

# 3GPP Security: LTE/SAE and Home (e)NB

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## Introduction

- ❑ **3GPP SA Working Group 3 (3GPP SA3)**
  - specifying security mechanisms and functions
  - in 3G UMTS, SAE/LTE systems and beyond
  
- ❑ **ETSI: one of the founding Standards Developing Organizations of 3GPP**
  
- ❑ **ETSI OCG Security: transversal security co-ordination ad hoc group of ETSI**

A dark blue world map is centered in the background of the slide, showing the continents in a lighter shade of blue.

# SAE/LTE security



## SAE/LTE implications on security

- ❑ Security implications due to
  - *Flat architecture*: RAN protocols terminate in eNB
  - Interworking with legacy and non-3GPP networks
  - Allowing eNB placement in untrusted locations
  - New business environments with less trusted networks involved
  - Trying to keep security breaches as local as possible

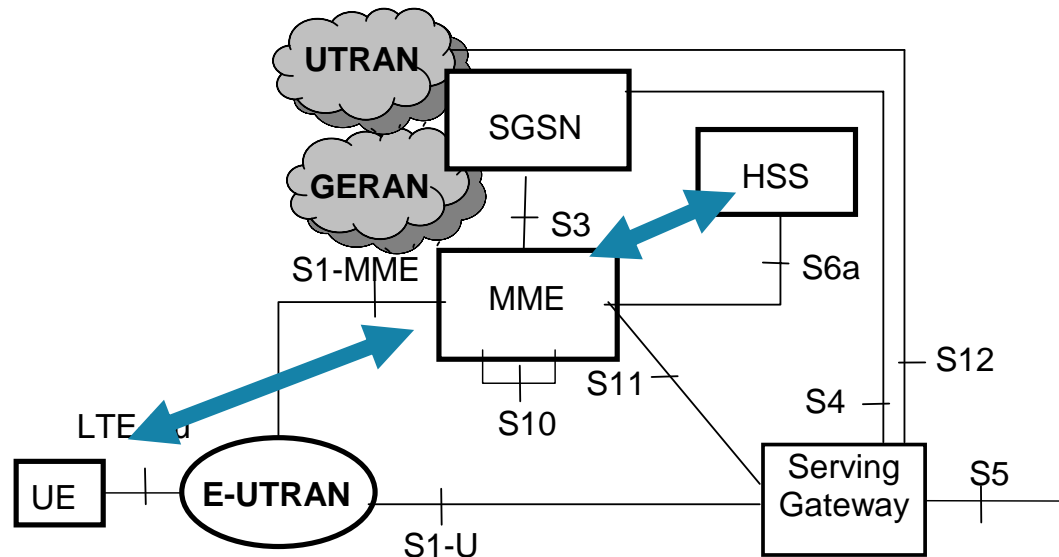


- ❑ Extended Authentication and Key Agreement
- ❑ More complex key hierarchy
- ❑ More complex interworking security
- ❑ Additional security for eNB (compared to NB/BTS/RNC)

## Security functions

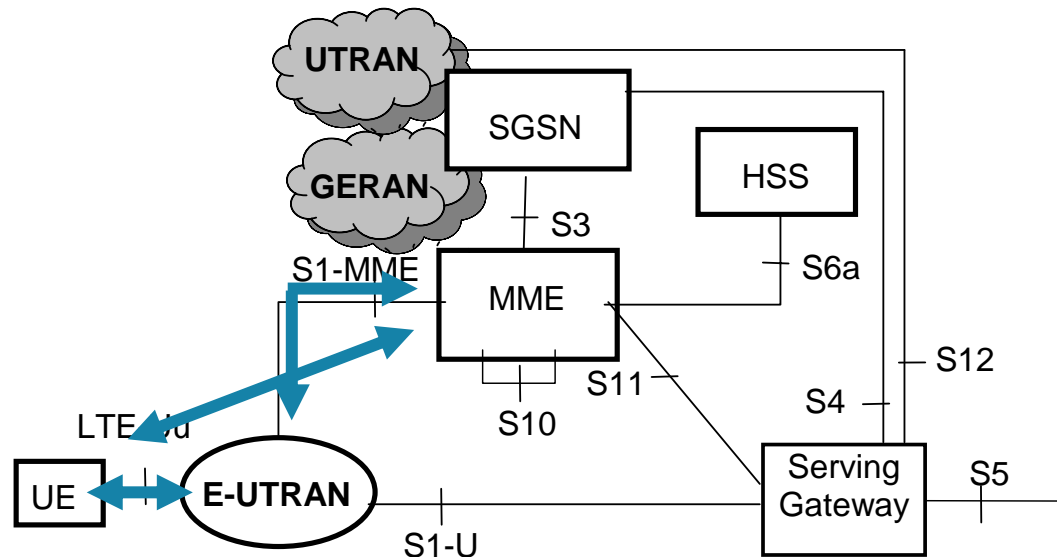
- ❑ **Authentication and key agreement**
  - UMTS AKA re-used for SAE
  - SIM access to LTE is explicitly excluded (USIM R99 onwards allowed)
- ❑ **Signalling protection**
  - For core network (NAS) signalling, integrity and confidentiality protection terminates in MME (Mobility Management Entity)
  - For radio network (RRC) signalling, integrity and confidentiality protection terminates in eNodeB
- ❑ **User plane protection**
  - Encryption terminates in eNodeB
  - Separate protection in on network interfaces
- ❑ **Network domain security used for network internal interfaces**

