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# 4G to 5G Evolution: In-Depth Security Perspective

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# Objectives

- Introduction
- 4G security and issues
- 5G security details and virtualization considerations
- 5G security next steps
- Apply and Summary

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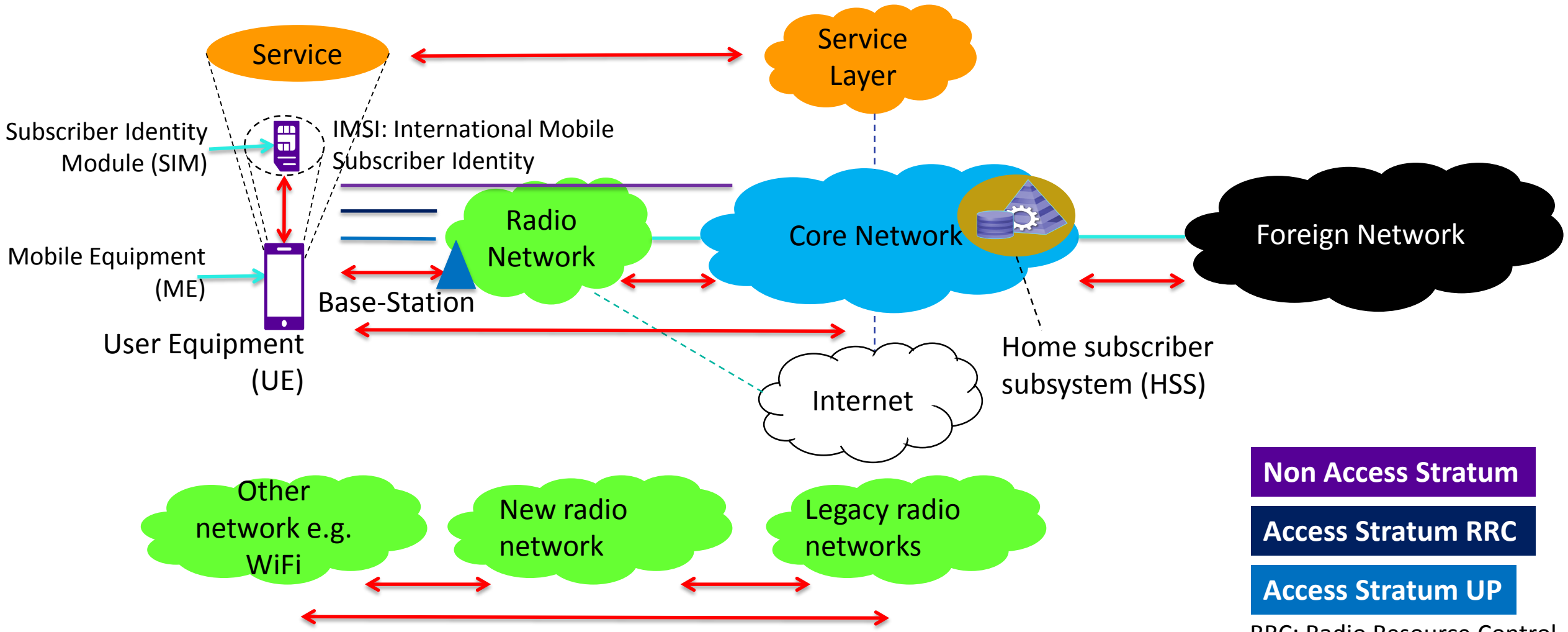
# Introduction

# 3GPP and Specifications Timeline

- 3GPP is the mobile communications specifications group
- 3GPP SA3 is the working group that develops mobile communications security specifications


| | | | | | |
|---|---|---|---|---|---|
| **Specification** | TS 33.102 | TS 33.401 & 402 | TS 33.401 | TS 33.501 | TS 33.501 + ? |
| **Release** | Release 3 | Release 8 | Release 15 | Release 15 | Release 16 |
| **Year** | 2000 | 2009 | 2017 | 2018 | 2019 |

# Mobile Network Security – Introduction



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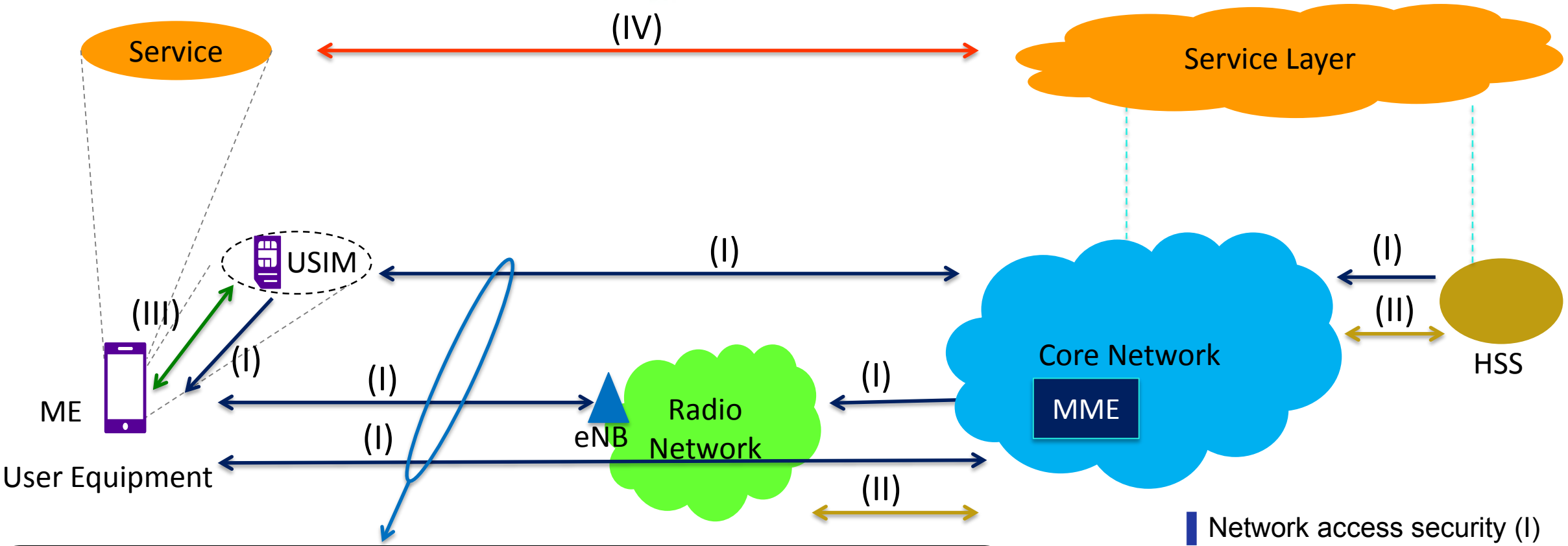
# 4G Security and Issues

# 4G Security: Architecture




- Mutual authentication
- Integrity for control plane
- Confidentiality optional for both control and user planes
- Privacy provisioned by temporary identity

- Network access security (I)
- Network domain security (II)
- User domain security (III)
- Application domain security (IV)
- Visibility and configurability of security (V)

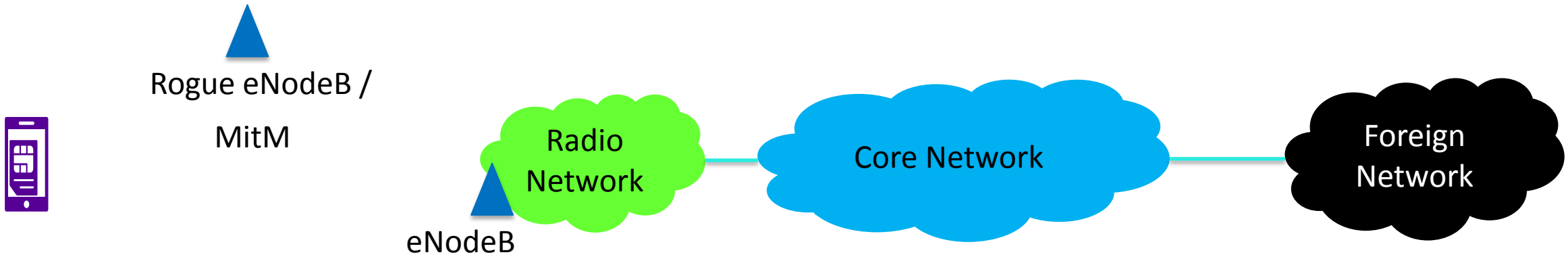


USIM: Universal Subscriber Identity Module; ME: Mobile Equipment; MME: Mobility Management Entity; HSS: Home Subscriber Subsystem

# Potential Threats on 4G

- IMSI in clear
- Temporary identity not changed
- No UP integrity protection
- Bid-down to GSM

