IETF-125 Hackathon

5G-I2NSF: An Integrated Security System for 5G Networks with I2NSF

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IETF-125 5G-I2NSF System for Integrated Security Services in 5G Networks

Champion: Jaehoon Paul Jeong (SKKU)

IETF-125 5G-I2NSF Project

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- Joo-Sang Youn (DEU)

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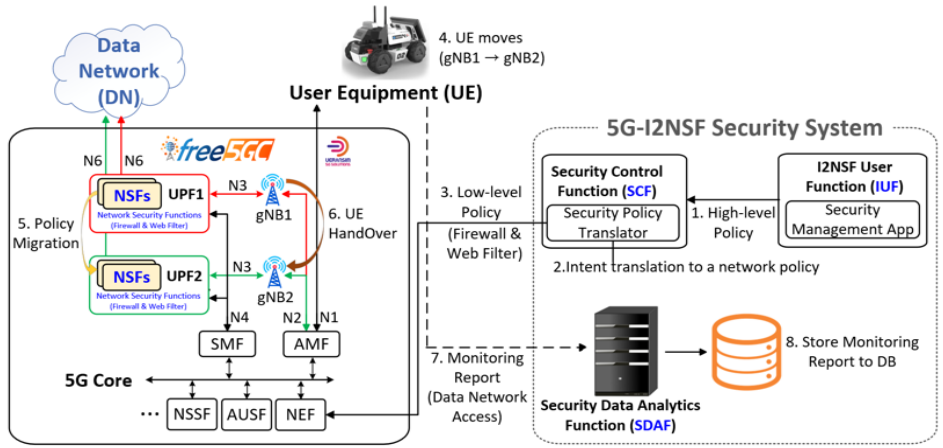
Students:

- Yoseop Ahn (SKKU)
- Jiwon Suh (SKKU)
- Jiwon Yoo (SKKU)

5G-I2NSF System



Objectives

- This project proposes an integrated framework for automated security orchestration in 5G edge environments based on the Interface to Network Security Functions (I2NSF) framework.
- This framework translates high-level YANG/XML security policies into low-level rules and dynamically deploys Network Security Functions (NSFs) within a User Plane Function (UPF).
- It supports seamless security policy migration during a User Equipment (UE)'s handover to maintain consistent security enforcement with minimal latency.

Future Work

- We will employ a Large Language Model (LLM) to interpret natural language intents and automatically generate YAML-based policies.
- AI-driven analysis will further enhance security services through adaptive learning, anomaly detection, and policy refinement.

5G-I2NSF Development Environment

- OS: Ubuntu 22.04
- Free5GC VM: version 4.1.0
- UERANSIM VM (UE & RAN): version 3.2.6
- GitHub Repository: https://github.com/jaehoonpauljeong/5G-I2NSF/tree/main/IETF-125

Workflow of the 5G-I2NSF Testbed

1. A high-level security policy is first created by an I2NSF User Function (IUF) according to a user's intent, and a Security Control Function (SCF) converts it into a corresponding low-level security policy.
2. This policy is forwarded to a Session Management Function (SMF) through a Network Exposure Function (NEF), enabling the required Network Security Functions (NSFs) to be instantiated in a UPF.
3. When a UE moves from a base station (gNB1) to another base station (gNB2) through handover, the 5G system anticipates the next serving gNB and proactively transfers the NSF's security policies (e.g., firewall and web filtering) from the current UPF (UPF1) to the next UPF (UPF2).
4. An Access and Mobility Management Function (AMF) coordinates the handover of the moving UE while the SMF reestablishes the N4 session with UPF2.
5. The UE's traffic logs are sent to a Security Data Analytics Function (SDAF) as an Analyzer to verify whether the deployed NSFs properly enforce the security policies or not.

Goal of Hackathon Project

- **Goal**
  - To make an Edge-Based Security System in 5G Networks with the Interface to Network Security Functions (I2NSF) Framework which is the IETF standard.

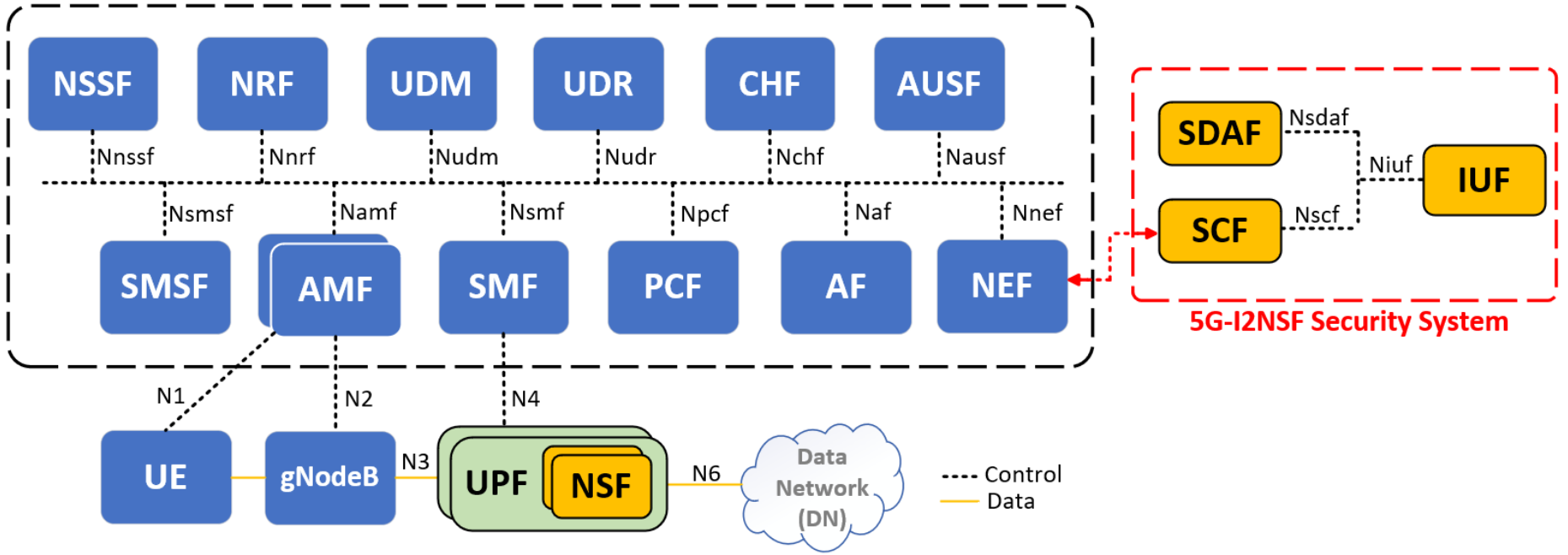
- **Security Policy Provisioning** through **Edge-Based I2NSF Framework**
  - Integration of I2NSF to 5G as Edge Approach rather than Cloud Approach.
  - Formation of I2NSF Components as 5G Network Functions (NFs) and also I2NSF Interfaces as 5G Interfaces.

