Mobility Management in Cellular Networks (LTE)

Irfan Ali

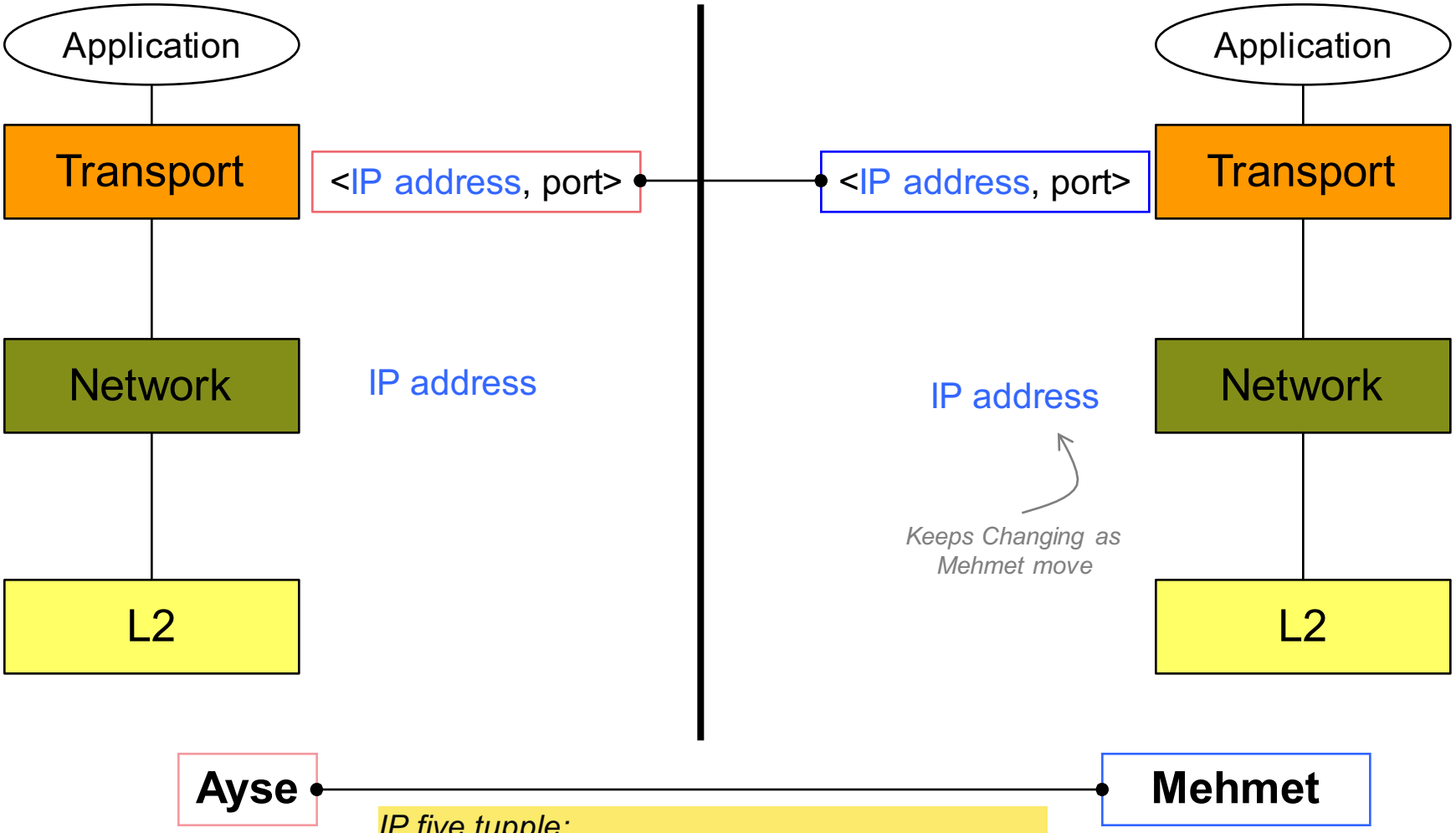
Overview

- ***Mobility as an IP address continuity problem***
  - Introduction to IP tunneling
- ***Requirement for Context Transfer***
- ***(Connected-mode) Mobility support in LTE***
  - X2 handover
  - S1 handover

What is the problem being solved?

- *Service Continuity is the problem being solved by mobility management.*
- *Service Continuity*
  - As the mobile moves around in the network its IP-based services (web browsing, file-transfer, IM, VoIP, streaming video) should be maintained.
- *For an IP connection either, using UDP or TCP, to be continued, the IP address should not change.*
- *3GPP Cellular networks try to solve the IP-service continuity problem by assuming that the IP protocol stack on both the mobile node (MN) and correspondent node (CN) are un-modified IP stacks, i.e. they do not have any additional mobility support built into them.*
  - In the IP mobility support part, we will cover mobility schemes that do not make this assumption.
- *Hence, the 3GPP **network** provides mobility support.*
- *The mechanism used is a "tunneling" mechanism.*