Interconnect threats due to SS7 & Diameter



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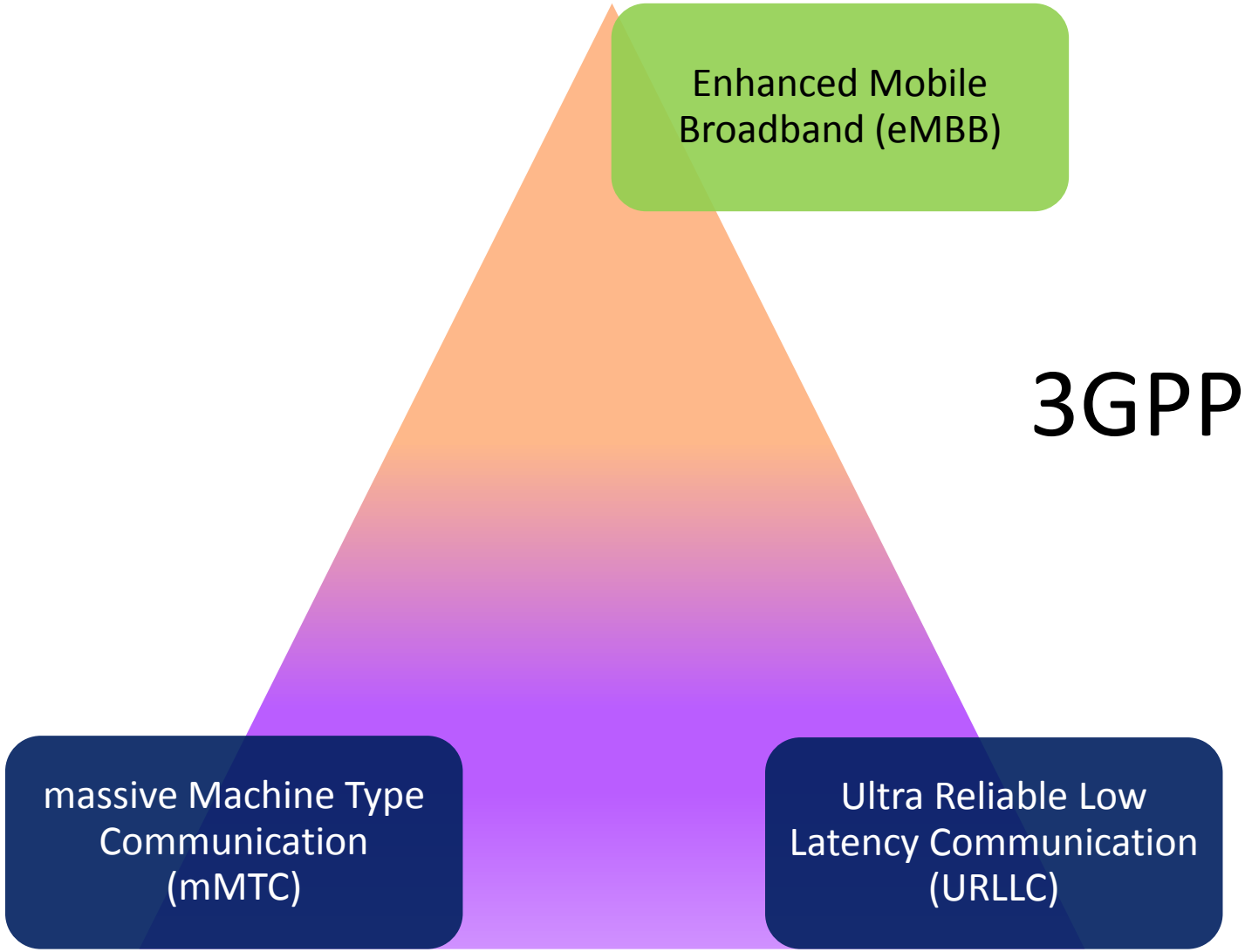
# 5G Security

