Wireless Cellular Network Security: Part 6

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References

- D. Forsberg, G. Horn, W.-D. Moeller, V. Niemi, “*LTE Security*”, John Wiley and sons, 2nd edition, 2013.

EPS Authentication and Key Agreement (AKA)

User Identification

- EPS uses the International Mobile Subscriber Identity (IMSI), which is a permanent subscriber identity, to uniquely identify a subscriber
  - ❑ as in GSM and UMTS
- IMSI crucial for EPS security since the permanent authentication key K used in EPS AKA is identified by the IMSI
  - ❑ K is stored in the Authentication Centre (AuC) and in the Universal Subscriber Identity Module (USIM), but nowhere else
  - ❑ this is similar to the case in GSM and UMTS, where the permanent authentication key K_i was identified by IMSI
- For user identity confidentiality, a temporary identity is associated with an IMSI in EPS:
  - ❑ called Globally Unique Temporary UE Identity (GUTI)
  - ❑ recall: in GSM and UMTS, TMSI was used instead of GUTI

User Identity Confidentiality

- EPS protects confidentiality of the user identity as in GSM and UMTS:
    - ❑network assigns the user a temporary identity (GUTI) sent in a message protected from eavesdropping
    - ❑GUTI provides an unambiguous identification of the UE that does not reveal the user’s permanent identity– the IMSI
    - ❑GUTI can be used by the network and the UE during signalling between them, and can be translated by them to IMSI
- MME sends GUTI to UE only after protection for non-access stratum (NAS) signalling has been enabled

Terminal Identification

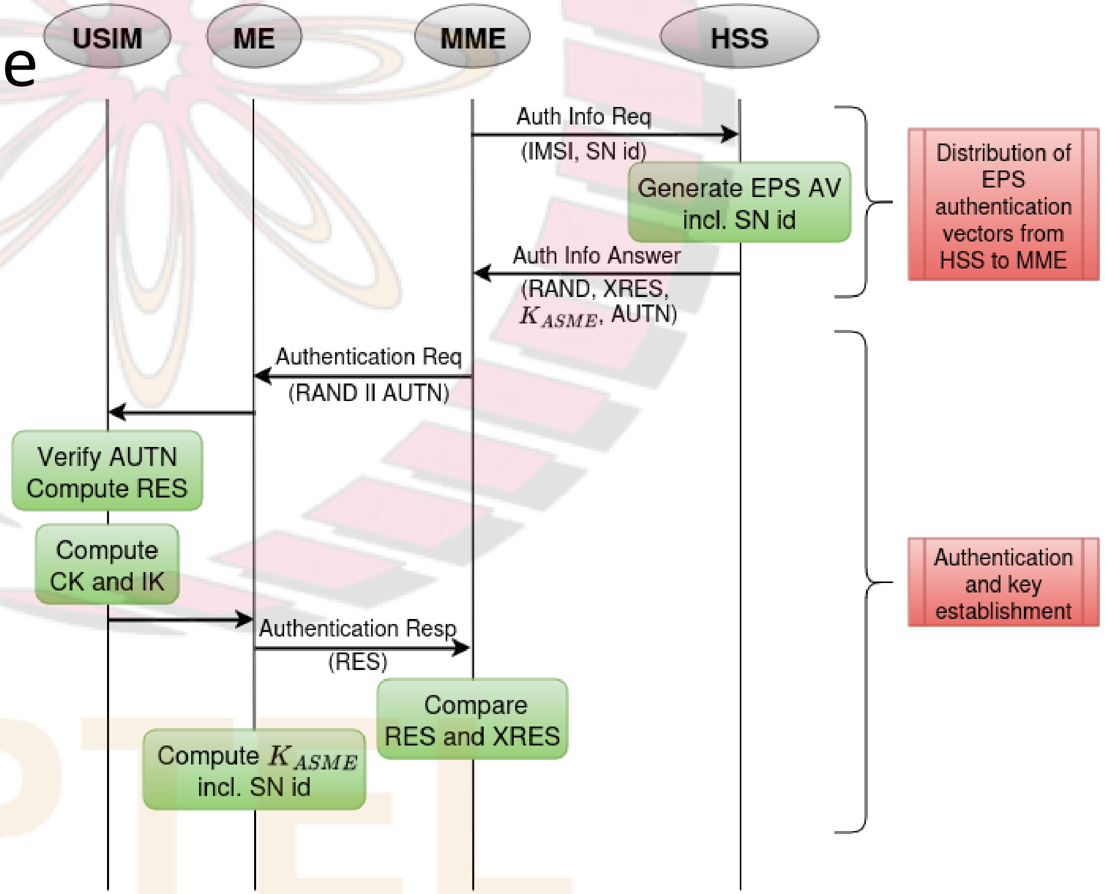
- GSM, 3G and EPS all use the same type of permanent terminal (phone) identity:
  - the International Mobile Equipment Identity (IMEI)
- Uses of IMEI number:
  - Cellular network uses IMEI number to identify phone accessing the network
  - If a mobile phone is stolen, the owner can have his/ her network provider use the IMEI number to blocklist the phone
  - Law enforcement and intelligence services can use an IMEI number as input for tracking phones; are sometimes able to locate a phone with an accuracy of a few meters

