Honors Option for NSSA 245

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Cellular Cryptography

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Topics

- What drove mobile network design?
- How does authentication/ authorization happen?
- How does transport-layer security work?

Constraints of a Mobile Network

- Radio roaming
- Access method and core are independent
- Billing and QoS

Structure

SIM Card (SIM)

User Endpoint (UE)

Base Station/Radio (eNB/ng-eNB)

Mobility Management Engine (MME)

Packet Core

Home Subscriber Server (HSS)

SIM Card (SIM)

- Chip for Network Authentication
- Inside of the User Endpoint
- Cryptographic Operations, Data Storage
- Data about the subscriber
- TPM to store keys
- Duplicate of data on HSS

SIM Card (SIM)

User Endpoint (UE)

Base Station/Radio (eNB/ng-eNB)

Mobility Management Engine (MME)

Packet Core

Home Subscriber Server (HSS)

User Endpoint (UE)

- Device that a user interacts with
- Phone, Laptop, Car, Vending Machine
- Contains the SIM Card
- Radios to connect to the network

SIM Card (SIM)

User Endpoint (UE)

Base Station/Radio (eNB/ng-eNB)

Mobility Management Engine (MME)

Packet Core

Home Subscriber Server (HSS)

Mobility Management Engine (MME)

- Per Region
- Part of the EPC
- Owned by Serving Network
- Manages connection to the network

SIM Card (SIM)

User Endpoint (UE)

Base Station/Radio (eNB/ng-eNB)

Mobility Management Engine (MME)

Packet Core

Home Subscriber Server (HSS)

Home Subscriber Server (HSS)

- Part of Packet Core
- Owned by home carrier
- Stores data about customers and SIM cards
- Manages authentication, QoS, Billing, etc.

SIM Card (SIM)

User Endpoint (UE)

Base Station/Radio (eNB/ng-eNB)

Mobility Management Engine (MME)

Packet Core

Home Subscriber Server (HSS)

AAA

Authentication vs Authorization

Authentication

- Who is a SIM card assigned to?
- Is this a legitimate device?
- Is this device on a legitimate network?

Authorization

- Is a user allowed to roam on this network?
- Can a user access certain carrier resources?
- What QoS should this device expect?

Authentication and Authorization

- Challenge/Response
- SIM/UE initiates a connection to MME
- MME forwards SIM data to HSS
- HSS gives a random value to the SIM, and tells MME what to expect as output

