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# Use Case for P4 Programmability by Tenants of Future Mobile Virtual Networks
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## Abstract

Support for multi-tenancy has been the subject of recent work on P4 switch programming. This draft further describes a potential use case where a tenant programs a virtual network built over a mobile network, and discusses related requirements. The use case is based on the existing 5GLAN feature, since it is a well documented virtual network architecture supported by 5G.

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## 1. Introduction

In the context of data centers, it has been shown that P4 programs provided by tenants could be used to program and control virtual network instances [Stoyanov]. This could be extended to virtual networks provided by 5G or future mobile networks. This document discusses such a use case, using 5GLAN as a baseline, since this recent 5G feature has a well documented architecture. However, this type of feature is NOT currently planned in 3GPP, it is explored here as a possible future evolution.

As part of its improving integration with other networks, the 5G network has now the ability to provide LAN-like connectivity between 5G devices. This "5GLAN" feature provides a virtual LAN service between devices which are members of a configured group. Section 5.1 of [I-D.ravi-icnrg-5gc-icn] provides a description of the 5G network functions and interfaces relevant to 5GLAN, which are otherwise specified in [TS23.501] and [TS23.502]. From the 5GLAN service customer standpoint, the 5G network operates as a switch.

However, today network operators do not have the option to use network programming (such as P4) to program 5GLANs, as they could for fixed network switches. A form of network programming would nevertheless help to cope with the ever-increasing complexity of the 5G network and its future evolutions. It would also help further integrating mobile networks, as a piece of infrastructure, with other home, enterprise and data center networks.

In this document we describe a use case for P4 programming of 5GLANs by tenants in Section 2. An expected outcome of this work is a list of requirements initiated in Section 3. This document is also part of a larger effort to gather use cases related to computing in the network, that is documented in [I-D.irtf-coinrg-use-cases].

## 2. A Use Case for Programmability of 5GLANs, by Tenants

In the use case depicted in Figure 1, a 5G customer operates a network including a 5GLAN network segment (seen as a single logical switch), as well as fixed segments. This can be in a plant or enterprise network, using for an example a 5G Non-Public Network (NPN). The customer uses P4 programs to determine the operation of the fixed and 5GLAN switches. The customer provisions a 5GLAN P4 program into the mobile network, and can also operate a controller.

In Figure 1, the mobile devices (or User Equipment nodes) UE1, UE2, UE3 and UE4 are in the same 5GLAN, as well as Device1 and Device2 (through UE4).

```
                                           ..... Customer ......
                                P4 program :                   :
                                deployment :         Operation :
                                           V                   :
        +-----+  air interface +----------------+              :
        | UE1 +----------------+                |              :
        +-----+                |                |              :
                               |                |              :
        +-----+                |                |              V
        | UE2 +----------------+     5GLAN      |      +------------+
        +-----+                |    Logical     +------+ Controller |
                               |     Switch     |  P4  +-------+----+
        +-----+                |                |  runtime     |
        | UE3 +----------------+                |  API         |
        +-----+                |                |              |
                               |                |              |
        +-----+                |                |              |
      +-+ UE4 +----------------+                |              |
      | +-----+                +----------------+              |
      |                                                        |
      | Fixed or wireless connection                           |
      |                                    P4 runtime API      |
      |  +---------+           +-------------------------------+
      +--+ Device1 |           |
      |  +---------+           |
      |                        |
      |  +---------+    +------+-----+
      `--+ Device2 +----+ P4 Switch  +--->(fixed network)
         +---------+    +------------+
```

Figure 1: Use Case for P4 Programming by a 5GLAN Customer

Looking in more details in Figure 2, the 5GLAN P4 program can be split between multiple data plane nodes (PDU Session Anchor (PSA) User Plane Functions (UPF), other UPFs, or even mobile devices), although in some cases the P4 program may be hosted on a single node. In the most general case, a distributed deployment is useful to keep traffic on optimal paths, because, except in simple cases, within a 5GLAN all traffic will not pass through a single node.