TCP Socket: “IP five tupple” binding

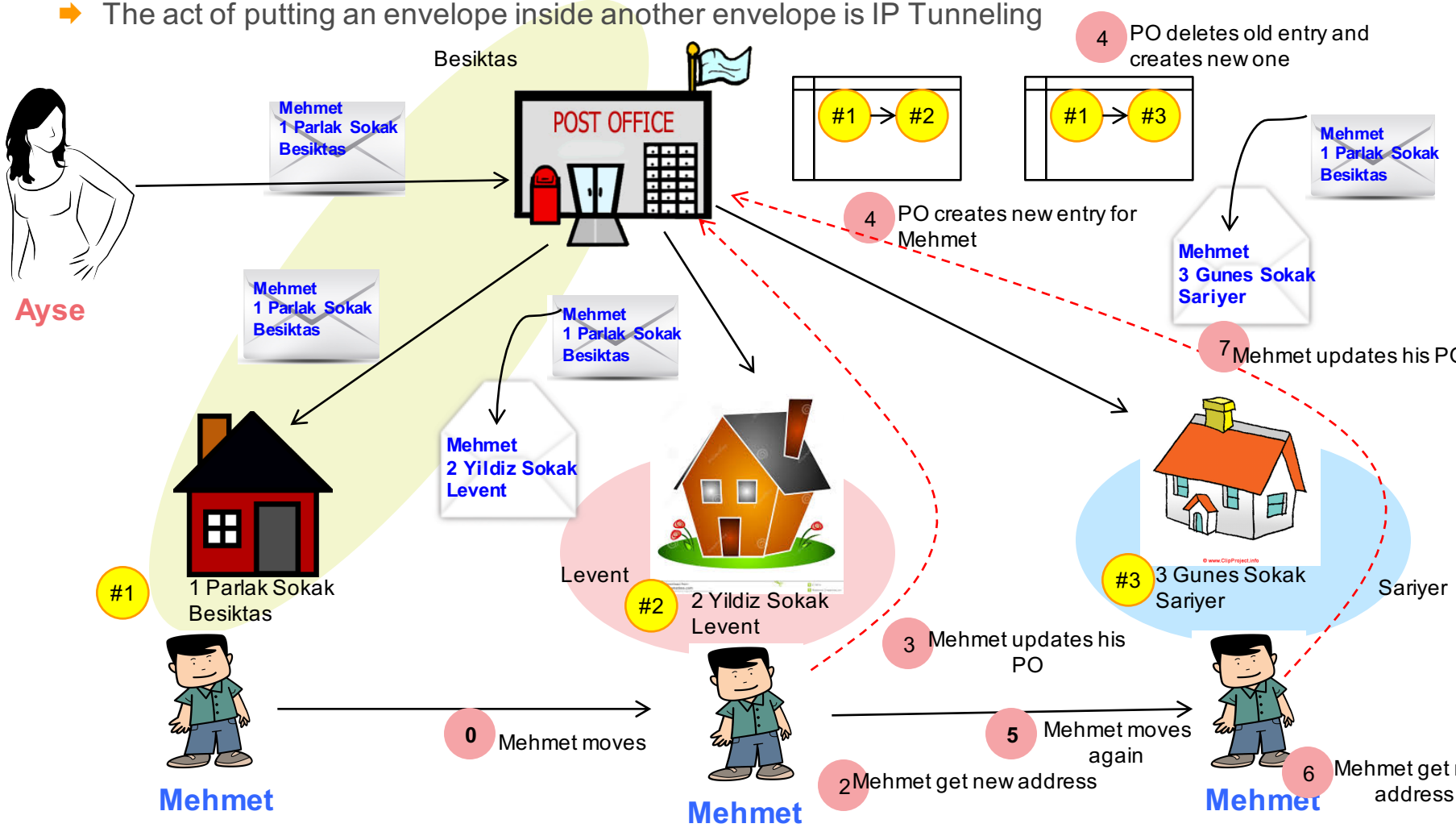


IP five tupple:

- Source Ip address, Source IP port,
- Destination Ip address, Destination IP port, and
- Protocol (TCP, UDP, SCTP)