# Authentication and key agreement



- ❑ HSS generates authentication data and provides it to MME
- ❑ Challenge-response authentication and key agreement procedure between MME and UE

# Confidentiality and integrity of signalling



- ❑ RRC signalling between UE and E-UTRAN
- ❑ NAS signalling between UE and MME
- ❑ S1 interface signalling
  - protection is not UE-specific
  - optional to use





## Crypto-Algorithms

### ❑ Two sets of algorithms

- 128-EEA1 and 128-EIA1 (identical to UEA2 and UIA2 for UMTS)
- AES and SNOW 3G chosen as basis
  - Principle: should be as different from each other as possible

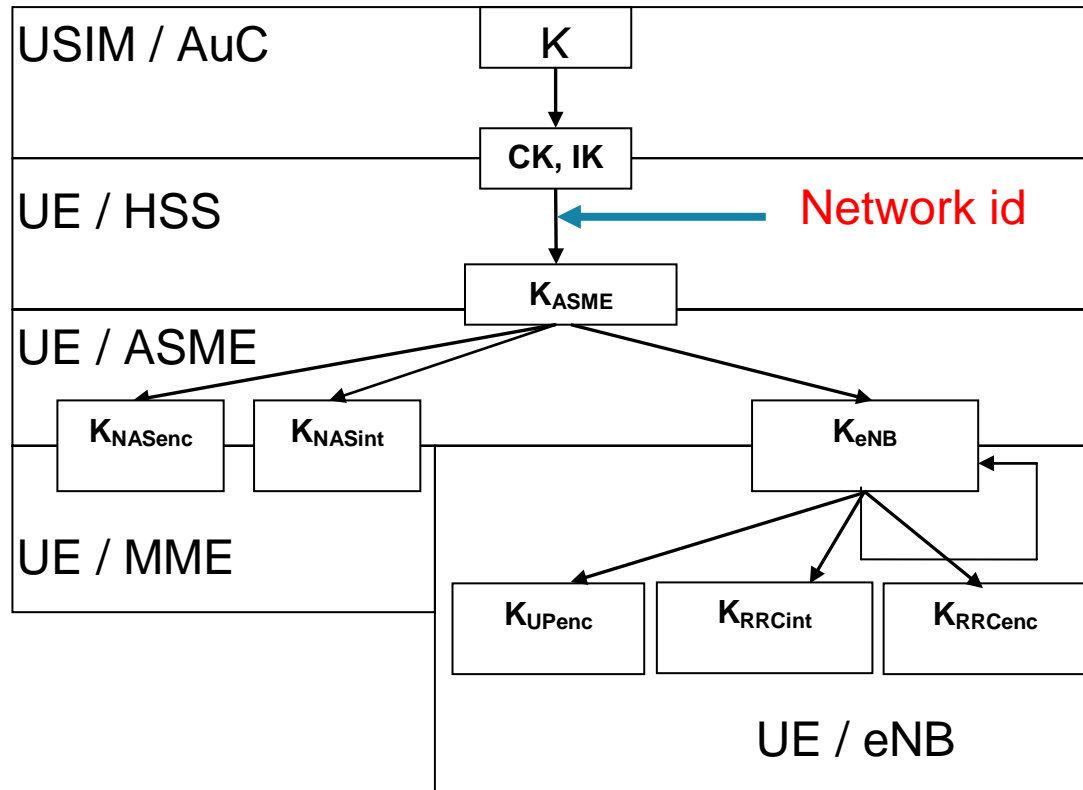
### ❑ Rel-99 USIM is sufficient

- Key length 128 bits
  - included possibility to add 256-bit keys
- Deeper key hierarchy than UMTS
- (one-way) key derivation function needed

