Enabling ICN in 3GPP's 5GC Architecture

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Draft Outline

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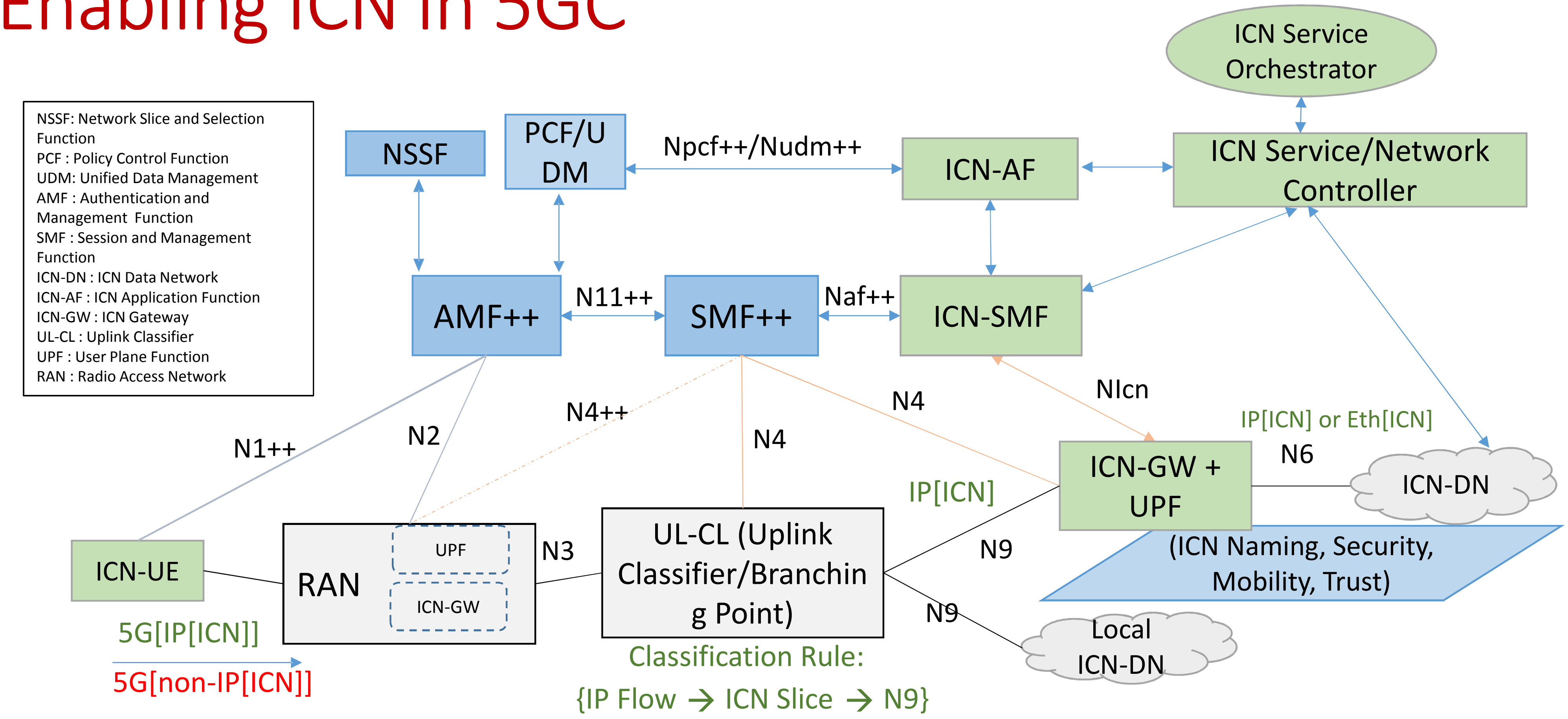
Draft Updates

- New co-author Dirk Trossen
- Update to the 5G/ICN architecture
  - We call ICN-AP as ICN-GW to avoid misinterpretation as anchor point function in current 5GC network.
- Discussion on various considerations related to leveraging non-IP PDU provision for ICN in 5G
- Discussion on IP-o-ICN realizations over 5GC
- Use Case Scenario
  - Smart Mobility using IP-o-ICN
  - Multiuser VR Use Case