Terminal Identity Confidentiality

- Recall:
  - mechanism for protecting the user identity confidentiality in EPS same as it was in GSM and UMTS
- In contrast, there is an improvement in EPS with respect to GSM and UMTS regarding the terminal identity confidentiality
- In GSM and UMTS, it is possible that:
  - the network requests the terminal identity at any time, even before the signalling protection has been set up
  - without signalling protection already set up, the UE would respond by sending the terminal identity in the clear
  - as a user tends to use the same terminal for an extended period of time, the terminal identity would also give strong hints regarding the user identity
- This is no longer possible in EPS:
  - in EPS, the UE does not send IMEI to the network upon a network request before NAS security has been activated

EPS AKA Procedure

- The EPS AKA procedure consists of following:
  - ❑a procedure to generate EPS authentication vectors (AVs) in the Home Subscriber Server (HSS) upon request from the MME, and to distribute them to the MME
  - ❑a procedure to mutually authenticate and establish a new shared key between the serving network (SN) and the UE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MME
HSS
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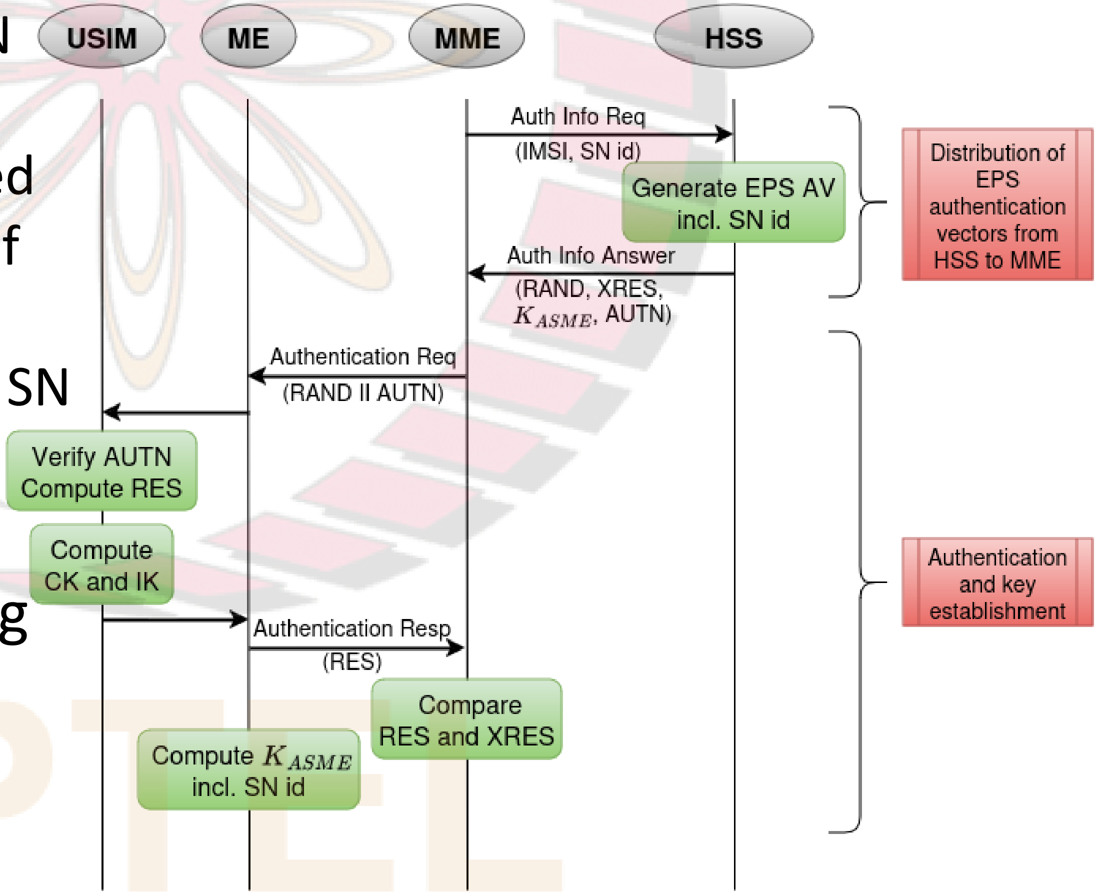
Generate EPS AV incl. SN id
Auth Info Answer
(RAND, XRES, K_{ASME}, AUTN)
Distribution of EPS authentication vectors from HSS to MME
Authentication Req
(RAND || AUTN)
Verify AUTN Compute RES
Compute CK and IK
Authentication Resp
(RES)
Compare RES and XRES
Compute K_{ASME} incl. SN id
Authentication and key establishment

