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Octets	8	7	6	5	4	3	2	1
1	Next Header							
2	Header Extension Length = n							
3	Routing Type = 0x04							
4	Segment Left							
5	Last Entry = m							
6	Flags							
7	Tag (1 st Octet)							
8	Tag (2 nd Octet)							
p to (p+15)	Segment List [0] (128 bits IPv6 Address)							
...	...							
q to (q+15)	Segment List [m] (128 bits IPv6 Address)							
(q+16) to (8n+8)	Optional Type Length Value objects (variable)							

Fig. 1

(57) **Abstract:** A transmitting entity of a mobile communications system encapsulates data packets of a session between network elements of the mobile communications system into IPv6 headers and forwards the data packets to a receiving entity. Each of the IPv6 headers comprises a source address of the transmitting entity for transmitting the data packets and a destination address of the receiving entity for receiving the data packets. A tunnel endpoint identifier which is to be used for user plane transport between the transmitting entity and the receiving entity is encoded in the destination address.



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TUNNEL ENDPOINT ENCODING FOR MOBILE NETWORK ARCHITECTURE

TECHNICAL FIELD

At least some embodiments relate to encoding a tunnel endpoint (TE) identifier (ID), e.g. a GTP-U TE ID, into any IPv6 based mobile network architecture, e.g. segment routing (SRv6) architecture.

BACKGROUND

GTP-U is used for carrying user data within a GPRS core network and between a radio access network and the GPRS core network. GTP-U is also used between network elements, e.g. radio access network elements. According to GPRS, a UE session is mapped 1-to-1 to a specific GTP tunnel (e.g. TE ID).

LIST OF ABBREVIATIONS

15	3GPP	Third Generation Partnership Project
	4/5G	Fourth/Fifth Generation
	5GC	5G Core
	AMF	Access and Mobility Management Function
	ARP	Address Resolution Protocol
20	DN	Data Network (=The Internet)
	DHCP	Dynamic Host Configuration Protocol
	EUI-64	Extended Unique Identifier (EUI), allows a host to assign itself a unique 64-Bit IPv6 interface identifier (EUI-64)
	F1	Logical interface in 5G , between gNB-CU and gNB-DU
25	F1 AP ID	F1 Application Protocol ID
	FIB	Forwarding Information Base
	gNB	New radio (5G) node B (BTS)
	gNB-CU	gNB-Centralized Unit
	gNB-DU	gNB-Distributed Unit
30	GPRS	General Packet Radio Service
	GTP	GPRS Tunneling Protocol
	GTP-U	GTP-User Plane
	ID	Identifier
	IETF	Internet Engineering Task Force
35	IETF DMM	IETF Distributed Mobility Management

	IGP	Interior Gateway Protocol
	LTE	Long Term Evolution
	N3	5G logical interface between gNB - UPF
	N6	5G logical interface between UPF – Data Network
5	N9	5G logical interface UPF – UPF
	ND	Neighbor Discovery
	NG	interface between NG-RAN and 5GC
	NR	New Radio
	PCE	Path Computation Element
10	PE	Provider Edge
	RAN	Radio Access Network
	SID	Segment ID
	SR	Segment Routing
	SRv6	Segment Routing IPv6
15	TE ID	GTP-U Tunnel Endpoint ID
	UE	User Equipment
	UPF	User Plane function
	X2	LTE/4G interface between eNodeBs
	Xn	5G interface between gNodeBs

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SUMMARY

At least some embodiments are directed to a definition of mapping of TE ID into an IPv6 address, e.g. SID. Preferably, the mapping is defined such that TE ID does not need to be unique over all gNBs served by a particular UPF.

25

Further, at least some embodiments are concerned with a definition of how segment routing is used in F1 and X2/Xn interfaces, NG interface, as well as in pre-5G systems such as GPRS, 3G, HSPA, LTE, which use GTP-U tunneling.

30 Methods, apparatuses and non-transitory storage media according to at least some embodiments are specified by the appended claims.

In the following, example embodiments will be described with reference to the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a diagram illustrating an IPv6 segment routing extension header format.

- 5 Fig. 2 shows a diagram illustrating an IPv6 address structure according to at least some embodiments.

Fig. 3 shows flowcharts illustrating processes according to at least some embodiments.

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Fig. 4 shows a schematic block diagram illustrating SRv6 nodes and interfaces.

Fig. 5 shows a schematic diagram illustrating an SRv6 architecture in which an example embodiment is applied.

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Fig. 6 shows a signaling diagram illustrating a PDU session resource setup.

Fig. 7 shows a schematic block diagram illustrating a configuration of entities in which examples of embodiments are implementable.