The Post Office Analogy

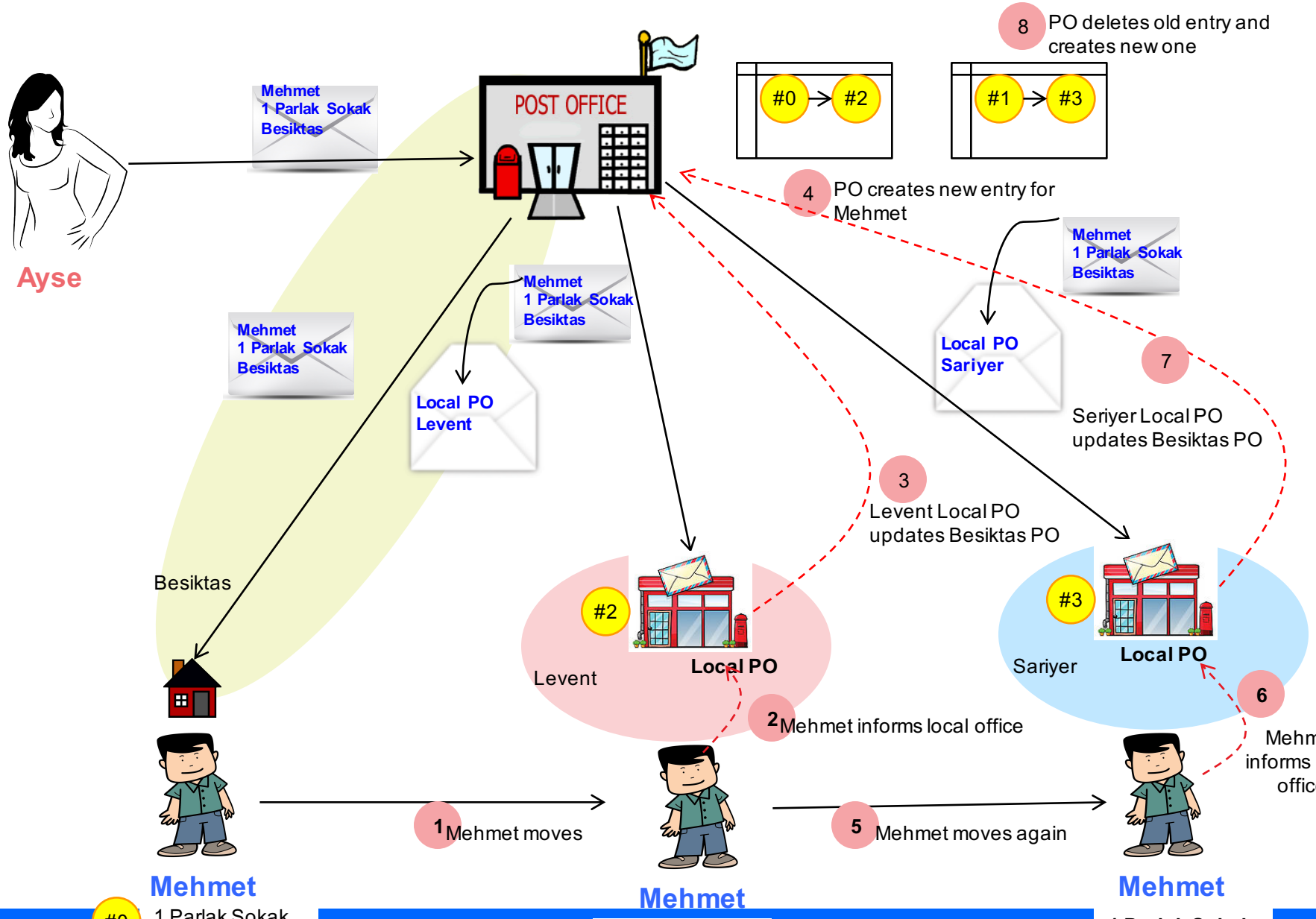
- ***The best analogy of IP Tunneling mechanism is that of a post-office and letter forwarding***
  - The act of putting an envelope inside another envelope is IP Tunneling



A few points about the analogy

- *Ayse is unaware that Mehmet is moving.*
  - ➡ Only if Mehmet replies to Ayse and puts his new address in envelope will Ayse be aware of Mehmet's mobility.
- *The postman only looks at the outer envelope. He does not need to be aware that the envelope contains another envelope.*
- *Mehmet is aware of his movements and is actively involved in updating his address.*
- *Whenever Mehmet moves to his new address, he gets a new address.*
- *In cellular network, the idea is not to provide a new address (IP address) to Mehmet whenever he moves. Also, Mehmet should not be involved in signalling for updating the master post-office.*

