DMM Working Group   U. Chunduri, Ed.
Internet-Draft   R. Li
Intended status: Standards Track   Huawei USA
Expires: January 17, 2019   J. Tantsura
                                                      Nuage Networks
                                                        L. Contreras
                                                          Telefonica
                                                           X. De Foy
                                   InterDigital Communications, LLC
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Transport Network aware Mobility for 5G
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Abstract

   This document specifies a framework and a mapping function for 5G
   mobile user plane with transport network slicing, integrated with
   Mobile Radio Access and a Virtualized Core Network. The integrated
   approach specified in a way to address all the mobility scenarios
   defined in [TS23.501] and to be backward compatible with LTE
   [TS.23.401-3GPP] network deployments.

   It focuses on an optimized mobile user plane functionality with
   various transport services needed for some of the 5G traffic needing
   low and deterministic latency, real-time, mission-critical services.
   This document describes, how this objective is achieved agnostic to
   the transport underlay used (IPv4, IPv6, MPLS) in various deployments
   and with a new transport network underlay routing, called Preferred
   Path Routing (PPR).

Requirements Language

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in RFC2119 [RFC2119].

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
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1. Introduction and Problem Statement

3GPP Release 15 for 5GC is defined in [TS.23.501-3GPP],
[TS.23.502-3GPP], [TS.23.503-3GPP]. A new user plane interface N9
[TS.23.501-3GPP] has been created between 2 User Plane
Functionalities (UPFs). While user plane for N9 interface being
finalized for REL16, both GTP-U based encapsulation or any other
compatible approach is being considered [CT4SID]. Concerning to this
document another relevant interface is N3, which is between gNB and
the UPF. N3 interface is similar to the user plane interface S1U in
LTE [TS.23.401-3GPP]. This document:

o does not propose any change to existing N3 user plane
   encapsulations to realize the benefits with the approach specified
   here

o and can work with any encapsulation (including GTP-U) for the N9
   interface.

[TS.23.501-3GPP] defines various Session and Service Continuity (SSC)
modes and mobility scenarios for 5G with slice awareness from Radio
and 5G Core (5GC) network. 5G System (5GS) as defined, allows
transport network between N3 and N9 interfaces work independently
with various IETF Traffic Engineering (TE) technologies.

However, lack of underlying Transport Network (TN) awareness can be
problematic for some of the 5GS procedures, for real-time, mission-
critical or for any deterministic latency services. These 5GS
procedures including but not limited to Service Request, PDU Session,
or User Equipment (UE) mobility need same service level
characteristics from the TN for the Protocols Data Unit (PDU)
session, similar to as provided in Radio and 5GC for various 5QI's
defined in [TS.23.501-3GPP] .

1.1. Acronyms

5QI   - 5G QoS Indicator

AMF   - Access and Mobility Management Function (5G)

BP   - Branch Point (5G)

CSR   - Cell Site Router

DN   - Data Network (5G)

        eMBB   -   enhanced Mobile Broadband (5G)

        FRR   -   Fast ReRoute

        gNB   -   5G NodeB

        GBR   -   Guaranteed Bit Rate (5G)

        IGP   -   Interior Gateway Protocols (e.g. IS-IS, OSPFv2, OSPFv3)

        LFA   -   Loop Free Alternatives (IP FRR)

        mIOT   -   Massive IOT (5G)

        MPLS   -   Multi Protocol Label Switching

        QFI   -   QoS Flow ID (5G)

        PPR   -   Preferred Path Routing

        PDU   -   Protocol Data Unit (5G)

        PW   -   Pseudo Wire

        RQI   -   Reflective QoS Indicator (5G)

        SBI   -   Service Based Interface (5G)

        SID   -   Segment Identifier

        SMF   -   Session Management Function (5G)

        SSC   -   Session and Service Continuity (5G)

        SST   -   Slice and Service Types (5G)

        SR   -   Segment Routing

        TE   -   Traffic Engineering

        ULCL   -   Uplink Classifier (5G)

        UPF   -   User Plane Function (5G)

        URLLC   -   Ultra reliable and low latency communications (5G)

1.2. Solution Approach

This document specifies a mechanism to fulfil the needs of 5GS to
transport user plane traffic from gNB to UPF for all service
continuity modes [TS.23.501-3GPP] in an optimized fashion. This is
done by, keeping mobility procedures aware of underlying transport
network along with slicing requirements. TN with mobility awareness
described here in a way, which does not erase performance and latency
gains made with 5G New Radio(5GNR) and virtualized cellular core
network features developed in [TS.23.501-3GPP].