- **Internet Drafts for the 5G-I2NSF Project**
  - https://datatracker.ietf.org/doc/draft-ahn-nmrg-5g-security-i2nsf-framework/

I2NSF-based Integration for 5G Security Services

➢ Integration of I2NSF-based Components in 5G Service-Based Architecture

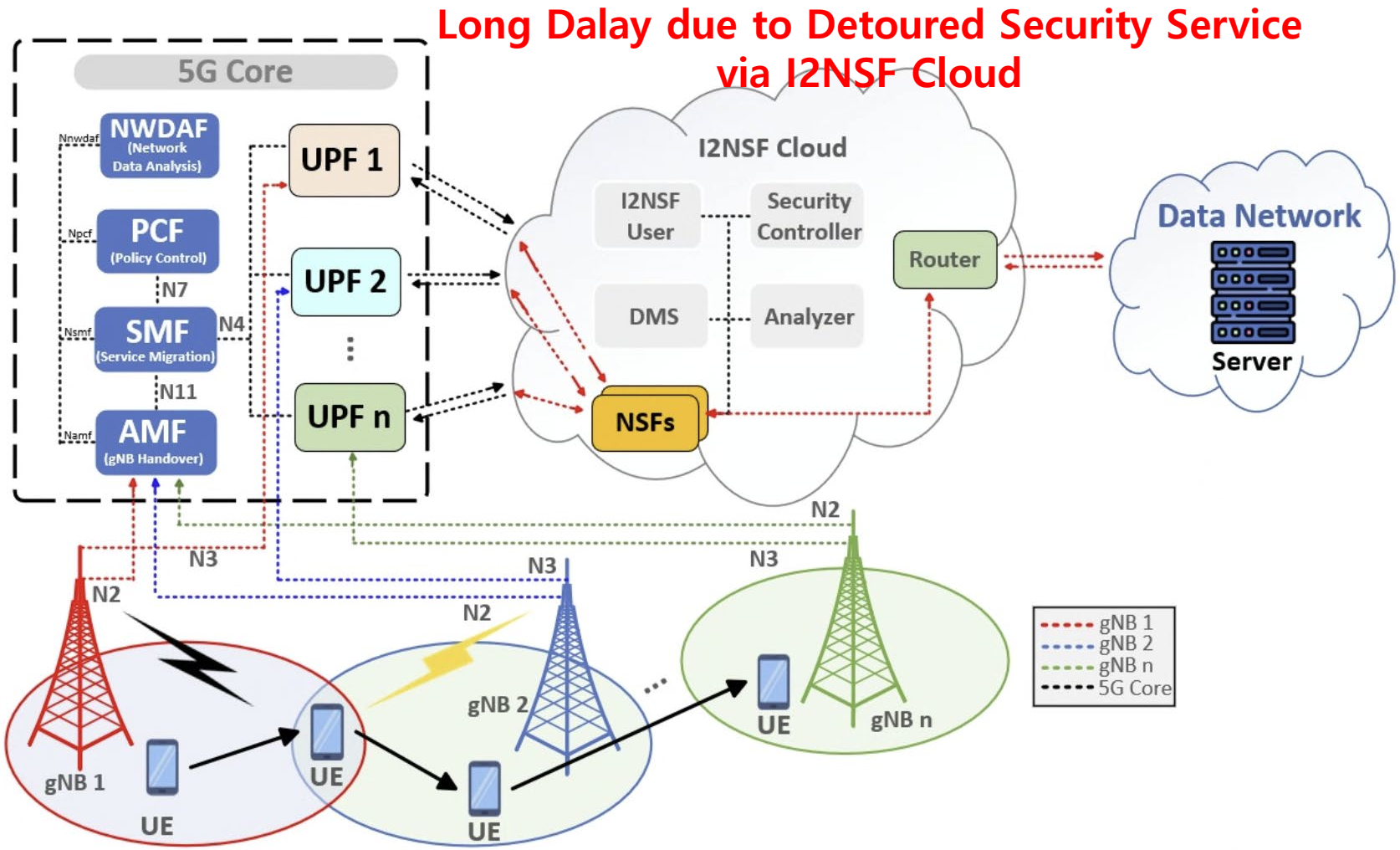
- To enhance edge-based security management in 5G networks, the I2NSF framework with I2NSF components (e.g., IUF, SCF, and SDAF) is integrated with the 5G Core Network.
  - IUF (I2NSF User Function), SCF (Security Control Function), and SDAF (Security Data Analytics Function)
- The I2NSF framework generates security policies, enforces them, and analyzes security activities through NSFs (Network Security Functions) deployed with UPFs for efficient security.



