Enforcement of Roaming Restriction during I-RAT TAU/RAU procedures: Issues, and Way Forward

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Background wrt IRAT HO

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<= Rel-11 Key Issues
IRAT HO : Background (1/2)

- DCM presented following 4 problematic scenarios in S2-123023
- Basic setup
  - VPLMN deploys E-UTRAN and UTRAN, but E-UTRAN is for their subscribers and not for inbound roamers; an E-UTRAN roaming agreement is NOT in place between PLMNs. The Gp-interface connects VPLMN SGSN and HPLMN GGSN. S8-interface is NOT in place.
  - An inbound roamer uses an E-UTRAN capable UE for UTRAN roaming.
- Issue #1: IRAT HO from UTRAN to EUTRAN
- Issue #2: IRAT HO from pre-R8 UTRAN to EUTRAN
- Issue #3: IRAT release w/ redirection from UTRAN to EUTRAN
- Issue #4: Fast redirection from UTRAN to EUTRAN

Although presented for roaming scenarios, the problem exist in non-roaming cases as well

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<= Rel-11 Key Issues
IRAT HO : Background (2/2)

- Issue#1: IRAT HO from UTRAN to EUTRAN
  1. source RNC initiates an Inter-RAT handover to E-UTRAN and sends a Relocation Required message to the source SGSN
  2. Inter-RAT handover continues and, at last, the UE sends a HO to E-UTRAN Complete message to the target eNodeB
  3. UE sends a TAU Request message through eNodeB to MME
  4. MME finds that the authentication procedure fails and returns a TAU Reject message with the cause value #15
  5. UE adds the TA to the forbidden TA list and switches to UTRAN
  6. steps (1) and (2) occur.
  7. UE reads broadcasted system information, finds that the TA is in the forbidden TA list, and switches back to UTRAN
  8. steps (6) and (7) repeat

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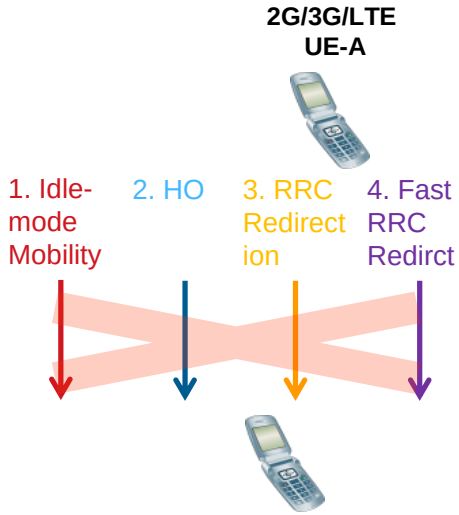
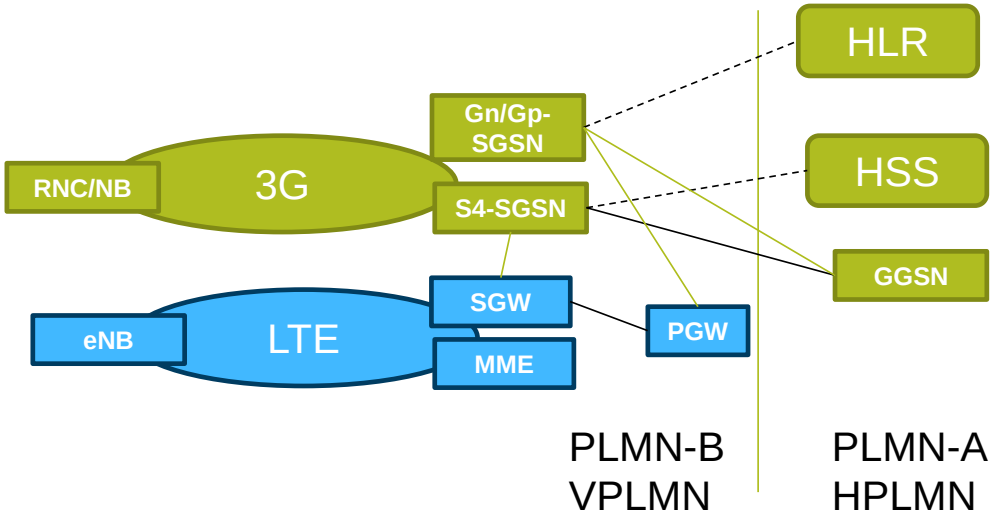
<= Rel-11 Key Issues
IRAT HO : Desired Behaviour