Section 2 describes two methods, with which Transport Network (TN)
aware mobility can be built irrespective of underlying TN technology
used. Using Preferred Path Routing (PPR) as TN Underlay is detailed
in Section 3. Section 3.4 further describes the applicability and
procedures of the same with 5G SSC modes on N3 and N9 interfaces. At
the end, Section 6 recapitulates the benefits of specified approach
in mobile networks.

2. Transport Network (TN) and Slice aware Mobility on N3/N9

```
                     Service Based Interfaces (SBI)
      ----+-----+-----+----+----+-----+----+--------+-----+----+------
          |     |     |    |    |     |    |        |     |    |
      +---+---+ |  +--+--+ | +--+---+ | +--+--+  +--+--+  | +-+--+
      | NSSF  | |  | NRF | | | AUSF | | | UDM |  | NEF |  | | AF |
      +-------+ |  +-----+ | +------+ | +-----+  +-----+  | +----+
         +---+----+  +--+--+  +---=++   +--------------+-+
         |  AMF   |  | PCF |  | TNF |   |      SMF       |
         +---+--+-+  +-----+  +-+-+-+   +-+-----------+--+
            N1  |               | |       |      To   |
       to-UE+----+  N2    +----Ns---+ +-Nn-+  N4  +--Nn-+ N4
             |     |      |        | |     | |       | |
         +---+---+  +--++           +-+--+---+    +-+-----+     +----+
         |gNB+======+CSR+------N3-----+  UPF   +-N9--+  UPF  +--N6--+ DN |
         +---+      +---+             +-+------+    +-------+     +----+
                                        | +----+
                                        +-| DN |
                                      N6   +----+
```
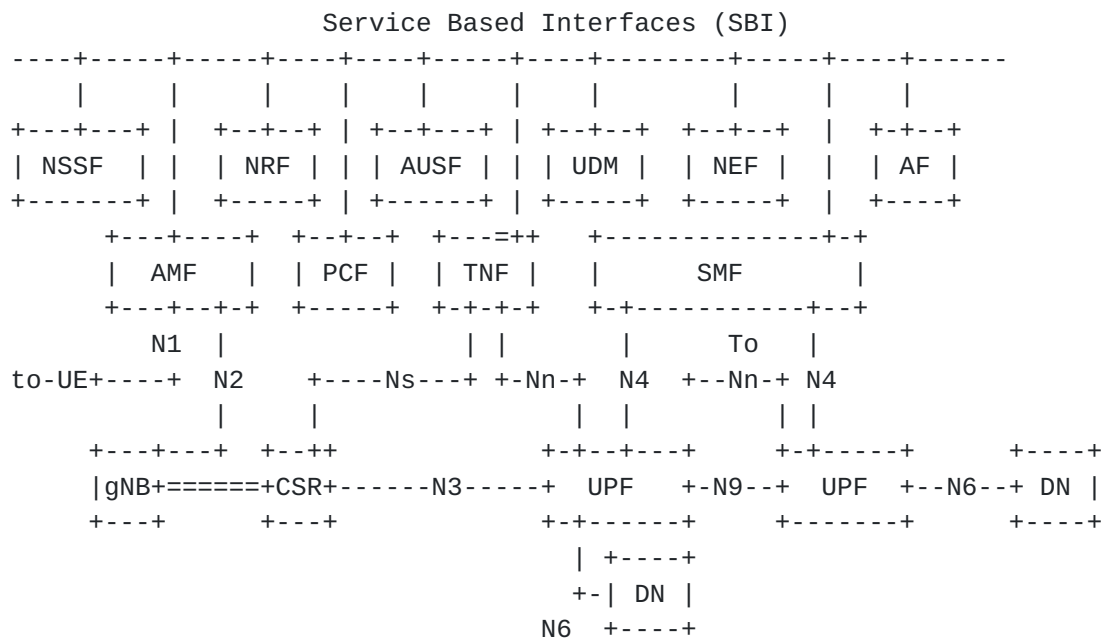
Figure 1: 5G Service Based Architecture

The above diagrams depicts one of the scenarios of the 5G network
specified in [TS.23.501-3GPP] and with a new and virtualized control

component Transport Network Function (TNF). A Cell Site Router (CSR)
is shown connecting to gNB. Though it is shown as a separate block
from gNB, in some cases both of these can be co-located. This
document concerns with backhaul TN, from CSR to UPF on N3 interface
or from Staging UPF to Anchor UPF on N9 interface.