### ❑ Public and open

- Can be downloaded to look at
- Available from ETSI web site and GSMA web site

# Key hierarchy in LTE/SAE



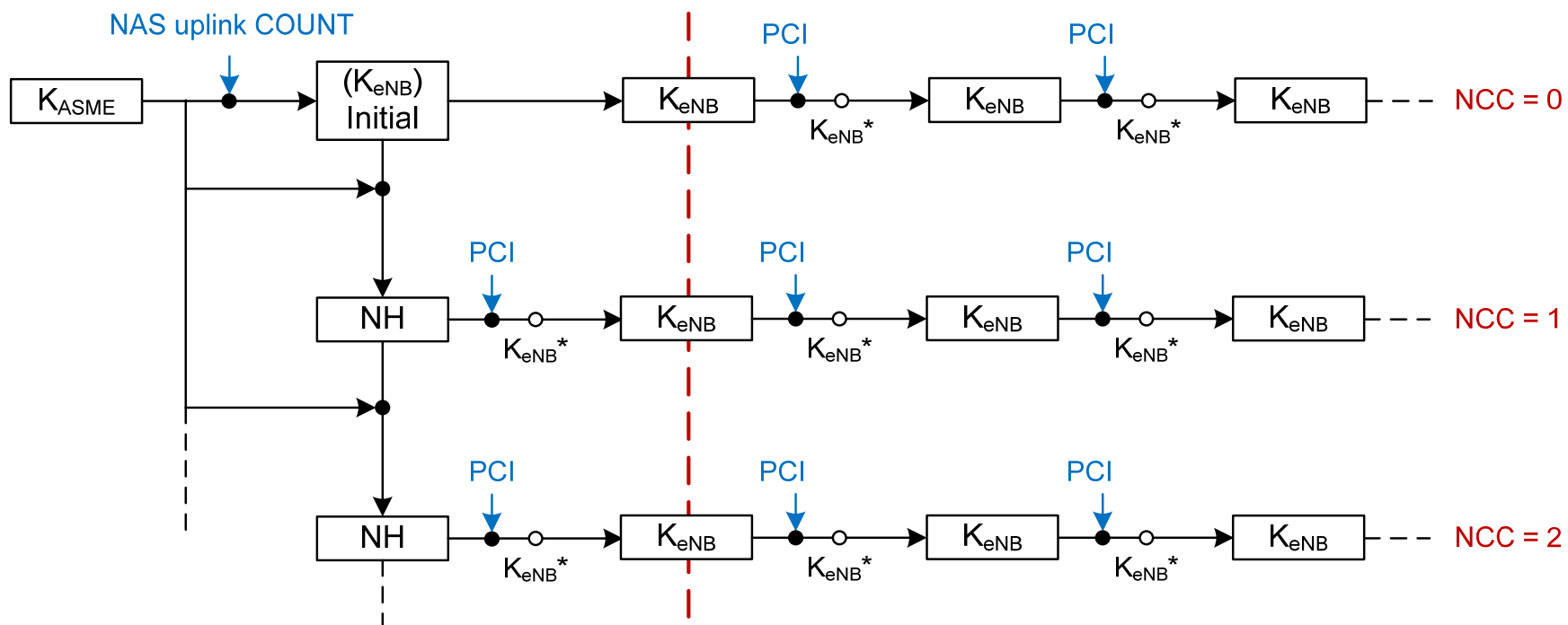
## Cryptographic network separation

- ❑ Authentication vectors are specific to the serving network
  - AV's usable in UTRAN/GERAN cannot be used in EPS
- ❑ AV's usable for UTRAN/GERAN access cannot be used for E-UTRAN access
  - Solution by a “**separation bit**” in AMF field
- ❑ On the other hand, Rel-99 USIM is sufficient for EPS access
  - ME has to check the “separation bit” (when accessing E-UTRAN)
  - EAP-AKA' created in IETF

## Handovers without MME involvement

- ❑ Handovers are possible directly between eNB's
  - for performance reasons
- ❑ If keys would be passed as such, all eNB's in a "HO chain" would know all the keys → one compromised eNB would compromise all eNB's in the "HO chain"
- ❑ Countermeasures:
  - One-way function used before key is passed (**Backward security**)
  - MME is involved after the HO for further key passes (**Forward security**, effective after two hops)
  - When MME involved already during the HO, Forward security is effective already after one hop

