Exploring an **IMS** deployment without third-party hardware

As part of our constant effort to continually expand our knowledge base, we wanted to explore the role that an **IP multimedia Subsystem (IMS)** plays on a communications network.

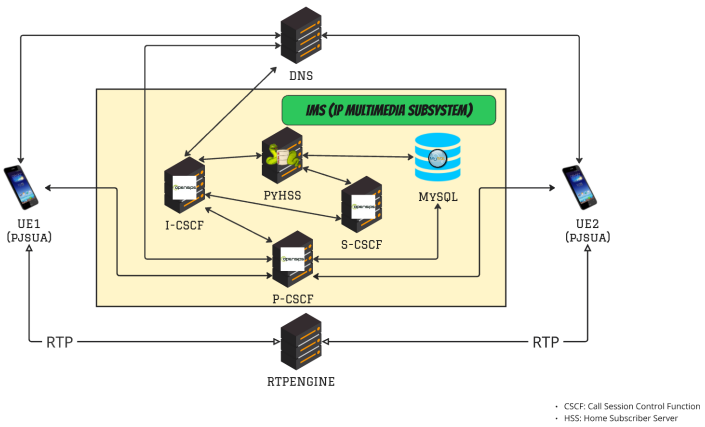
However we quickly realize that most educational literature assume a fiscal setup with actual hardware and equipment. Is it not possible, and even preferable, to get a initial understanding and minimal interactions with this technologies before diving into expensive purchasing?

We resolved ourselves to do precisely that by trying to get a call working, on a single host setup, making use of only software-based solutions.

But what is an IMS?

IMS is an **IP-based network subsystem developed by 3GPP to provide multimedia services**, such as voice, video, messaging, and conferencing, over both mobile and fixed-access networks. **IMS** enables interoperability between different technologies and facilitates the transition from traditional **circuit-switched (CS)** networks to fully **packet-based (IP)** networks.

Key components



The core **IMS** is composed of various elements, most important of which are:

- **Call Session Control Function (CSCF)**

  Call control and session management. Composed of:

  - **Proxy-CSCF (P-CSCF):** Entry point to the **IMS** network.
  - **Interrogating-CSCF (I-CSCF):** Routes **SIP** request towards the S-CSCF and assigns it to a user performing registration.
  - **Serving-CSCF (S-CSCF):** Session control services, including acting as a *registrar*.

- **Home Subscriber Server (HSS)**

  Database containing user and subscription related information.

Protocols

Session Initiation Protocol (SIP)

An application-layer control (signaling) protocol for creating, modifying, and terminating sessions with one or more participants. These sessions include Internet telephone calls, multimedia distribution, and multimedia conferences.[1]

Digest Using Authentication and Key Agreement (AKA)

AKA is a challenge-response based mechanism that uses symmetric cryptography to authenticate **User Equipments (UEs)**. When working with **IMS** the appropriate credentials are stored both on the server itself and on the user device.[2]

Diameter Protocol

The **Diameter base protocol** is intended to provide an **Authentication, Authorization, and Accounting (AAA)** framework for applications such as network access or **IP** mobility in both local and roaming situations.[3]

The **Diameter SIP application** allows a client to request authentication and authorization information for **SIP-based IP multimedia services**. Furthermore, it provides extra functions, such as the ability to download or receive updated user profiles, or rudimentary routing functions that can assist a **SIP server** in finding another one allocated to the user.[4]

Making a call

On a **4G/5G network** a call between two **UE** requires some setup and can be split into three different stages:

[1] Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol", RFC 3261, DOI 10.17487/RFC3261, June 2002, https://www.rfc-editor.org/info/rfc3261.

[2] Niemi, A., Arkko, J., and V. Torvinen, "Hypertext Transfer Protocol (HTTP) Digest Authentication Using Authentication and Key Agreement (AKA)", RFC 3310, DOI 10.17487/RFC3310, September 2002, https://www.rfc-editor.org/info/rfc3310.

[3] Fajardo, V., Ed., Arkko, J., Loughney, J., and G. Zorn, Ed., "Diameter Base Protocol", RFC 6733, DOI 10.17487/RFC6733, October 2012, https://www.rfc-editor.org/info/rfc6733.

[4] Garcia-Martin, M., Ed., Belinchon, M., Pallares-Lopez, M., Canales-Valenzuela, C., and K. Tammi, "Diameter Session Initiation Protocol (SIP) Application", RFC 4740, DOI 10.17487/RFC4740, November 2006, https://www.rfc-editor.org/info/rfc4740.

1. **Attach process**

   Refers to the initial authentication and IP assignment of a **UE**. This process occurs primarily outside of the **IMS**.

2. **Initial registration**

   The issuing of a `REGISTER` request (**SIP**) by a connecting **UE**, and the authorization process involving **AKA** and **Diameter**.