# 3GPP 5G Specification Phases

Phase 1

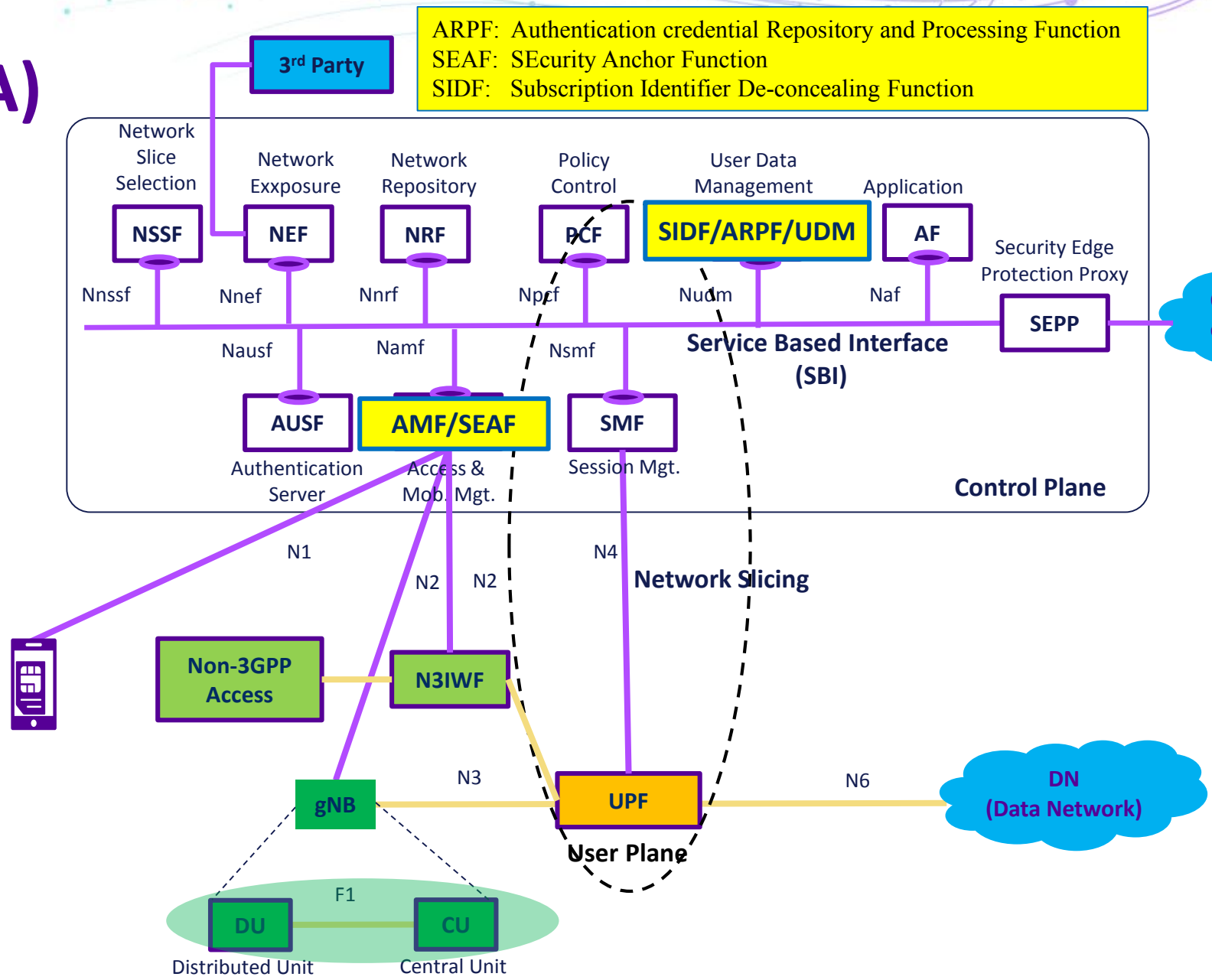



Phase 2

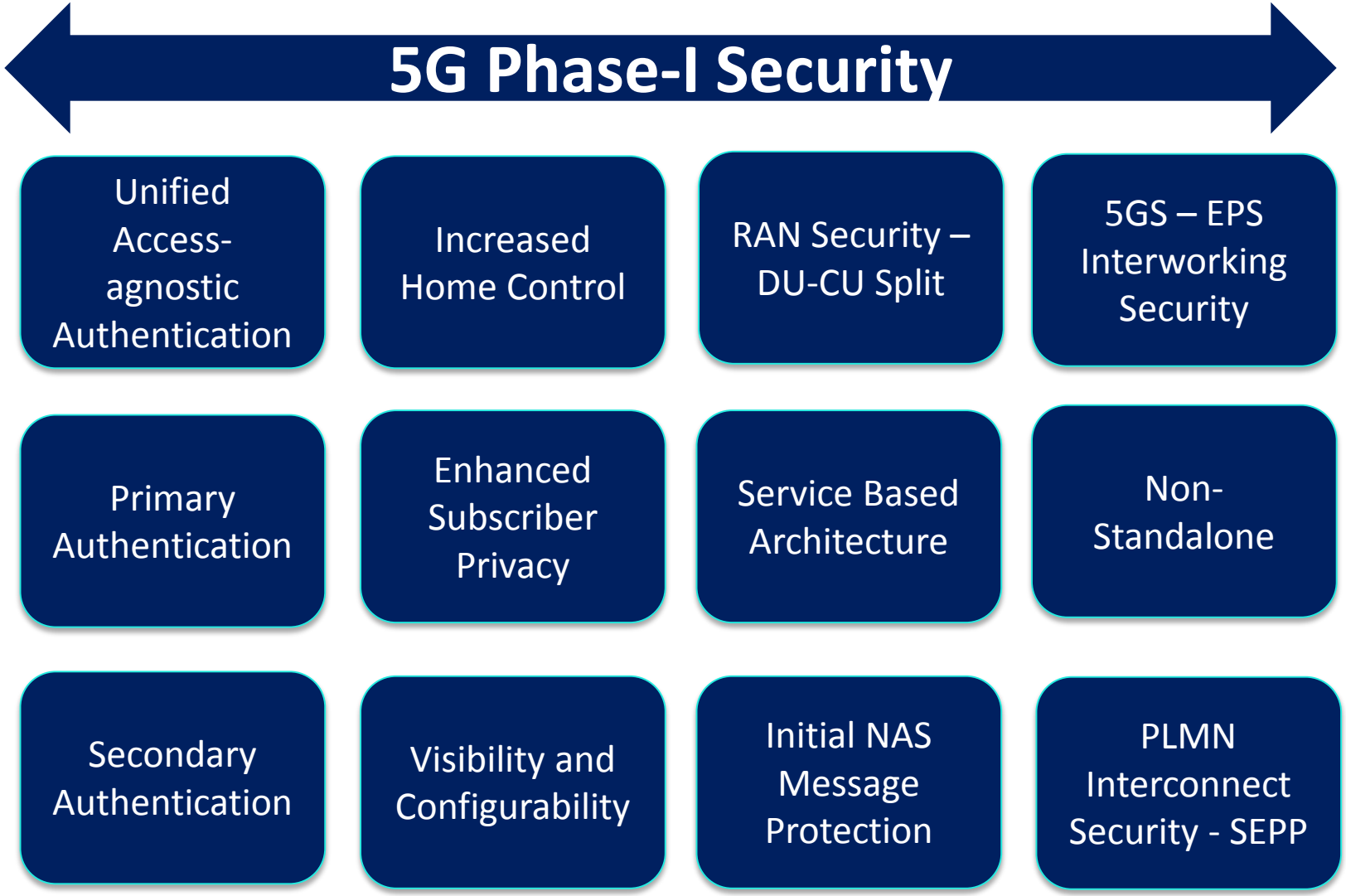
3GPP phase based 5G specification

# Service Based Architecture (SBA)

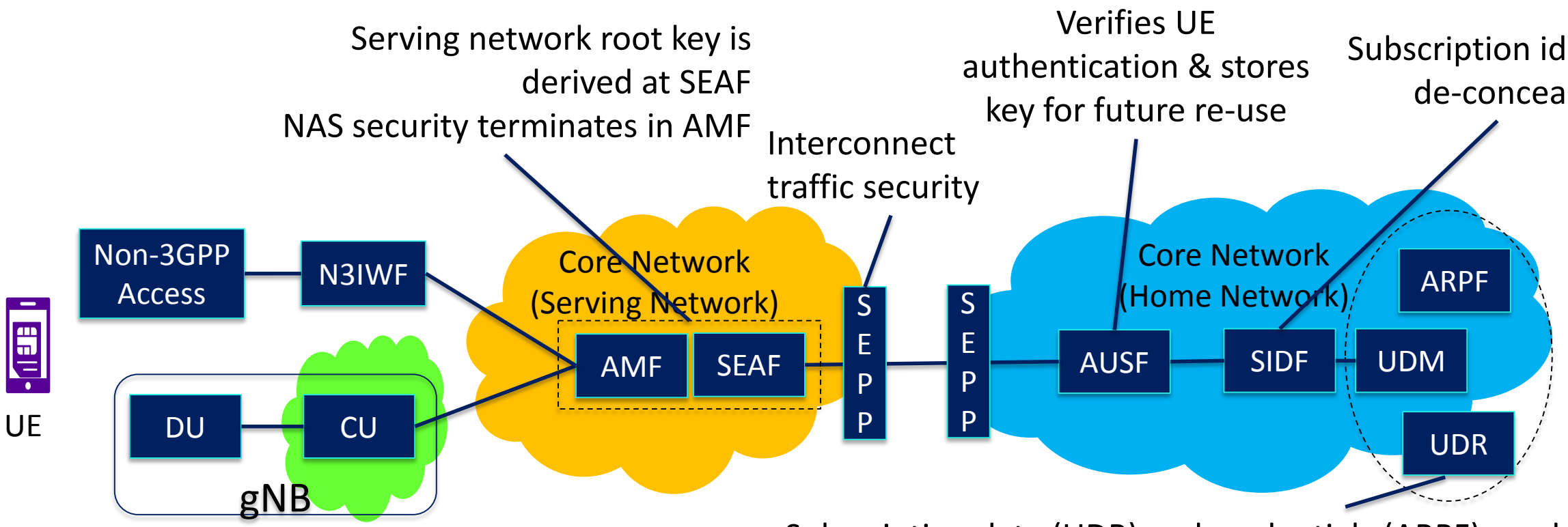
SBA and network slicing bring cloud and NFV technologies to mobile network



# Overview of 5G Phase-I Security



# Security Functions in 5G Architecture




AS terminates at CU & N3IWF
No security function is performed at DU

Subscription data (UDR) and credentials (ARPF) used by UDM for authentication credential generation, user identification etc.

AMF: Access Management Function
ARPF: Authentication credential Repository & Processing Function
AUSF: AUthentication Server Function
CU: Central Unit
DU: Distributed Unit
N3IWF: Non-3GPP Inter Working Function

SEAF: SEcurity Anchor Function
SEPP: SEcurity Protection Proxy
SIDF: Subscription Identifier De-concealing Function
UDM: Unified Data Management
UDR: Unified Data Repository
UE: User Equipment

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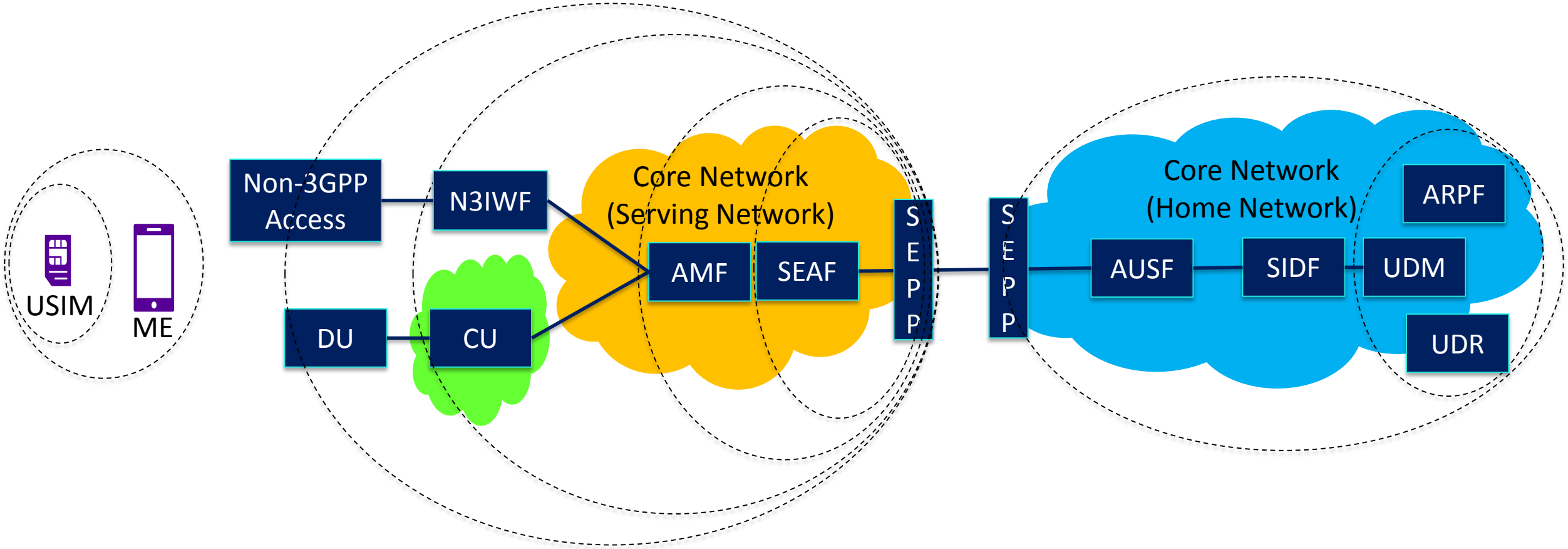
# Trust-Model