# $K_{eNB}$ derivations



## Interworking with UTRAN/GERAN (1/2)

- UE may be registered in both SGSN and MME simultaneously
  - when moving from one system (*source*) to the other (*target*) **both native** content (keys created earlier in the *target* system) **and mapped** content (converted from the keys in the *source* system) may exist
  - **Note:** native keys only for Rel-8 SGSN, not for legacy SGSN

## Interworking with UTRAN/GERAN (2/2)

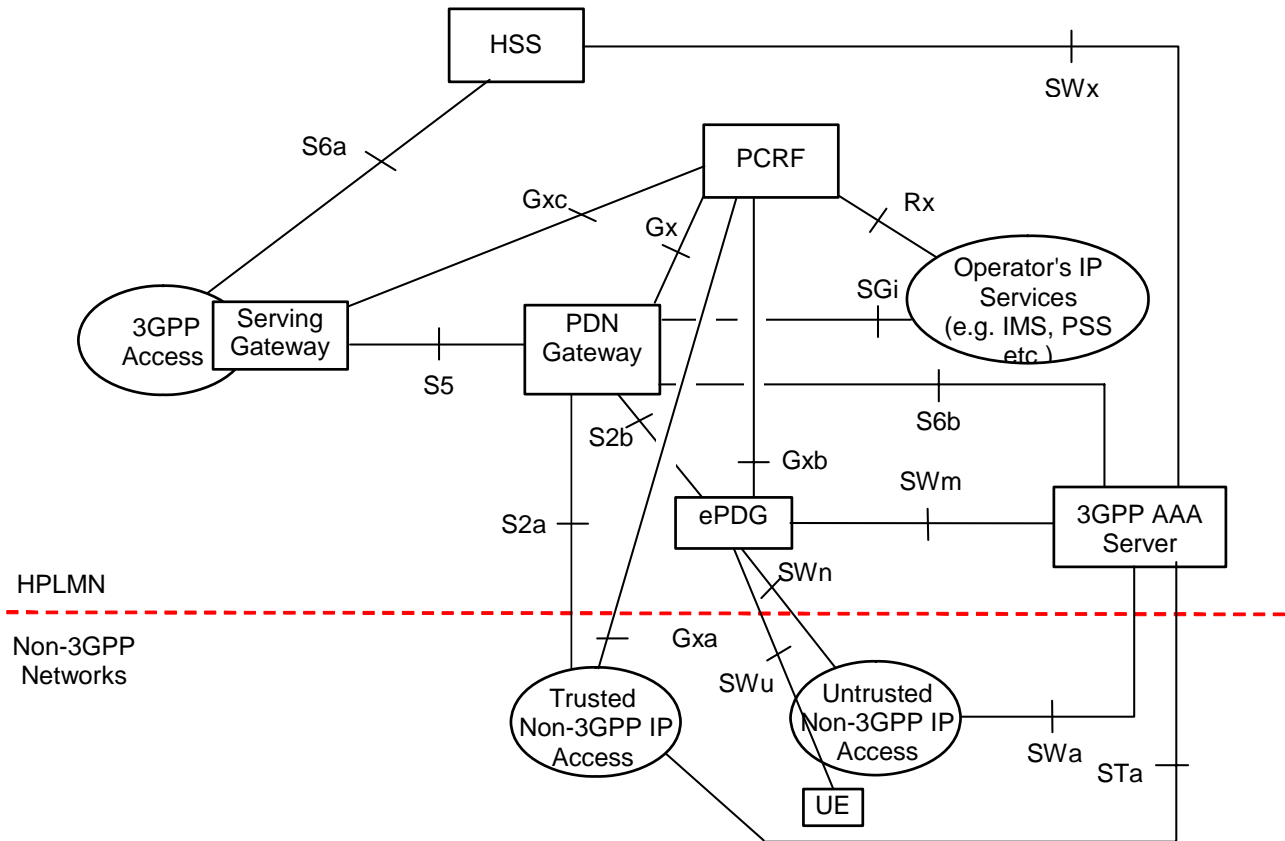
### ❑ Idle mode transition

- From E-UTRAN to UTRAN: either *mapped* or *native* keys are used (depending on the identity used in *Routing Area Update Request*)
- From UTRAN to E-UTRAN: *native* keys are used *but* an exceptional case exists also

### ❑ Handover

- From E-UTRAN to UTRAN: *mapped* keys are used
- From UTRAN to E-UTRAN: *mapped* keys are used *but* it is possible to activate the *native* keys after HO completed (using *key-change-on-the-fly* procedure)