The Post Office Analogy… Revisited



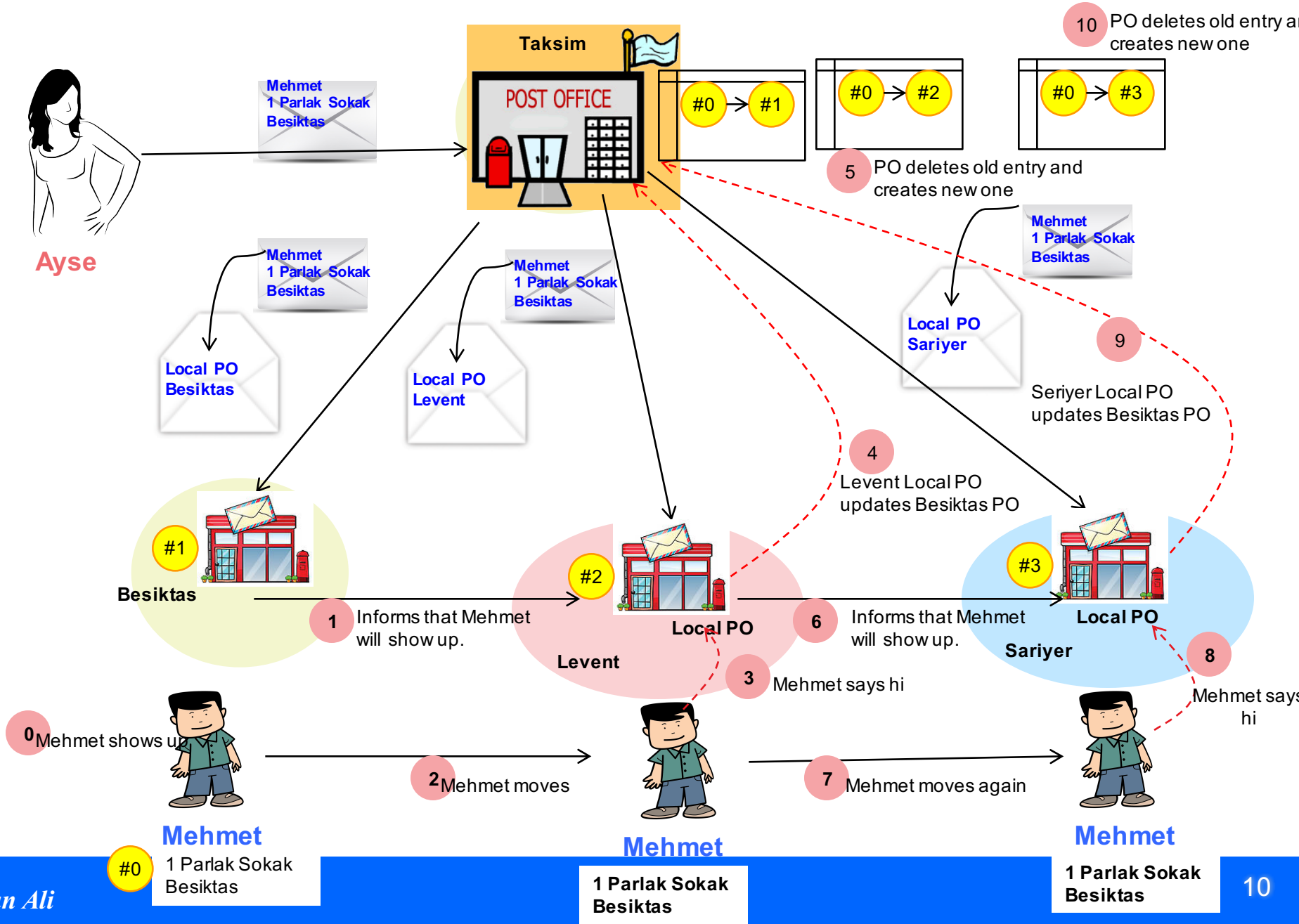
A few points about the analogy revisted

- *Mehmet is not getting a new global address when he moves to the new locality.*
  - However, the local post office needs to know how to get hold of Mehmet (sits next to the local tea-house, etc.). Think of the local post-office as a village.
- *Mehmet is aware of mobility and informs the local post-office. However, this mobility is "below" the level of mailing-address.*
  - Below the IP layer.
- *How does the new local post-office figure out the where the master post-office of Mehmet is at?*
  - Either Mehmet can provide this information to the new local post-office, or
  - The new local post-office can get this information from the old local post-office.

The Analogy and LTE

- *To simplify assume SGW and PGW are one node.*
- *The PGW is the master post-office (Besiktas PO)*
- *The eNB is the local post-office where the UE is.*
- *Even when the UE is in Besiktas, the letters to UE are tunneled to the Besiktas PO and the Besiktas PO delivers the letter to Mehmet.*
- *The mobility of Mehmet is controlled by the eNB (local office). The old local-office (source-eNB) informs the new local office (target eNB) that Mehmet is being moved and provides information, eg Besiktas PO address, to the new local-office.*
- *When Mehmet shows up at the new local-office, the new local-office updates the master local-office.*

The (almost) exact Post Office Analogy for LTE X2 Handover



Parts of mobility protocol

- *There are two key parts:*
  - Signalling part: This is the part which deals with informing the master post-office that the UE has showed up and to tell the master post-office about where to send the tunneled packets of the recipient
  - Tunneling part: This is concerned with encapsulating the IP packet (envelope inside another envelop).
- *For GTP, GTP-C is the signalling protocol and GTP-U is the tunneling protocol.*
  - Though GTP-C is the signalling protocol part of GTP, the GTP-U tunnel on the S1 interface (eNB-SGW) a combination of S1-AP protocol (eNB-MME) and GTP-C on S11 interface (MME-SGW). The GTP-U tunnel on S5 interface is setup by GTP-C on S5 interface.
- *For MIPv4/MIPv6, MIPv4/MIPv6 itself is the signalling protocol. GRE tunneling is typically used as the tunneling protocol*