- The idea is to block any mobility from 3G to LTE for a UE in the VPLMN, when any of the following is true:
  - A. VPLMN does not have LTE Roaming Agreement, or
  - B. Lack of EPS subscription data, or
  - C. "E-UTRAN not allowed" in the subscription profile
- #1, #2, and #3 are solved (see next slides)
- #4: implementation dependent solution

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<= Rel-11 Key Issues
IRAT HO : Solution (1/2)

- Pre-Rel8: No solution standardized. Not even recommended to have this configuration when interworking w/ EUTRAN
  - Issue#2
- Rel-8 onwards:
  - Issue #1
    - IDLE MODE: Solved via RFSP Index
    - CONNECTED MODE (Handover): Solved via EUTRAN Service HO IE
  - Issue#3:
    - Solved via EUTRAN Service HO IE
- Solution for 23.060 (S2-124907/9, 4812/13), 23.401 (S2-124892/93/94/95), 23.221 (S2-124981, 4386/87/88)
- Issue#4: Not solved by standards but RAN added some hints as to turning off pre-redirect feature in certain cases (implementation-dependent)

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New Developments

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<= Rel-11 Key Issues
IRAT HO : What happened in CT4#60

- CT4 implemented on SA2 recommendations
- In addition, CT4 approved C4-130237 (against Rel-8 29.002) to allow even a GnGp SGSN to understand “EUTRAN not allowed” when present in ARD
- In further discussing this topic, CT4 found an issue wrt IRAT HO (not directly related to SA2’s proposed solution, but something more basic)
- CT4 sent LS OUT in C4-130417

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<= Rel-11 Key Issues
IRAT HO : Where to go from hereon?

- In general, there are two parts to further IRAT HO related issues:
  - Part 1: How to deal w/ network internals
    - Covered by this presentation
  - Part 2: What cause code is sent to UE to try and influence its behaviour?
    - Covered by NSN DP (S2-13xxxxx revision of S2-130412)
- Cisco initiated offline email discussions on CT4's presented scenario

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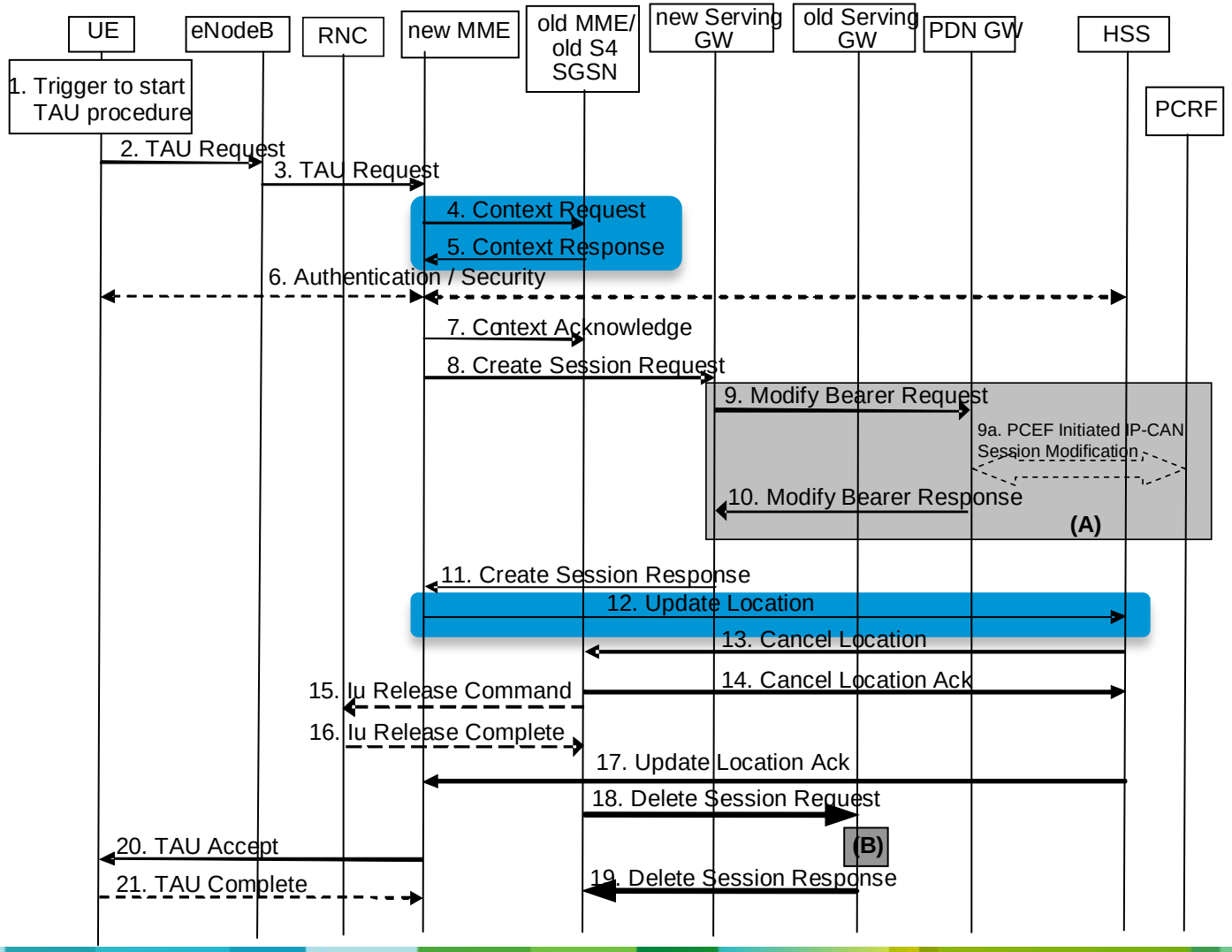
(23.401 sec. 5.3.3.1)

