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SPRING Use cases for Mobile Network
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Abstract

The ability for a node to specify a forwarding path, other than the normal shortest path, that a particular packet will traverse, benefits a number of network functions. Source-based routing mechanisms have previously been specified for network protocols, but have not seen widespread adoption. In this context, the term 'source' means 'the point at which the explicit route is imposed'.

The objective of this document is to illustrate some use cases that provide the traffic engineering and the load balancing for mobile and transport network, applying segment routing.

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Table of Contents

1. Introduction

In a mobile network, GTP is the protocol developed for tunneling and encapsulation of data units and control messages in GPRS. GTP for the Evolved 3GPP system comes in two variants, control and user plane. The control plane GTP-C handles the signaling, and it is needed in addition to the protocol for pure transfer of user related data, GTP-U. [3GPP TS 23.060]

GTP-U is used for carrying user data within the GPRS core network and between the radio access network and the core network. The user data transported can be packets in any of IPv4 or IPv6 formats. GTP-C is out of scope in this document.

IP packets are forwarded through the GTP tunnel between the P-GW and the eNB for transmission to the UE in a mobile network. These GTP tunnels are established per EPS bearer when a user is attached to the LTE network. EPS uses the concept of EPS bearers to route IP traffic from a gateway in the PDN to the UE. A bearer is an IP packet flow with a defined quality of service (QoS) between the gateway and the UE.

On the other hand, IP transport networks may provide data transmission and interaction between the gateways and the UE. The mobile nodes are connected to an IP transport network in overlay. Therefore the mapping between transport nodes and mobile nodes may be needed to consistently guarantee QoS in terms of priority control, traffic engineering and load balancing.

For simplicity we only describe GTP tunneling in the context of LTE (Long Term Evolution), which aims to provide seamless Internet Protocol (IP) connectivity between user equipment (UE) and the packet data network (PDN). Indeed GTP tunneling also applies to earlier generations of mobile networks, such as purely UMTS-based mobile networks.

Segment routing mechanisms [draft-ietf-spring-problem-statement] have been developed to provide the traffic engineering and the load balancing for networks. These mechanisms are also applicable to an IP-based mobile and transport network. Therefore this document addresses how to utilize segment routing mechanisms in a mobile network.

The objective of this document is to illustrate some use cases that provide QoS in a mobile and transport network by applying segment routing.

1.1. Terminology and abbreviations

Much of the terminology used in this document has been defined by the 3rd Generation Partnership Project (3GPP), which defines standards for mobile service provider networks. Although a few terms are defined here for convenience, further terms can be found in [RFC6459].

AS   Access Switch

AR   Aggregation Router

CE   Customer Edge Router

EPC Evolved Packet Core

EPS Evolved Packet System

ER   Edge Router

GTP GPRS (General Packet Radio Service) Tunneling Protocol

GTP-U GTP user data tunneling

UE   User equipment like tablets or smartphones

eNB enhanced NodeB, radio access part of the LTE system

S-GW Serving Gateway, primary function is user plane mobility

P-GW Packet Gateway, actual service creation point, terminates 3GPP mobile network, interface to Packet Data Networks (PDN)

PE   Provider Edge Router

HSS Home Subscriber System (control plane element)

MME Mobility Management Entity (control plane element)

S-IP Source IP address

D-IP Destination IP address

IMSI The International Mobile Subscriber Identity that identifies a mobile subscriber

PCRF 3GPP standardized Policy and Charging Rules Function

2. Mobile network overview

The major functional components of a LTE network are shown in Figure 1 and include user equipment (UE) like smartphones or tablets, the LTE radio unit named enhanced NodeB (eNB), the serving gateway (S-GW) which together with the mobility management entity (MME) takes care of mobility and the packet gateway (P-GW), which finally terminates the actual mobile service. These elements are described in detail in [TS.23.401]. Other important components are the home subscriber system (HSS) and the policy and charging rule function (PCRF), which are described in [TS.23.203]. The P-GW interface towards the SGi-LAN is called the SGi-interface, which is described in [TS.29.061].

In LTE, a mobile network consists of some LTE components (specifically EPS) and GTP connections between eNB and S-GW, and between S-GW and P-GW are established, as shown in Figure 1. An IP packet for a UE is encapsulated in a GTP-U packet and tunneled cross multiple interfaces (the S5/S8 interface from the P-GW to the S-GW, the S1 interface from the S-GW to the eNB), and the radio interface from the eNB to the UE.

The LTE components would be connected in overlay to MPLS components such as AS, AR and ER in an IP transport network. The interactions between LTE components occur through MPLS components.

EPS provides the user with IP connectivity to a PDN for accessing the Internet, as well as for running services such as Voice over IP (VoIP). An EPS bearer is typically associated with a QoS. Multiple bearers can be established for a user in order to provide different QoS streams or connectivity to different PDNs.

```
   +----------------------------------------+
   | Mobile Network       [HSS]             |    [OTT Appl. Platform]
   |                        |               |              |
   |           +--------- [MME]  [PCRF]-----+--------+     |
   |           |            |      |        |        |     |
   |           +         [S-GW]  [P-GW]     |        |  Internet
   |           |     S1-U   |S5/S8 |        |        |     |
   | [UE] -- [eNB]----------+------+        |        |     |
   |           |                   |        |        |     |
   +===========|===================|========+  +-----+-----+-------+
   |           |                   |        |  |                   |
   |         [AS] - [AR(PE)] == [ER(PE)] == +--+----[SGi-LAN]      |
   |                                        |  |        |          |
   |                                        |  |        |          |
   |                                        |  | [Appl. Platform]  |
   | IP Transport Network                   |  |                   |
   +----------------------------------------+  +-------------------+
```

Figure 1 Architecture for mobile and transport network

2.1. GTP tunneling

GTP-U tunnels are used to carry encapsulated T-PDUs and signalling messages between a given pair of GTP-U Tunnel Endpoints. The Tunnel Endpoint ID (TEID) which is present in the GTP header shall indicate which tunnel a particular T-PDU belongs to. In this manner, packets are multiplexed and de-multiplexed by GTP-U between a given pair of Tunnel Endpoints. G-PDU is user data packet (T-PDU) plus GTP-U header, sent between GTP network nodes. T-PDU is a user data packet, for example an IP datagram, sent between a UE and a network entity in an external packet data network. A T-PDU is the payload that is tunneled in the GTP-U tunnel [3GPP TS 29.281].