Currently specified Control Plane (CP) functions Access and Mobility
Management Function (AMF), Session Management Function (SMF) and User
plane (UP) components gNodeB (gNB), User Plane Function (UPF) with
N2, N3, N4, N6 and N9 are relevant to this document. Other
Virtualized 5G control plane components NRF, AUSF, PCF, AUSF, UDM,
NEF, and AF are not directly relevant for the discussion in this
document and one can see the functionalities of these in
[TS.23.501-3GPP].

N3 interface is similar to S1U in 4G/LTE [TS.23.401-3GPP] network and
uses GTP-U [TS.29.281-3GPP] encapsulation to transport any UE PDUs
(IPv4, IPv6, IPv4v6, Ethernet or Unstructured). N9 interface is a
new interface to connect UPFs in SSC Mode3 Section 3.4.3 and right
user plane protocol/encapsulation is being studied through 3GPP CT4
WG approved study item [CT4SID] for REL-16.

TN Aware Mobility with optimized transport network functionality is
explained below. How PPR fits in this framework in detail along with
other various TE technologies briefly are in Section 3 and Section 4
respectively.

2.1. Discrete Approach

In this approach transport network functionality from gNB to UPF is
discrete and 5GS is not aware of the underlying transport network and
the resources available. Deployment specific mapping function is
used to map the GTP-U encapsulated traffic at gNB at UL and UPF in DL
direction to the appropriate transport slice or transport Traffic
Engineered (TE) paths. These TE paths can be established using RSVP-
TE [RFC3209] for MPLS underlay, SR [I-D.ietf-spring-segment-routing]
for both MPLS and IPv6 underlay or PPR
[I-D.chunduri-lsr-isis-preferred-path-routing] with MPLS, IPv6 with
SRH, native IPv6 and native IPv4 underlays.

In this case, the encapsulation provided by GTP-U helps carry
different PDU session types (IPv4, IPv6, IPv4IPv6, Ethernet and
Unstructured) independent of the underlying transport or user plane
(IPv4, IPv6 or MPLS) network. Mapping of the PDU sessions to TE
paths can be done based on the source UDP port ranges (if these are
assigned based on the PDU session QCIs, as done in some deployments
with 4G/LT) of the GTP-U encapsulated packet or based on the 5QI or
RQI values in the GTP-U header. Here, TNF as shown in Figure 1 need

not be part of the 5G Service Based Interface (SBI). Only management
plane functionality is needed to create, monitor, manage and delete
(life cycle management) the transport TE paths/transport slices from
gNB to UPF (on N3/N9 interfaces). This approach provide partial
integration of the transport network into 5GS with some benefits.

One of the limitations of this approach is the inability of 5GS
procedures to know, if underlying transport resources are available
for the traffic type being carried in PDU session before making
certain decisions in the 5G CP. One example scenario/decision could
be, a target gNB selection in Xn mobility in SSC Mode1, without
knowing if the target gNB is having a underlay transport slice
resource for the 5QI of the PDU session. The below approach can
mitigate this.

2.2. Integrated Approach

Network Slice Selection Function (NSSF) as defined in
[TS.23.501-3GPP] concerns with multiple aspects related to creation,
selection, mobility, roaming and co-ordination among other CP
functions in 5GS. However, the scope is only in 5GC (both control
and user plane) and NG Radio Access network including N3IWF for non-
3GPP access. Slice functionality is per PDU session granularity.
While this fully covers needed functionality and resources from UE
registration, Tracking Area (TA) updates, mobility and roaming,
resources and functionalities needed from transport network is not
specified. This is seen as independent functionality though part of
5GS. If transport network is not factored in an integrated fashion
w.r.t available resources (with network characteristics from desired
bandwidth, latency, burst size handling and optionally jitter) some
of the gains made with optimizations through 5GNR and 5GC can be
degraded.

To assuage the above situation, TNF is described (Figure 1) as part
of control plane. This has the view of the underlying transport
network with all links and nodes as well as various possible underlay
paths with different characteristics. TNF can be seen as supporting
PCE functionality [RFC5440] and optionally BGP-LS [RFC7752] to get
the TE and topology information of the underlying IGP network.