Handovers, or
Mobility Management in Connected Mode

Overview of Handovers

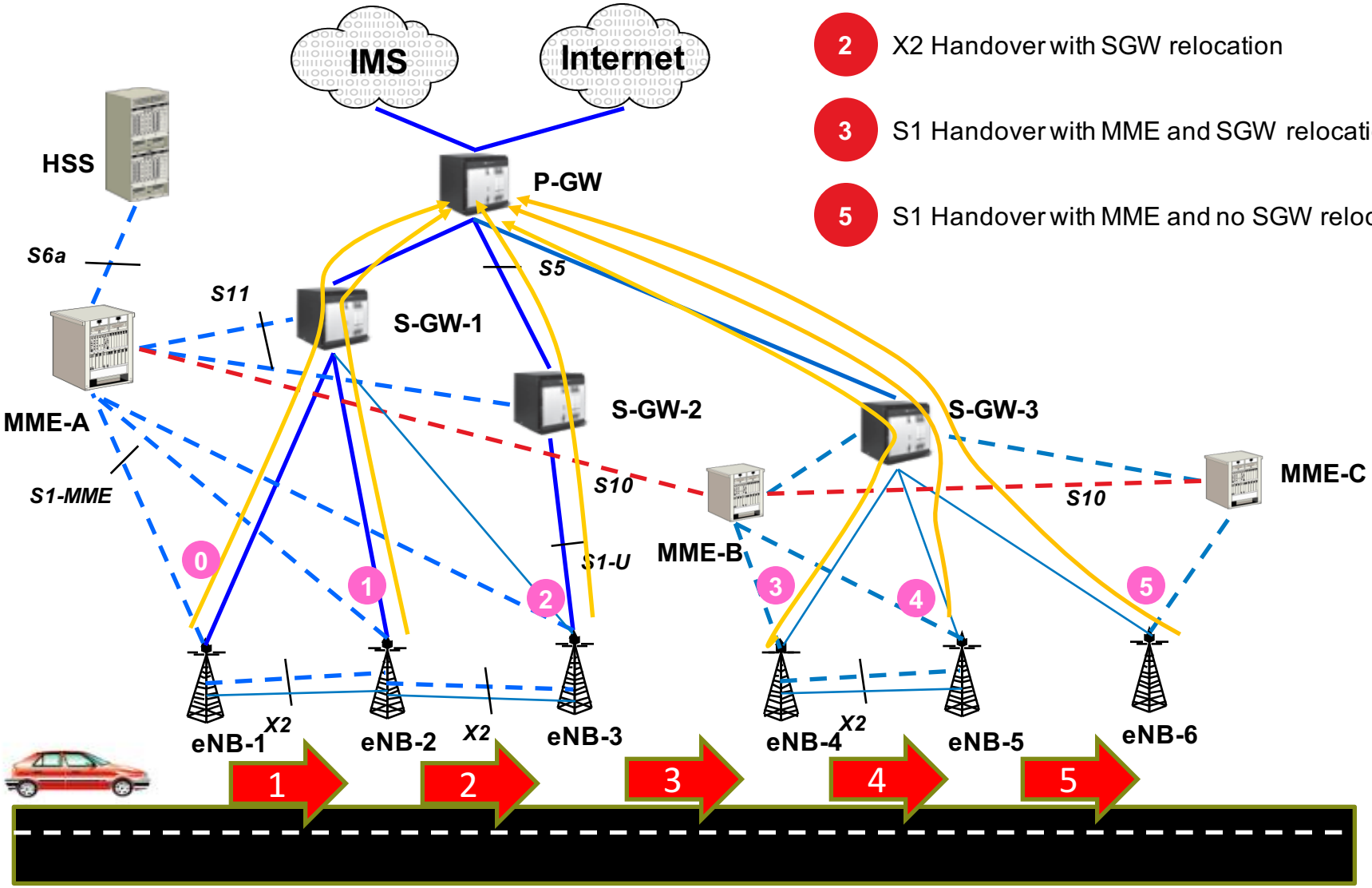
- ***All handovers in LTE are prepared handovers***
  - Resources are prepared in the target eNB, before the UE connects to the target eNB
- ***All handovers in LTE are UE assisted network controlled***
  - The UE is asked to make measurements of neighbouring cells by the source eNB and report back to the source eNB.
  - The source eNB decides as to which target eNB the UE should be handed over to and directs the UE to that particular target eNB.

Measurement (1 of 2)

- There is no need to indicate neighbouring cell to enable the UE to search and measure a cell i.e. E-UTRAN relies on the UE to detect the neighbouring cells;
- For the search and measurement of inter-frequency neighbouring cells, at least the carrier frequencies need to be indicated;
- eNB signals reporting criteria for event-triggered and periodical reporting
  - *Events can be defined eg to be low Rx threshold on current cell, etc.*
- Black lists can be provided to prevent the UE from measuring specific neighbouring cells.

Types of handovers

1. X2 Handover with no SGW relocation
2. X2 Handover with SGW relocation
3. S1 Handover with MME and SGW relocation
5. S1 Handover with MME and no SGW relocation

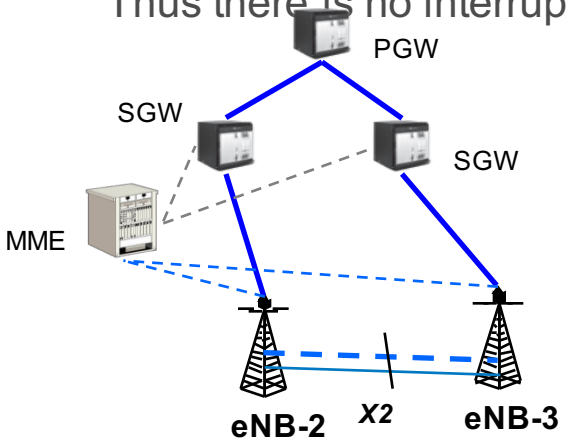


X2 Handovers cannot have an MME change, i.e for an X2 HO, both the source-eNB and target-eNB have to be under the control of the same MME.

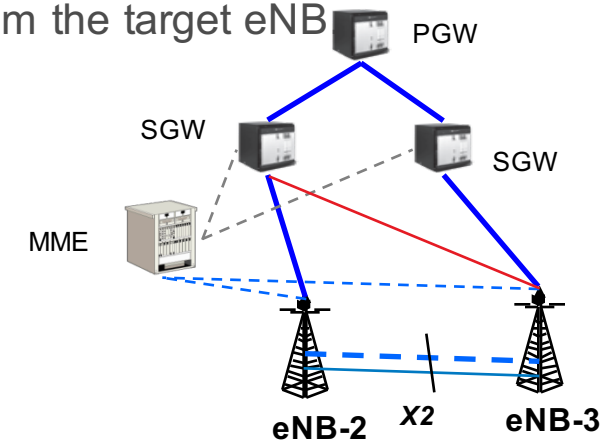
X2 HO with S-GW relocation

X2 HO Basics

- ***X2 Handovers cannot have an MME change.***
  - Both the source-eNB and target-eNB have to be under the control of the same MME.
- ***X2 Handovers with S-GW relocation assumes that there is connectivity between the Source S-GW and the target eNB.***
  - The reason being that in X2 handover the MME is informed after the X2 HO is complete, i.e the UE has already moved to the target eNB. If the target eNB has no connectivity to the source SGW, then packet in UL and DL will be dropped untill the MME moves the SGW.
  - Only S1-HO is allowed in this case. In S1-HO, if SGW is relocated, the MME in handover preparation tells the SGW to be ready to accept packets from the target eNB. Thus there is no interruption in traffic from the target eNB



