PFCP protocol development and Testing for 5GCore

The promise of 5G

The innovation of mobile network is measured by the number before G. The last innovation, 5G, is expected to take off ground in 2020 horizon. Unlike the previous generation of mobile network, 5G supports at least three vertical services. Each service has unique characteristics. Those three services are Enhanced Mobile Broadband(eMB), Massive Machine Type Communication, and Ultra-reliable and low-latency communication. 5G delivers multi-Gpbs peak rates, ultra-low latency, and massive capacity. This empowers 5G to interconnects not only humans, but also object, machine and devices.

The main components of 5G

The mobile network has radio access network and core network. In 5G, access network uses 5G New Radio technology and core network is referred as 5GCore.

Design principal of 5GCore

New design of 5Gcore is centered around SDN, NFV, and Service Based Architecture (SBA) principals.

Software Defined Network (SDN) is the separation of the control and data plane in a standard manner. This enables single control plane entity to manages many data plane entities. Second benefits is that control and data plane entity can scale up independently. SDN is mentioned as Control and User Plane Separation (CUPS) in 3GPP core network.

3GPP reviews this principals and validates the need in the core network. It started separating control and data plane in SGW/PGW of 4G network with new protocol, Packet Forwarding Control Protocol(PFCP).

The PFCP is adopted in 5GCore with required modification/evolution. 5GCore uses PFCP between SMF (i.e. control plane) and UPF (i.e. data plane).

Session Management Function (SMF)

As name implies, the role of the SMF is to manage the user session (i.e. managing user plane data path). Technically speaking, user session is referred as Protocol Data Unit (PDU) session in 5G. The user should establish the PDU session before sending data to applications, etc. Several PDU Session can be established simultaneously. Each PDU session is linked to Data Network Name (DNN), which is referred as Access Point Name (APN) in 2G, 3G, and 4G.

As discussed before, SMF is control plane entity, where as UPF is data plane entity. Both play a role to manage the PDU session. The communication between SMF and UPF or N4 interface (3GPP terminology), is defined in 3GPP PFCP protocol which is specified in 3GPP TS 29.244 specification.

User Plane Function (UPF)

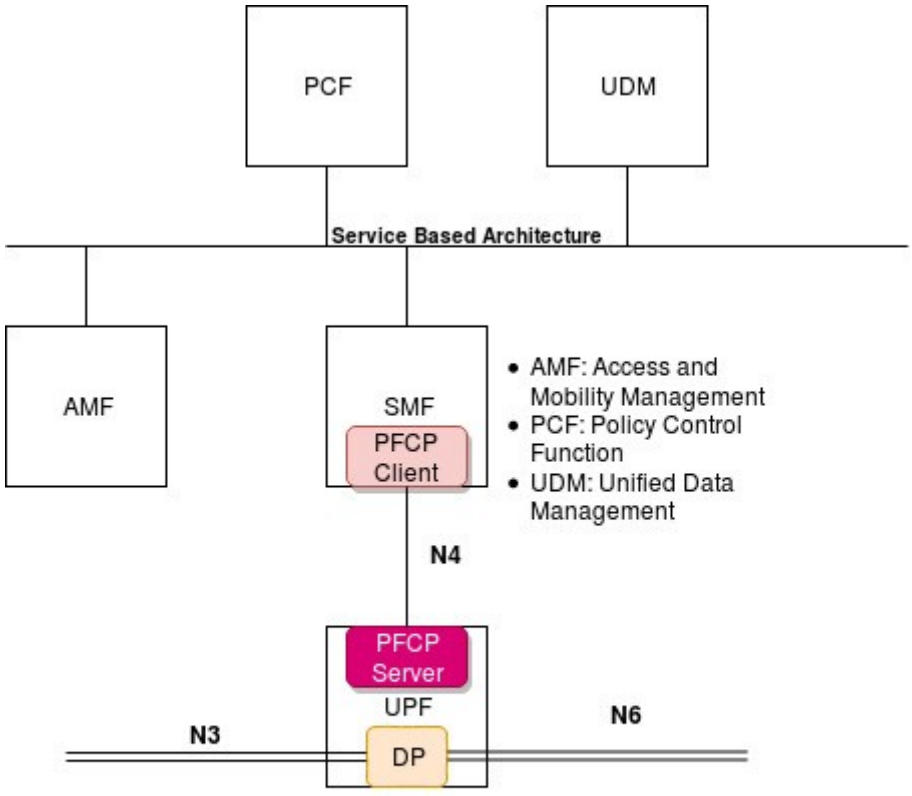
UPF handles packet forwarding of each PDU session and applies QoS on each PDU session, relying on rules from SMF. The user data can be placed in IPv4, IPv6 or Ethernet. The wireless RAN and DNN are made connected by UPF.

PFCP protocol in N4 Interface

PFCP protocol has many notions to describe a PDU session. Those are Packet Detection Rules(PDR), Forwarding Action Rule (FAR), Usage Reporting Rule(URR) and QoS Enforment Rule -QER).

1. Packet Detection Rule (PDR) describes of what packets (of the flow) should be detected for a PDU session. This rule is linked with other four rules.
2. FAR defines what action (e.g. forwarding, dropped, buffered, or duplicated) to be performed on the detected packet using PDR. In the case of buffering, Buffering Action Rule (BAR) describes how much data to be buffered and how to notify SMF.
3.URR contains information for reporting of usage information of network resource for that session. SMF will forward usage information from UPF to billing entity.
4. What QoS treatment should be given for the PDU session is described in QER.

Using above notions, PFCP protocol has defined request/response message for **session establishment, modification and deletion**. These message are generally initiated by SMF.



N4 Interface in the 5GCore

PFCPImplementation and Testing

As shown in the architecture, PFCP protocol interconnects SMF and UPF in 5Gcore network. One possible implementation is that PFCP client can be placed in SMF and N4 server can be placed in UPF.

PFCP client is developed in Golang, supporting session establishment, modification and deletion. The source code (i.e. N4-GO) is available in [1]

To verify interoperability from different implementation, I choose UPF, developed using Vector Packet Processing (VPP) technology from TravelPing [2]. The UPF is running in a docker container.

During the testing phase, client makes initially an association with UPF and gets details of Userplane IP resource information of UPF which will be used to assign tunnel ID for each session by the client. After that client requests a new session with details only for uplink traffic. Then, it requests a modification of session with a downlink traffic details. Finally, it deletes the session.

Conclusion

The benefits of SDN concept is yet to validate in Mobile core network in practice. In similar to openflow, PFCP protocol, proposed by 3GPP is verbose and satisfying the needs of mobile network(e.g. QoS, usage report).

The initiative of open source implementation of PFCP will drive and help independent validation of protocol and benefits. Therefore, it can speed up the adoption of the 5Gcore. The initial test around PFCP protocol shows interoperability from two different implementation.

Currently, limited features of PFCP protocol implementation along open source UPF is made available public. Therefore, interested parties can experiment and contribute. The test is performed only at PFCP protocol level. It means that the data flow via UPF is not made and PFCP client is not connected to AMF..

In the next release, N4-GO will support session report message in addition to currently available session establishment, modification and deletion messages. The session report helps inform the SMF about UP usage report, inactivity indication observed in the PDU session, and downlink data notification. These message will include Quality Enforcement Rule (QER) and Usage Report Rule (URR).

References

[1] https://bitbucket.org/sothy5/n4-go/src/master/
[2] https://github.com/travelping/vpp/tree/feature/1908/upf