transaction identity								octet 2a*
Message type								octet 3
Other information elements as required								octet 4 octet n

General message organization example for a plain 5GS NAS message

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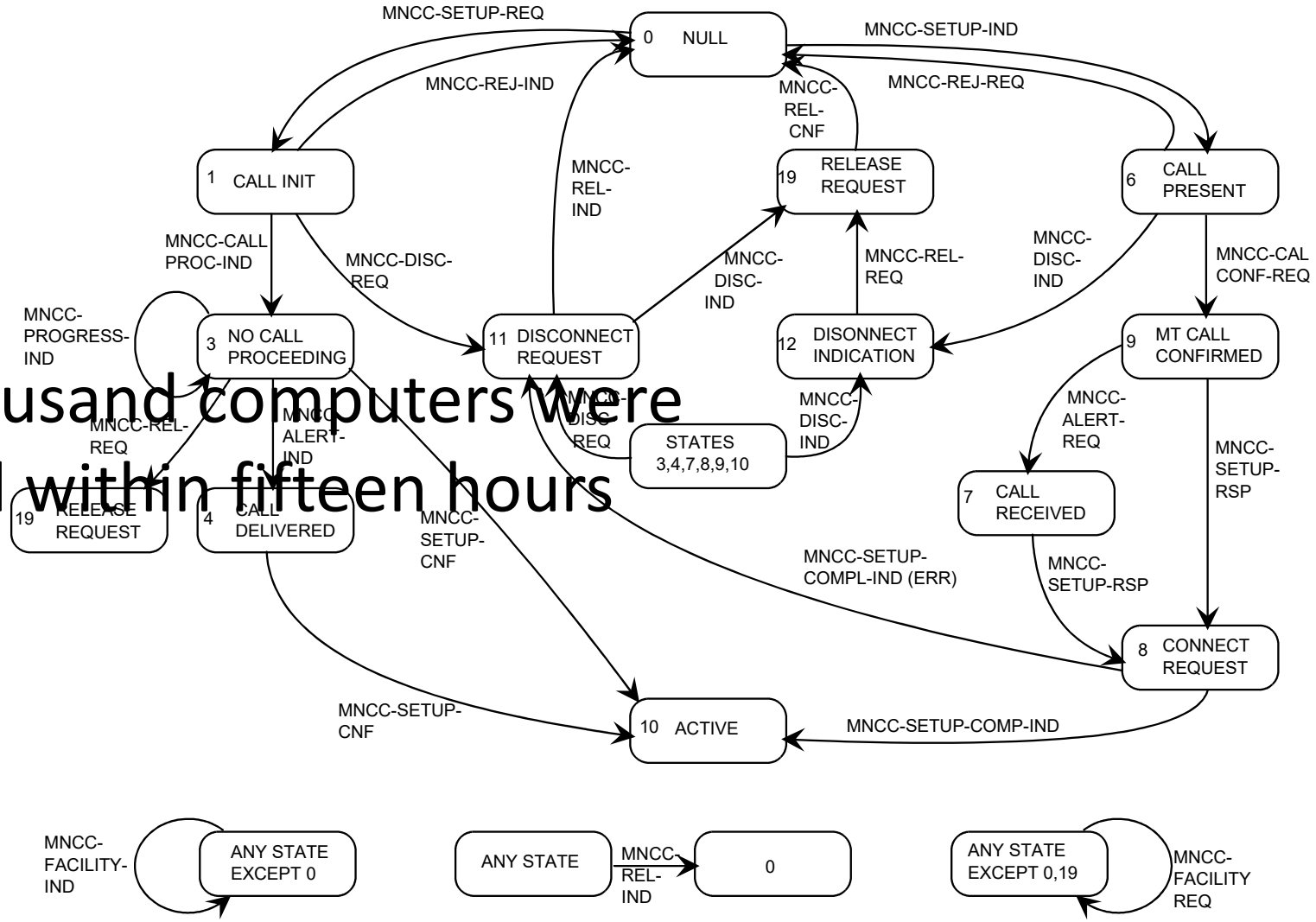
Mobile Station Call Control state