AMF: Access Management Function
ARPF: Authentication credential Repository & Processing Function
AUSF: AUthentication Server Function
CU: Central Unit
DU: Distributed Unit
ME: Mobile Equipment
USIM: Universal Subscriber Identity Module

N3IWF: Non-3GPP Inter Working Function
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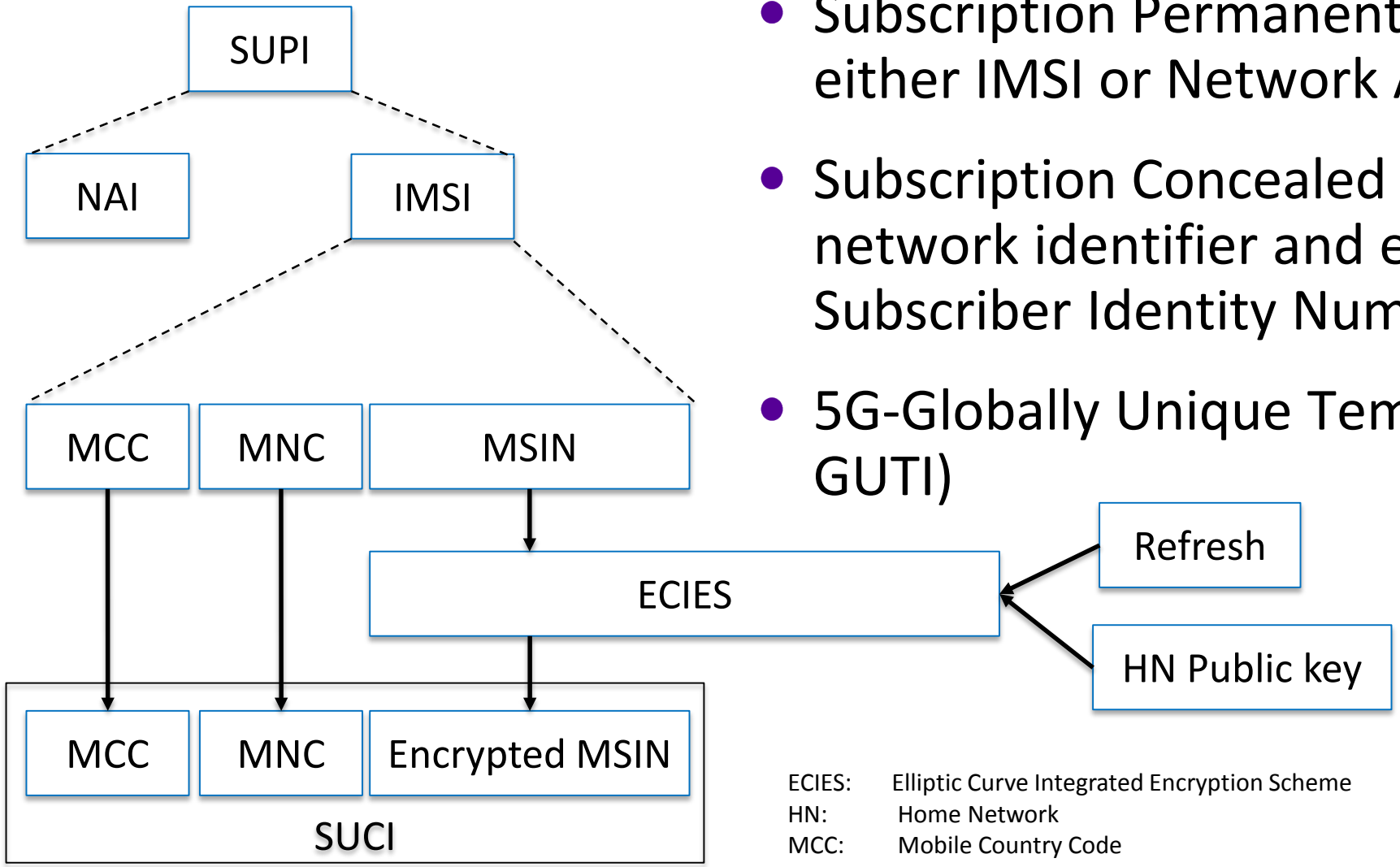
# Identities




- Subscription Permanent Identifier (SUPI) can be either IMSI or Network Access Identifier (NAI)
- Subscription Concealed Identifier (SUCI) is home network identifier and encrypted Mobile Subscriber Identity Number (MSIN)
- 5G-Globally Unique Temporary UE Identity (5G-GUTI)

ECIES: Elliptic Curve Integrated Encryption Scheme
HN: Home Network
MCC: Mobile Country Code
MNC: Mobile Network Code

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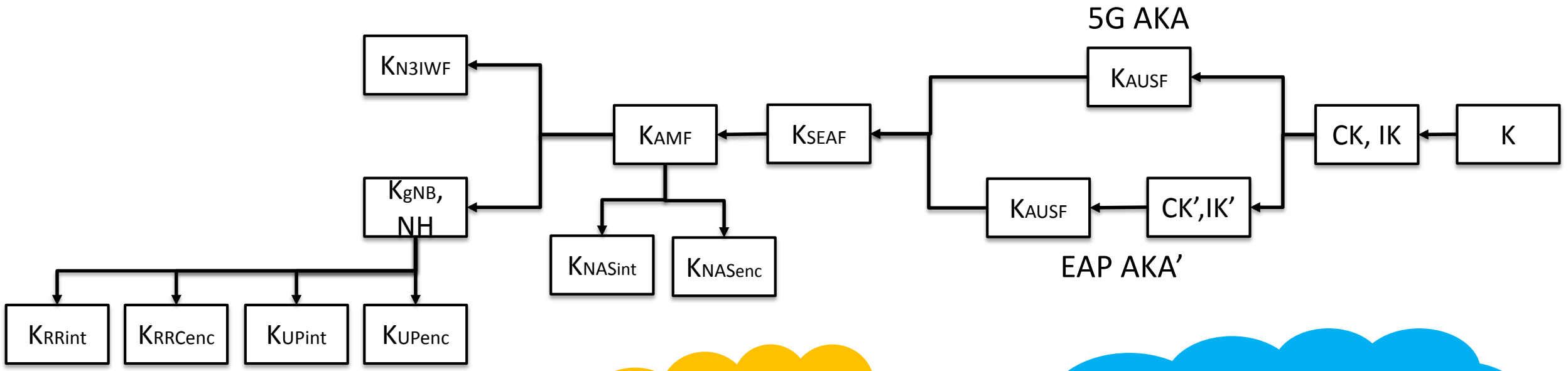
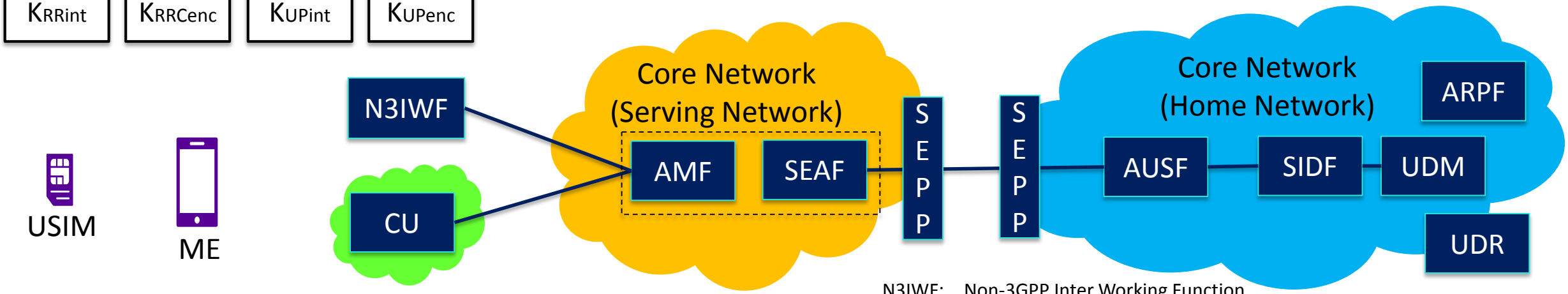
# Key Hierarchy




K | Rest

AMF: Access Management Function
ARPF: Authentication credential Repository & Processing Function
AUSF: AUthentication Server Function
CU: Central Unit
ME: Mobile Equipment
USIM: Universal Subscriber Identity Module