3. **Call setup**

   A normal **SIP** call setup routed by the **IMS**. Usually an **RTP proxy** is used to take care of media communication between the devices

IMS core setup

This approach consist of a bare bones **IMS** deployment, making use of the following services:

- **OpenSIPS IMS CE**
- **rtpengine**
- **PyHSS**

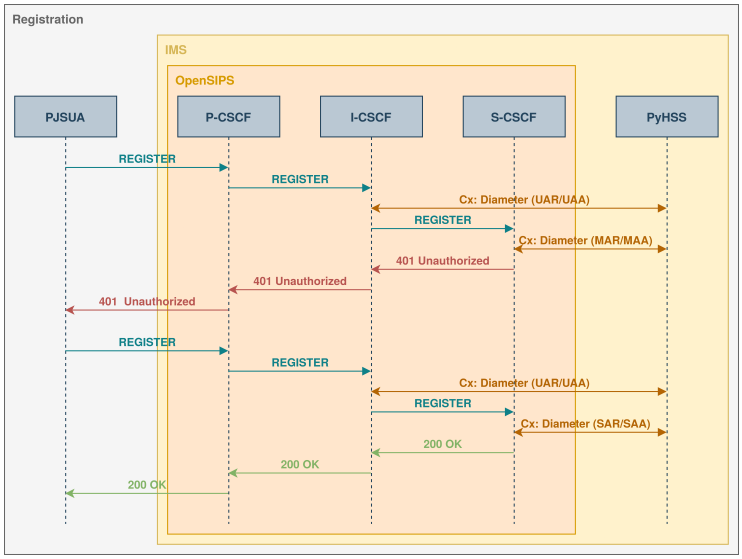
Here, we discard the **Core Network** in which the **IMS** is supposed to run and generate **SIP trafic** using 2 **PJSUA** clients that simulate our endpoint devices.

In order to correctly authenticate some arguments are needed:

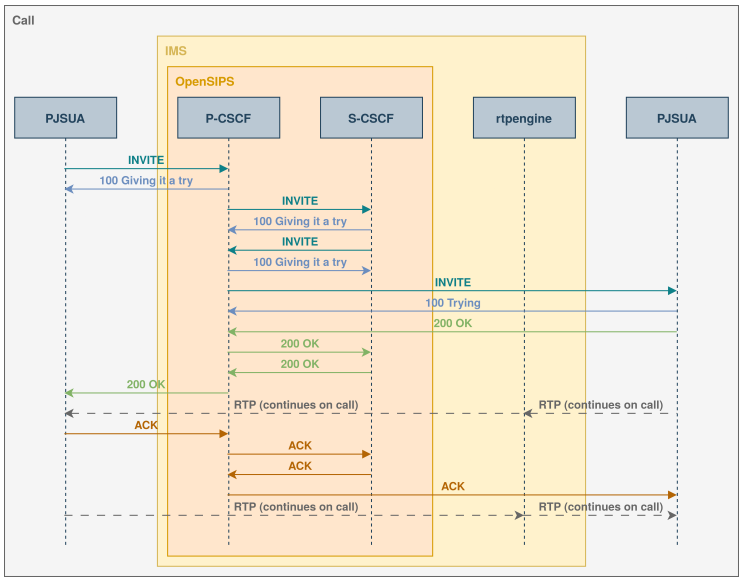
```
pjsua \
    --registrar=sip:ims.mnc001.mcc001.3gppnetwork.org \
    --id=sip:<imsi>@ims.mnc001.mcc001.3gppnetwork.org \
    --nameserver=<dns> \
    --proxy sip:pcscf.ims.mnc001.mcc001.3gppnetwork.org \
    --realm=ims.mnc001.mcc001.3gppnetwork.org \
    --username=<imsi>@ims.mnc001.mcc001.3gppnetwork.org \
    --password="$(echo <aka_k> | xxd -r -p)" \
    --aka-op="<aka_op>" \
    --aka-amf="<aka_amf>" \
    --use-ims
```

> **Note**
> Keep in mind that `--aka-op` and `--aka-amf` options weren't part of **PJSUA** cli interface until this commit and are only available for version 2.16 and onward.

Registration



Call



Simulate a 4G network

We can also try to more fatefully recreate a real deployment by using the **docker open5gs** repo as a starting point. One of the included setup describes a 4G deployment to which a simulated **UE** can connect to. However, there is no way to generate **SIP** traffic from that device to the **IMS**, to fix that we'll need to use the `srslte` image as a base on top of which we'll build our **PJSUA**

clients and route their traffic trough the tunnel interface that encapsulates and simulates the radio network.

Conclusion

We have demonstrated that for simple setups focusing on the core functionalities of **IMS** it is totally possible to use simulated devices and local setups without extra hardware, there's also promise in the simulation of radio networks with tools like **ZeroMQ** and **srsRAN** for more complete and in depth setups.