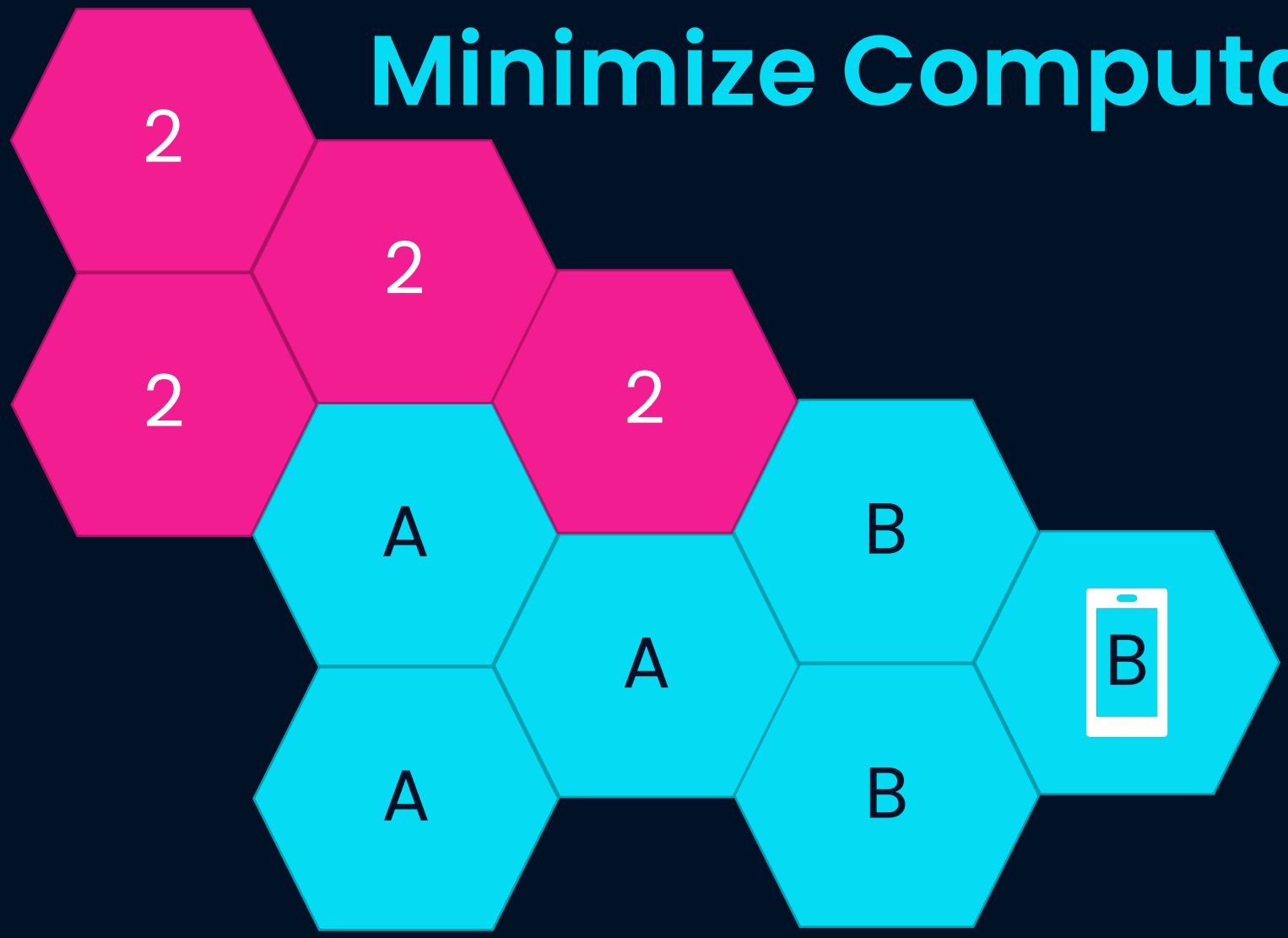
Keys

- Root is stored on HSS and derived on SIM
- Derive down
- Limit scope
  - Add parameter at each step, cannot reverse upwards
- HSS is a relay