CT4 scenario
I-RAT TAU Procedure: Basic Call Flow (1/3)



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CT4 scenario
I-RAT TAU Procedure: Basic Call Flow (2/3)

- The UE attaches to UMTS network
- The SGSN downloads the subscription information from the HSS/HLR; The AccessRestrictionData (ARD) has "E-UTRAN not allowed" flag set => E-UTRAN roaming restriction shall be enforced for the UE

2. UE reselects the RAT and performs TAU procedure

4. MME sends Context Request message to the SGSN

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CT4 scenario
I-RAT TAU Procedure: : Basic Call Flow (3/3)

5. SGSN responds with successful Context Response message. The MM contexts are transferred to the MME. The SGSN starts guard timer.

8. MME proceeds w/ Session creation at SGW and PGW

12. MME queries HSS. HSS rejects it w/ (No EPS Subscription found)

- ➔ TAU fails at Step 17. as the UE is not provisioned with EPS. TAU procedure is rejected with a cause code#15 “No Suitable Cells in Tracking Area”. UE stores the TAI in the “forbidden tracking area for roaming” list
  - ➔ No GUTI is included
- ➔ UE may go back to 3G, perform a RAU or search for alternate TA in same 4G PLMN to try and perform TAU again
  - ➔ If it performs RAU again, then it must use native P-TMSI since no mapped identity can be derived

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CT4 scenario
I-RAT TAU Procedure: : When does this occur?

- Could occur under at least the following scenarios:
  - LTE-capable UE (3G SIM in a 4G UE case) aggressively looks for and tries to latch onto LTE (despite of other RATs being available, and SPID/RFSP saying not to) – observed in field
  - Coverage boundary areas
  - When user is moving (e.g. driving car) e.g. RA1→TA1→RA2
  - ….

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (1/10)?