Draft Objectives

- **Motivate the benefits of enabling ICN in 5G**
  - ICN enabled session-less transport, edge Computing, Storage/Caching, Seamless Mobility to handle several high bandwidth and low latency applications (eMBB, MMTC and URLLC)
- **Propose architectural control and user functions to enable ICN in 5GC taking advantage of flexibility of the design considering network slicing, NFV/SDN principles**
- **Using the non-IP PDU for native deployment of ICN in 5G**
- **Use case Scenarios**
  - Smart Mobility
  - Multi-viewer VR
  - Seamless Mobility

Enabling ICN in 5GC



- ICN can be transported over IP or as non-IP PDUs towards ICN-DN
- ICN-SMF handles session management of ICN-AP NF. AMF++/SMF++ enforce functions to allow UE subscription authentication to ICN DN, and provision rules in RAN, UL-CL and other intermediate UPFs to enable UE-ICN to anchor to ICN-AP.
- ICN-AF can push ICN PDU session requirements to PCF/UDM for slice selection or session management functions between the RAN and the ICN-AP

Non-IP PDU Provision Considerations

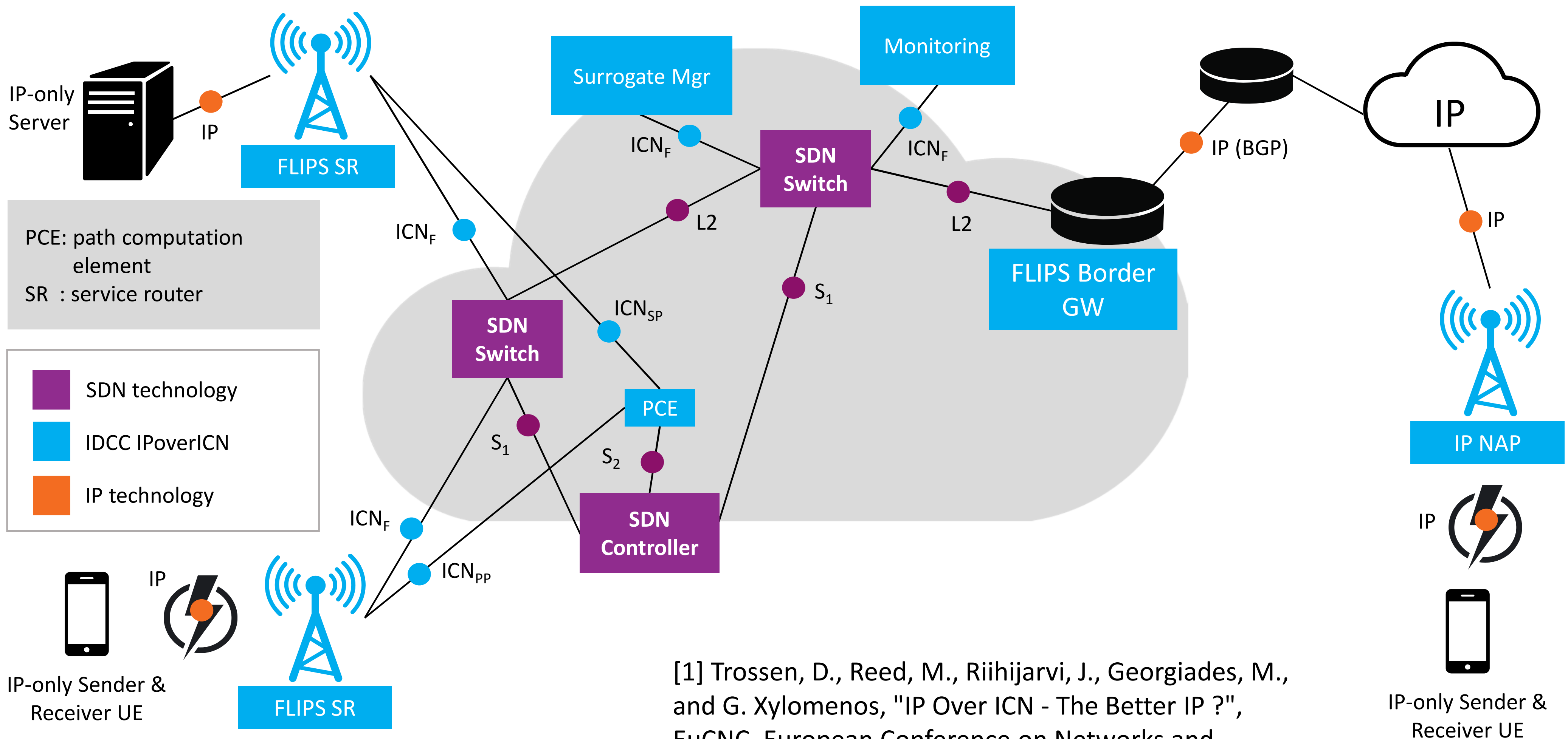
- In this mode, the ICN-UE will operate without any IP configuration
- For maximum efficiency, the ICN-GW can be realized in the RAN.
  - Caching and Mobility can enabled in the RAN
- **Following are considerations to allow ICN as one of the non-IP PDU types which 5G can support.**
- **Attach Procedures/Control Plane for UE with non-IP PDN**
  - Extended Mechanisms required to authenticate/authorize ICN UEs at device or service level
  - This can be extended to authorize service access, as ICN is about networking services.
  - Mechanisms described in TS.23.501 using existing AUSF/UDM/PCF functions can be potentially extended towards this.
  - Can be extended to include ICN specific authentication function (ICN-AF)
    - AMF++/SMF++ and ICN-SMF functions to support non-IP PDU management
  - Current LTE identifies the connectivity type using PCO-IE, i.e. IP versus non-IP PDU, could be used for control plane session management
- **User Plane for UE with non-IP PDN**
  - Requires mechanism to identify ICN PDUs for policing, charging or legal interception
  - A flat ICN realization requires a distributed mechanism to handle these functions
  - ICN by design doesn’t include consumer identity, lower layer identities (e.g. PDCP/MAC) can be used towards this.
  - Further Slice-ID (from NSSAI) could be used in the UPF to map ICN flows to appropriate ICN slice