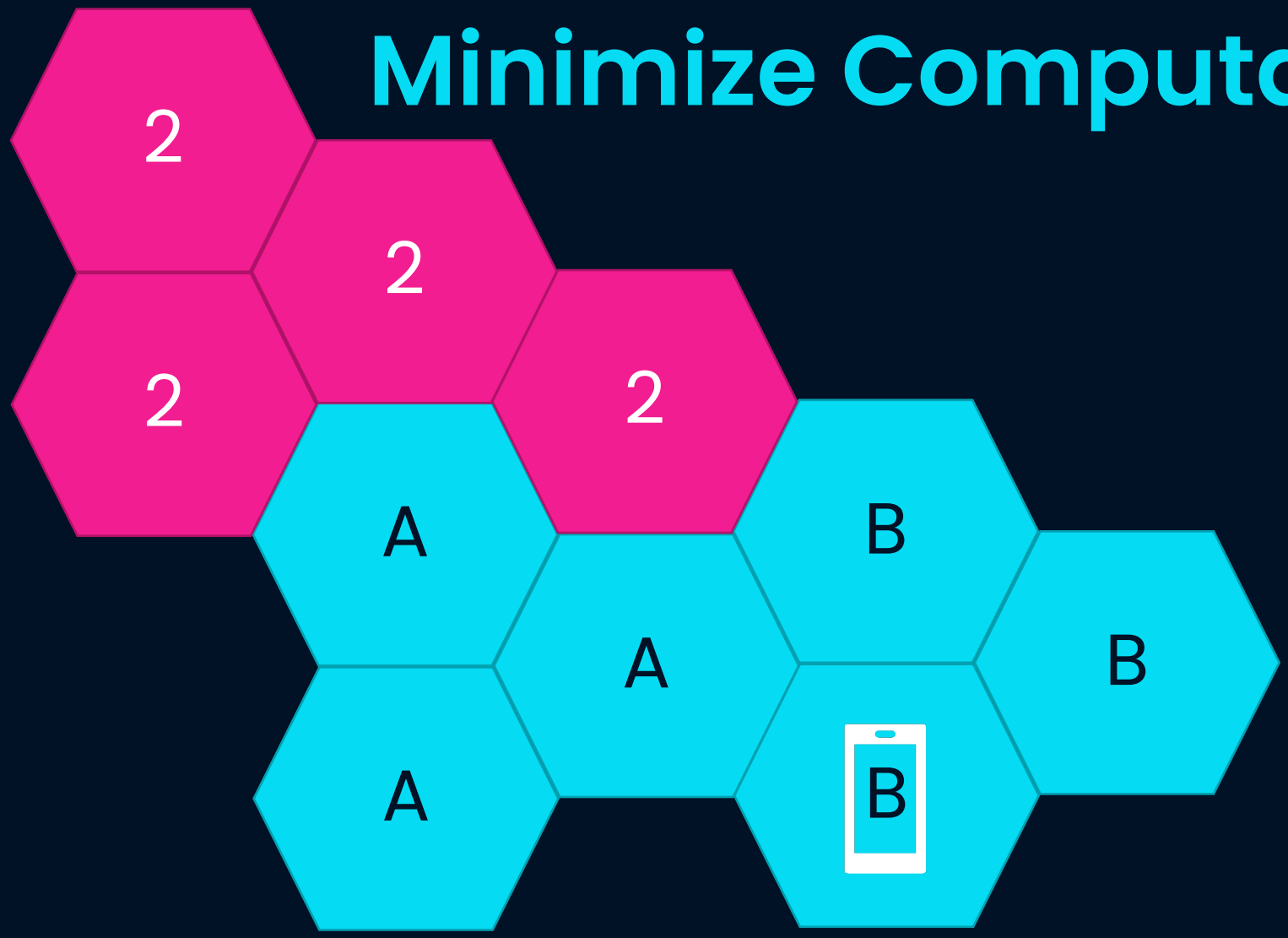
Keys

- K is stored on SIM
- Cipher Key, Integrity Key on HSS
  - Derivation is Carrier-Specific
- K_{ASME} is per SN/SEQ, on MME
- K_{eNB} adds COUNT, at eNodeB