EPS AKA (contd.)

- Goals achieved by EPS AKA similar to those for UMTS AKA, with following enhancement:
  - ❑ EPS AKA provides implicit SN authentication, which UMTS AKA does not
- Implicit SN authentication achieved as follows:
  - ❑ SN id is one of the inputs used in computation of K_{ASME}
- Home network (HSS):
  - ❑ verifies the identity of a SN requesting AVs and
  - ❑ ensures that the SN id, used as input for computation of key K_{ASME} in AVs, matches the verified identity of the SN to which the AVs are sent
- Hence, a SN cannot obtain AVs with keys corresponding to the id of another SN
  - ❑ thus, SN authentication achieved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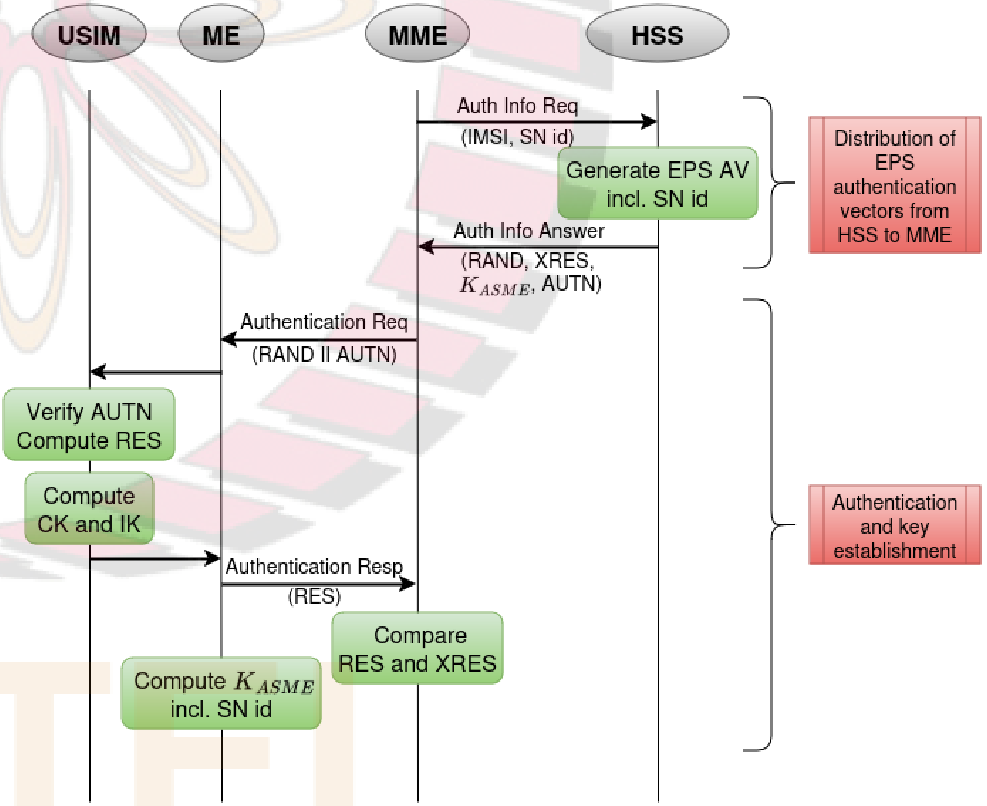
EPS AKA (contd.)

