Enabling ICN in 3GPP's 5G NextGen Core Architecture

https://www.ietf.org/id/draft-ravi-icnrg-5gc-icn-03.txt

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Introduction

- Related WG Draft
  - draft-irtf-icnrg-icn-lte-4g-03 (Native Deployment of ICN in LTE, 4G Mobile Networks)
    - which enables ICN over 4G systems.

- The present I-D: draft-ravi-icnrg-5gc-icn-03
  - To enable ICN over 5G systems.
  - Leverage some similar design principle in draft-irtf-icnrg-icn-lte-4g-03 with some extensions unique to 5G systems.

Updates in v03

Section 5.2.3 (New)
- Borrowed the similar design principle from Section 4 of draft-irtf-icnrg-icn-lte-4g-03

Section 6 (New)
- The whole section was re-written to replace previous Section 6 in v02
- Several subsections are left for future updates.

Recap : 5GC Architecture

Non-Roaming & Service-Based Interfaces (SBI)

Control Plane

```
+------+    +------+    +-----+    +-----+    +-----+    +-----+
| NSSF |    | NEF  |    | NRF |    | PCF |    | UDM |    | AF  |
+--o---+    +--o---+    +--o--+    +--o--+    +--o--+    +--o--+
Nnssf|       Nnef|       Nnrf|      Npcf|      Nudm|      Naf|
-----+----------+----------+---------+---------+---------+---------
         Nausf|            Namf|           Nsmf|
         +--o--+            +--o--+          +--o--+
         | AUSF|            | AMF |          | SMF |
         +-----+            +-+-+-+          +--+--+
                             /  |               |
              +---------------+ |               |
         N1  /             |N2  |          N4|  +-N9/Nx-+
         +------+          |    |           |  |        |
        /                  |    |           |  |        V
  +-+--+                +----+--+   N3  +-+-+------+--+ N6  +----+
  | UE +---------------+ (R)AN +------+     UPF      +---->+ DN |
  +----+                +-------+          +------------+      +----+
```

Data Plane
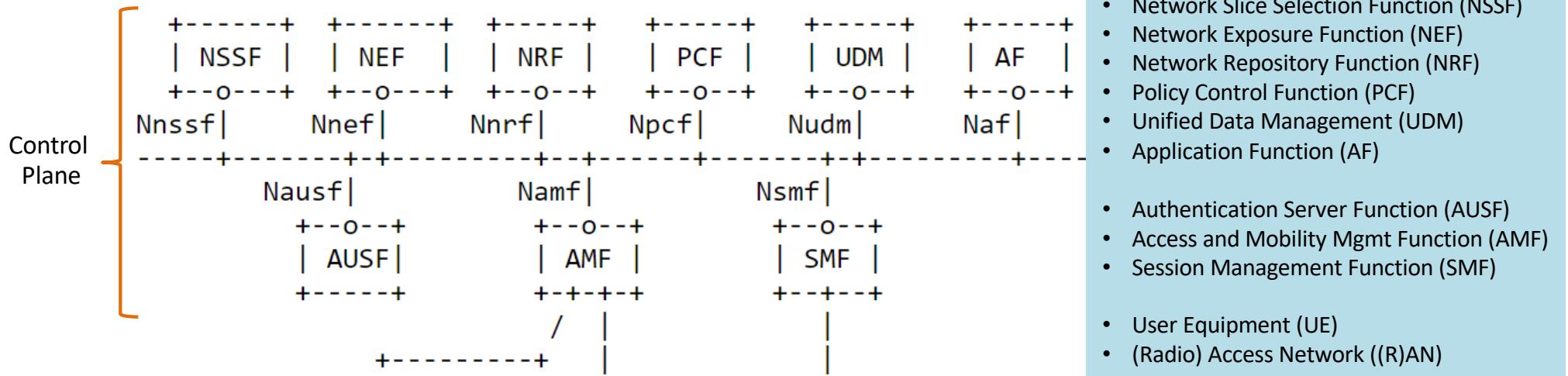
- Network Slice Selection Function (NSSF)
- Network Exposure Function (NEF)
- Network Repository Function (NRF)
- Policy Control Function (PCF)
- Unified Data Management (UDM)
- Application Function (AF)