Minimize Computation



Minimize Computation



Change eNodeB

K

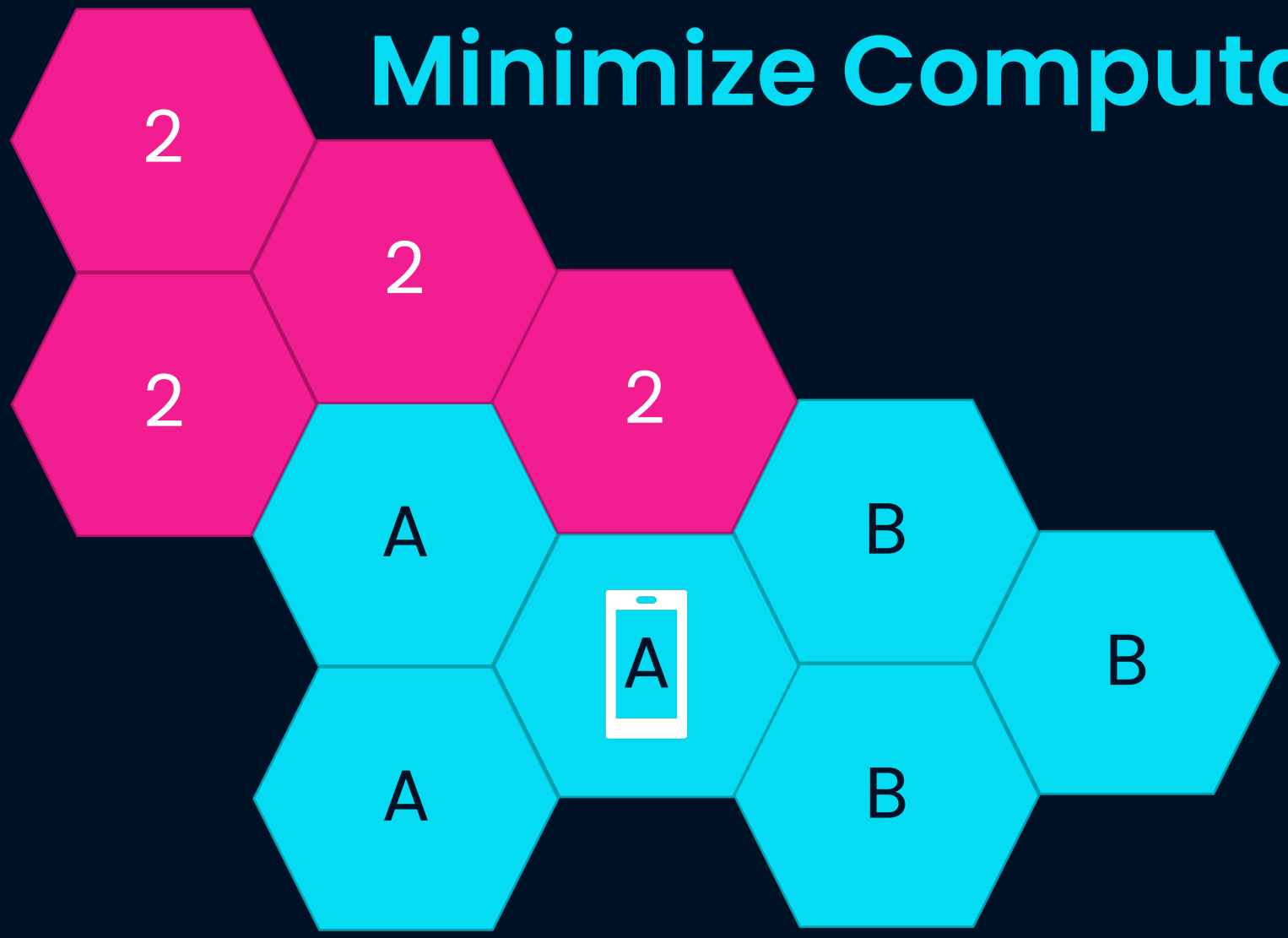
CK, IK

SEQ

K_{ASME}

K_{eNB}

Minimize Computation



Change MME

K

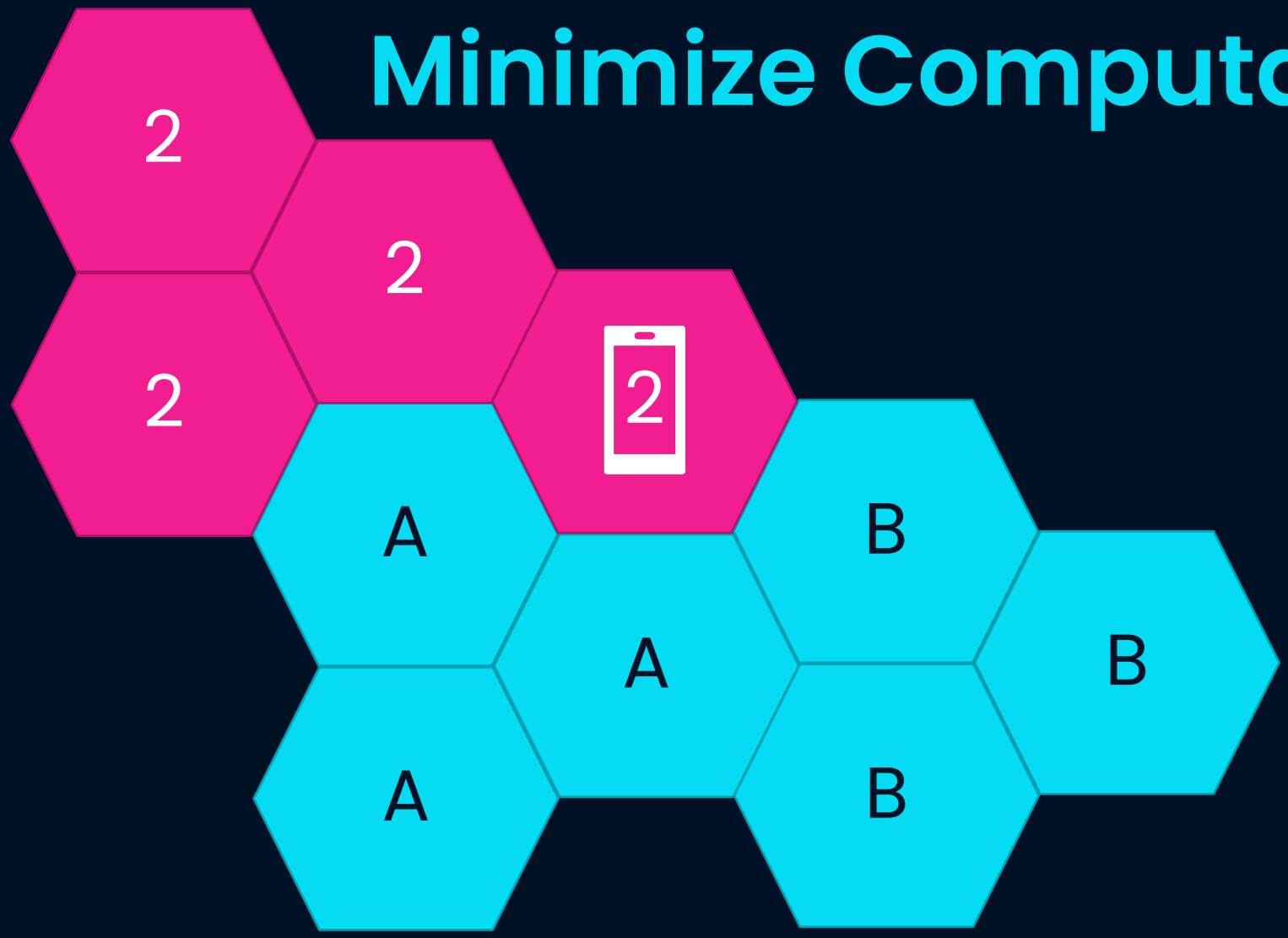
CK, IK

SEQ

K_{ASME}

K_{eNB}

Minimize Computation



Change SN

K

CK, IK

SEQ

K_{ASME}

K_{eNB}

Opportunities for Failure

- Incorrect MAC
- SEQ Synchronization Failure
- Incorrect AV type
- Invalid Authentication (XRES ≠ RES)
- Retransmission of (RAND, AUTN)