A south bound interface Ns is shown which interacts with the gNB/CSR.
'Ns' can use one or more mechanism available today (PCEP [RFC5440],
NETCONF [RFC6241], RESTCONF [RFC8040] or gNMI) to provision the L2/L3
VPNs along with TE underlay paths from gNB to UPF.

These VPNs and/or underlay TE paths MUST be similar on all gNB/CSRs
and UPFs concerned to allow mobility of UEs while associated with one
of the Slice/Service Types (SSTs)as defined in [TS.23.501-3GPP]. A

north bound interface 'Nn' is shown from one or more of the transport
network nodes (or ULCL/BP UPF, Anchor Point UPF) to TNF as shown in
Figure 1. It would enable learning the TE characteristics of all
links and nodes of the network continuously (through BGP-LS [RFC7752]
or through a passive IGP adjacency and PCEP [RFC5440]).

With the TNF in 5GS Service Based Interface, the following additional
functionalities are required for end-2-end slice management including
the transport network:

o In the Network Slice Selection Assistance Information (NSSAI) PDU
   session's assigned transport VPN and the TE path information is
   needed.

o For transport slice assignment for various SSTs (eMBB, URLLC,
   MIoT) corresponding underlay paths need to be created and
   monitored from each transport end point (gNB/CSR and UPF).

o During PDU session creation, apart from radio and 5GC resources,
   transport network resources needed to be verified matching the
   characteristics of the PDU session traffic type.

o Mapping of PDU session parameters to underlay SST paths need to be
   done. One way to do this is through 5QI/QFI information in the
   GTP-U header and map the same to the underlying transport path
   (including VPN or PW). This works for uplink (UL) direction.

o For downlink direction RQI need to be considered to map the DL
   packet to one of the underlay paths at the UPF.

o If any other form of encapsulation (other than GTP-U) either on N3
   or N9 corresponding 5QI/QFI or RQI information MUST be there in
   the encapsulation header.

o If SSC Mode3 Section 3.4.3 is used, segmented path (gNB to
   staging/ULCL/BP-UPF to anchor-point-UPF) with corresponding path
   characteristics MUST be used. This includes a path from gNB/CSR
   to UL-CL/BP UPF [TS.23.501-3GPP] and UL-CL/BP UPF to eventual UPF
   access to DN.

o Continuous monitoring of transport path characteristics and
   reassignment at the endpoints MUST be performed. For all the
   effected PDU sessions, degraded transport paths need to be updated
   dynamically with similar alternate paths.

o During UE mobility event similar to 4G/LTE i.e., gNB mobility (Xn
   based or N2 based), for target gNB selection, apart from radio
   resources, transport resources MUST be factored. This enables

handling of all PDU sessions from the UE to target gNB and this
require co-ordination of AMF, SMF with the TNF module.

Changes to detailed signaling to integrate the above for various 5GS
procedures as defined in [TS.23.502-3GPP] is beyond the scope of this
document.

3. Using PPR as TN Underlay

In a network implementing source routing, packets may be transported
through the use of Segment Identifiers (SIDs), where a SID uniquely
identifies a segment as defined in [I-D.ietf-spring-segment-routing].
Section 5.3 [I-D.bogineni-dmm-optimized-mobile-user-plane] lays out
all SRv6 features along with a few concerns in Section 5.3.7 of the
same document. Those concerns are addressed by a new backhaul
routing mechanism called Preferred Path Routing (PPR), of which this
Section provides an overview.

The label/PPR-ID refer not to individual segments of which the path
is composed, but to the identifier of a path that is deployed on
network nodes. The fact that paths and path identifiers can be
computed and controlled by a controller, not a routing protocol,
allows the deployment of any path that network operators prefer, not
just shortest paths. As packets refer to a path towards a given
destination and nodes make their forwarding decision based on the
identifier of a path, not the identifier of a next segment node, it
is no longer necessary to carry a sequence of labels. This results
in multiple benefits including significant reduction in network layer
overhead, increased performance and hardware compatibility for
carrying both path and services along the path.