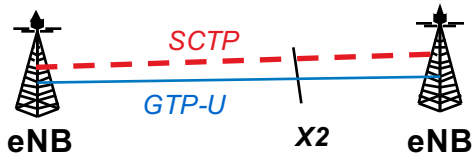
X2 handover not allowed; only S1 HO in this case

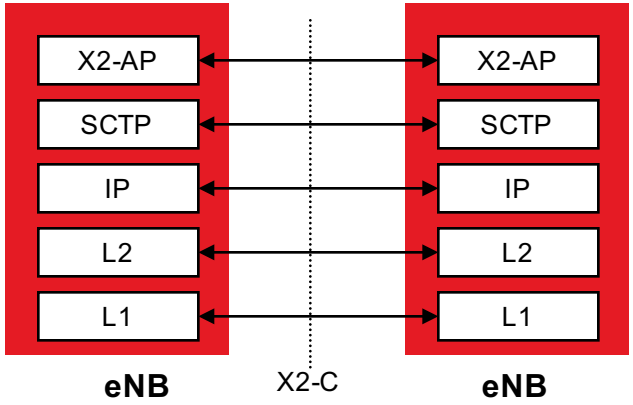


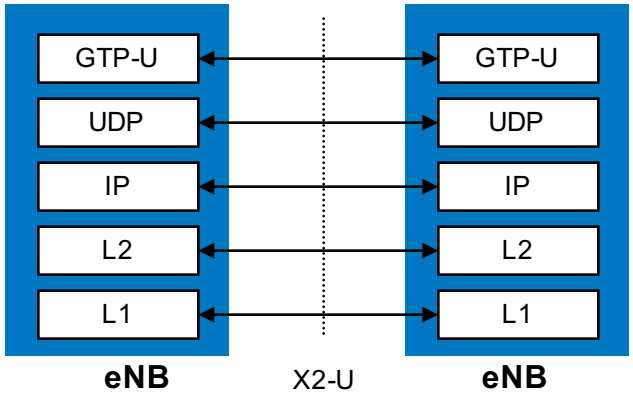
X2 handover allowed

X2 Interface background

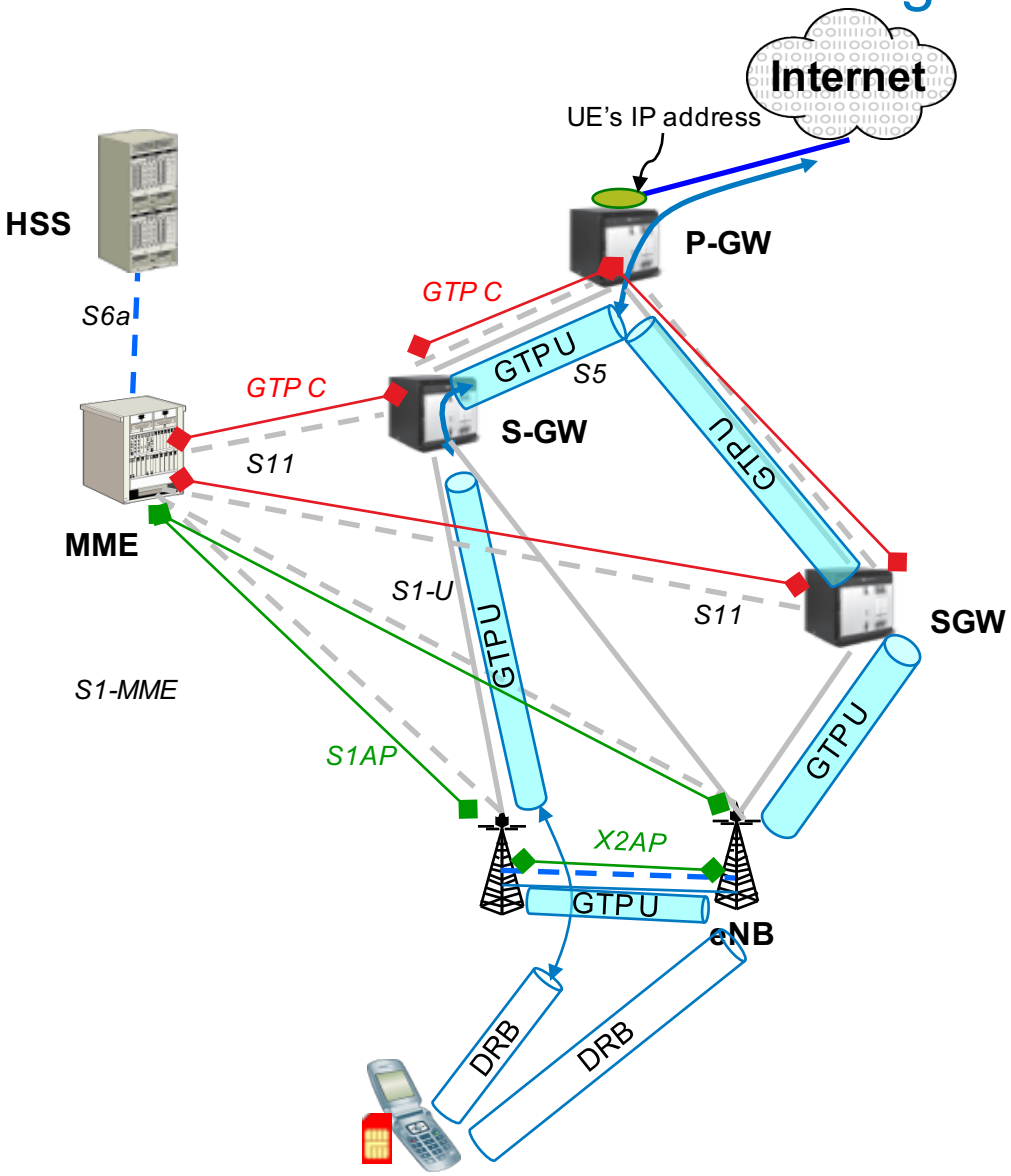
- ***Stream Control Tranport Protocol (SCTP) (RFC 4960) is used on the control plane.***
  - SCTP provides reliability by allowing “multi-homing” of connection.
  - SCTP created by the Signal Transmission (SIGTRAN) group is the transport protocol of choice for reliable transmission of signalling messages in IETF.
- ***GTP-U is used on the user plane of X2***
  - It is used for optional forwarding of traffic from the source eNB to the target eNB during the handover procedure.
  - Two tunnels are created for each bearer for which forwarding needs to occur.
    - One for forwarding UL traffic (from target eNB to source eNB)
    - The second one for forwarding DL traffic (from source eNB to target eNB)