- "14. If the timer started in step 4 is not running, the old MME removes the MM context. Otherwise, the contexts are removed when the timer expires. It also ensures that the MM context is kept in the old MME for the case the UE initiates another TAU procedure before completing the ongoing TAU procedure to the new MME. The old MME acknowledges with the message Cancel Location Ack (IMSI)."
- Context Procedure guard timer in old nodes (MME/SGSN) isn't specified by Stage 2 or 3 – so its implementation specific
- If UE returns to 3G after expiration of this guard timer, then SGSN will delete MM context
- Subsequent RAU from UE will fail; UE needs to perform PDP Ctx Activation again
- Observations:
  - SGSN was aware of EUTRAN restriction via ARD, subscription OR local config (all agreed as part of IRAT HO solns in previous mtgs)
  - MME proceeds w/ session creation at SGW (same or new) and PGW
  - UE is required to perform additional signalling for re-activating PDP Ctxs
- Question:
  - What sense is there in SGSN despite of being aware of RAT-restrictions for THAT user due to prior Location Update/ULR w/ HSS/HLR (in other words, knowing that TAU/RAU will fail) successfully responding to Context Request?

At TAU rejection by MME, lets follow-through w/ a number of subsequent S4-scenarios to find out whether existing timer based mechanism is sufficient

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (2/10)?

1. Context guard timer doesn't expire
   1. During TAU, MME picked new SGW
      1. RAU to 3G happens w/ previous SGSN
      2. RAU to 3G happens w/ new SGSN
   2. During TAU, MME picked same SGW as previous SGSN
      1. RAU to 3G happens w/ previous SGSN
      2. RAU to 3G happens w/ new SGSN
2. Context guard timer expires
   1. During TAU, MME picked new SGW
      1. RAU to 3G happens w/ previous SGSN
      2. RAU to 3G happens w/ new SGSN
   2. During TAU, MME picked same SGW as previous SGSN
      1. RAU to 3G happens w/ previous SGSN
      2. RAU to 3G happens w/ new SGSN

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (3/10)?
1.1.1: During TAU MME picked new SGW, RAU to 3G happens w/ previous SGSN, Ctx timer running

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would “own” this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that’s not relevant for discussion here)
  - MME picked new SGW
  - Session creation was successful. Hence
    - New SGW:
      - C- plane path to MME
      - U-plane path to PGW
    - Previous SGW
      - C-plane path to SGSN
      - U-plane path to PGW
    - PGW
      - C-plane path switched from previous SGW to new SGW
      - U-plane path switched from previous SGW to new SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn’t defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands back on same SGSN as previous
- SGSN has MM Ctx, and PDP Ctx as Context guard timer still running
  - SGSN sends MBReq to previous SGW per 23.060 6.9.2.1a step 9A
  - SGW sends MBReq to PGW per 23.060 6.9.2.1a step 9A lists
  - PGW switches tunnels to previous SGW

All Well

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (4/10)?
1.1.2: During TAU MME picked new SGW, RAU to 3G happens w/ new SGSN, Ctx timer running (1/2)

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would “own” this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that’s not relevant for discussion here)
  - MME picked new SGW
  - Session creation was successful. Hence
    - New SGW:
      - C- plane path to MME
      - U-plane path to PGW
    - Previous SGW
      - C-plane path to previous SGSN
      - U—plane path to PGW
    - PGW
      - C-plane path switched from previous SGW to new SGW
      - U-plane path switched from previous SGW to new SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn’t defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands on different SGSN
- New SGSN uses P-TMSI etc to get Context from previous SGSN

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (4/10)?
1.1.2: During TAU MME picked new SGW, RAU to 3G happens w/ new SGSN, Ctx timer running (2/2)

- Previous SGSN has Context guard timer still running. So Ctx Transfer procedure is successful.
- New SGSN now has MM Ctx, and PDP Ctx
- New SGSN may pick
  - Same SGW as previous SGSN
    - New SGSN sends MBReq to same SGW picked by previous SGSN per 23.060 6.9.2.1a step 9A
    - Previous SGW sends MBReq to PGW per 23.060 6.9.2.1a step 9B
  - Different SGW than previous SGSN
    - New SGSN sends CSReq to previous SGW per 23.060 6.9.2.1a step 9A
    - Previous SGW sends MBReq to PGW per 23.060 6.9.2.1a step 9B
  - Different SGW than previous SGSN but same SGW as selected by MME
    - Per 29.274 sec. 7.2.1, SGW deletes the previous session locally, and accepts the new one from new SGSN

Since new SGSN gets Ctx from previous SGSN, SGW reference point is wrt the one picked by previous SGSN NOT MME