An Integrated Security System for 5G Networks with I2NSF

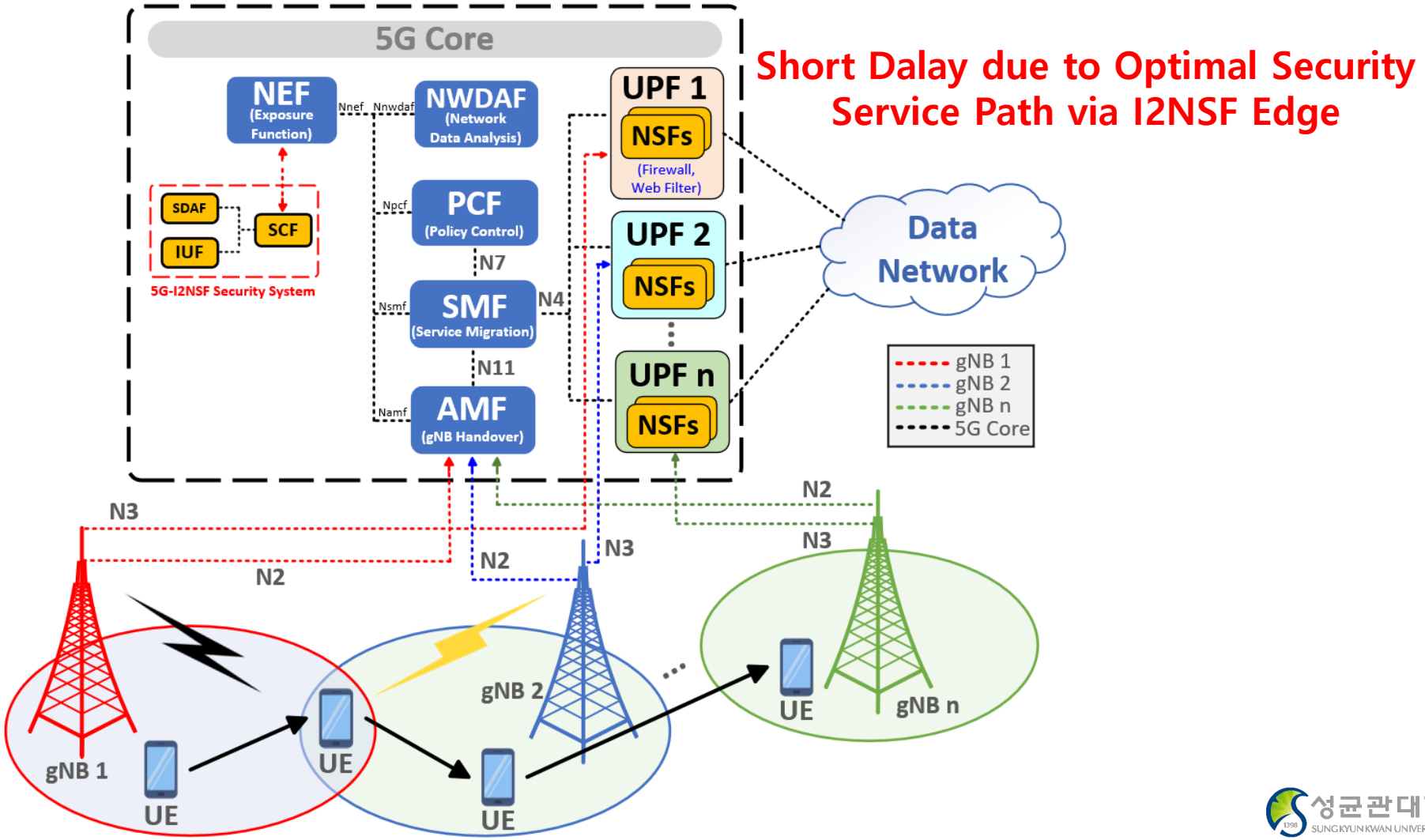
I2NSF Cloud Approach for 5G Networks

- **Legacy:** Execution of NSFs in I2NSF Cloud outside of 5G Core Networks
  - Long delay by a detoured path from a UE to I2NSF Cloud for security services.



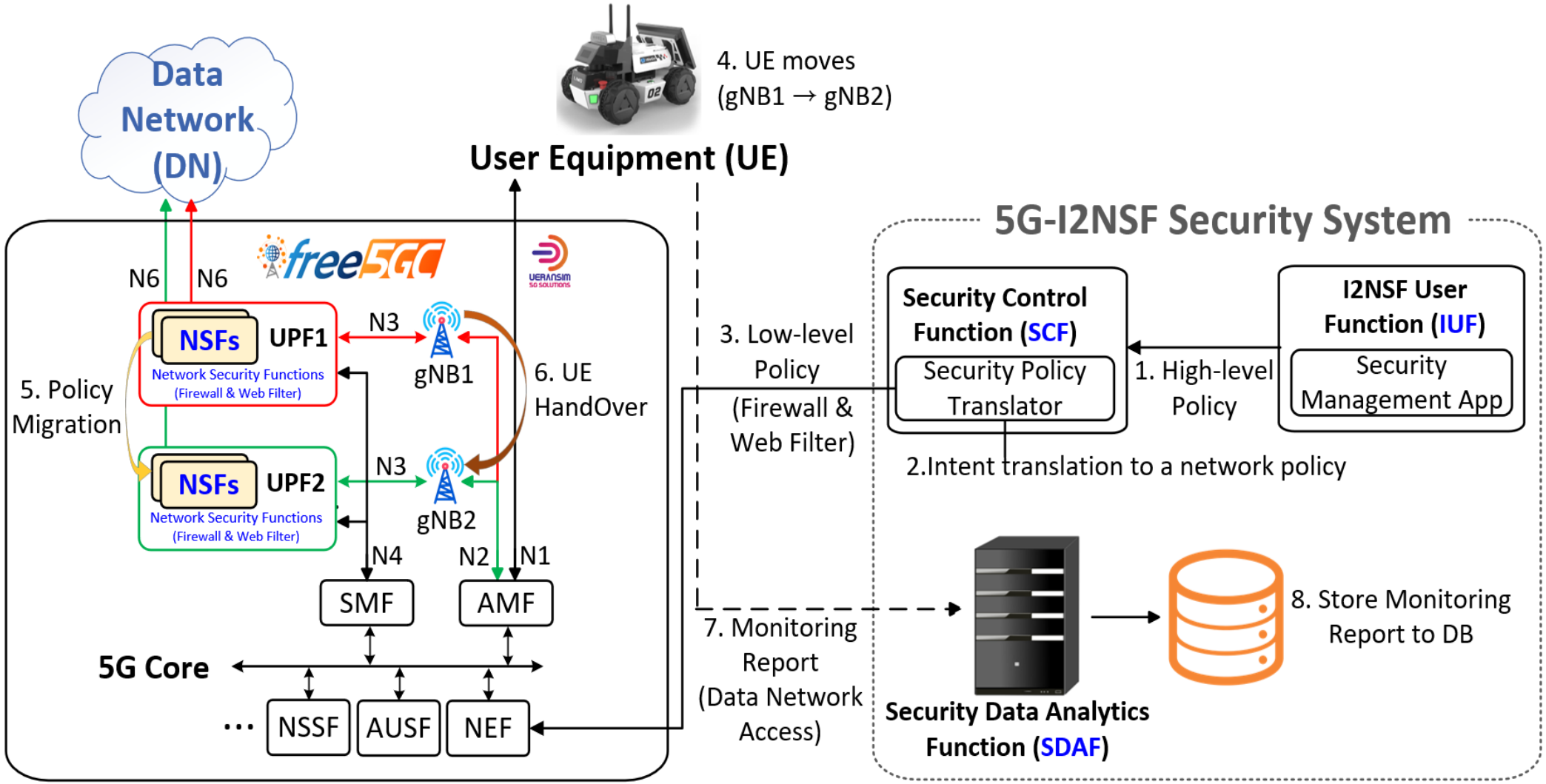
I2NSF Edge Approach for 5G Networks

- **Legacy:** Execution of NSFs in I2NSF Cloud inside of 5G Core Networks
  - Short delay by an optimal path from a UE to I2NSF Edge for security services.