two thousand computers were infected within fifteen hours

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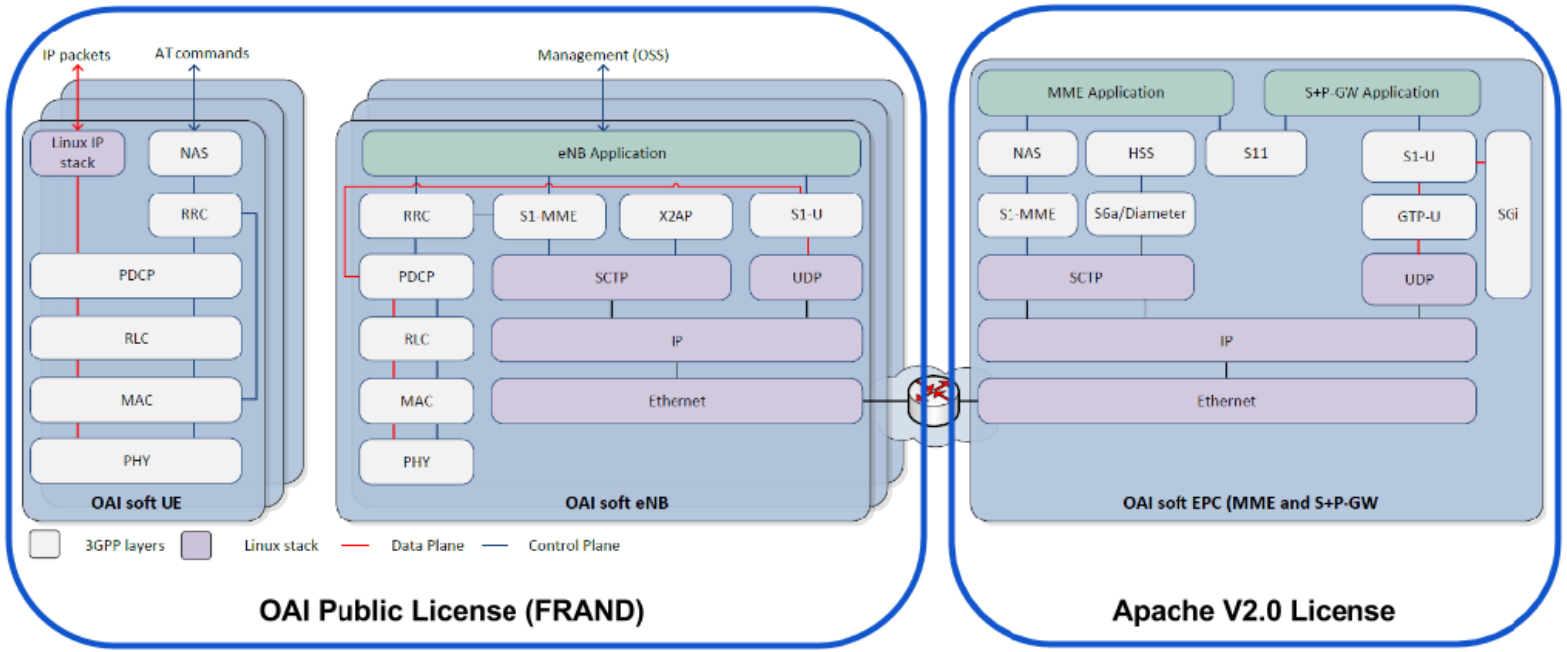
Data Capture

- Using Wireshark installed at the gNB and 5G/4G Core
- With the following filters:
  - nas-5gs: Non-Access-Stratum 5GS (NAS)PDU (2.6.0 to 3.4.0, 358 fields)
  - nas-eps: Non-Access-Stratum (NAS)PDU (1.2.0 to 3.4.0, 365 fields)
  - gtp: GPRS Tunneling Protocol (1.0.0 t 3.4.0, 354 fields)
  - gtpv2: GPRS Tunneling Protocol V2 (1.2.0 to 3.4.0, 738 fields)
- Generating csv files
- Fine tuning and removing irrelevant parameters
- Aggregating and feeding to the Machine Learning Platform



Research Challenges

- When the ML learning platform detects an outlier i.e. abnormal situation which is found to be an attack by a security expert can this outlier be transformed to an Indicator of Compromise to be shared in MISP:
  - An outlier is a deviation from on a normal situation profile which is modelled by complex algorithm and may not be transformed to an IoC
  - A normal situation of one network is different from others: number and types of susbcription, traffic, configuration, etc.
- Conversely, it may also be challenging to use IoC in the training of the ML Platform
- How can experiences/lessons learned from the fixed network can be used in the mobile network? And Vice versa?