N3IWF: Non-3GPP Inter Working Function
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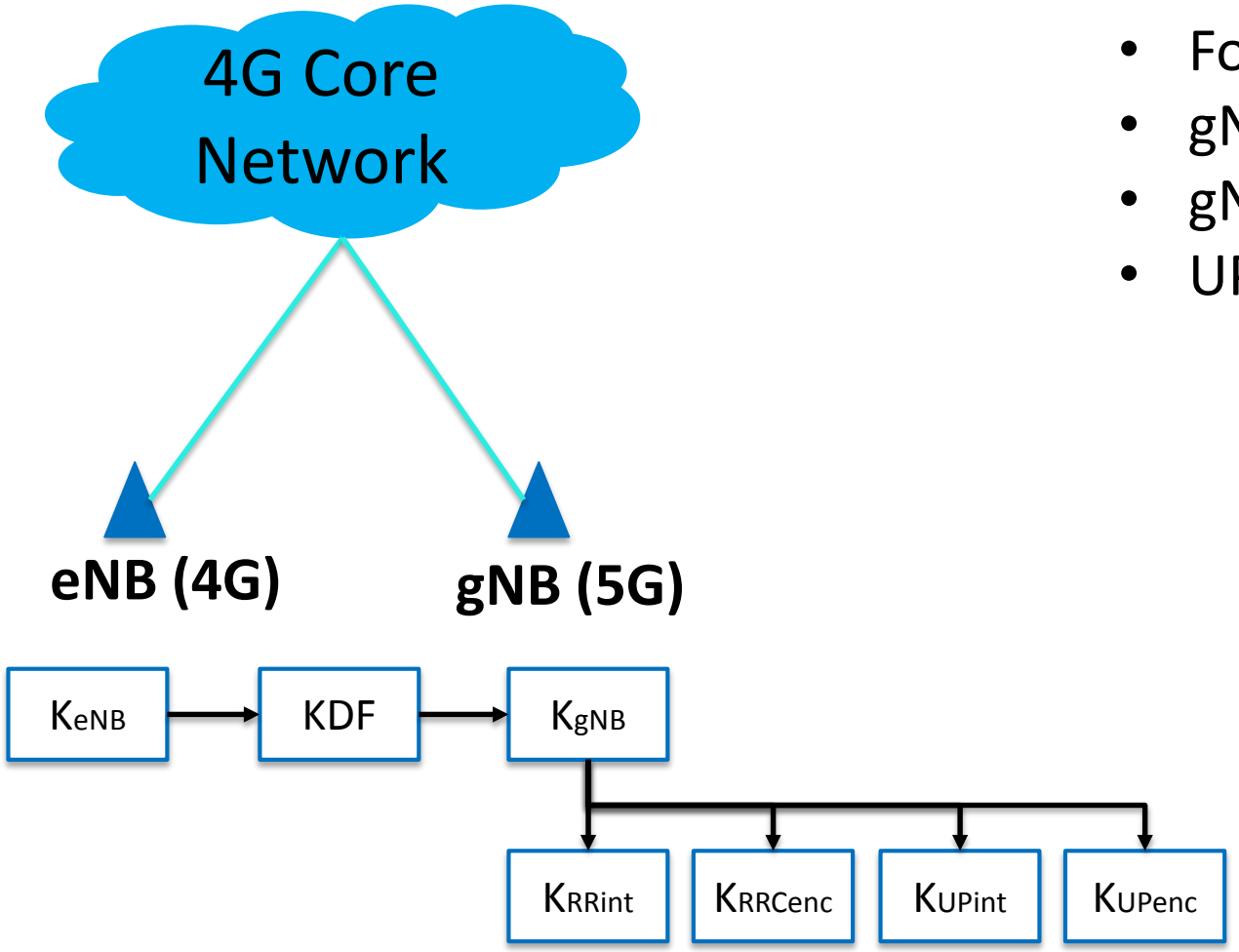
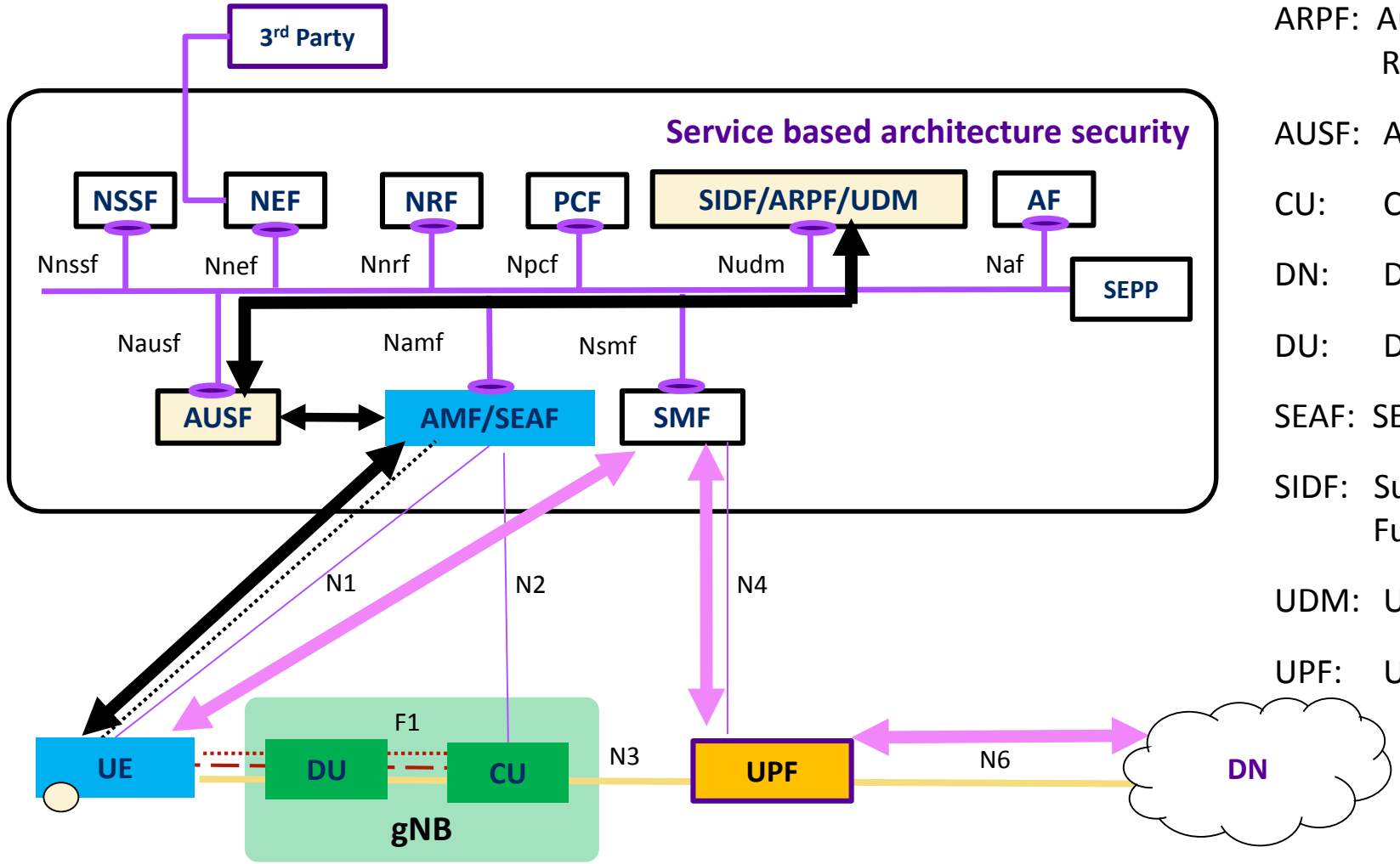
# Non-Standalone (NSA) Security




- For fast availability of 5G
- gNB connected to existing 4G core network
- gNB (5G) keys are derived from eNB (4G) key
- UP integrity protection not available