An Integrated Security System for 5G Networks with I2NSF

➢ 5G-I2NSF System



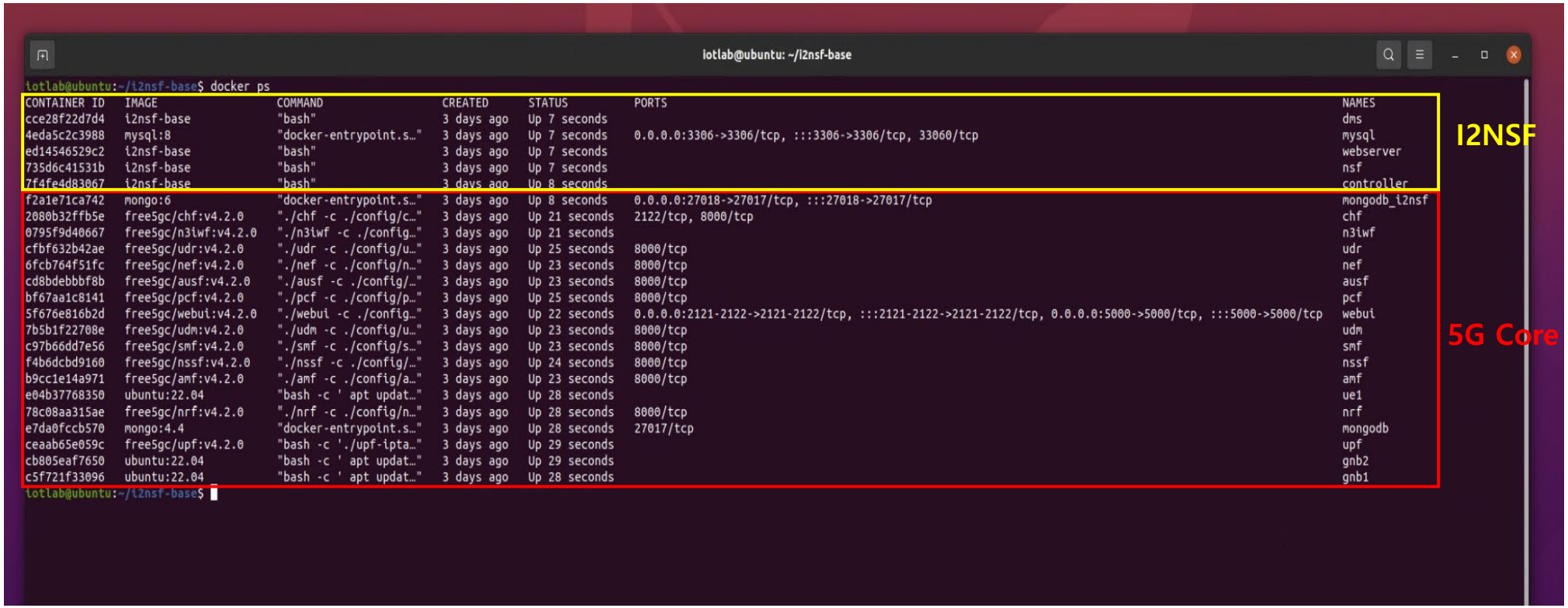
What we learned

- We designed and deployed the 5G-I2NSF system in a containerized environment using technologies such as Docker.

- This allowed the entire testbed system to run in a containerized environment while integrating I2NSF security functions with the Free5GC 5G network.
  - I2NSF and Free5GC are running in a Cloud-Native Environment.

Demonstration of 5G-I2NSF (1/4)

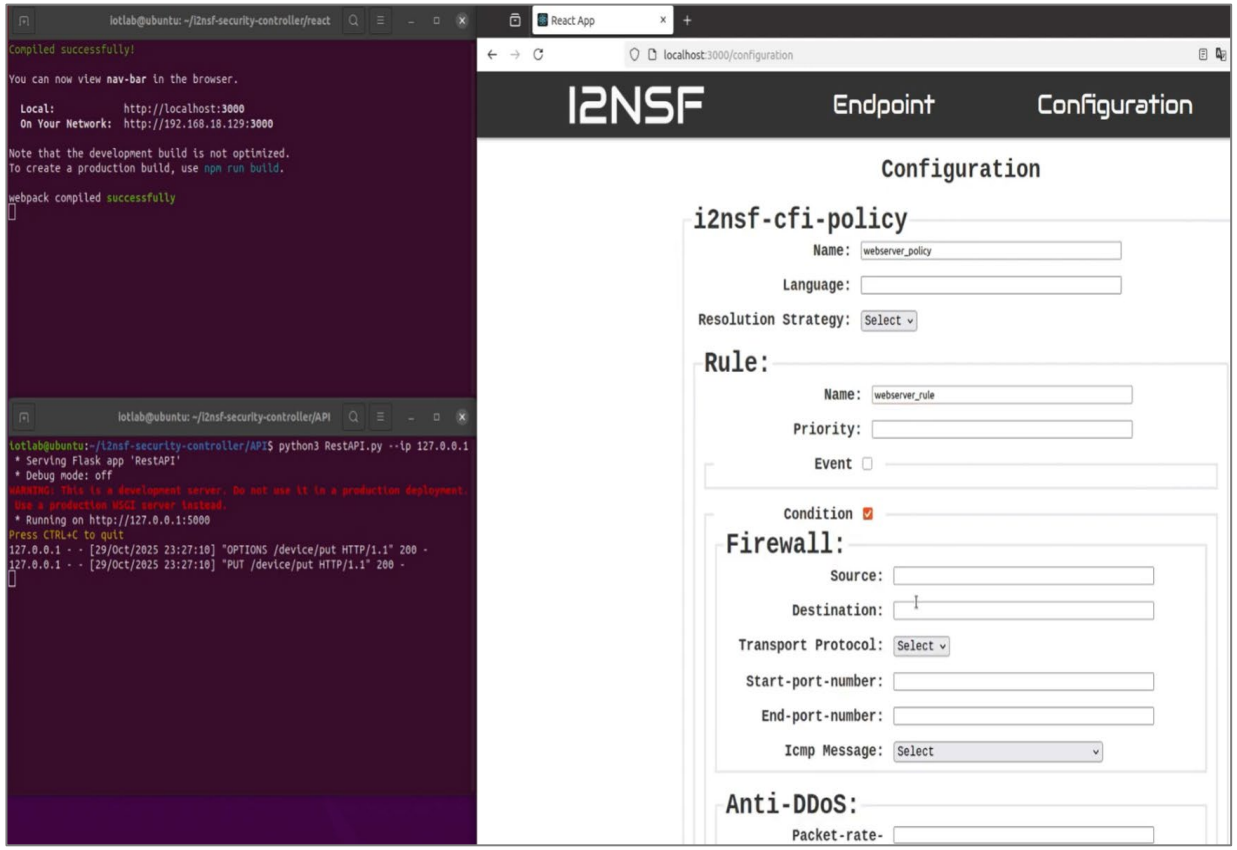
➢ Containerized 5G Core Network with I2NSF Framework