Non-IP PDU Provision Considerations

- **Mobility Handling**
  - Involving IP networking between the RAN and the UPF is inefficient
  - Efficient handling by collocating ICN-GW with RAN
  - Requires integration with 5G and ICN CP/UP functions
- **Routing Considerations**
  - 5GC follows LTE's centralized session management and routing approach using the SMF
  - Scalability challenges in a flat ICN realization where multi-source and multipath routing can be taken advantage of
  - Explore feasibility of distributed routing approaches within the 5GC framework
- **Mobile Edge Computing**
  - ICN level service orchestration to exploit services deployed in network [1] or using in-network approach like NFN.
  - Routing challenge, to direct ICN service flows to closest service or in-network compute instance

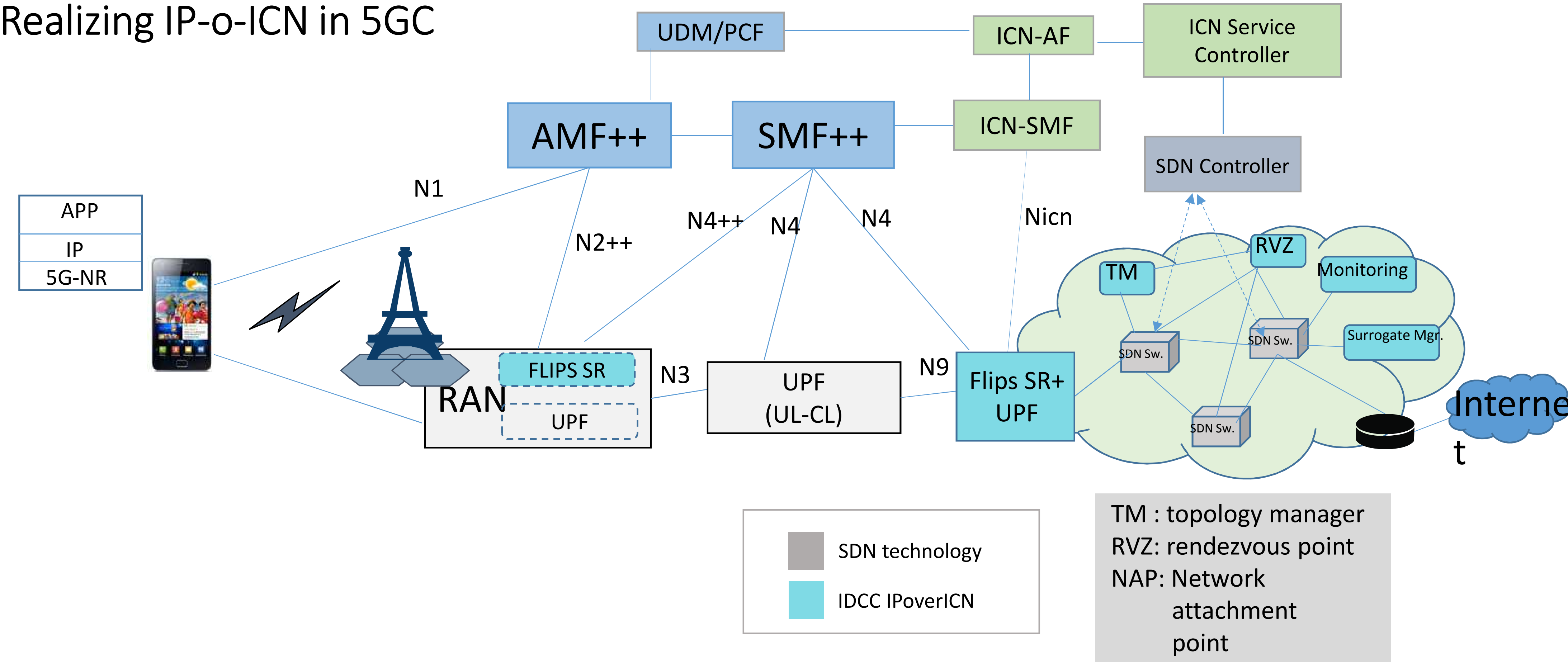
[1] Ravindran, R., Liu, X., Chakraborti, A., Zhang, X., and G.Wang, "Towards software defined ICN based edge-cloud services", IEEE, CloudNet, 2013.

Realization of IP-over-ICN Architectures: Example of IDCC's Flexible IP Services (FLIPS)