In Figure 2, P4 programs could be deployed in UPF1, UPF2, UPF3, UE3 and UE4.  In this example, UE1-UE2 traffic is using a local switch on PSA UPF1, UE1-UE3 traffic is tunneled between PSA UPF1 and PSA UPF2 through the N19 interface, and UE1-UE4 traffic is forwarded through an external Data Network (DN).  Traffic between Device1 and Device2 is forwarded through UE4.

```
                            +-----+          +-----+      +------------+
                            | AMF |          | SMF |      | Controller |
                            +-+-+-+          +--+--+      +-----+------+
                             /  |               |             P4|
                  +---------+   |             N4|        Runtime|
             N1  /              |N2             |               V
         +------+               |               |     (all P4 programs*)
        /                       |               |
     +--+--+  air interface +---+-----+ N3 +-+--+----------+  N6  +-----+
     | UE1 +----------------+  (R)AN  +----+   PSA UPF1*   +----->+     |
     +-----+                +---------+    +-+-------+-----+      |     |
        |                       |            |  |    |            |     |
     +--+--+                +---+-----+      |  |    |            |     |
     | UE2 +----------------+  (R)AN  +------'  |    | N19        | DN |
     +-----+                +---------+         |    |            |     |
        |                       |               |    |            |     |
     +--+--+                +---+-----+    +----+----+-----+      |     |
     | UE3*+----------------+  (R)AN  +----+    PSA UPF2*  +      |     |
     +-----+                +---------+    +---------+-----+      |     |
        |                       |               |    | N19        |     |
     +--+--+                +---+-----+    +----+----+-----+  N6  |     |
   +-+ UE4*+----------------+  (R)AN  +----+    PSA UPF3*  +----->+     |
   | +-----+                +---------+    +---------------+      +-----+
   |
   | Fixed or wireless connection
   |
   |  +---------+
   +--+ Device1 |           (* indicates the presence of a P4 program)
   |  +---------+
   |
   |  +---------+    +------------+
   `--+ Device2 +----+ P4 Switch* +--->(fixed network)
      +---------+    +------------+
```

Figure 2: Use Case Details

Rationale for using P4 programming by 5GLAN tenants include:

* A unified programming model can facilitate replacing between fixed and 5G technologies, as well as sharing controller, code and expertise.

* Making P4 (or equivalent) programming available to 5G customers can increase the level of customization available to them, when compared with typical configuration capabilities.

* If P4 programs can influence the 5G service (e.g., request specific QoS for some flows), this increases the level of in-depth customization available to 5G customers.

For example, a P4 5GLAN program could perform the following:

* Allow or block flows, and request rules from an SDN controller for each new flow, or for flows to/from specific hosts that needs enhanced security.

* Forward a copy of some flows towards a node for storage and analysis.

* Update counters based on specific sources/destinations or protocols, for detailed analytics.

* Associate traffic between specific endpoints, using specific protocols, or originated from a given application, to a given slice, while other traffic use a default slice.

* Experiment with a new routing protocol (e.g., ICN), using a P4 implementation of a router for this protocol. (This could use unstructured PDU sessions.)

In the following section we discuss major requirements identified in this use case.

## 3. Requirements for Mobile Network Programming by Tenants

* Splitting/Distribution: program logic can be applied exactly once or at least once per packet, while allowing optimal forwarding path by the 5G network.

  - A 5GLAN P4 program may run on a single UPF on a simple setup, but will need to be split in larger setups.

  - It could be possible to split the program manually (i.e., by the programmer based on a model), or automatically (which is studied in [I-D.hsingh-coinrg-reqs-p4comp] and [Sultana]).

* Multi-Tenancy Support: multiple P4 instances can run on the same 5G network nodes.

  - In [Stoyanov], tenant P4 programs can run within the control of a host P4 program.

* 5G Network Awareness: a P4 program can be able to influence, and be influenced by, the 5G network service.

  - For example, a P4 program may be aware of the slice used by a flow, and possibly influence slice selection.

  - Additionally, some information and actions may be available on some nodes and not others. This can impose additional constraints on distributed P4 programs location.

* Mobility Support: program logic should be applied on all packets of a flow even if the source or destination(s) of the flow is relocated to another attachment point.

* Security: programs and networks should be protected against security risks, that include overuse or misuse of network resources, injection of traffic, access to unauthorized traffic.

## 4. Informative References

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