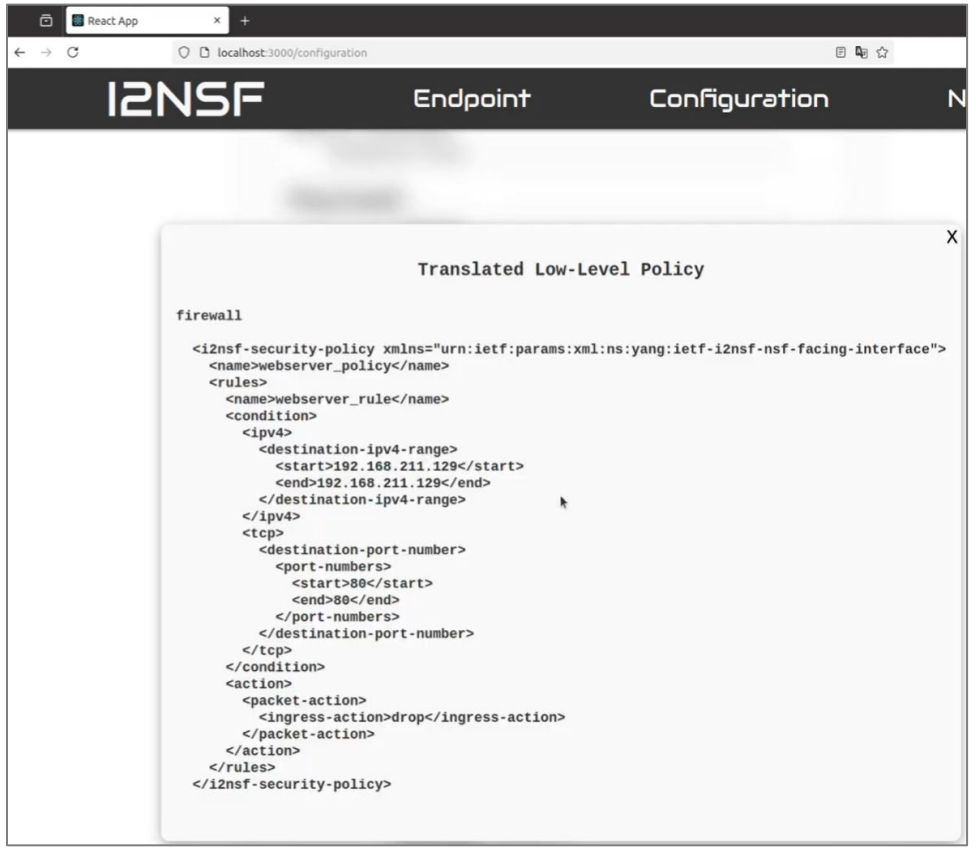
Docker Containers for I2NSF NSFs and Free5GC 5G Core Network

Demonstration of 5G-I2NSF (2/4)

➢ Security Policy Translation



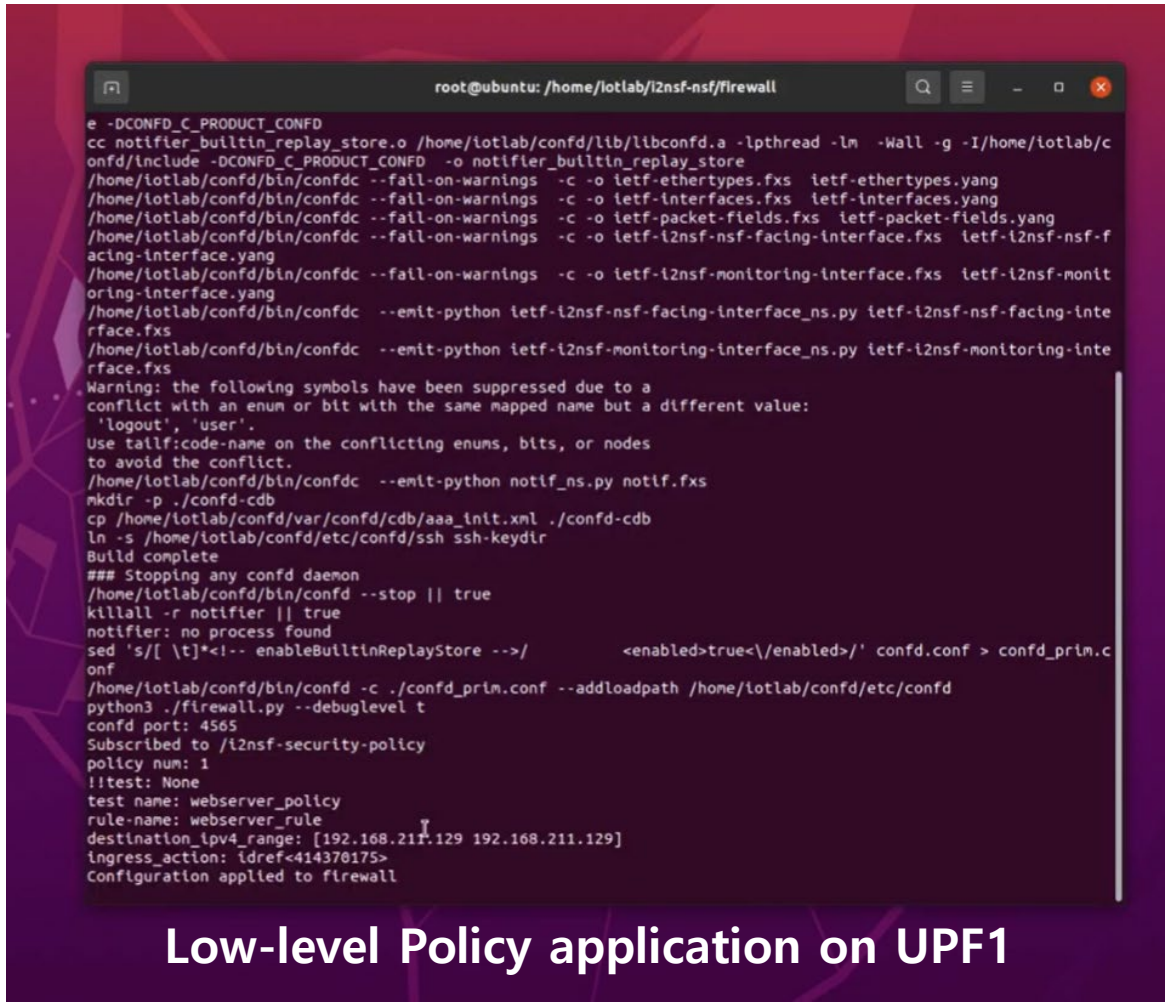
I2NSF User Function (IUF) for High-level Security Policy



