Development Progress of 5G Core in OAI

Luhan Wang
Beijing Univ. of Posts & Telec.
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Contents

- Overview of 5G Service Based Architecture
- Current Work in 5GS SBA —— MME Splitting
- Current Work in 5GS SBA —— SBI Design
- Next Step
Overall Timeline of 5G Architecture in 3GPP

- 3GPP SA2 Started “Study on Architecture for Next Generation System” (NextGen) from **Nov. 2015**.
- After one year study, NextGen is completed in Nov. 2016, with output 3GPP TR 23.799 v14.0.
- 3GPP SA1 already finished 5G requirement specification TS 22.261 in **March, 2017**.
- SA2 Service-based Architecture is agreed as a basis for 5G System, 3GPP TS 23.501, Rel15.
- CT4/CT3 has already evaluated candidate protocols for SBA, TR29.891, **August 2017**.

Based on the study, two specifications will be generated:
- TS 23.501: System Architecture for the 5G System
- TS 23.502: Procedures for the 5G System
5G Network is Designed as Service-based Architecture

5G architecture can be represented in two ways:

Fig 1. 5G System Architecture Service-based Interface

Fig 2. 5G System Architecture in reference point representation

Transition from “Network Function” to “Network Function Service”

All 5GS interfaces are realized by Service Based Interfaces,
Except N1, N2, N3, N4, N6, N9
=> AMF, SMF, UDM, AUSF, PCF, NRF, NEF
What’s Service-based Architecture of 5G?

5G Service-based Architecture is defined with “Network function service” + “Service-based interface”

An NF service is one type of capability exposed by an NF (NF Service Producer) to other NF (NF Service Consumer) two types of primitive operations: “Request & Response” And “Subscribe-Notify”

NF Services is expected to be self-contained, reusable and use management schemes independently of other NF services offered by the same Network Functions (e.g. for scaling, healing, etc.)
Benefits of Service-based Architecture

**Modularity & Reusability**
- The network is composed of modularized services, also known as **Microservices**.
- Services can be reused among different network functions.

**Cloud-Native**
- **Continuous delivery**, shrinking testing and integration timescales (moving towards continuous integration) which reduces the time to market for installing bug fixes, and rolling out new features.
- **Containerization**, allowing individual services updated/extended with minimal impact to other services.

**Extensibility**
- Service based interfaces can be easily extended without introducing new reference points
- Traffic can be easily balanced or offloaded by deployment new NF service instance.

**Openness**
- Together with some control functions (i.e. authentication), service based interface can be easily exposed to external users, such as 3rd-party application providers.
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Plan of 5G Core development

※ Develop 5G Core by restructuring openair-cn.

※ Steps

- **Step 1. Split of MME into AMF and SMF**
  - MME-1: 5G AMF
  - MME-2: 5G SMF

- **Step 2. Split of SPGW into UPF and SMF**
  - SMF (X-GW-C+MME/ESM)
    - UP Abstraction
      - OF
      - REST
      - Linux tools

- **Step 3. Split of HSS to UDM and AUSF**
  - 5G UDM (Cassandra DB)
  - 5G AUSF (HSS)
  - 5G PCF (PCRF)
MME Splitting Principles

- Change synchronous calls into asynchronous messages

- Split Coupled contexts

- Change multiple threads into multiple progresses.
EMM and ESM are similar to AMF and SMF in 5G Core. Use EMM and ESM to imitate AMF and SMF.

- Change EMM-ESM sap synchronous procedure calls to asynchronous ITTI messages
  - **Current:**
    - Request by Procedure call, `esm_sap_send`, `emm_sap_send`
    - Response by function return value,
      
      ```c
      rc = esm_sap_send(&esm_sap)
      If (rc != RETURNerr && esm_sap.err == ESM_SAP_SUCCESS)
      ```
EMM and ESM are similar to AMF and SMF in 5G Core. Use EMM and EMS to imitate AMF and SMF.

- Change EMM-ESM sap synchronous procedure calls to asynchronous ITTI messages.
  - After:
    - Create a dedicated task to process ESM/EMM messages, in src/oai_mme/oai_mme.c,
      `itti_create_task( TASK_ESM_SAP, & esm_sap_message_process, NULL)`
    - Define TASK MESSAGES,
      `MESSAGE_DEF(ESM_SAP, MESSAGE_PRIORITY_MED, esm_sap_test_t , esm_sap)`
    - Request by sending intertask messages
      `MessageDef *esm_sap_msg_p = itti_alloc_new_message(TASK_EMM_SAP, ESM_SAP_TEST);`
      ```c
      ... 
      itti_send_msg_to_task(TASK_ESM_SAP,INSTANCE_DEFAULT,esm_sap_msg_p)
      ```
    - Receiving messages by `itti_receive_msg`;
    - Response also by sending intertask messages, need to define messages, including
      NAS_EMMAS_MESSAGE/NAS_EMMREG_MESSAGE/
Separate EMM and ESM contexts

EMM and ESM are similar to AMF and SMF in 5G Core
use EMM and EMS to imitate AMF and SMF

• Separate UE ESM context from UE EMM context

  - **Current:**
    - ESM and EMM context are coupled together.
      \[ emm\_context\_s \rightarrow esm\_context \]
  
  - **After:**
    - Create a collection of PDN/ESM contexts, store them in a hashtable
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5GS Service Based Interface Design

Requirements for SBI

- Bidirectional communication
- Reliable communication
- Low Response Time, Scalability
- Forward compatibility
- Ease of Upgrade
- Ease and speed of deployment,
- Resource-efficiency
- Protocol enables stateless operation.
- Security...