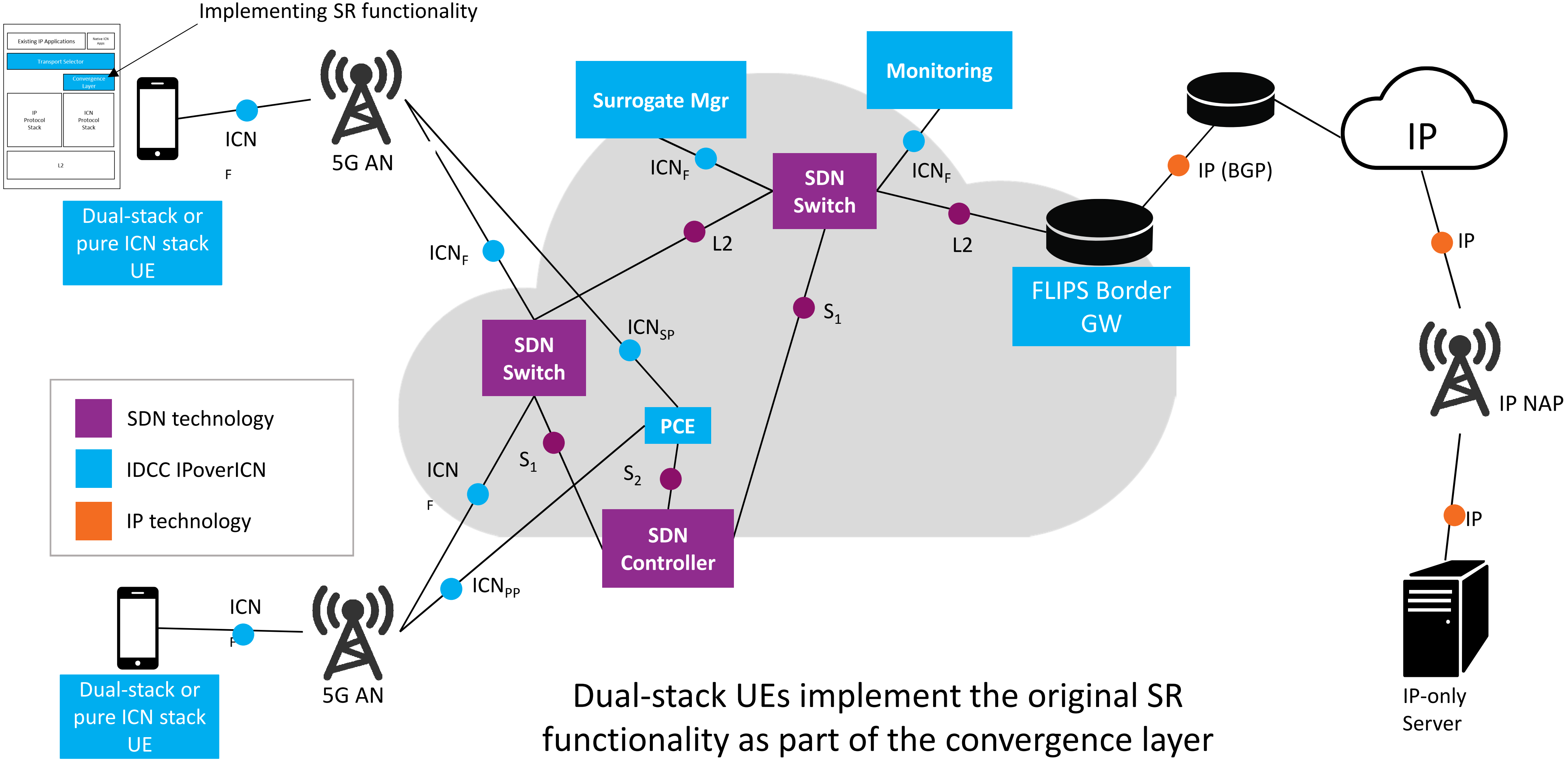
[1] Trossen, D., Reed, M., Riihijarvi, J., Georgiades, M., and G. Xylomenos, "IP Over ICN - The Better IP ?", EuCNC, European Conference on Networks and Communications , July, 2015.