Details of the IGP extensions for PPR are provided here:

o IS-IS - [I-D.chunduri-lsr-isis-preferred-path-routing]

o OSPF - [I-D.chunduri-lsr-ospf-preferred-path-routing]

3.1. PPR with Transport Slicing aware Mobility on N3/N9

PPR does not remove GTP-U, unlike some other proposals laid out in
[I-D.bogineni-dmm-optimized-mobile-user-plane]. Instead, PPR works
with the existing cellular user plane (GTP-U) for both N3 and any
approach selected for N9 (encap or no-encap). In this scenario, PPR
will only help providing TE benefits needed for 5G slices from
transport domain perspective. It does so without adding any
additional overhead to the user plane, unlike SR-MPLS or SRv6. This
is achieved by:

o For 3 different SSTs, 3 PPR-IDs can signaled from any node in the
   transport network. For Uplink traffic, gNB will choose the right
   PPR-ID of the UPF based on the 5QI value in the encapsulation
   header of the PDU session. Similarly in the Downlink direction
   matching PPR-ID of the gNB is chosen for the RQI value in the
   encapsulated SL payload. The table below shows a typical mapping:

5QI (Ranges)/ RQI (Ranges)	SST	Transport Path Info	Transport Path Characteristics
Range Xx - Xy X1, X2(discrete values)	MIOT (massive IOT)	PW ID/VPN info, PPR-ID-A	GBR (Guaranteed Bit Rate) Bandwidth: Bx Delay: Dx Jitter: Jx
Range Yx - Yy Y1, Y2(discrete values)	URLLC (ultra-low latency)	PW ID/VPN info, PPR-ID-B	GBR with Delay Req. Bandwidth: By Delay: Dy Jitter: Jy
Range Zx - Zy Z1, Z2(discrete values)	EMBB (broadband)	PW ID/VPN info, PPR-ID-C	Non-GBR Bandwidth: Bx

Figure 2: 5QI/RQI Mapping with PPR-IDs on N3/N9

o It is possible to have a single PPR-ID for multiple input points
   through a PPR tree structure separate in UL and DL direction.

o Same set of PPRs are created uniformly across all needed gNBs and
   UPFs to allow various mobility scenarios.

o Any modification of TE parameters of the path, replacement path
   and deleted path needed to be updated from TNF to the relevant
   ingress points. Same information can be pushed to the NSSF, AMF
   and SMF as needed.

o PPR can be supported with any native IPv4 and IPv6 data/user
   planes (Section 3.2 with optional TE features Section 3.3 . As

   this is an underlay mechanism it can work with any overlay
   encapsulation approach including GTP-U as defined currently for N3
   interface.

3.2. Path Steering Support to native IP user planes

   PPR works in fully compatible way with SR defined user planes (SR-
   MPLS and SRv6) by reducing the path overhead and other challenges as
   listed in [I-D.chunduri-lsr-isis-preferred-path-routing] or
   Section 5.3.7 of [I-D.bogineni-dmm-optimized-mobile-user-plane]. PPR
   also expands the source routing to user planes beyond SR-MPLS and
   SRv6 i.e., native IPv6 and IPv4 user planes.

   This helps legacy transport networks to get the immediate path
   steering benefits and helps in overall migration strategy of the
   network to the desired user plane. It is important to note, these
   benefits can be realized with no hardware upgrade except control
   plane software for native IPv6 and IPv4 user planes.

3.3. Service Level Guarantee in Underlay

   PPR also optionally allows to allocate resources that are to be
   reserved along the preferred path. These resources are required in
   some cases (for some 5G SSTs with stringent GBR and latency
   requirements) not only for providing committed bandwidth or
   deterministic latency, but also for assuring overall service level
   guarantee in the network. This approach does not require per-hop
   provisioning and reduces the OPEX by minimizing the number of
   protocols needed and allows dynamism with Fast-ReRoute (FRR)
   capabilities.

3.4. PPR with various 5G Mobility procedures

   PPR fulfills the needs of 5GS to transport the user plane traffic
   from gNB to UPF in all 3 SSC modes defined [TS.23.501-3GPP]. This is
   done in keeping the backhaul network at par with 5G slicing
   requirements that are applicable to Radio and virtualized core
   network to create a truly end-to-end slice path for 5G traffic. When
   UE moves from one gNB to another gNB, there is no transport network
   reconfiguration require with the approach above.