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (5/10)?
1.2.1: During TAU MME picked same SGW as previous SGSN. RAU to 3G happens w/ previous SGSN, Ctx timer running

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would "own" this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that's not relevant for discussion here)
  - MME picked same SGW
  - Session modification was successful. Hence
    - SGW:
      - C- plane path switched from previous SGSN to MME
      - U-plane path to PGW
    - PGW
      - C-plane path remains to same SGW
      - U-plane path remains to same SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn't defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands back on same SGSN as previous
- SGSN has MM Ctx, and PDP Ctx as Context guard timer still running
  - SGSN sends MBReq to SGW per 23.060 6.9.2.1a step 9A
  - SGW send MBReq to PGW per 23.060 6.9.2.1a step 9A

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (6/10)?
1.2.2: During TAU MME picked same SGW as previous SGSN, RAU to 3G happens w/ new SGSN, Ctx timer running (1/2)

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would "own" this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that's not relevant for discussion here)
  - MME picked new SGW
  - Session modification was successful. Hence
    - SGW:
      - C- plane path switched from previous SGSN to MME
      - U-plane path to PGW
    - PGW
      - C-plane path remains to same SGW
      - U-plane path remains to same SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn't defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands on different SGSN
- New SGSN uses P-TMSI etc to get Context from previous SGSN

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (6/10)?
1.2.2: During TAU MME picked same SGW as previous SGSN, RAU to 3G happens w/ new SGSN, Ctx timer running (2/2)

- Previous SGSN has Context guard timer still running. So Ctx Transfer procedure is successful.
- New SGSN now has MM Ctx, and PDP Ctx
- New SGSN may pick
  - Same SGW as previous SGSN & MME
    - New SGSN sends MBReq to same SGW picked by previous SGSN per 23.060 6.9.2.1a step 9A
    - Previous SGW sends MBReq to PGW per 23.060 6.9.2.1a step 9B
  - Different SGW than previous SGSN & MME
    - New SGSN sends CSReq to previous SGW per 23.060 6.9.2.1a step 9A
    - Previous SGW sends MBReq to PGW per 23.060 6.9.2.1a step 9B

Since new SGSN gets Ctx from previous SGSN, SGW reference point is wrt the one picked by previous SGSN NOT MME

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (7/10)?
2.1.1: During TAU MME picked new SGW, RAU to 3G happens w/ previous SGSN, Ctx timer expires

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would "own" this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that's not relevant for discussion here)
  - MME picked new SGW
  - Session creation was successful. Hence
    - New SGW:
      - C- plane path to MME
      - U-plane path to PGW
    - Previous SGW
      - C-plane path to SGSN
      - U-plane path to PGW
    - PGW
      - C-plane path switched from previous SGW to new SGW
      - U-plane path switched from previous SGW to new SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn't defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands back on same SGSN as previous
- But Ctx guard timer expired on SGSN
  - Per 23.401 5.3.3.1 step 14, SGSN removes MM context
  - Per 23.401 5.3.3.1 step 18, SGSN removes local PDP Ctx resources + sends DSReq (OI) to SGW
- Since SGSN has no MM Ctx or PDP Ctx, RAU fails
- UE needs to perform re-ATTACH to 3G if it needs service again
- PGW has hanging resources until UE performs re-ATTACH

Ouch!

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (8/10)?
2.1.2: During TAU MME picked new SGW, RAU to 3G happens w/ new SGSN, Ctx timer expires (1/2)

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would "own" this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that's not relevant for discussion here)
  - MME picked new SGW
  - Session creation was successful. Hence
    - New SGW:
      - C- plane path to MME
      - U-plane path to PGW
    - Previous SGW
      - C-plane path to previous SGSN
      - U—plane path to PGW
    - PGW
      - C-plane path switched from previous SGW to new SGW
      - U-plane path switched from previous SGW to new SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn't defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands on different SGSN

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (8/10)?
2.1.2: During TAU MME picked new SGW, RAU to 3G happens w/ new SGSN, Ctx timer expires (1/2)

- New SGSN uses P-TMSI etc to get Context from previous SGSN
- But Ctx guard timer expired on previous SGSN
  - Per 23.401 5.3.3.1 step 14, SGSN removes MM context
  - Per 23.401 5.3.3.1 step 18, SGSN removes local PDP Ctx resources + sends DSReq (OI) to SGW
- Since previous SGSN has no MM Ctx or PDP Ctx, it rejects Ctx Request from new SGSN
- RAU fails
- UE needs to perform re-ATTACH to 3G if it needs service again
- PGW has hanging resources until UE performs re-ATTACH

Ouch!