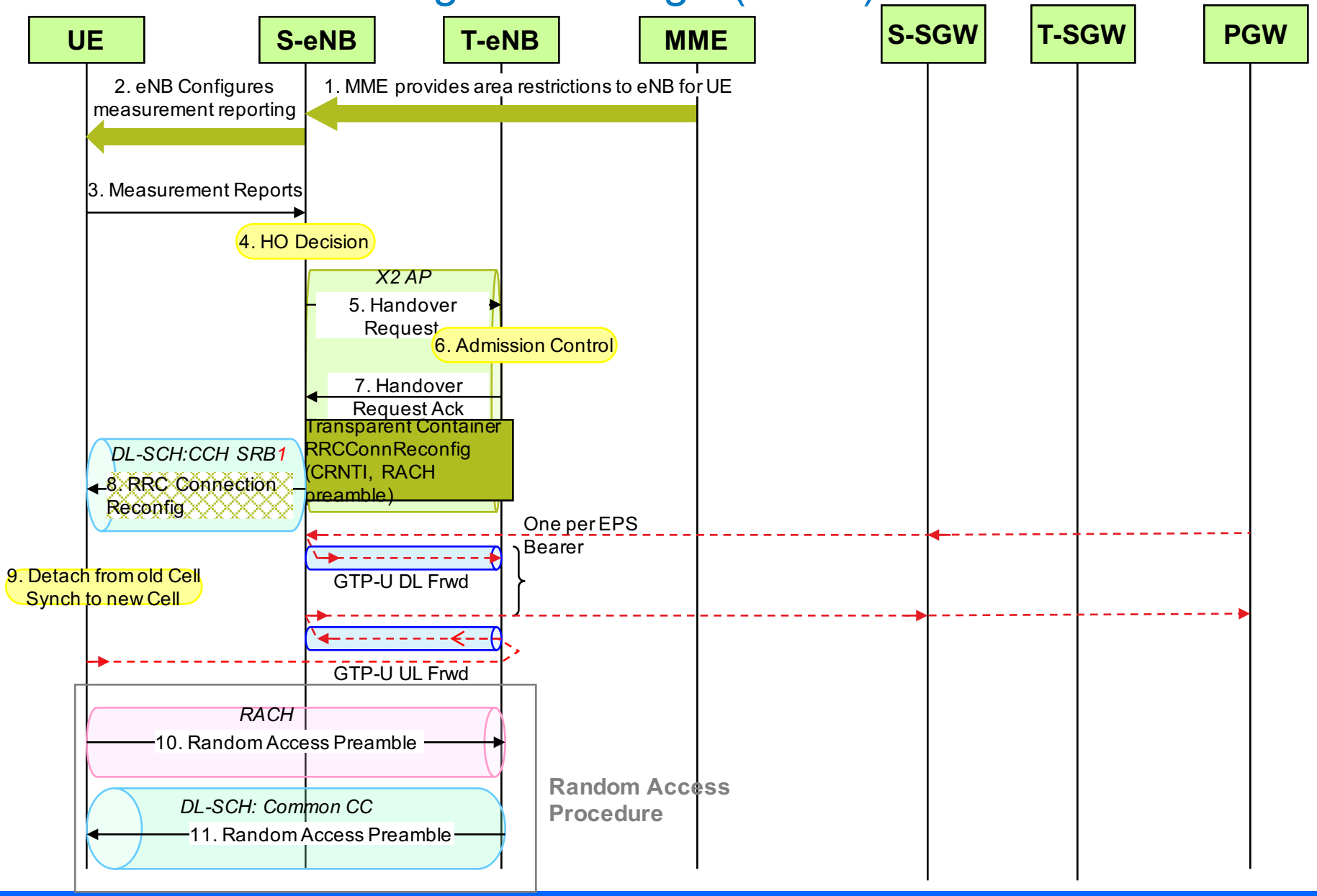


X2 Handover with SGW Change

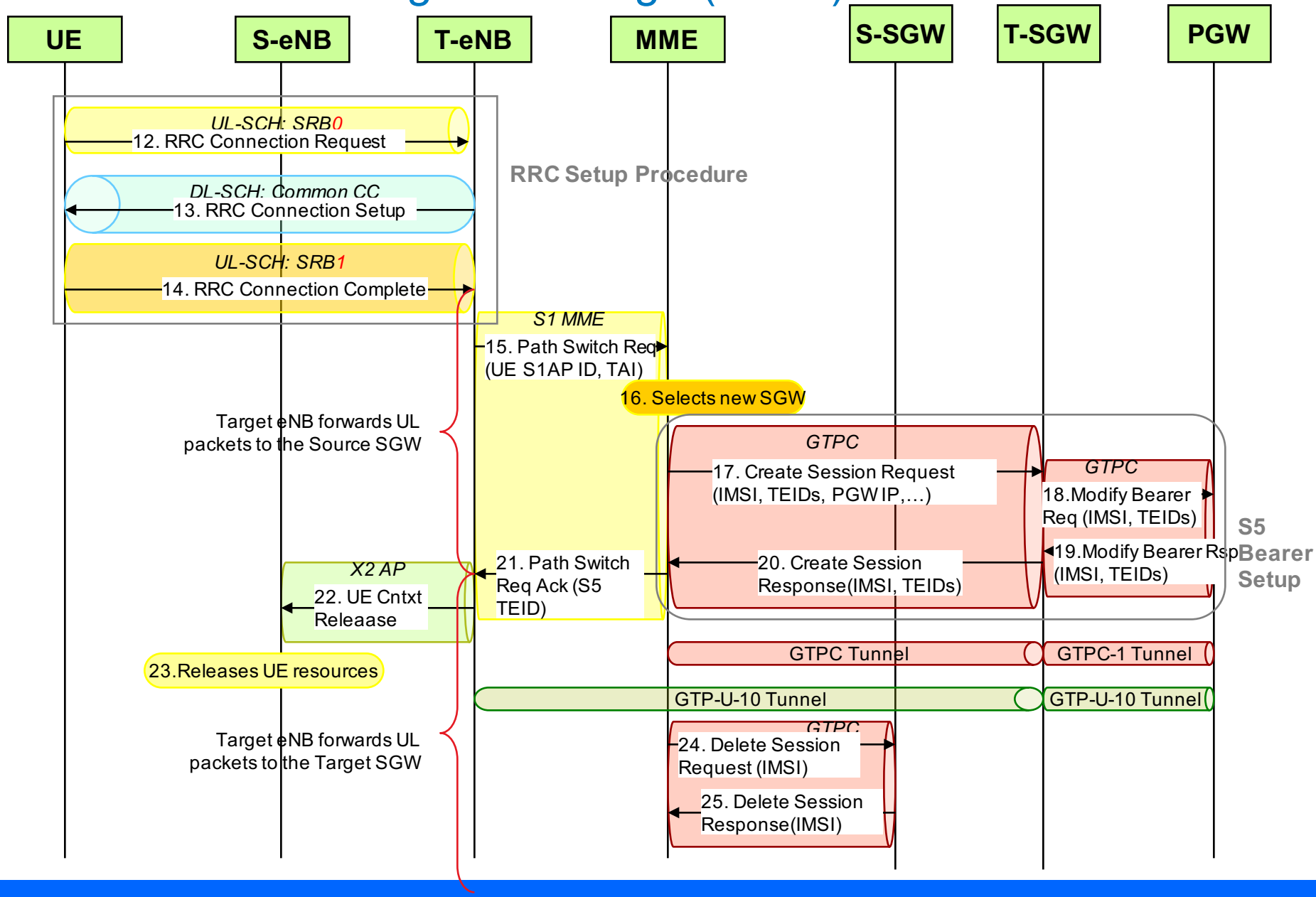


- MME UE S1AP ID has to be unique across all eNBs that are connected to the MME.
- S5-C PGW F-TEID has to be unique across all SGWs that are connected to the PGW.
- UL S5-U PGW F-TEID has to be unique across all SGW that are connected to the PGW

X2-HO with Serving GW change (1 of 2)



X2-HO with Serving GW change (2 of 2)



Summary of LTE handover

- *All handovers are prepared and network controlled.*
  - The UE is provided the slot to attempt random access also during the preparation phase from the target eNB.
  - “Transparent Target to Source Container” is used by the target eNB to provide preparation information to the UE.
- *The SGW in UL direction is expected to receive packets from target eNB for the UE and forward it to the PGW before receiving path switch message.*
  - So the UL GTP TEID allocated for the UE by SGW for S1-U should be unique across all eNBs connected to the SGW.
  - The same is true for PGW from SGW.