   SSC mode would be specified/defaulted by SMF. No change in the mode
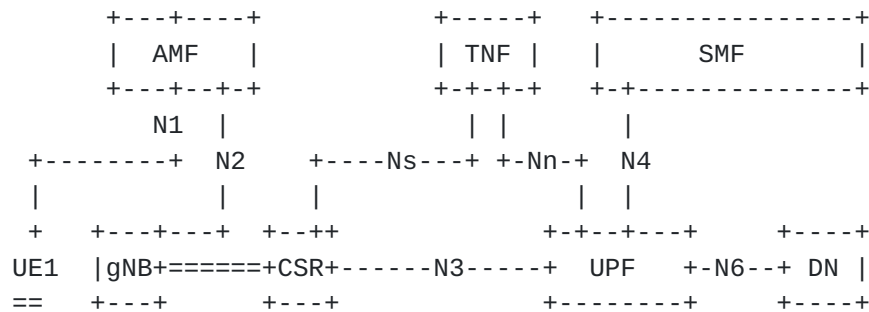   once connection is initiated and this property is not altered here.

3.4.1. SSC Mode1

```
        +---+----+              +-----+   +----------------+
        |  AMF   |              | TNF |   |      SMF       |
        +---+--+-+              +-+-+-+   +-+--------------+
          N1   |                  | |       |
   +--------+  N2     +----Ns---+ +-Nn-+  N4
   |           |      |             |  |
   +    +---+---+  +--++            +-+--+---+     +----+
  UE1   |gNB+======+CSR+------N3-----+  UPF   +-N6--+ DN |
  ==     +---+        +---+            +--------+     +----+
```

Figure 3: SSC Mode1 with integrated Transport Slice Function

After UE1 moved to another gNB in the same UPF serving area

```
        +---+----+              +-----+   +----------------+
        |  AMF   |              | TNF |   |      SMF       |
        +---_--+-+              +-+-+-+   +-+--------------+
             |                    | |        |
            N2     +----Ns---+ +-Nn-+   N4
             |      |             |  |
    +----+--+    +-+-+            ++--+----+     +----+
    |gNB1+======+CSR+------N3-----+  UPF   +-N6--+ DN |
    +----+        +---+            +---+----+     +----+
                                      |
                                      |
                                      |
                                      |
    +----+        +--++               |
  UE1   |gNB2+======+CSR+------N3--------+
  ==    +----+        +---+
```
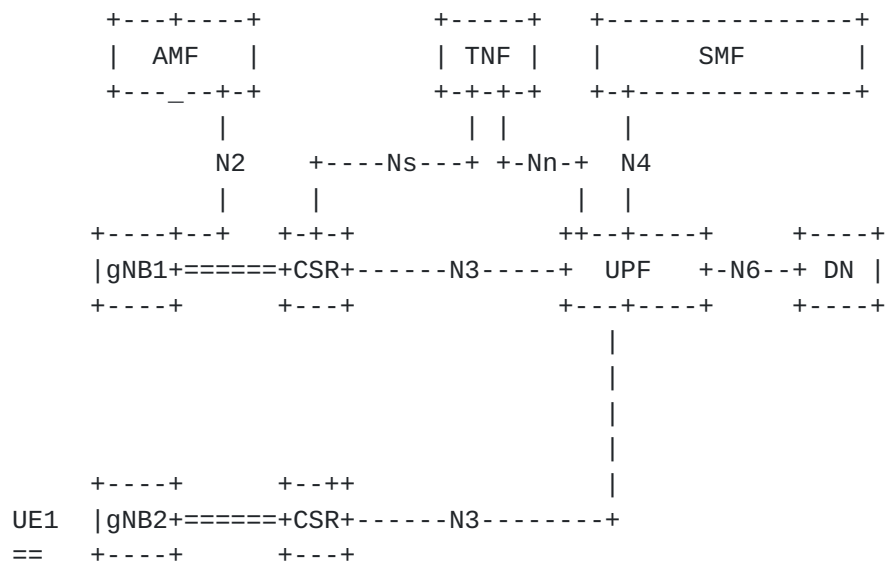
Figure 4: SSC Mode1 with integrated Transport Slice Function

In this mode, IP address at the UE is preserved during mobility
events. This is similar to 4G/LTE mechanism and for respective
slices, corresponding PPR-ID (TE Path) has to be assigned to the
packet at UL and DL direction. During Xn mobility as shown above,
AMF has to additionally ensure transport path's resources from TNF
are available at the target gNB apart from radio resources check (at
decision and request phase of Xn/N2 mobility scenario).