- The MME invokes the procedure by requesting EPS AVs from the HSS
- The Authentication Information Request includes the IMSI and the SN id of the requesting MME
- SN id is required for the computation of K_{ASME} in the HSS
- Upon receipt of the Authentication Information Request from MME:
  - ❑ the HSS may have pre-computed AVs available and retrieve them from the HSS database, or
  - ❑ it may compute them on demand
- The HSS sends an Authentication Information Answer back to the MME:
  - ❑ contains an ordered array of *n* EPS AVs $(1, \ldots, n)$
  - ❑ if $n > 1$, the EPS AVs are ordered based on sequence number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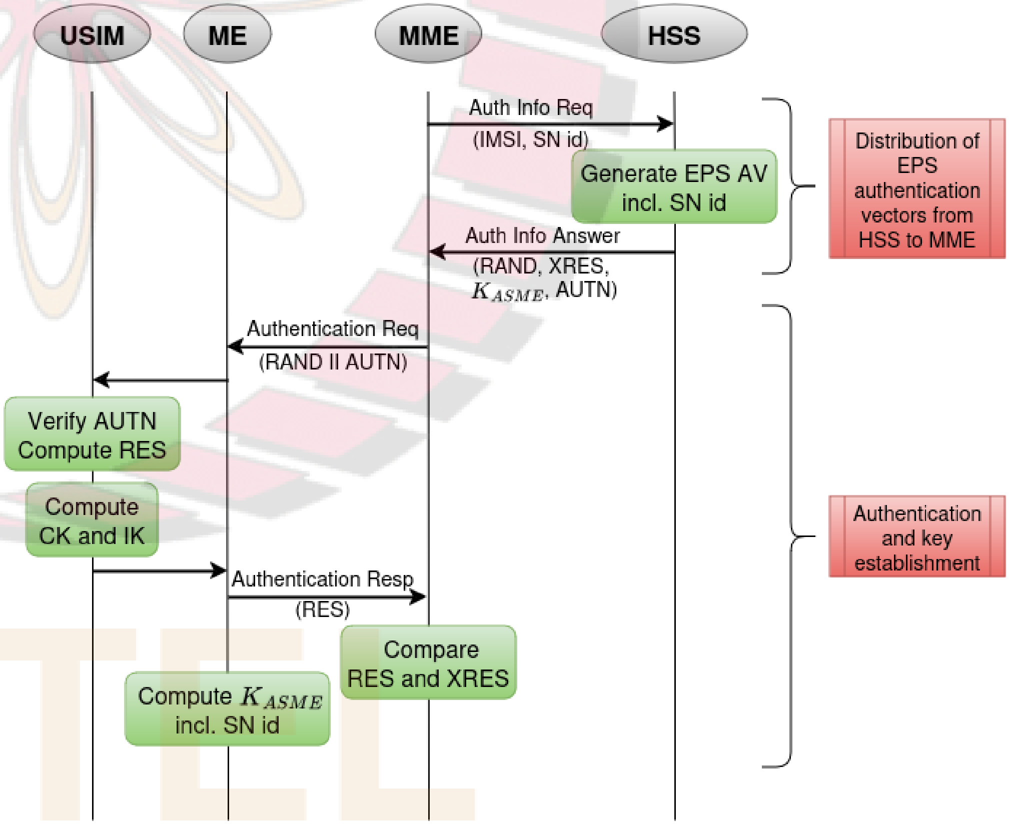
EPS AKA (contd.)