- Authentication Server Function (AUSF)
- Access and Mobility Mgmt Function (AMF)
- Session Management Function (SMF)

- User Equipment (UE)
- (Radio) Access Network ((R)AN)
- User Plane Function (UPF)
- Data Network (DN)

| Service APIs | Service Centric Design | 5GLAN for EC | Distributed LAN Support | Introduce a new UPF | Control and User Plan Split | One CN for all RATs | Decoupling of RAT and Core Network | Unstructured PDU payload | Non-IP PDU Session Support |

5GC Design Principles

Recap : ICN over 5GS – Control Plane Extensions

```
                                    +------------+
                                    |    5G      |
                                    | Services   |              +----------------+
                                    |   (NEF)    |              |      ICN       |
                                    +------+-----+              |    Service     |
                                           |       +--------+   |  Orchestrator  |
                                           |       |        |   +-------+--------+
                                           |       |        |           |
    +----+ +--------+   Npcf++/Nudm++  +-+--+-+    |           |
    |NSSF| |PCF/UDM+------------------+ ICN-AF|    |           |
    +-+--+ +-+-----+                  +---+--+    |   +------+---------+
      |      |                            |       |   |      ICN       |
      |      |                            |       +---+Service/Network|
      |      |                            |       |   |  Controller   |
    +-+----+-+-+     +-------+    +---+--+ |   |   +-------+--------+
    |        |N11++ |        |Naf++ |    |   +---+           |
    | AMF++  +------+ SMF++ +------+ICN-SMF|               |
    |        |      |       |      |       |               |
    +----+--+--+    +--+---+    +---+--+                   |
         |  |          |            |NIcn                  |
         |  +-------+  +-------+    +----------+           |
         |          |          |              |           |
         |          |          |          +--+--+      +--+--+
         |          |          |          |     |      |     |
    |N1++ |     |N2  |     |N4  |     +----+ICN-GW+------+ICN-DN|
         |          |          |     | N9 | +UPF |  N6  |     |
    +----+-+ +-----+----+  +----+----+ | |  +------+      +------+
    |      | |RAN +----+|  | UL-CL/  +--+
    |ICN-UE+--+    |UPF ||  |Branching|
    |      | |  |  +----++--+ Point   |
    |      | |  | +------+| N3|        +---+      +------+
    +------+ |  | |ICN-GW||  +---------+  | N9 | Local|
             |  | +------+|              +----+ICN-DN|
             +----------+                      +------+
```
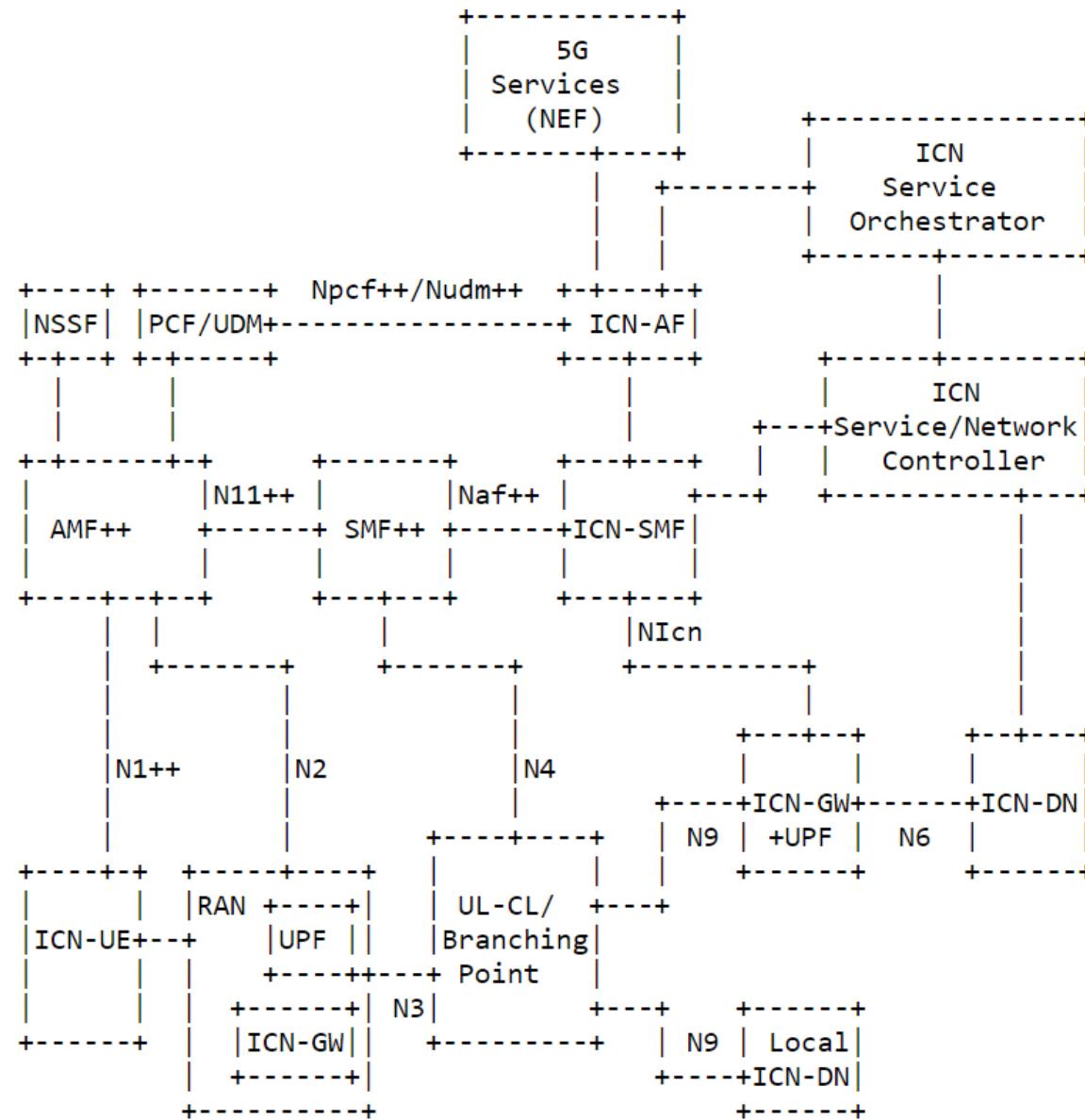
ICN over 5GS – User Plane Dual Stack