KDF: Key Derivation Function

# Security Associations




ARPF: Authentication credential Repository and Processing Function

AUSF: AUthentication Function

CU: Central Unit

DN: Data Network

DU: Distributed Unit

SEAF: SEcurity Anchor Function

SIDF: Subscription Identifier De-concealing Function

UDM: Unified Data Management

UPF: User Plane Function

Primary authentication

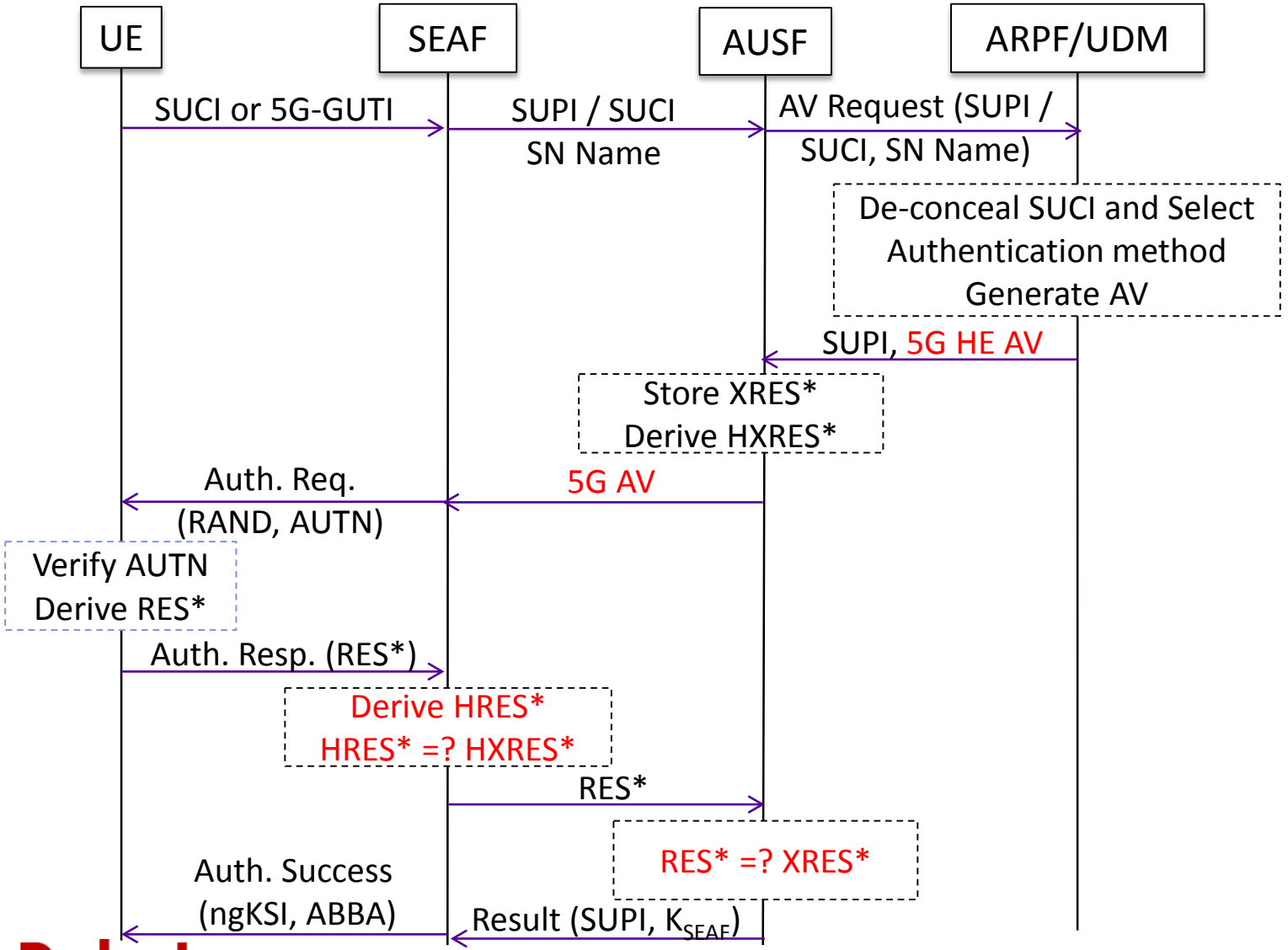
Secondary authentication

NAS Confidentiality/Integrity

RRC Confidentiality/Integrity

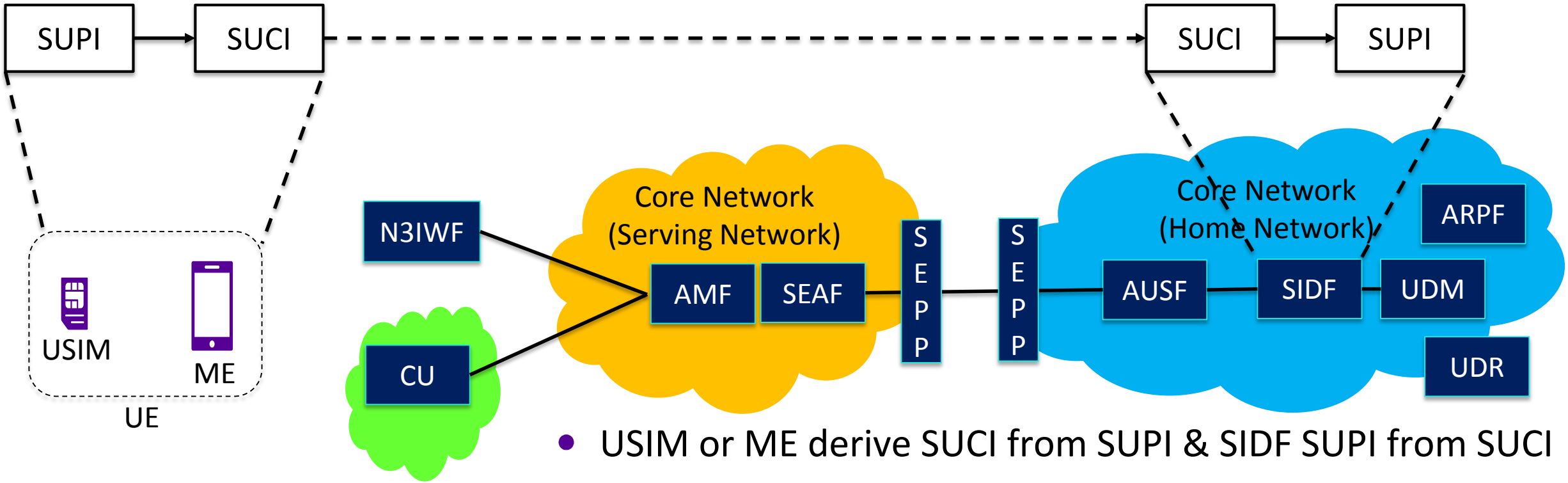
UP Confidentiality/Integrity

# Primary Authentication based on 5G AKA




- 5G Home Environment Authentication Vector (HE AV):
  (RAND, AUTN, (X)RES*, KAUSF)
  - (X)RES* = KDF (CK|IK, (X)RES)
- 5G Authentication Vector:
  (RAND, AUTN, HXRES*, KSEAF)
  - H(X)RES* = KDF (RAND, (X)RES*)
- ME derives RES* from RES & CK,IK
- $K_{SEAF}$ is bound to the serving network name (SN-name)
- ngKSI: Key Set Identifier in 5G
- ABBA: Anti-Bidding down Between Architectures parameter provides protection against bidding down of security features from higher to a lower release

# Enhanced Subscriber Privacy




- USIM or ME derive SUCI from SUPI & SIDF SUPI from SUCI
- Home Network Public Key is stored in USIM

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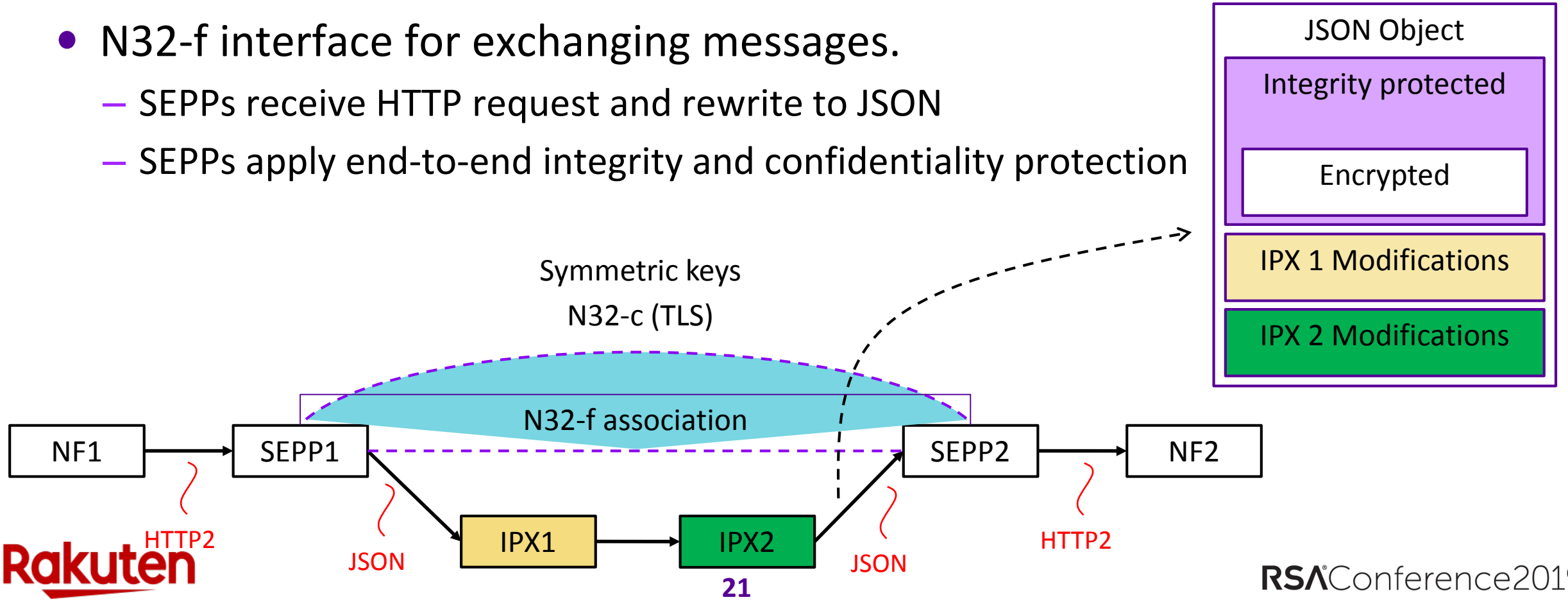
# Interconnect Security