# Inter-working with non-3GPP networks (1/2)



Extract from TS 23.402 (one of several architecture figures)



## Inter-working with non-3GPP networks (2/2)

- ❑ **Three options for mobility between 3GPP and non-3GPP networks:**
  - **Proxy Mobile IP: no user-specific security associations between the Proxy and Home Agent**
  - **Client MIPv4: tailor-made security mechanisms are used**
  - **Dual Stack MIPv6: IPsec with IKEv2 is used between UE and HA**
- ❑ **IPsec tunnel (with evolved Packet Data Gateway) is used in case the non-3GPP network is untrusted by the operator (of EPS network)**
- ❑ **Authentication is run by EAP-AKA or EAP-AKA' procedures, in both cases based on USIM**

# Home (e) Node B security

## H(e)NB Security specification work

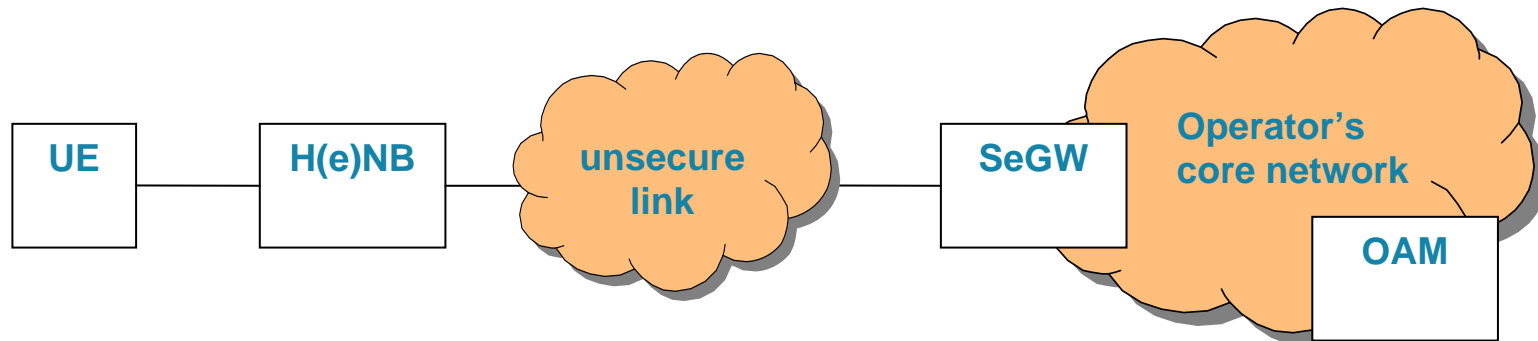
### ❑ TR 33.820

- Technical Report (informative)
- Approved in March 2009
- Study on Security of Home (e) Node B

### ❑ TS 33.xyz

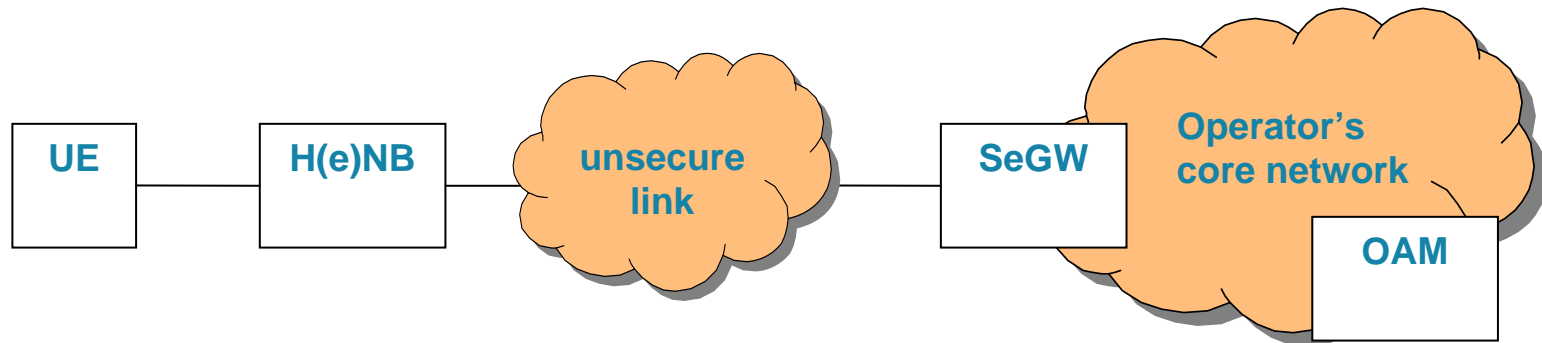
- Technical Specification (normative)
- Currently under development
- 3GPP Security Aspects of Home NodeB and Home eNodeB