3.4.2. SSC Mode2

In this case, if IP Address is changed during mobility (different UPF
area), then corresponding PDU session is released. No session
continuity from the network is provided and this is designed as an
application offload and application manages the session continuity,
if needed. For PDU Session, Service Request and Mobility cases
mechanism to select the transport resource and the PPR-ID (TE Path)
is similar to SSC Mode1.

3.4.3. SSC Mode3

In this mode, new IP address may be assigned because of UE moved to
another UPF coverage area. Network ensures UE suffers no loss of
'connectivity'. A connection through new PDU session anchor point is
established before the connection is terminated for better service
continuity.

```
        +---+----+              +-----+   +----------------+
        |  AMF   |              | TNF |   |      SMF       |
        +---+--+-+              +-+-+-+   +-+-----------+--+
           N1  |                 | |        |           |
    to-UE+----+  N2 +-------Ns---+ +-Nn-+  N4         N4|
           |  |                    | |        |           |
        +-------+--+         +--+-------+--+    +-----+-+
        |gNB/CSR   +---N3---+ BP/ULCL UPF +-N9--+  UPF  +-N6--
        +----------+         +----------+--+    +-------+ to DN
                                        | +----+
                                        +-| DN |
                                     N6  +----+
```
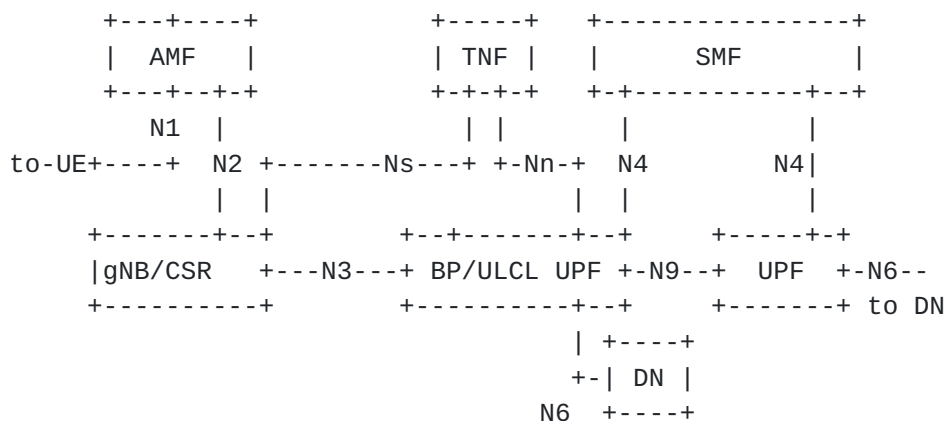
                Figure 5: SSC Mode3 and Service Continuity

In the uplink direction for the traffic offloading from UL/CL case,
packet has to reach to the right exit UPF. In this case packet gets
re-encapsulated with ULCL marker (with either GTP-U or the chosen
encapsulation) after bit rate enforcement and LI to the anchor UPF.
At this point packet has to be on the appropriate VPN/PW to the
anchor UPF. This mapping is done based on the 5QI to the PPR-ID of
the exit node by selecting the respective TE PPR-ID (PPR path) of the
UPF. If it's a non-MPLS underlay, destination IP address of the
encapsulation header would be the mapped PPR-ID (TE path).

In the downlink direction for the incoming packet, UPF has to
encapsulate the packet (with either GTP-U or the chosen
encapsulation) to reach the BP/ULCL UPF. Here mapping is done for
RQI parameter in the encapsulation header to PPR-ID (TE Path) of the
BP/ULCL UPF. If it's a non-MPLS underlay, destination IP address of
the encapsulation header would be the mapped PPR-ID (TE path). In
summary:

o Respective PPR-ID on N3 and N9 has to be selected with correct
   transport characteristics from TNF.

o For N2 based mobility AMF/SMF has to ensure transport resources
   are available for N3 Interface to new ULCL and from there the
   original anchor point UPF.

o For Service continuity with multi-homed PDU session same transport
   network characteristics of the original PDU session (both on N3
   and N9) need to be observed for the newly created PDU session.