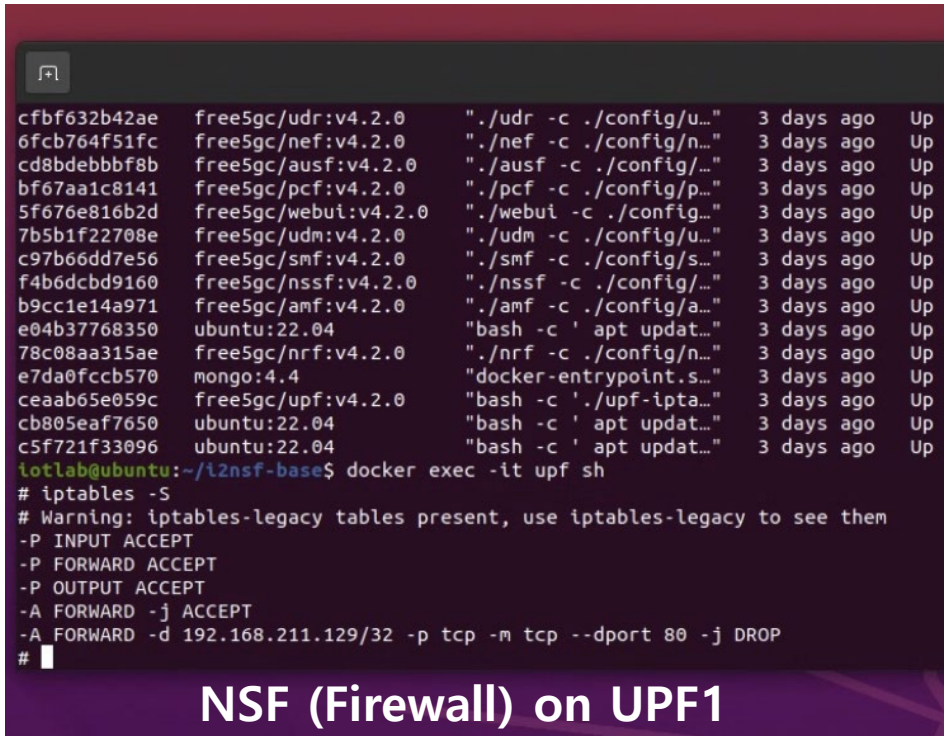
Security Control Funtion (SCF) for
Low-level Security Policy Generation

Demonstration of 5G-I2NSF (3/4)

➢ NSF (Firewall) Generation on UPF



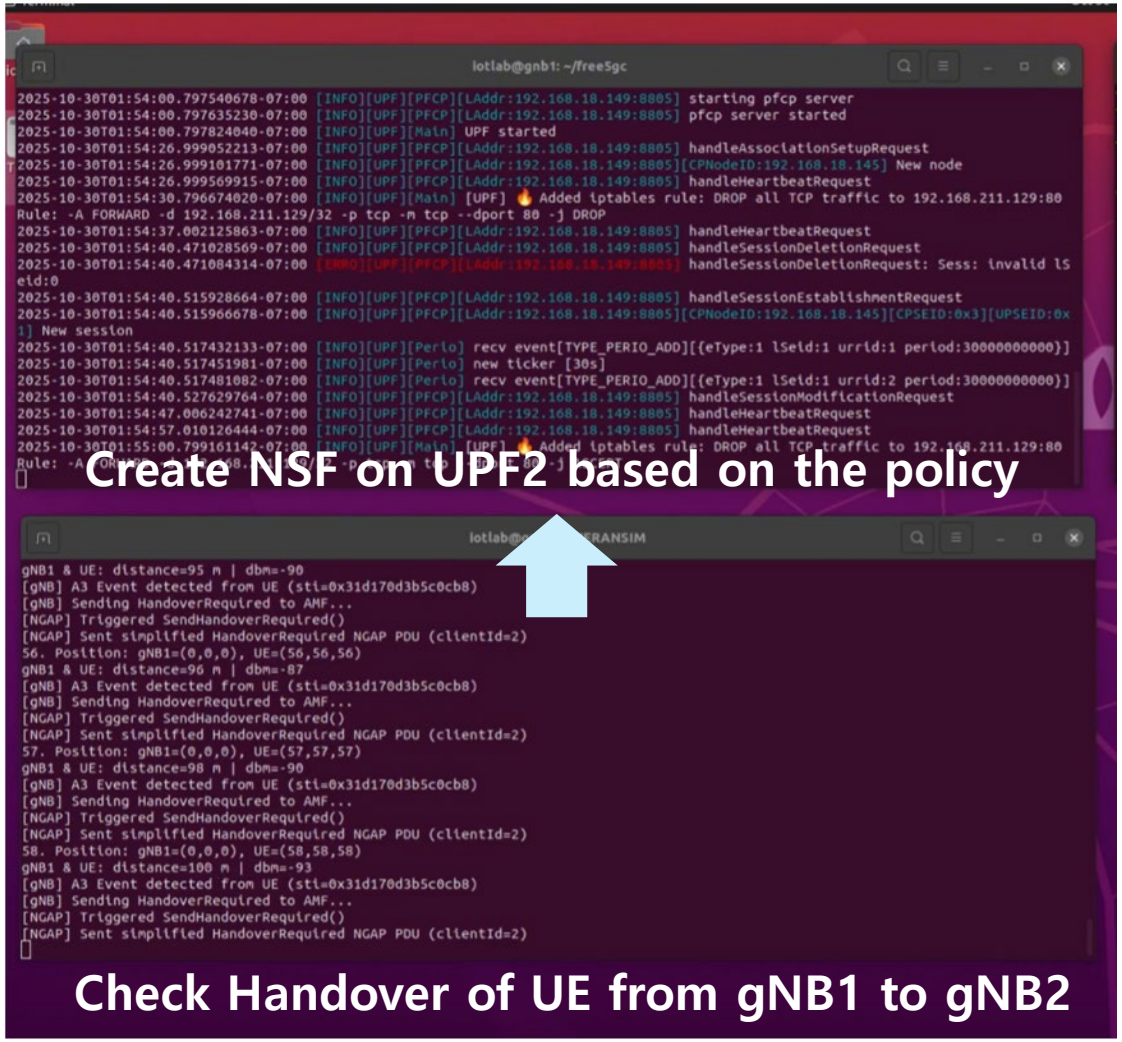
Low-level Policy application on UPF1



NSF (Firewall) on UPF1

Demonstration of 5G-I2NSF (4/4)

