OAI EPC in Production Networks
Facebook co-founded the Telecom Infra Project (TIP) in 2016 (www.telecominfraproject.com)

<table>
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<th>The Telecom Infra Project (TIP) is an engineering-focused initiative driven by operators, infrastructure providers, system integrators, and other technology companies that aim to reimagine the traditional approach to building and deploying telecom network infrastructure.</th>
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<td>TIP will explore new approaches and technologies across three initial focus areas: access, backhaul, and core and management. The project groups within these areas will leverage the unique engineering and operational expertise of each member. They will focus on developing new technologies and exploring new approaches to deploying in both developed and emerging markets.</td>
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<td>This will not be a small undertaking and no single company can do it alone. Openness and collaboration can help everyone move faster in unlocking new efficiencies and innovations, as proven through other initiatives such as the Open Compute Project.</td>
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OAI in TIP?

TIP provides a place where open innovation on telecom infrastructure happens.

- **TIP as legal framework** allowing companies to participate and collaborate on telecom infrastructure innovations.
- **TIP providing tooling to collaborate**: general communication, collaboration on documentation, SW and HW projects.
- **Open reference implementations**: SW and HW, fully functional references to base innovation on.
- **TIP community labs**: spaces to meet physically, innovate together, test and enjoy the success.
1991 (September): First version of the Linux kernel released to the Internet

mid-1990s: Linux runs on cluster computers at NASA and elsewhere

late 1990s: Dell, IBM and Hewlett-Packard offer commercial support for Linux on their hardware; Red Hat and VA Linux have initial public offerings

2001 (second quarter): Linux server unit shipments recorded a 15% annual growth rate

2004: Linux shipped on approximately 50% of the worldwide server blade units, and 20% of all rack-optimized servers

https://www.wikiwand.com/en/Linux_adoption
Critical domains for production grade OSS

Responsive maintainer ecosystem actively managing the codebase:

- **Code Maintenance:**
  - Bugfixing
  - Stability
  - Performance

- **Code Evolution:**
  - Architecture: Refactoring to
    - Improve Performance
    - Improve Stability
    - TTM for new features

- **Functionality:**
  - Features
  - Roadmaps
  - Releases

- **Solution:**
  - Manageability
  - Packaging and Deployment
  - Documentation
  - Instrumentation

- **Completeness and Correctness:**
  - Continuous build
  - Unit tests
  - Interoperability testing results
Driving Broader Adoption

Maintainer ecosystem covering critical domains of production software
- Bugfixing, Stability, Performance
- Features, roadmaps, release management
- Architecture: Refactoring to improve performance, stability and TTM for new features
- Manageability, deployment, instrumentation
- Interoperability testing results

Optional for commercial adoption
- Support ecosystem offering SLAs

Where are we today?
- Powerful Gitlab based sourcecode repository and wiki pages – enterprise edition needed?
  - Code Review flows
  - Roadmaps and Features
  - Room for more transparency on roadmaps and code review process
Working more formally with GitLab

Frontend TODO:
- [x] app/assets/javascripts/boards/components/issue_card_inner.js

Does this MR meet the acceptance criteria?
- [x] Changelog entry added, if necessary
- [x] Documentation created/updated
- [x] API support added
  - Tests
    - [x] Added for this feature/bug
    - [x] All builds are passing
- [x] Conform by the merge request performance guides
- [x] Conform by the style guides
- [ ] Branch has no merge conflicts with master (if it does - rebase it please)
- [ ] Squashed related commits together

What are the relevant issue numbers?
#1904

Performance testing
Data to seed database gitlab-ce$1657660
Edited 2 days ago

Request to merge multiple_assignee_backend1 into master (2646 commits behind)

- Pipeline #7765275 failed for @abd3a1.

⚠️ This merge request contains merge conflicts
What have we been looking into so far

Focus is CN, not eNB stack (currently). Also no work on major enhancements in the direction HetNet/multi RAT, interoperability, interconnect to 2G/3G PS and CS domains.

Robustness: corner cases (could be considered as features), like
- Handling for the scenario when IMSI is not present in HSS
- Duplicate Session/Context due to incomplete cleanup
- Fail if MTU cannot be read correctly
- Remove hash table insert from emm_ctx_set_valid_imsi
- Fix free_wrapper to actually set the underlying pointer to NULL
- Handle SCTP reset
- Clear out s11 state after session delete