Realizing IP-o-ICN in 5GC



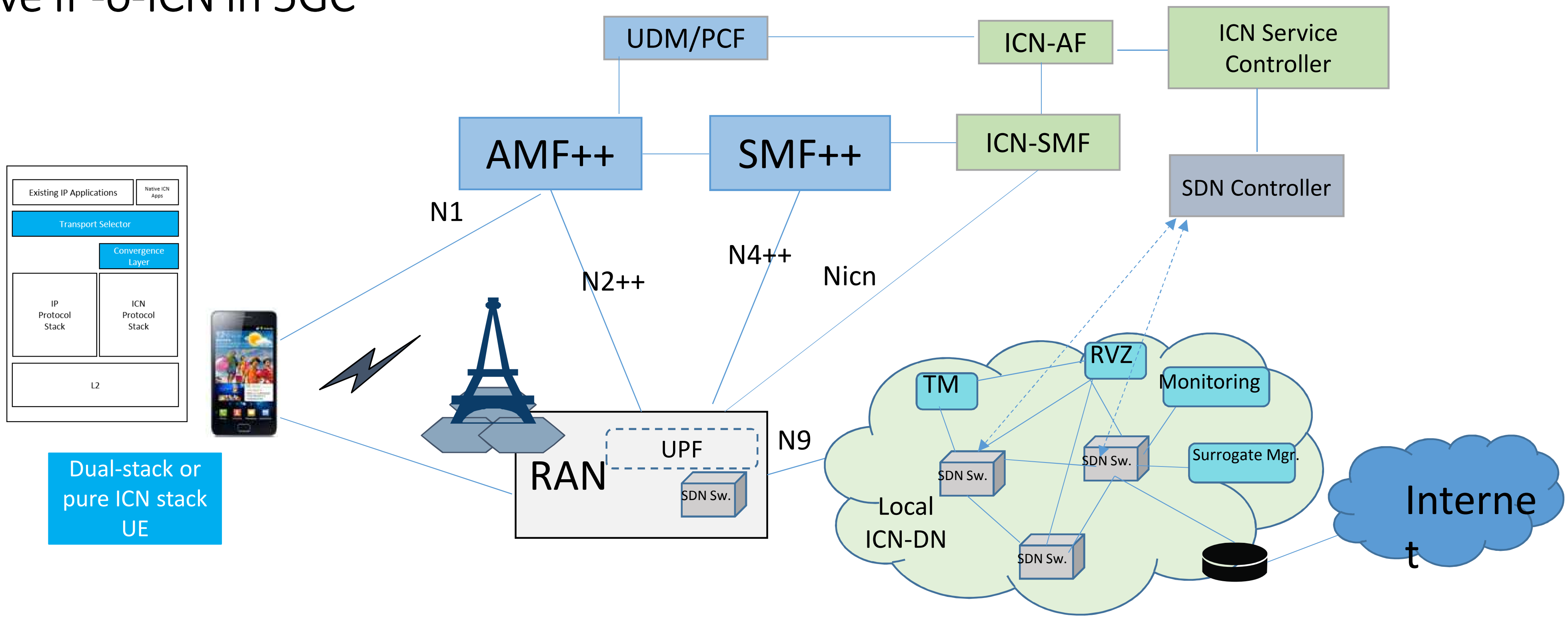
- The proposed 5GC extensions shall allow realization of ICN architectures such as PURSUIT over 5GC
- IP-o-ICN adaptation user plane functions (FLIPS-NAP) can be realized in the RAN or as DN service.

Native IP-over-ICN: A Terminal Version



Dual-stack UEs implement the original SR functionality as part of the convergence layer