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (9/10)?
2.2.1: During TAU MME picked same SGW as previous SGSN. RAU to 3G happens w/ previous SGSN, Ctx timer expires

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would “own” this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that’s not relevant for discussion here)
  - MME picked same SGW
  - Session modification was successful. Hence
    - SGW:
      - C- plane path switched from previous SGSN to MME
      - U-plane path to PGW
    - PGW
      - C-plane path remains to same SGW
      - U-plane path remains to same SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn’t defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands back on same SGSN as previous
- But Ctx guard timer expired on SGSN
  - Per 23.401 5.3.3.1 step 14, SGSN removes MM context
  - Per 23.401 5.3.3.1 step 18, SGSN removes local PDP Ctx resources + sends DSReq (OI) to SGW
- Since SGSN has no MM Ctx or PDP Ctx, RAU fails
- UE needs to perform re-ATTACH to 3G if it needs service again
- PGW has hanging resources until UE performs re-ATTACH

Ouch!

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (10/10)?
2.2.2: During TAU MME picked same SGW as previous SGSN, RAU to 3G happens w/ new SGSN, Ctx timer expires (1/2)

- Prior to ULA reject by HSS
  - SGSN responded successfully to Ctx Transfer procedure; so MME indicates that it would “own” this UE from hereon (unless UE ofcourse decides to do RAU in middle of TAU – but that’s not relevant for discussion here)
  - MME picked new SGW
  - Session modification was successful. Hence
    - SGW:
      - C- plane path switched from previous SGSN to MME
      - U-plane path to PGW
    - PGW
      - C-plane path remains to same SGW
      - U-plane path remains to same SGW
- After TAU REJECT w/ #15, UE sees previous 3G coverage
  - Rollback behaviour (of successful session creation by MME on SGW/PGW) isn’t defined!
- UE performs RAU w/ native identity (P-TMSI, RAI etc); lands on different SGSN

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CT4 scenario
I-RAT TAU Procedure: What is the Problem (10/10)?
2.2.2: During TAU MME picked same SGW as previous SGSN, RAU to 3G happens w/ new SGSN, Ctx timer expires (2/2)

- New SGSN uses P-TMSI etc to get Context from previous SGSN
- But Ctx guard timer expired on previous SGSN
  - Per 23.401 5.3.3.1 step 14, SGSN removes MM context
  - Per 23.401 5.3.3.1 step 18, SGSN removes local PDP Ctx resources + sends DSReq (OI) to SGW
- Since previous SGSN has no MM Ctx or PDP Ctx, it rejects Ctx Request from new SGSN
- RAU fails
- UE needs to perform re-ATTACH to 3G if it needs service again
- PGW has hanging resources until UE performs re-ATTACH

Ouch!

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CT4 scenario
I-RAT TAU Procedure: Observations

- There is no guarantee that UE will actually return back to 3G after TAU REJECT
- There is also no guarantee that UE will return back to 3G after TAU REJECT under Context Timer's guard timer
- If Context Timer is exceeded then, as per earlier, no matter which RAU scenario we consider, those RAUs fail!

➔Placing Context Timer to a 'high enough value' is not a reliable solution (see next few slides)

- CT4 proposal aims at reject the Context Transfer so that the subsequent cascade of events do no occur
  - It's a much cleaner approach
- In addition, MME's rollback behaviour after TAU REJECT isn't defined

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT

- Neither Stage 2 nor Stage 3 specify how MME should behave in this case
- 3 possible choices exist
  - MME only locally deletes resources; (same) SGW and PGW resources untouched
  - MME locally deletes resources + old SGW resources deleted; PGW resources untouched
  - MME locally deletes resources + old SGW + PGW resources deleted
- Lets apply these 3 choices to previous scenarios where Ctx timer was still running – hence SGSN had the required MM Ctx

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.1.1

- MME local clean up only
  - SGSN will re-establish tunnel w/ previous SGW and PGW
  - SGW picked by MME has hanging resources!
- MME locally deletes resources + old SGW resources deleted; PGW resources untouched
  - SGSN will re-establish tunnel w/ previous SGW and PGW
- MME locally deletes resources + old SGW + PGW resources deleted
  - SGSN will establish tunnel w/ previous SGW
  - But, when that SGW sends MBReq to PGW, it will fail (because PGW received DSReq from MME). However, RAU will succeed.
  - UE won't have PDP Ctxs – so would need to re-establish those

Ouch!!!