New Section 5.2.3 in v03

TCL: Transport Convergence Layer

```
+--------+                                                              +--------+
| App    |                                                              | APP    |
+--------+                                                              +--------+
| TCL *  |..............................................| TCL  * |.|.|  TCL  * |
+--------+                                              +--------+-+-+ +--------+
| ICN&IP |..............................................| ICN&IP |.|.| ICN&IP |
|   *    |                                              |   *    | | |   *    |
+--------+  | +----+------+  | +------+------+  | +------+--+  | +--------+
| PDCP  |.|.|PDCP|GTP-U |.|.|GTP-U | GTP-U|.|.|GTP-U |  | | |        |
+--------+ | +----+------+ | +------+------+ | +------+  | | | |        |
| RLC   |.|.|RLC |UDP/IP|.|.|UDP/IP|UDP/IP|.|.|UDP/IP|L2|.|.|   L2    |
+--------+ | +----+------+ | +------+------+ | +------+  | | | |        |
| MAC   |.|.| MAC| L2   |.|.| L2   | L2   |.|.| L2   |  | | | |        |
+--------+ | +----+------+ | +------+------+ | +------+  | | +--------+
| L1    |.|.| L1 | L1   |.|.| L1   | L1   |.|.| L1   |L1|.|.|   L1    |
+--------+ | +----+------+ | +------+------+ | +------+--+ | +--------+
   UE    |     gNB/RAN     |      UPF        |    UPF      |    DN
         |                 |    (UL-CL)      | (PDU Anchor)|
         |                 |                 |             |
        Uu                N3                N9            N6
```
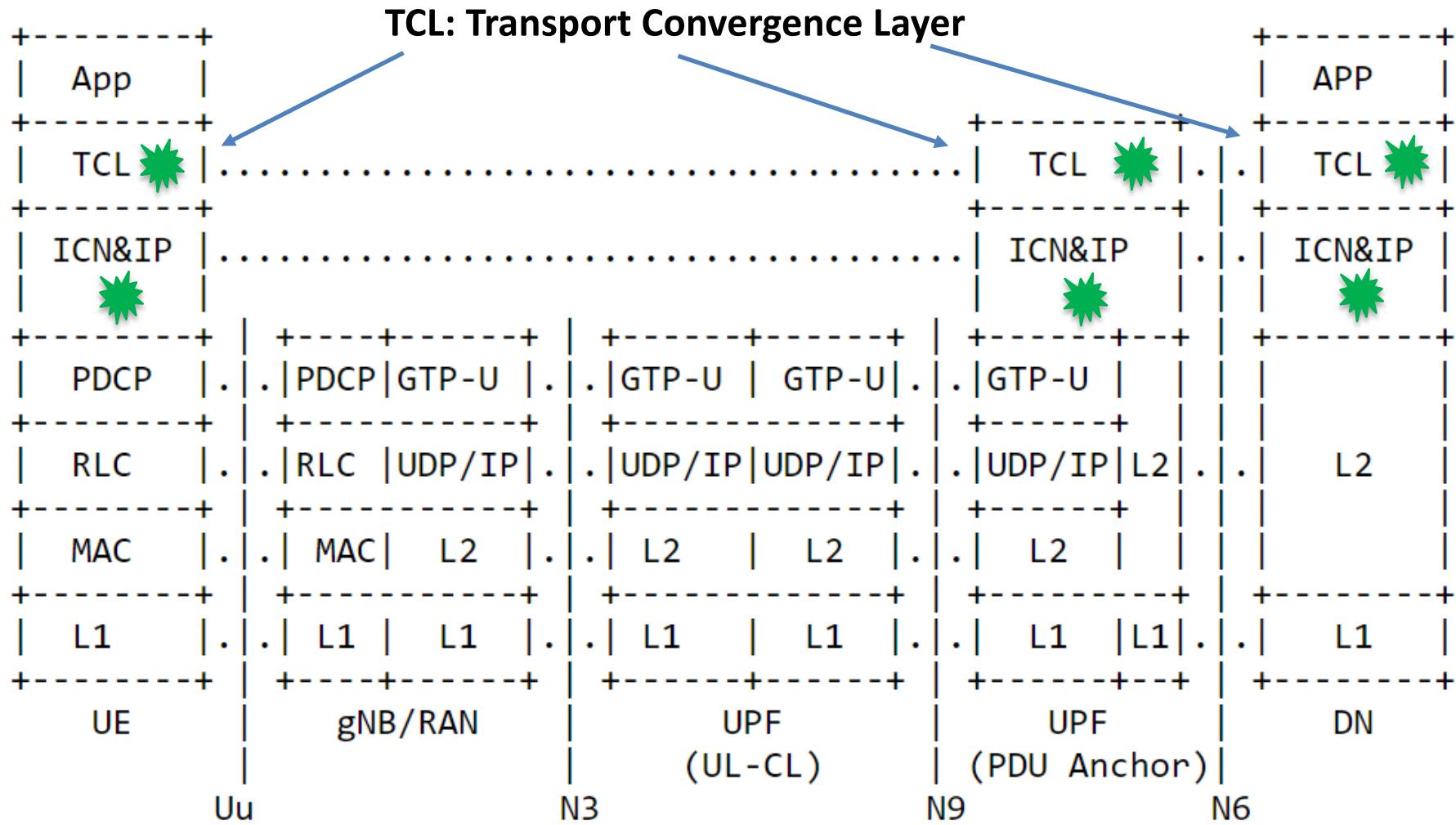
ICN over 5GLAN