## Home (e)NB Security architecture (1/2)



- ❑ **CSG (Closed Subscriber Group)**
  - group of subscribers permitted to access one or more cells of the PLMN with restricted access (“CSG cells”)
- ❑ **Hosting party**
  - party hosting H(e)NB and having contract with PLMN operator
- ❑ **Hosting Party Module (HPM)**
  - module holding credentials for authentication of hosting party
- ❑ **Security Gateway**
  - element at the edge of the core network terminating security association(s) for backhaul link between H(e)NB and core network
- ❑ **Trusted Environment (TrE)**
  - logically separate entity and set of functions/resources within H(e)NB
  - trustworthy environment to execute software and store sensitive data (e.g. PS keys)

## Home (e)NB Security architecture (2/2)



- ❑ Air interface between UE and H(e)NB backwards compatible with UTRAN
- ❑ H(e)NB access operator's core network via a Security Gateway (SeGW)
  - Backhaul between H(e)NB and SeGW may be unsecure
- ❑ SeGW represents operator's core network
  - To perform mutual authentication with H(e)NB
  - Mutual authentication may need support of authentication server or PKI
- ❑ Security tunnel established between H(e)NB and SeGW
  - to protect information transmitted in backhaul link
- ❑ Secure communication required for OAM

## Threats

- ❑ **Compromise of HeNB credentials**
  - e.g. cloning of credentials
- ❑ **Physical attacks on HeNB**
  - e.g. physical tampering
- ❑ **Configuration attacks on HeNB**
  - e.g. fraudulent software updates
- ❑ **Protocol attacks on HeNB**
  - e.g. man-in-the-middle attacks
- ❑ **Attacks against the core network**
  - e.g. Denial of service
- ❑ **Attacks against user data and identity privacy**
  - e.g. by eavesdropping
- ❑ **Attacks against radio resources and management**

All threats  
addressed by  
countermeasures  
in Technical  
Report 33.820

## Authentication

Consists of:

- ❑ H(e)NB identity authentication
- ❑ Trusted Environment (TrE) identity authentication
- ❑ H(e)NB device identity and TrE identity binding
- ❑ The H(e)NB integrity verification

Two separate concepts of authentication:

- ❑ Mutual authentication of H(e)NB and operator's network (mandatory)
  - H(e)NB Identity authenticated by network
    - credentials stored in TrE in H(e)NB
  - identity of operator's network authenticated by H(e)NB
- ❑ Authentication of hosting party by operator's network (optional)
  - credentials contained in a separate Hosting Party Module (HPM) in H(e)NB
  - bundled with the device authentication (one step)
- ❑ Authentication either by certificates or EAP-AKA
  - Protocol used: IKEv2

## Other security mechanisms

- ❑ **Device Integrity Check**
- ❑ **Location Locking**
  - **Location identification (UE reporting/Surrounding Cell or Local )**
  - **Location authentication and authorization**
  - **Solutions**
    - IP address based
    - Macro-cell/UE reporting based
    - (A)GPS based
    - Combination of the above
- ❑ **Access Control Mechanism**
  - **ACL for Pre-R8 UE accessing HNB**
  - **CSG for H(e)NB**
- ❑ **OAM**
  - **Hop-by-hop**
  - **End-to-end**
- ❑ **Clock Synchronization**
  - **Based on backhaul link between H(e)NB and SeGW**
  - **Based on security protocol of clock synchronization protocol**



# Summary and Conclusions

## Summary and Conclusions

### □ SAE/LTE security

- New architecture and business environment require enhancements to 3G security
- Radio interface user plane security terminates in base station site
- Cryptographic separation of keys
- Forward/backward security in handovers
- Different security mechanisms in many inter-working cases with both 3GPP and non-3GPP access networks

### □ Home (e)NB security

- Device Authentication
  - Solutions based on either EAP-AKA or Certificates adequate for pre-R8 deployments
  - Certificate-based solution, coupled with TrE, is mandatory part of Release 9
- HPM Authentication
  - Optional to implement and EAP-AKA based
- Authentication Protocol
  - IKEv2

# Thank you!

For more information:

[www.etsi.org](http://www.etsi.org)

[www.3gpp.org](http://www.3gpp.org)