- LTE standard recommends *n* =1; so typically only one AV is sent at a time
  - ❑ recall: in GSM and UMTS AKA, five AVs are sent at a time
- This is because the need for frequently contacting the HSS for fresh AVs has been reduced in EPS through the availability of the local master key K_{ASME}
  - ❑ K_{ASME} is not used for encryption or message integrity; hence, not exposed like Ciphering Key (CK) and Integrity Key (IK) in UMTS
  - ❑ hence does not need to be renewed very often
- Based on the local master key, and keys derived from it, an MME can offer secure services even when links to the HSS are unavailable
- Pre-computed AVs no longer usable when the user moves to a different SN owing to the binding of the local master key K_{ASME} to the SN id
- Each EPS AV is used for one run of the AKA procedure between the MME and the USIM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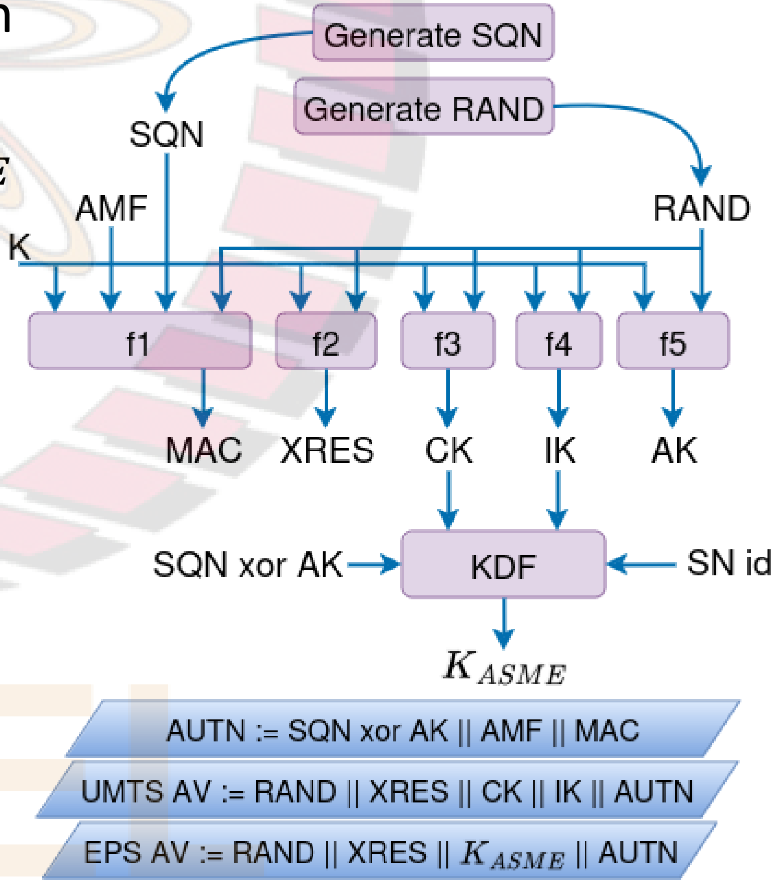
Generation of Authentication Vectors