- Path-based Forwarding over Nx Interface for End-to-End LAN Communication (As Defined in 3GPP)
  - The path between the source and destination UPFs is encoded through a bitfield, provided in the packet header as a path identifier.
  - Each bitposition in said bitfield represents a unique link in the network.
    - Upon receiving an incoming packet, each UPF inspects said bitfield for the presence of any local link that is being served by one of its output ports. If no link is being found, the packet is dropped.
  - path identifiers are bidirectional and can therefore be used for request/response communication without incurring any need for path computation on the return path.

- Path-based Forwarding Example
  - Scenario: Sending a packet from one Layer 2 device (UE) connected to one UPF (via a RAN) to a device connected to another UPF
  - Procedure:
    - Provide the MAC address of the destination and perform a header re-write by providing the destination MAC address of the ingress UPF when sending from source device to ingress and placing the end destination MAC address in the payload.
    - Upon arrival at the egress UPF, after having applied the path-based forwarding between ingress and egress UPF, the end destination address is restored while the end source MAC is placed in the payload with the egress L2 forwarder one being used as the L2 source MAC for the link-local transfer.
    - At the flat/proxy device, the end source MAC address is restored as the source MAC, creating the perception of a link-local L2 communication between the end source and destination devices.

General Packet Structure:

```
+---------+---------+----------+-----------+-----------+
| Src MAC | Dst MAC |  pathID  |  NAME_ID  |  Payload  |
+---------+---------+----------+-----------+-----------+
```
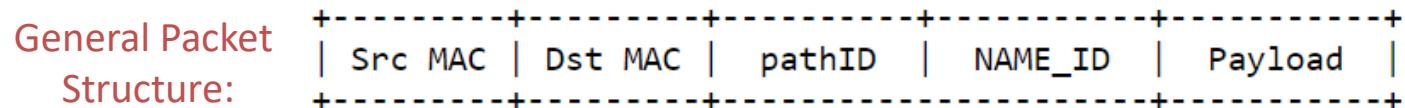
IP-based Services over ICN over 5GLAN (1/2)

- Key Ideas
  - Internet Service as a Named Service Transaction (NST): Internet services are being interpreted as the main unit of transfer to be routed over an ICN layer in one or more other devices.
  - Four-Layer Flat Protocol Stack: As a result of this name-based interpretation of any Internet service, the protocol stack in end devices flattens to four layers with Internet services and ICN, with ICN acting as a name-based routing layer for all IP protocol implemented atop, with Layer 1 and 2 realizing the end-to-end packet forwarding.
  - Map Internet Services (e.g. HTTP) to ICN Layer: the ICN layer uses an interaction with the Name Resolver (NR) to register and discover HTTP-based services for determining the suitable end-to-end packet forwarding information.
  - Service Proxy Devices: Interfaces to legacy devices and peering networks are preserved through service proxy devices, which terminate a traditional Internet protocol stack communication and translate it into a resulting flat protocol transaction.