➢ UE Handover and Policy-based NSF Creation on UPF

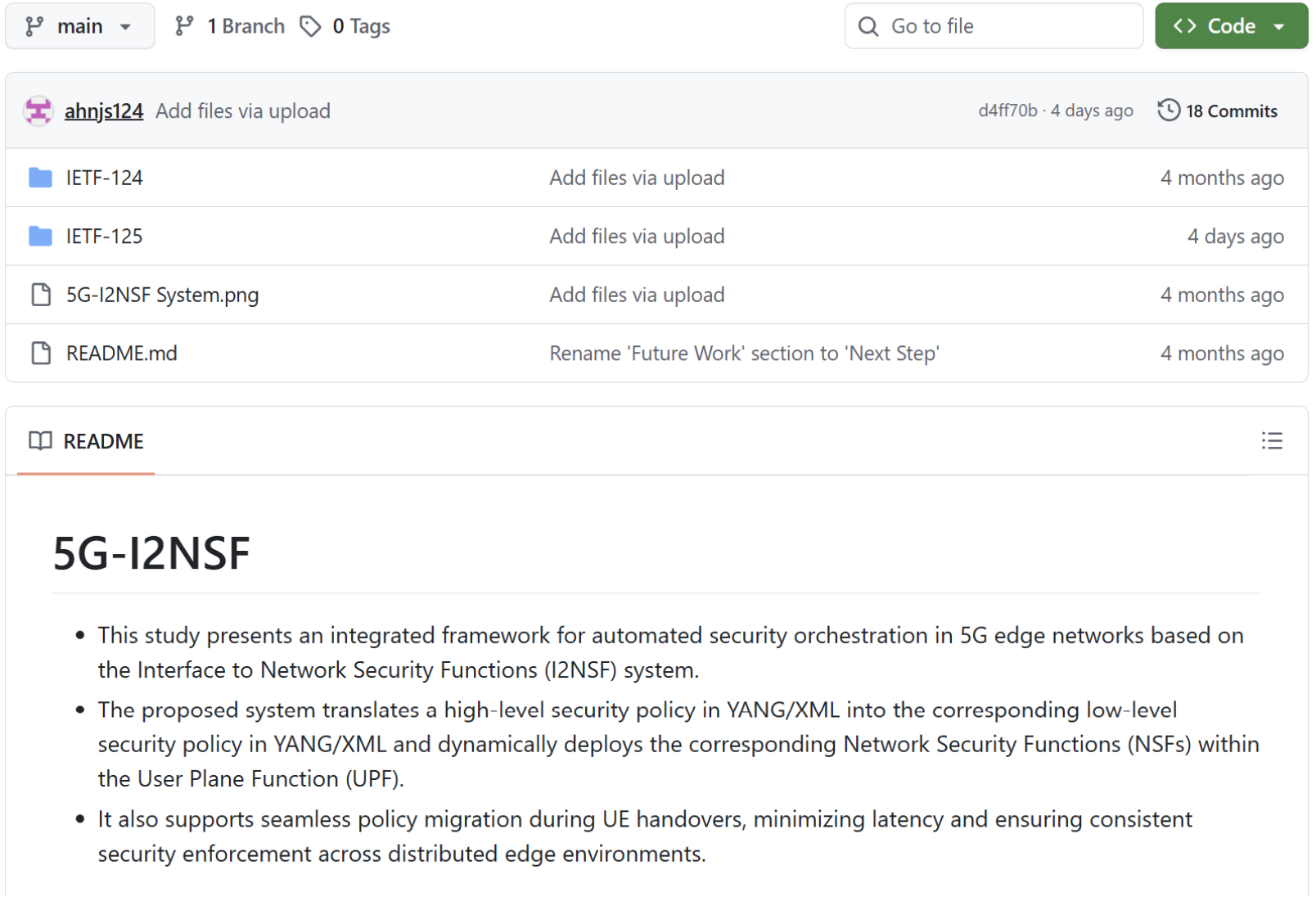



```
2dc6ea07f2c5   ubuntu:22.04          "bash -c ' apt updat…"   About a minute ago
0ad48c2e3cf3   ubuntu:22.04          "bash -c ' apt updat…"   About a minute ago
21b3751a9018   free5gc/upf:v4.2.0    "bash -c './upf-ipta…"   About a minute ago
cce28f22d7d4   i2nsf-base            "bash"                   3 days ago
4eda5c2c3988   mysql:8               "docker-entrypoint.s…"   3 days ago
ed14546529c2   i2nsf-base            "bash"                   3 days ago
735d6c41531b   i2nsf-base            "bash"                   3 days ago
7f4fe4d83067   i2nsf-base            "bash"                   3 days ago
f2a1e71ca742   mongo:6               "docker-entrypoint.s…"   3 days ago
iotlab@ubuntu:~/free5gc-compose$ docker exec -it upf2 sh
# iptables -S
# Warning: iptables-legacy tables present, use iptables-legacy to see them
-P INPUT ACCEPT
-P FORWARD ACCEPT
-P OUTPUT ACCEPT
-A FORWARD -j ACCEPT
-A FORWARD -d 192.168.211.130/32 -p tcp -m tcp --dport 80 -j DROP
#
```