GTPv1-U tunnel endpoints do not need to perform any IP routing functions in respect to inner IP packet since it shall be encapsulated at the GTPv1-U sender with a GTP header, Outer UDP and IP header.

Outer UDP/IP is the only path protocol defined to transfer GTP messages in a mobile network. The UDP source port may be allocated dynamically by the sending GTP-U entity. Dynamic allocation of the UDP source port may help balancing the load in the network even though the scheme does not allow to deterministically force a specific path, using ECMP.

For illustration, Figure 2 shows how the GTP encapsulation process works. The user data packet itself including the header and payload is preserved and kept unchanged. The packet is just added a GTP header used by the receiving end to identify which tunnel the packet is associated to. This GTP encapsulated packet is transported between the two tunnel endpoints using a transport layer header, specifically an outer IP/UDP header.

```
+----------+-----------+--------+----------+-----------+
| Outer IP | Outer UDP | GTP-U  |   User Data Packet   |
|  Header  |  Header   | Header |    (IP datagram)     |
+----------+-----------+--------+----------+-----------+
|<-------------------->|<---------------------------->|
|Transport layer header|        GTP-U message         |
```

Figure 2 GTP encapsulation

2.2. Quality of Service (QoS)

In a typical case, multiple applications may be running in a UE at any time, each one having different QoS requirements. For example, a UE can be engaged in a VoIP call while at the same time browsing a web page or downloading an FTP file. VoIP has more stringent requirements for QoS in terms of delay and delay jitter than web browsing and FTP, while the latter requires a much lower packet loss rate. In order to support multiple QoS requirements, different bearers are set up within the Evolved Packet System, each being associated with a QoS.

In the access network, it is the responsibility of the eNB to ensure the necessary QoS for a bearer over the radio interface. Each bearer has an associated QoS Class Identifier (QCI), and an Allocation and Retention Priority (ARP). The QCI specifies values for the priority handling, acceptable delay budget and packet loss rate for each QCI label. The QCI label for a bearer determines how it is handled in the eNB.

IP packets mapped to the same EPS bearer receive the same bearer-level packet forwarding treatment. In order to provide different bearer-level QoS, a separate EPS bearer must therefore be established for each QoS flow. User IP packets must then be filtered into the appropriate EPS bearers [3GPP TS.23.203].

Meanwhile, considerations about traffic engineering schemes and different QoS requirements would not explicitly mentioned until now in terms of IP transport network.

In addition, a simple traffic engineering scheme using ECMP would lead to no load balancing and result to inefficient use of transport resources because mobile services have different type of application and QoS requirements. Congestion on the shortest path link could be difficult to avoid when network status is not normal, for example the higher than usual traffic demand and dynamically changing traffic patterns.

In this regard, segment routing is regarded as a good way to provide traffic engineering and load balancing for IP transport network in mobile environment.

3. Use case

LTE nodes (e.g., eNB, S-GW and P-GW) in overlay are connected to the routers in a transport network and have interactions with each other via them. LTE components are assumed to have multiple interfaces to the routers and an interface for packet forwarding would be selected, depending on PCE's decision. PCE makes path computation using traffic matrix that describes the bandwidth requirements between sources and destinations in a network.

In order to more clearly explain use cases for a mobile network, LTE nodes with multi-paths through IP transport nodes are shown in Figure 3. Each LTE node is connected to IP transport nodes that have corresponding two transport paths alternatively. Two shortest paths between LTE nodes, B-C and G-H, are assumed respectively. Two alternative paths between LTE nodes, A-E-D and F-I, are assumed respectively.

An UE is connected to Internet (actually, a certain server) via both mobile and transport nodes. In the example when the higher than usual traffic is occurring, the shortest path between eNB and P-GW (segment list eNB=B=C=S-GW=G=H=P-GW) has low delay but is highly utilized. As a result, no load balancing will happen and QoS requirements of the different applications will not be satisfied. In this regard, an alternative path should be selected by using a segment list (eNB=A=E=D=S-GW=F=I=P-GW) instead. With explicit path allocation to dynamically changing traffic patterns, inefficient use

of transport resources and QoS degradations could be avoided. Therefore in a mobile network, segment routing would lead to more optimal load distribution and forwarding for different types of applications.

For example, a specific path would be chosen by analyzing QCI since it could represent QoS characteristics in terms of packet delay and packet loss. Higher delay and underutilized path could be used for delivery of delay insensitive service as represented by QCI.

```
     UE-----eNB=====S-GW=====P-GW----Internet
             | \   /  | |\    / |
             A  B-C   D F G---
-                               -                              H  I
              \      /   \      |
               E----+     +-----+
```

Figure 3 LTE nodes connected to multi-paths via IP transport nodes

4. Security Considerations

TBD

5. IANA Considerations

TBD

6. References

6.1. Normative References

None

6.2. Informative References

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7. Acknowledgments

TBD

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