Discussion in 3GPP

<table>
<thead>
<tr>
<th>HTTP oriented</th>
<th>Diameter oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSON/Protobuf/BSON</td>
<td>AVP</td>
</tr>
<tr>
<td>HTTP1.1 / HTTP2</td>
<td>Diameter</td>
</tr>
<tr>
<td>TLS</td>
<td>(optional)TLS/DTLS</td>
</tr>
<tr>
<td>QUIC</td>
<td>TCP/SCTP</td>
</tr>
<tr>
<td>TCP</td>
<td>UDP</td>
</tr>
</tbody>
</table>
5GS Service Based Interface Design

• Comparison between Diameter and HTTP/2

**Diameter (over SCTP)**

1. Maturity and performance proven
   - Diameter is 10+ years matured within mobile networks (WLAN, IMS, EPC, ...).
   - Diameter is high-performant (SCTP, binary encoding), highly reliable and has features related to load control, feed-back and priority based overload control which aren’t available with http.
   - Roaming and non-roaming interfaces

2. Reusability of existing 3GPP implementations/deployments
   1. mainly 3GPP user community (“telco sillo”)

**HTTP/2 (over TLS/TCP)**

1. Cloud-native and Service Based Architecture
   - http based API’s are cloud-friendly, easy to deploy and open
   - http is native to service based architecture
   - http REST APIs supported on northbound NEF interfaces & in MEC

2. Future-proof
   - http is used in large non-telecom ecosystem.
   - Largest user community for Web services. Rich landscape of frameworks, tools and SW libraries. Large SW developer communities with required competence.
   - Majority of the telecommunication companies align to re-use common IT technique for 5GCN

3. Industry dynamics in favor of HTTP
   - Preference for HTTP expressed by several operators & majority of companies

   HTTP/2 favored from cloud transformation & SBA perspectives and Industry dynamics
5GS Service Based Interface Design

• Performance Verification HTTP/1.1 VS HTTP/2

Performance under high concurrency

<table>
<thead>
<tr>
<th></th>
<th>HTTP/1.1</th>
<th>HTTP/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requests completed per second</td>
<td>9877 req/s</td>
<td>28653 req/s</td>
</tr>
<tr>
<td>Header compression</td>
<td>0%</td>
<td>84.88%</td>
</tr>
</tbody>
</table>

HTTP/2 has better performance than HTTP/1.1
5GS Service Based Interface Design

### Performance Verification Serialization Format

<table>
<thead>
<tr>
<th>Format</th>
<th>Binary or ASCII</th>
<th>Schema required?</th>
<th>Standardized?</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSON</td>
<td>ASCII</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>BSON</td>
<td>Binary</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Protocol Buffers</td>
<td>Binary</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>XML</td>
<td>ASCII</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Protocol Buffer has great advantages in term of performance
5GS SBA Protocol Selection

- Service based Architecture protocol solution

1. SBA protocol: **HTTP/2**
2. Transport: **TCP**
3. Serialization protocol: **Protobuf**
4. API design style: **RESTful APIs** whenever possible, **complemented by custom methods** for service operations that cannot be designed as CRUD operations
5. **Uniform solution** for all 5G Service-Based Interfaces
6. Support of notifications with HTTP
7. HTTP features gap:
   - Missing features: Load control, Overload Control, Message Priority
Create Service based Architecture

- Create Service based Interface, communicate over HTTP/ProtoBuf based protocols
  - ESM and EMM run in independent applications.
  - ITTI is replaced by ITSI – InTer Service Interface
  - Implement service oriented mechanism. Like service registration/discover/communication

Service Level Model

- THREE ROLES
  - Service Provider
  - Service Requester/Consumer
  - Service Registry/Broker/Repository
- MEDIUM
  - Service based Interface
- THREE OPERATION
  - Publish(Registration)
  - Discover
  - Bind

AMF1/AUSF/SMF/AMF2.... SMF1/AUSF1/SMF2....
Next Step

- S/PGW Splitting
  - X-GW-C
  - X-GW-D
- Create SMF like module and UPF
  - Integration of X-GW-C and ESM
  - Implement UPF
- Create AMF like module
  - Create AMF based on NAS EMM
  - Interface between AMF and RAN
Thank you!

wluhan@bupt.edu.cn