NSF (Firewall) on UPF2

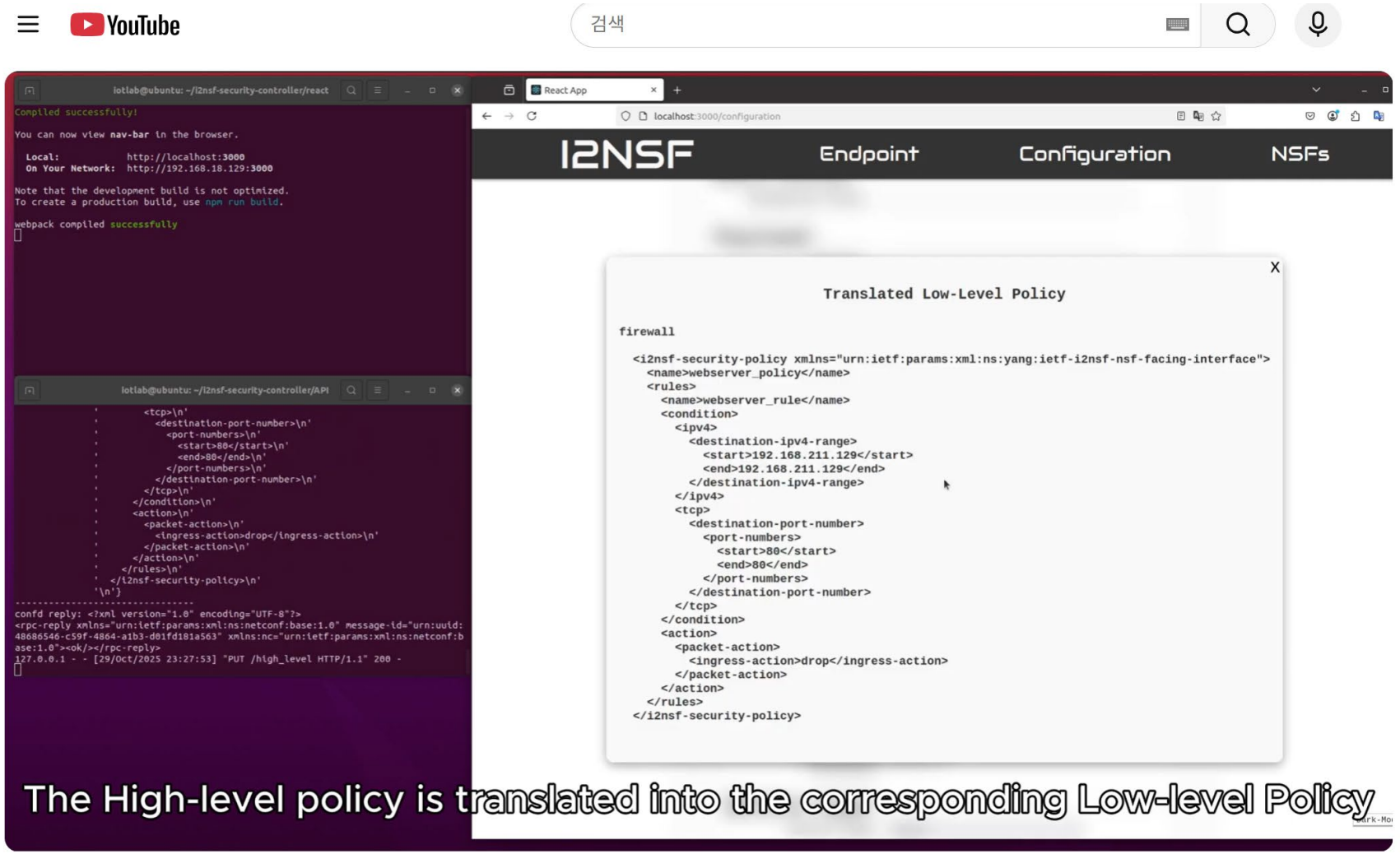
Open-Source Project for 5G-I2NSF

[URL] https://github.com/jaehoonpauljeong/5G-I2NSF/tree/main/IETF-125



Demonstration Video Clip for 5G-I2NSF

[URL] https://www.youtube.com/watch?v=YxX7MGFy65E



5G-I2NSF System for Integrated Security Services in 5G Networks

Next Steps

- We will design and implement the 5G protocol procedure for I2NSF considering the interaction among UE, AMF, SMF, SCF, and NSFs.
  - Under a handover scenario, a security policy will migrate from the current UPF of a UE to the next UPF of the UE.
  - An NSF will be launched proactively before the security policy migration.

- We will reflect our hackathon experience on our draft:
  - https://datatracker.ietf.org/doc/draft-ahn-nmrg-5g-security-i2nsf-framework/.

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- Yunchul Choi (ETRI)
- Bien Aime Mugabarigira (SKKU)
- Kehan Yao (China Mobile)

Students:

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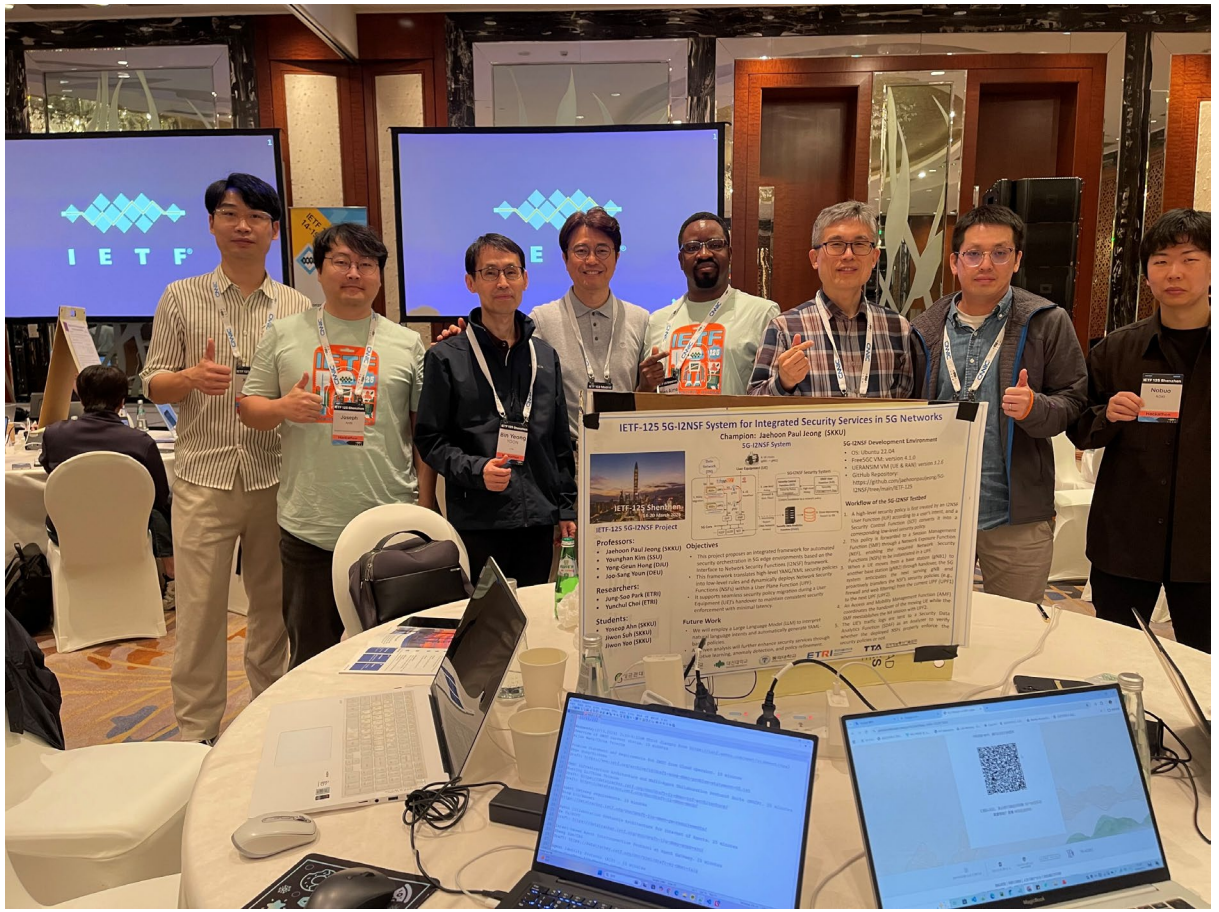
- Xudong Wang (SKKU)
- Jiwon Suh (SKKU)
- Jiwon Yoo (SKKU)
- Nobuo Aoki (Independent)

Hackathon Team Photo