Evolution Over Time

5G: Authenticate with Home Network

4G (LTE): Serving-Network-Specific Keys

3G (UMTS/CDMA2000): Mutual Authentication

2G (GSM/GPRS): Phone Authenticated by Network

Downgrade Attack

Broadcast 2G at super strong signal

5G: Authenticate with Home Network

4G (LTE): Serving-Network-Specific Keys

3G (UMTS/CDMA2000): Mutual Authentication

2G (GSM/GPRS): Phone Authenticated by Network

Network Components

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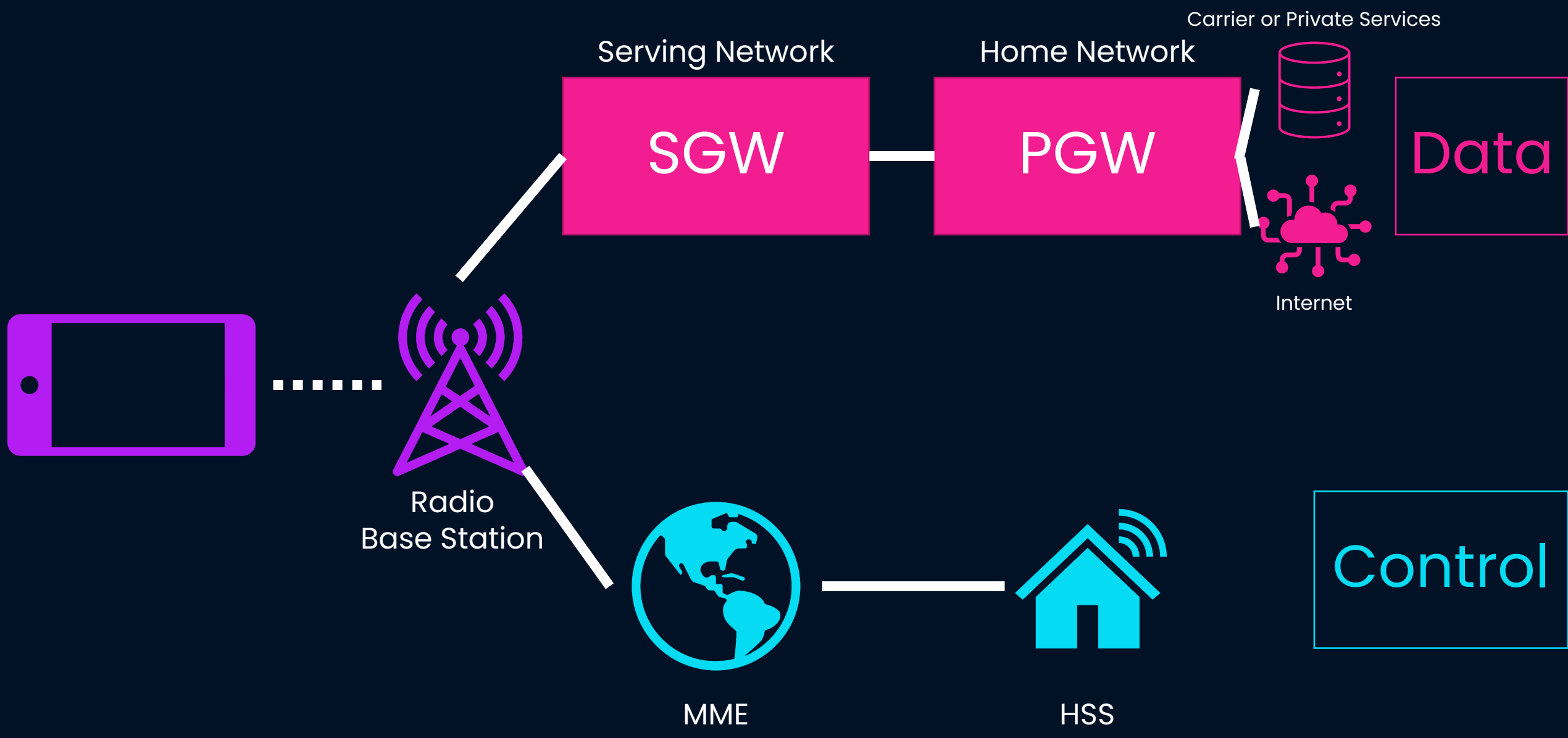
Carrier or Private Services
Serving Network
Home Network
SGW
PGW
Data
Internet
Radio
Base Station
Control
MME
HSS

Strata

Access Stratum

- Layer 2
- Between UE and Base Station

Non-Access Stratum

- Layer 3
- Between UE and MME

K_{RRCint}	COUNT	BEARER	Direction
128	32	5	1

AS

- Radio Resource Control (RRC) Protocol for signaling
- Some unencrypted comm before encrypted
- Packet Data Convergence Protocol for RRC & User Data

NAS

- All communication is integrity checked
- After establishing algorithm, all communication encrypted
- Key derived from HSS
- IMEI always secret

Algorithm-Independent

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