4. Other TE Technologies Applicability

RSVP-TE [RFC3209] provides a lean transport overhead for the TE path
for MPLS user plane. However, it is perceived as less dynamic in
some cases and has some provisioning overhead across all the nodes in
N3 and N9 interface nodes. Also it has another drawback with
excessive state refresh overhead across adjacent nodes and this can
be mitigated with [RFC8370].

SR-TE [I-D.ietf-spring-segment-routing] does not explicitly signal
neither bandwidth reservation nor mechanism to guarantee latency on
the nodes/links on SR path. But, SR allows path steering for any
flow at the ingress and particular path for a flow can be chosen.
Some of the issues around path overhead/tax, MTU issues are
documented at Section 5.3 of
[I-D.bogineni-dmm-optimized-mobile-user-plane]. Also SR allows
reduction of the control protocols to one IGP (with out needing for
LDP and RSVP).

However, as specified above with PPR (Section 3), in the integrated
transport network function (TNF) a particular RSVP-TE path for MPLS
or SR path for MPLS and IPv6 with SRH user plane, can be supplied to
NSSF/AMF/SMF for mapping a particular PDU session to the transport
path.

5. **New Control Plane and User Planes**

5.1. **LISP and PPR**

   PPR can also be used with LISP control plane for 3GPP as described in
   [I-D.farinacci-lisp-mobile-network]. This can be achieved by mapping
   the UE IP address (EID) to PPR-ID, which acts as Routing Locator
   (RLOC). Any encapsulation supported by LISP can work well with PPR.
   If the RLOC refers to an IPv4 or IPv6 destination address in the LISP
   encapsulated header, packets are transported on the preferred path in
   the network as opposed to traditional shortest path routing with no
   additional user plane overhead related to TE path in the network
   layer.

   Some of the distinct advantages of the LISP approach is, its
   scalability, support for service continuity in SSC Mode3 as well as
   native support for session continuity (session survivable mobility).
   Various other advantages are documented at
   [I-D.farinacci-lisp-mobile-network].

5.2. **ILA and PPR**

   If an ILA-prefix is allowed to refer to a PPR-ID, ILA can be
   leveraged with all the benefits (including mobility) that it
   provides. This works fine in the DL direction as packet is destined
   to UE IP address at UPF. However, in the UL direction, packet is
   destined to an external internet address (SIR Prefix to ILA Prefix
   transformation happens on the Source address of the original UE
   packet). One way to route the packet with out bringing the complete
   DFZ BGP routing table is by doing a default route to the UPF (ILA-R).
   In this case, how TE can be achieved is TBD (to be expanded further
   with details).

6. **Summary and Benefits with PPR**

   This document specifies an approach to transport and slice aware
   mobility with a simple mapping function from PDU Session to transport
   path applicable to any TE underlay.

   This also describes PPR
   [I-D.chunduri-lsr-isis-preferred-path-routing], a transport underlay
   routing mechanism, which helps with goal of optimized user plane for
   N9 interface. PPR provides a method for N3 and N9 interfaces to
   support transport slicing in a way which does not erase the gains
   made with 5GNR and virtualized cellular core network features for
   various types of 5G traffic (e.g. needing low and deterministic
   latency, real-time, mission-critical or AR/VR traffic). PPR provides
   path steering, optionally guaranteed services with TE, unique Fast-

ReRoute (FRR) mechanism with preferred backups (beyond shortest path backups through existing LFA schemes) in the mobile backhaul network with any underlay being used in the operator's network (IPv4, IPv6 or MPLS) in an optimized fashion.

7. Acknowledgements

TBD.

8. IANA Considerations

This document has no requests for any IANA code point allocations.

9. Security Considerations

This document does not introduce any new security issues.

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Authors' Addresses

   Uma Chunduri (editor)
   Huawei USA
   2330 Central Expressway
   Santa Clara, CA 95050
   USA

   Email: uma.chunduri@huawei.com

Richard Li
Huawei USA
2330 Central Expressway
Santa Clara, CA 95050
USA

Email: renwei.li@huawei.com

Jeff Tantsura
Nuage Networks
755 Ravendale Drive
Mountain View, CA 94043
USA

Email: jefftant.ietf@gmail.com

Luis M. Contreras
Telefonica
Sur-3 building, 3rd floor
Madrid 28050
Spain

Email: luismiguel.contrerasmurillo@telefonica.com

Xavier De Foy
InterDigital Communications, LLC
1000 Sherbrooke West
Montreal
Canada

Email: Xavier.Defoy@InterDigital.com