All Well

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.1.2 (1/3)

- MME local clean up only; IF New SGSN picked
  - Same SGW as previous SGSN
    - New SGSN will create tunnel on previous SGW (chosen by previous SGSN), SGW modified PGW
    - SGW picked by MME has hanging resources!
  - Different SGW than previous SGSN
    - New SGSN will create tunnel on new SGW and previous PGW
    - Upon RAU completion, previous SGSN will remove resources from SGW it selected
    - SGW picked by MME has hanging resources!
  - Different SGW than previous SGSN but same SGW as selected by MME
    - New SGSN will create tunnel on SGSN/MME SGW and previous PGW
    - Upon RAU completion, previous SGSN will remove resources from SGW it selected

Ouch!!!

All Well but by coincidence– can't be ensured or acted upon

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.1.2 (2/3)

- MME locally deletes resources + old SGW resources deleted; PGW resources untouched; IF New SGSN picked
  - Same SGW as previous SGSN
    - New SGSN will create tunnel on previous SGW (chosen by previous SGSN), SGW modified PGW
  - Different SGW than previous SGSN
    - New SGSN will create tunnel on new SGW and previous PGW
    - Upon RAU completion, previous SGSN will remove resources from SGW it selected
  - Different SGW than previous SGSN but same SGW as selected by MME
    - MME removes resources from SGW
    - New SGSN creates tunnel on that SGW
    - SGW creates tunnel on previous PGW
    - Upon RAU completion, previous SGSN will remove resources from SGW it selected

All Well

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.1.2 (3/3)

- MME locally deletes resources + old SGW + PGW resources deleted; IF New SGSN picked
  - Same SGW as previous SGSN
  - Different SGW than previous SGSN
  - Different SGW than previous SGSN but same SGW as selected by MME

Ouch!!!

  - No matter which SGW the SGSN picks, since resources are cleaned up by MME onto the PGW, UE's IP address is released
  - SGW's request to PGW will fail. However, RAU will succeed.
  - UE won't have PDP Ctxs – so would need to re-establish those

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.2.1

All Well

- MME local clean up only
  - SGSN will re-establish tunnel w/ previous SGW and PGW
- MME locally deletes resources + old SGW resources deleted; PGW resources untouched
  - MME deletes resources on SGW
  - When SGSN re-establishes tunnel w/ the SGW, SGW will reject the request (because Bearer Context was already released by MME)
- MME locally deletes resources + old SGW + PGW resources deleted
  - SGSN will establish tunnel w/ previous SGW
  - But, when that SGW sends MBReq to PGW, it will fail (because PGW received DSReq from MME). However, RAU will succeed.
  - UE won't have PDP Ctxs – so would need to re-establish tho

Ouch!!!

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.2.2 (1/3)

- MME local clean up only; IF New SGSN picked
  - Same SGW as previous SGSN & MME
    - New SGSN will create tunnel on previous SGW (chosen by previous SGSN & MME), SGW modified PGW
  - Different SGW than previous SGSN & MME
    - New SGSN will create tunnel on new SGW and previous PGW
    - Upon RAU completion, previous SGSN will try to remove resources from previous SGW it selected which will be rejected (because SGW will not have tunnel to this SGSN – as the tunnel was already shifted by the MME)

All Well

Ouch!!!

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.2.2 (2/3)

- MME locally deletes resources + old SGW resources deleted; PGW resources untouched; IF New SGSN picked
  - Same SGW as previous SGSN & MME
    - MME removed resources on previous SGW
    - Then New SGSN will modify tunnel on previous SGW which will be rejected (because SGW will not have tunnel to this SGSN – as the tunnel was already shifted by the MME)
  - Different SGW than previous SGSN & MME
    - MME removed resources on previous SGW
    - New SGSN will create tunnel on new SGW and previous PGW
    - Upon RAU completion, previous SGSN will try to remove resources from SGW it selected, but it will be unsuccessful as those resources were already deleted by the MME

Ouch!!!