- N32-c interface for capability and policy negotiation between Security Protection Proxies (SEPPs)
- N32-f interface for exchanging messages.
  - SEPPs receive HTTP request and rewrite to JSON
  - SEPPs apply end-to-end integrity and confidentiality protection



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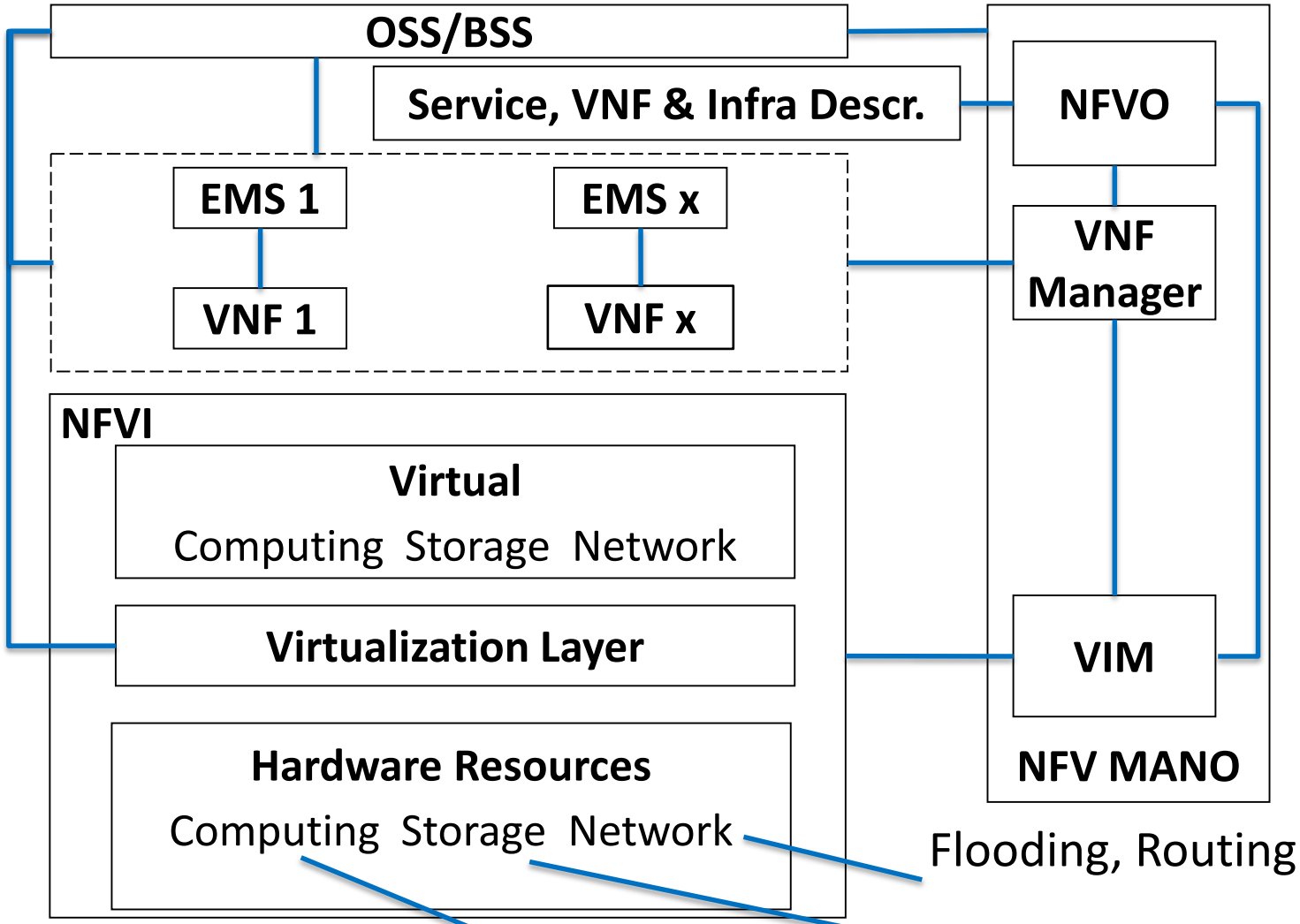
# Virtualization Security

# Threats – Summary




- Data manipulation
- Privilege misuse
- Package modification
- Rogue VNF
- Malicious code or tenant
- Configuration modification
- Resource allocation issues
- Image tampering
- Catalogue information exploit
- Uploading malicious images

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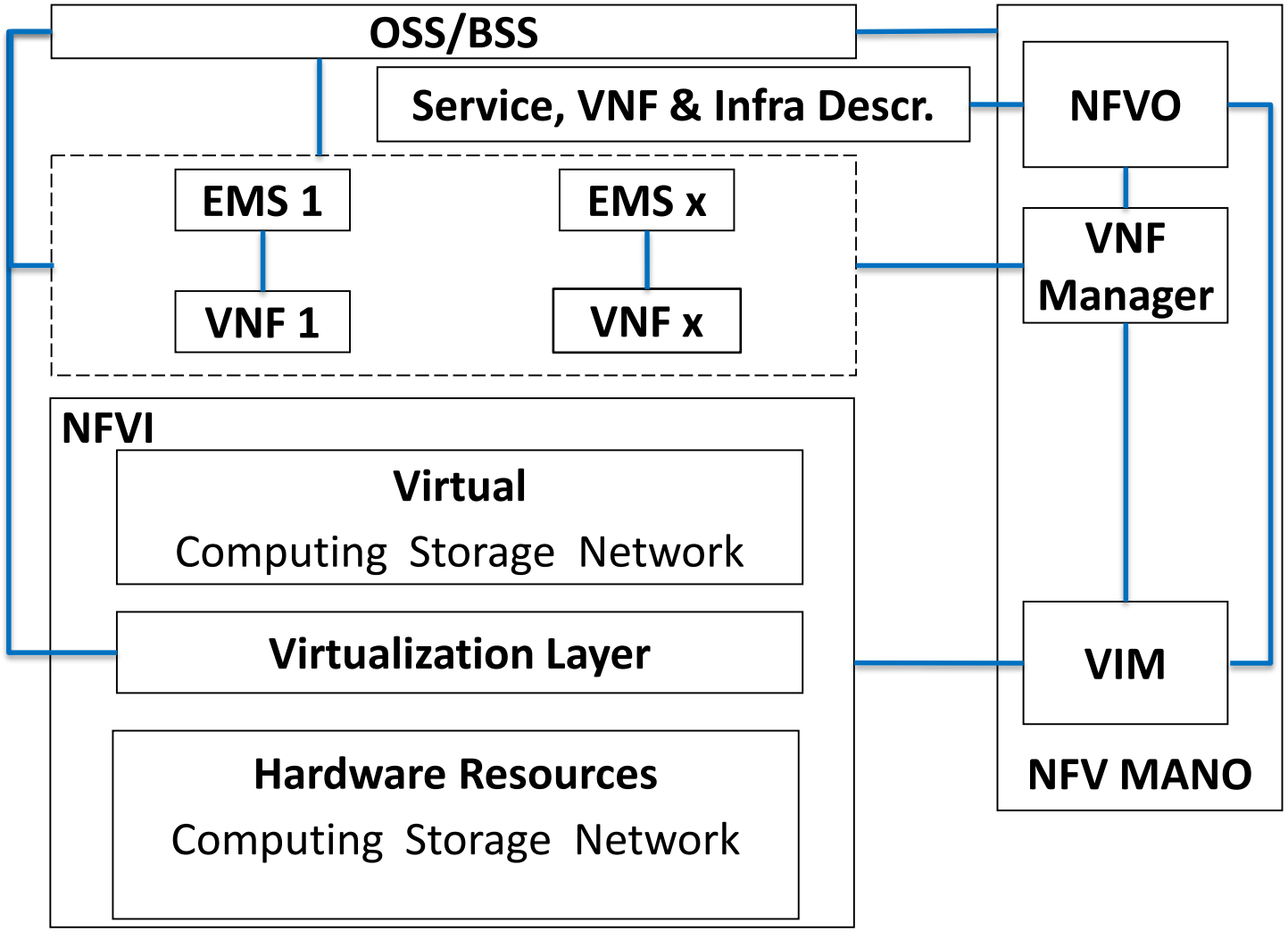
# Mitigation – Summary