IP-based Services over ICN over 5GLAN (2/2)
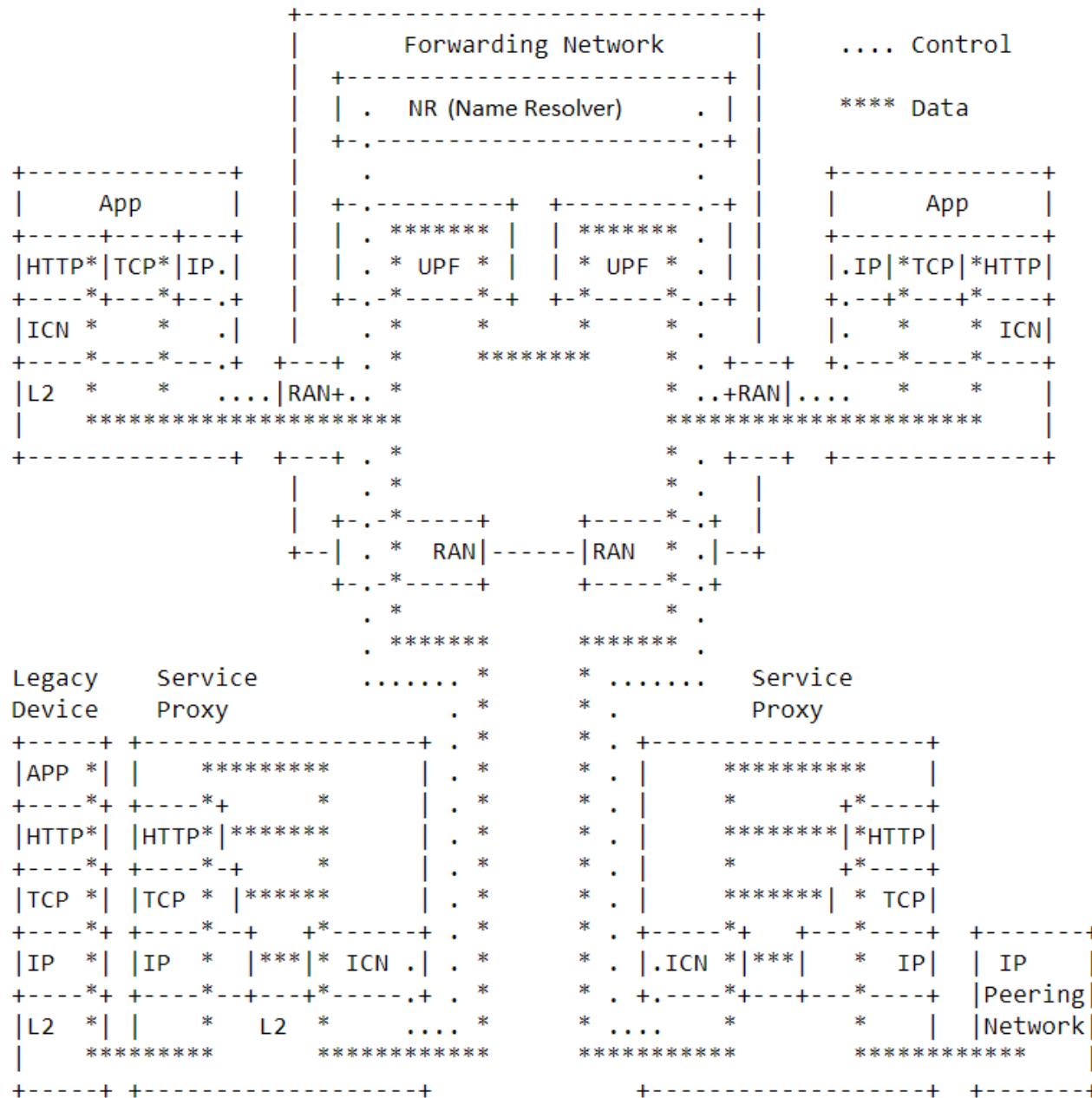
Assume an end-to-end LAN connectivity be provided by solutions such as 5GLAN

Next Steps

- Collect feedback from the ICNRG

- Proposed next steps
  - Address any comments during/after the IETF 104
  - Update Section 6 on ICN over 5GLAN Architecture. For example, the following subsections are currently left for future updates.
    - 6.2.6 – ICN Flow Management
    - 6.2.8 – Mobility Handling
    - 6.3 – ICN over 5GLAN
  - Host a demo for the next IETF 105 (July 2019)