All is NOTWell

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT 1.2.2 (3/3)

- MME locally deletes resources + old SGW + PGW resources deleted; IF New SGSN picked
  - Same SGW as previous SGSN
  - Different SGW than previous SGSN
  - Different SGW than previous SGSN but same SGW as selected by MME

  - No matter which SGW the new SGSN picks, since resources are cleaned up by MME onto the PGW, UE's IP address is released
  - SGW's request to PGW will fail. However, RAU will succeed.
  - UE won't have PDP Ctxs – so would need to re-establish those

Ouch!!!

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CT4 scenario
I-RAT TAU Procedure: MME Rollback behavior after TAU REJECT: Observations

- Only one of 3 choices makes logical sense to cause least amount of cascading issues
  - MME only locally deletes resources; (same) SGW and PGW resources untouched
  - **MME locally deletes resources + old SGW resources deleted; PGW resources untouched**
  - MME locally deletes resources + old SGW + PGW resources deleted
- Even then there will be cases where resources are left hanging on SGW (e.g. case 1.2.1 or 1.2.2)

If the <<old node>> rejects the Context Request, then we avoid getting into these rat-hole scenarios!!!

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Gn/Gp SGSN – MME Idle mode mobility has the same issue

a. User established their PDP via 3G network coverage, PDP is established via the PGW/GGSN collocated node
b. User then move to 4G coverage and a TAU is sent to MME
c. MME sends CONTEXT_REQUEST to SGSN
d. **SGSN sends back CONTEXT_RESPONSE with PDP info**
e. MME sends CREATE_SESSION_REQUEST to SGW
f. SGW sends MODIFY_BEARER_REQUEST to PGW
g. PGW sends MODIFY_BEARER_RESPONSE (because in this case PDP existed in PGW/GGSN)
h. As a result SGW sends CREATE_SESSION_RESPONSE back to MME
i. MME sends an "Update-Location-Request" to HSS.
j. HSS sends back a reject with cause-code DIAMETER_ERROR_UNKNOWN_EPS_SUBSCRIPTION 5420 (*this is because the sub is not 4G subscribed)*
k. As a result, MME sends TAU reject to UE with cause code TAU Reject Cause#15 NO SUITABLE CELLS IN TRACKING AREA
l. **At the same time, MME then sends DELETE_SESSION_REQUEST to SGW and as a result SGW sends DELETE_SESSION_REQUEST to PGW and session got clean up**
m. **At this point the UE then try a RAU to 3G again, the SGSN then sends a UPDATE_PDP_CONTEXT_REQ_MSG to the PGW/GGSN.** But in this case given the PGW/GGSN has already cleaned up the PDP and therefore, it reply with a cause code "GTP_NON_EXISTENT".

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CT4 scenario
I-RAT TAU Procedure: Should something be fixed here?

- Directionality of the issue:
  - GERAN/UTRAN → EUTRAN via TAU
    - Where Source SGSN is aware of IRAT restriction
  - EUTRAN → GERAN/UTRAN via RAU
    - Where Source MME is aware of IRAT restriction
- Issue w/ SGSN == Both S4- role, and Gn/Gp- role
- Only applicable to IDLE mode
- Which release:
  - IRAT HO was fixed from Rel-8
- Recommendation:
  - Add following to source nodes behaviour from Rel-8
    - If the <<old Node>> is aware of any xRAN access restrictions due to access restriction in subscription data or based on local configuration e.g. to reflect roaming restriction to UTRAN or GERAN, then it MAY reject the Context Request, if originating from a RAT with the identified restriction, with an appropriate cause code. The <<old node>> shall continue as if Context Request was never received.
  - Also add clarification text to mention that in case TAU procedure gets rejected at the point of HSS query, then MME is expected to rollback the changes it made (clean up own contexts, send DSR(OI) to SGW – similar to behaviour specified in 23.401 5.3.3.1 step 18.

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Thank you.