Stability: memory management and shared object access
List of submitted patches

- Service Request
- Periodic Tracking Area Update w/o Active Flag and with Active Flag
- MME UE Context - Key Management
- Move allocation of MME_UE_S1AP_ID from NAS to MME_APP module
- Handling of S1AP: Initial UE message when it comes with S-TMSI
- Handling the UE Context Release Request with Cause User Inactivity
- UE Context Release Request Procedure - Enhancements, cleanup and fixes
- Support for Mobile Reachability Timer and Implicit Detach timer
- Support for Implicit Detach
- EPC Statistics - New Stats
- S1AP UE context release implicitly
- ERROR IND - Graceful handling
- UE Context Release Procedure Guard Timer in S1AP
- T3450 timer expiry - Retx of Attach Accept
- T3460 Timer expiry - Retx of SMC and AUTH request whichever is applicable
- Fix for MME segmentation fault during repeated UE Attach/Detach using GUTI
- Removal of assert in the code for any incoming S1AP initiating message that is not handled currently
- DL and UL AMBR in Initial context setup Request - Align it with APN-AMBR value sent in NAS message
- Local clean up and UE context release procedure after sending Reject message to UE NAS.
- UE IP address allocation Failure : Attach + PDN Connectivity Reject
- UE not known in HSS/Subscriber : Attach Reject - Session Cleanup
- MME Crash during encoding of Attach Reject + PDN Connectivity Reject encoding
- PDN Connectivity Request - Optional IE Device Properties - Decode Failure (LTE UE Samsung Galaxy S7 phone)
- Fix for Authentication failure with cause sync failure
- Authentication Failure: S1 Signaling release, S1, MME and NAS context release
- Handling for the scenario when IMSI is not present in HSS
- Duplicate Session/Context due to incomplete cleanup
- Fail if MTU cannot be read correctly
- Remove hash table insert from emm_ctx_set_valid_imsi
- Fix free_wrapper to actually set the underlying pointer to NULL
- Handle SCTP reset
- Clear out s11 state after session delete
- Fix for heap overflow crash
- Fix double free of emm_data args pointer
- Fix SCTP handling in MME preventing double frees
- Fix EMM integrity protection
- Enhance Detach by generating “UEContextRelease” message after Detach-Accept
- Prevent stack overwrite while accessing IMSI
- Cleanup UE-initiated detach (non-switchoff /normal) scenario
- Remove SGW check for optional “address_allocation_via_nas_signalling”
- Send UE security capability in Initial Context Setup
- Attach result message now depends on attach request type: “EPS-only” succeeds as normal, with EPS-only attach. Combined EPS/IMSI succeeds with EPS-only attach and an EMM cause IE.”
- IPv4 Allocation mechanism defaults to via NAS signaling in the absence of UE preference in PCO
- Fix for ue radio cap for not enough buffer space (UEs with inter RAT capabilities)
- Misc cleanup and fixes related to cleanup of EMM and ESM context during UE context deletion
Fixes available in https://gitlab.eurecom.fr/oai/openair-cn/commits/fixed_broadband branch. This was branched-off in September 2016.

Getting merged in https://gitlab.eurecom.fr/oai/openair-cn/commits/integ_broadband
Work in Progress/Planned
Stability /Robustness – 32 UEs simultaneous signaling and data

[OAI - Enhancement] Memory Leaks

[OAI EPC Feature] Integration of OVS kernel module - Replacing the osmocom GTP-U kernel module with OVS kernel module

[OAI EPC Feature] Paging for DL data arrival for the UE in idle mode ( no S1-U tunnel )

[OAI EPC Feature] Support for GTP-U echo request/response

[OAI EPC Feature] Support for GTP-U Error Indication ( incorrect TE-ID)

[OAI EPC Feature] Support for Handling of eNB Reset

[OAI - Refactor] emm_proc_attach_request() way to complex/long/nested - Restructure it and enhance handling of attach request with same content

[OAI EPC Feature] S1AP indication of non-delivered NAS PDU

[OAI EPC Feature] Guard Timer in NAS for auth_info_request/rsp ( S6a message ) procedure with HSS over S6a interface

*BLUE – Wish-list features ( not committed)
[OAI EPC Feature] Add Support for sending EMM Information message just after completion of successful Attach.

[OAI EPC Feature] Handling of EMM status message

[OAI EPC Feature] Add support in OAI EPC for Multiple PDN connections

[OAI EPC Feature] Add support in OAI EPC for Multiple Bearers per UE per PDN.

[OAI EPC Feature] Initial context setup - Timer expiry and failure

[OAI EPC Feature] MME_UE_S1AP_ID - Management ( allocation /free) - New algorithm

[OAI Enhancement] TE-ID for GTP-C allocation - New Algorithm - At present UE context address is used as S11 GTP-C TE-ID and this may be one of the potential reason for instability in case of duplicate session creation

[OAI Enhancement] Dynamically allocate space for UE radio cap

[OAI EPC Feature] S1AP Error Indication – Proper handling

[OAI Feature] Detach (Network initiated )

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*BLUE – Wish-list features ( not committed)

*GREEN – Assumed that these are already supported in latest develop branch of OAI (not planned to implement)
[OAI Enhancement] Logging does not work in OAI during initialization

[OAI Investigate] Investigate the ITTI message interface not working when S11 interface is not specified. And fix it.

[OAI Enhancement] Cleanup old gtp tunnel when duplicated gtp tunnel setup found

[OAI Investigate] Hashtable implementation in OAI is very error prone

[OAI Enhancement] Remove references to _imsi and always use _imsi64 in various hash-tables

MISC Crashes;
- [Bug]SPGW crash during session creation (duplicate Session)
- [Bug]MME crash during multi-UE connect /data/disconnect in loop [OAI –

[OAI Investigate] Interface is based on GTPV1 (GTP-C) – This is 3rd party OSS code within OAI (nwEPC) and has basic support for GTP-C. Does not take care of error cases. Need review and clean up of basic messages

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*BLUE – Wish-list features (not committed)*
Other Opportunities

Collapsed eNB – WiFi router type eNB integrating minimal core network (eventually include some of the eNB++ slides)

Authentication as plugin – e2e authentication without SIM cards

Metering, DPI, Policy with SDN frameworks
SDN Frameworks in Telecom Infra

Core Network Opportunities
- Metering, QoS with OVS
- Re-Architecting EPC with more strict split of control and user plane

RAN opportunities
- Resource/Spectrum management via SDN controller
- Hierarchical controller architecture
Node-based Vertical vs. Function-based Horizontal Architecture

- Mobile transaction is partially processed at each node
- Rigid assembly of individual nodes leads to scaling, planning / modeling, and monitoring challenges
- Repetitive encap/decap at node boundaries, state replication

Regrouped Architecture

- Break the boundary of the nodes... there is no MME or S/P-GW any more!
- Inter-node encap/decap becomes unnecessary
- Now we are left with functions only
- Remove the duplicate functions
- Extract common functions
Looking forward to ...

Seeing you on the mailing list, discuss features and roadmaps and contribute