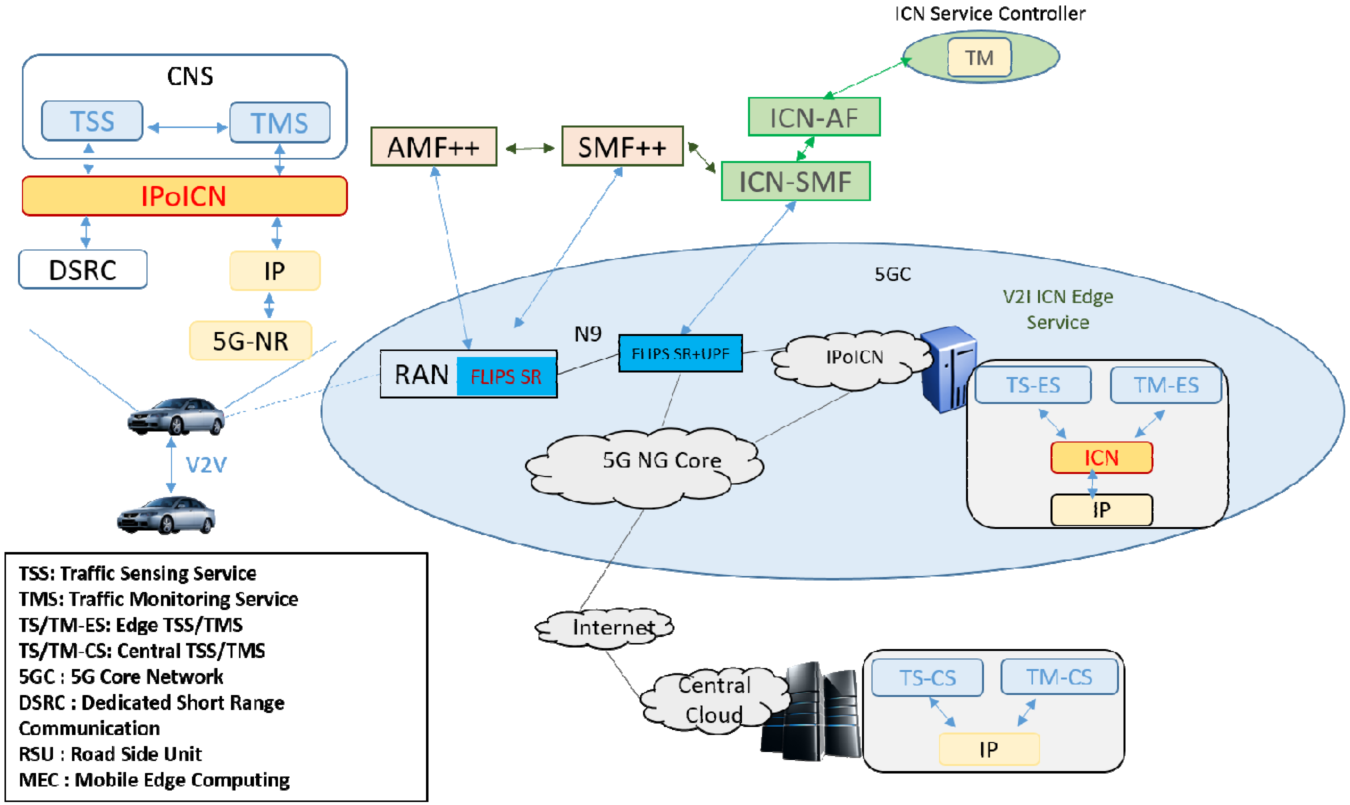
Native IP-o-ICN in 5GC



- In this realization, ICN frames are handled as non-IP PDUs, which are then networked to the edge ICN-local DN instance
- The SDN switch in the RAN can be another forwarding function to enable this ICN architecture.

Smart Mobility using IP-o-ICN

- Discussion of this scenario over IP-o-ICN architecture
- Assumes operation of IP-based MEC application over an ICN bearer
- ICN based methods used for Service Registration ensuring service requests reach the closest service instance
- Path Updates at the CNS end point used for IP mobility
- With IP-o-ICN, the TM-E instance can return a single L2 level multicast to reach multiple CNS at the same time
- ICN based registration also allows secure content delegation to in-network caching points, with HTTP requests being directed to the secure content edge server, avoiding any triangular routing issues.



Multi-user VR use case

- **Scenario**: multi-user virtual reality content delivery
  - Spatial and temporal correlation, e.g., joint event delivery such as for sports or education content around (e.g., historical) storyline
- **Observation**: overlap in retrieval pattern from various VR users
  - Temporal correlation makes this obvious
  - Spatial correlation results in segments being pulled quasi-synchronously, too
- Window of opportunity to deliver VR content to more than one user
  - Window might be small due to required low latency but still exists
- Multicast relations vary per request (due to likely slight differences in retrieval patterns from previous request)
  - Purely realized via L2 path-based forwarding
- This can also realized within 5GC setting through a ICN-MEC framework to serve locations as in stadiums, educational or tourism purposes, utilizing native ICN applications deployed on UEs.

Next Steps

- The draft explores the opportunities to leverage the flexibility of 5GC architecture to enable ICN to meet serveral 5G application requirements difficult in current IP setup.
  - 5G commercial deployment still 4-5yrs out.
  - Could influence Rel-16 and beyond.

- Potential Next Steps for this draft.
  - ICN Multicasting over Radio Access (interim presentation) [1]
  - Details on 5G/ICN functional support (non-IP PDU provision)
  - Separate discussions for ICN Applications (IoT versus Smart devices)
  - Mobility handling over ICN in 5GC
  - Managing QoS for heterogeneous applications
  - Distributed policy/charging mechanisms

- Would like to see the interest in the group to take it up as a RG item

[1]"Enabling Receiver oriented ICN multicast in Cellular Radio Access", https://datatracker.ietf.org/doc/slides-interim-2018-icnrg-01-sessa-enabling-cross-layer-receiver-oriented-dynamic-multicast-in-cellular-access-ravi-ravindran/