- Recall: a UMTS AV consists of:
  - ❑ a random 128-bit string (RAND), an expected response (XRES), a CK, an IK, and an authentication token (AUTN)
- In contrast, EPS AV consists of:
  - ❑ RAND, XRES, a local master key K_{ASME} and an AUTN
- Fig. shows generation of a UMTS AV by AuC, and generation of an EPS AV from this UMTS AV by HSS
- The AuC generates UMTS AVs for EPS AKA in exactly the same format as for UMTS AKA
- The HSS part outside the AuC derives K_{ASME} from CK and IK; in particular:
  - ❑ When the HSS receives the UMTS AV from the AuC, the HSS applies the KDF to CK, IK, SN id and, for technical cryptographic reasons, (SQN xor AK)
  - ❑ The result of the application of KDF is the key K_{ASME}
  - ❑ CK and IK can then be deleted in the HSS; they must never leave HSS



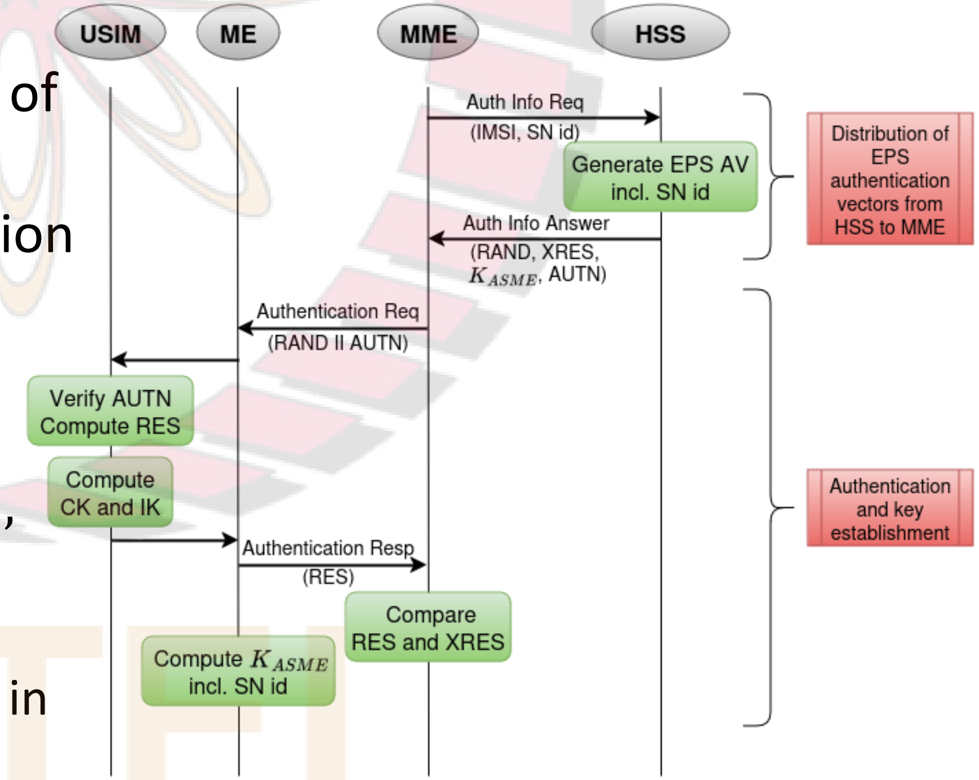
AUTN := SQN xor AK || AMF || MAC

UMTS AV := RAND || XRES || CK || IK || AUTN

EPS AV := RAND || XRES || K_{ASME} || AUTN

Mutual Authentication and Establishment of Shared Key between Serving Network and UE

- Purpose of this procedure is:
  - ❑ mutual authentication of user and MME,
  - ❑ establishment of a new local master key K_{ASME} between MME and UE
- K_{ASME} is subsequently used for deriving keys for the protection of user plane (UP) data, RRC signalling and NAS signalling
- Procedures used in EPS for handling of authentication requests and verification in USIM and authentication responses are same as in UMTS
- Difference:
  - ❑ when the ME receives (CK, IK) from the USIM, the ME computes K_{ASME}, using the same KDF and the same input parameters as the HSS
  - ❑ after this, CK and IK can be deleted in the ME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