- Secure boot and chain of trust
- Remote attestation
- Secure crash
- Security assurance, signing and verification of image
- VNF isolation
- Tenant and administrator isolation

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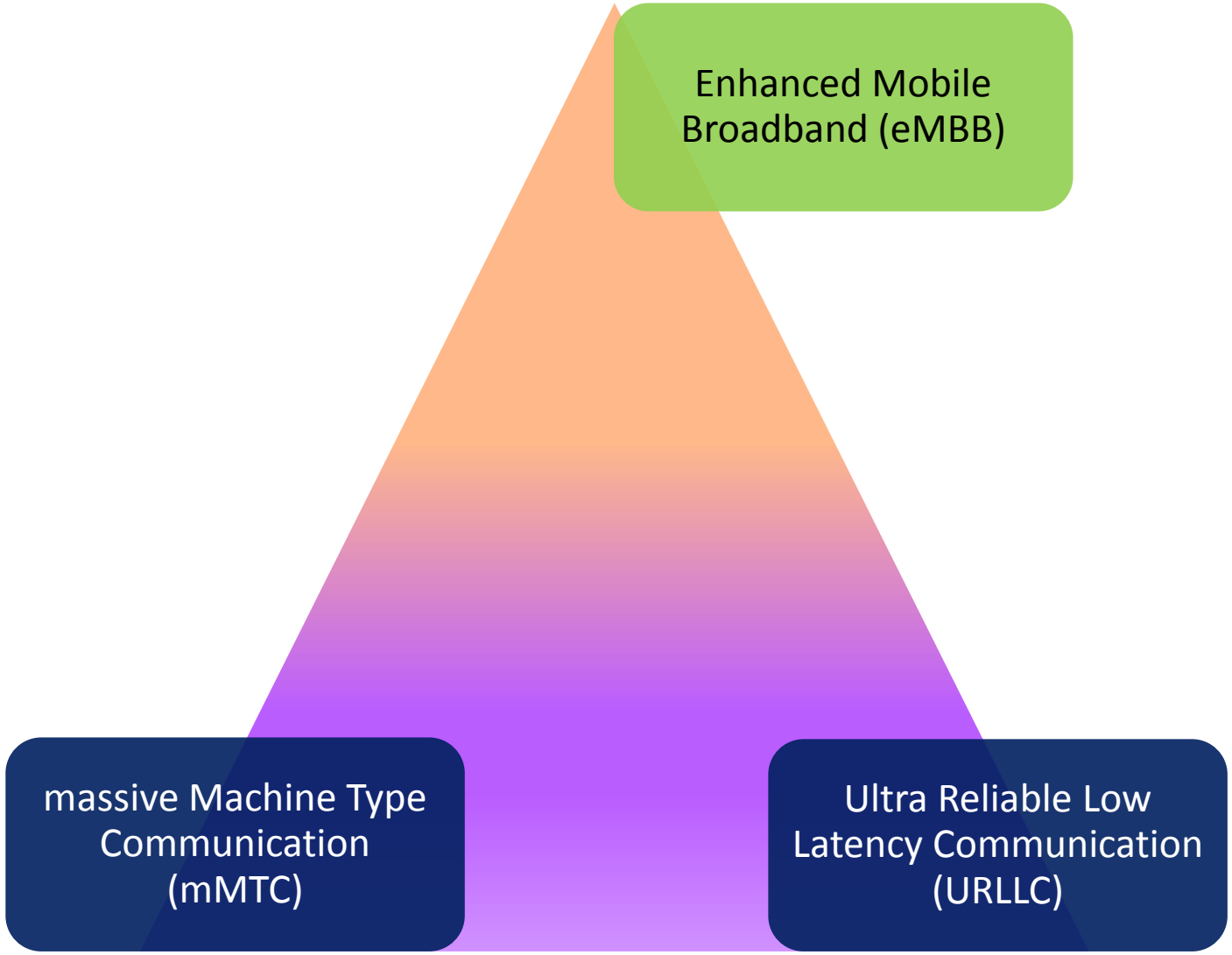
# 5G Security Next Steps

# 3GPP 5G Phase-2 Security

- Long-term key update
- 256 bits keys usage
- Security Assurance
- Network slicing security
- Location services security
- Security for 5G URLLC
- Security for Vertical & LAN Services

Phase 1

Phase 2

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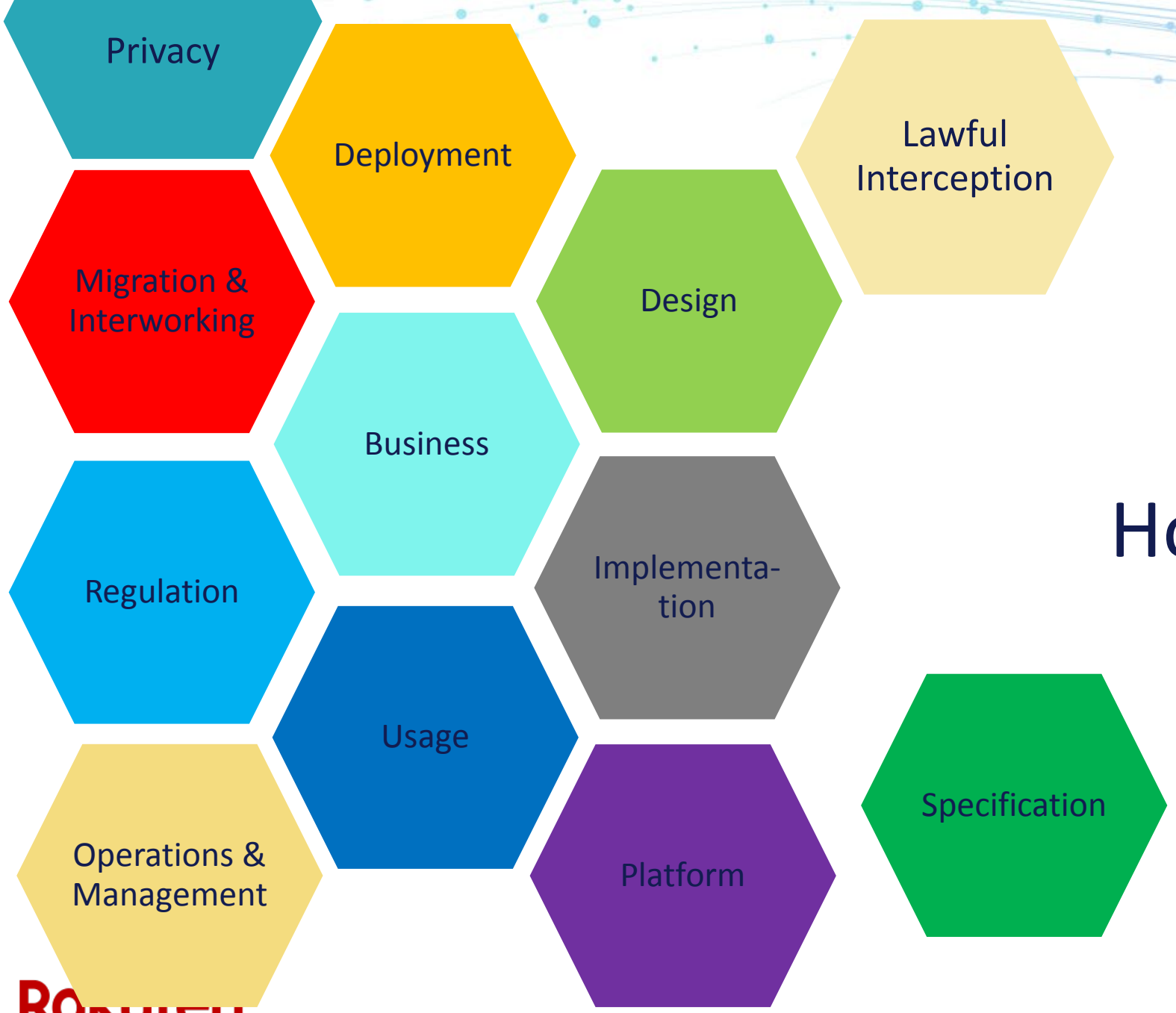
# Apply

# Apply

- Service providers (mobile operators, IT, digitization – IoT etc.)
  - Understand your organization's connectivity needs and security requirements
  - Map the requirements to 5G and virtualization
  - Develop appropriate management and automated control mechanisms
- Vendors
  - Verify 5G products security assurance requirements from 3GPP
  - Optimize implementation for virtualization
  - Consider security based on changing customer network architecture




# Holistic security from first step

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# Summary

# Summary

- 4G security and issues
- 5G security and how 4G security issue are mitigated
- 5G security details and virtualization considerations
- 5G security next steps

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# Questions?

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