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DESCRIPTION OF THE EMBODIMENTS

For example, in Segment Routing (SR) architecture which is an example of an IPv6 based mobile network architecture, an SID is a segment identifier which represents a specific segment in a segment routing domain. The SID type that
25 may be used is an IPv6 address, and also is referred to as SRv6 Segment or SRv6 SID.

It is to be noted that the IPv6 address definition as proposed according to at least some embodiments is applicable in any architecture that uses IPv6
30 addresses with or without SRv6 capability.

In a GPRS mobile network, for example, an UE session is mapped 1-to-1 to a specific GTP tunnel (e.g. TE ID). This 1-to-1 mapping is replicated in SR architecture to replace the GTP encapsulations with SRv6 encapsulations. This

approach minimizes the changes required for the entire mobile communications system. Note that in this approach the TE ID is embedded in each SID.

The UE session is set up between the UE and the mobile core network. The UE session is supported by several underlying legs or components, like the air interface, possibly F1 interface, NG interface, and so forth. User packets are encapsulated with GTP-U e. g. on the F1 and NG interfaces.

A segment routing (SR) header is illustrated in Fig. 1.

In octets p to q+15 of the SR header shown in Fig. 1, segments 0 to m, e.g. IPv6 addresses 0 to m, may be included in a Segment List[n]. In other words, Segment List [n] contains a 128 bit IPv6 address representing the nth segment in the segment list. The segment list is encoded starting from the last segment of an SR policy. In other words, the first element of the segment list, i.e. Segment List [0], contains the last segment of the SR policy, the second element contains the penultimate segment of the SR policy, and so on.

At least some embodiments are directed to how the TE ID fills the SID field. For example, typically there are multiple NG interfaces, one for each gNB, e.g. 500 gNBs per UPF. So there may be same TE ID used in different gNBs in case TE ID is unique only per particular gNB.

Further, at least some embodiments define segment routing for F1 and X2/Xn interfaces.

According to at least some embodiments, a TE ID is encoded into an IPv6 address. The IPv6 address is a 128-bit field, whereas TE ID comprises 32 bits.

Fig. 2 illustrates an IPv6 address format. For a globally routable IPv6 unicast address, the first 64 bits form the network prefix (e.g. with 48 bit routing prefix and 16 bits for subnets), while the remaining 64 bits comprise an interface identifier (host portion).

The 32-bit (4-octet) TE ID is used to multiplex different connections in the same GTP tunnel and map the connection to a bearer/context. TE ID is assigned locally by the receiving entity.

- 5 TE ID is useful in the SID, since then the SR node has access to traffic flow on individual bearer basis. On the other hand, the IPv6 routing process should not be impacted.

10 Typically, the interface ID is automatically generated from a MAC address (EUI-64), is randomly generated, or is assigned manually or e.g. by DHCP (Dynamic Host Configuration Protocol). The interface ID has to be unique on the link.

15 According to at least some embodiments, at least one of TE ID, network element ID and logical interface ID is mapped into the host portion (interface ID) of an IPv6 address.

20 Since the TE ID is allocated by the receiving entity, TE ID itself is unique per the element assigning it. The value assigned by the receiving entity is carried to the peer (e.g. endpoint) by a radio network control plane (e.g. NG-AP, Xn AP, F1 AP). In the transport network, flows from multiple elements are present, and also same TE ID values may exist, consider e.g. downlink direction on the NG interface. Each gNB assigns a TE ID locally, without knowing (or needing to know) which values are assigned by other gNBs. In a transport network element (e.g. a router) which connects multiple gNBs, traffic flows to multiple gNBs are
25 routed. For example, this is the case in Fig. 5 for nodes 53, 54 and UPF1 55.

The IP flows in SRv6 for 5G (or for 3GPP mobile network in general) is bound to a logical interface, such as F1 or NG N3-interface. On that interface, a unique identifier exists, such as F1 AP ID on F1 interface. For example, in case of F1,
30 the definition of F1 AP ID is: The gNB-CU UE F1 AP ID uniquely identifies the UE association over the F1 interface between gNB-CU and gNB-DU. Similar IDs exist for NG, Xn, S1, etc. According to an example implementation, in Fig. 2, a logical interface ID in the host portion comprises such logical interface identifier.

35 According to another example implementation, for the element ID in Fig. 2 an identifier is used that identifies a network element, e.g. the receiving entity. An

example of such identifier is gNB-DU ID. The gNB-DU ID is independently configured from cell identifiers, i.e. there is no connection between gNB-DU ID and cell identifiers. The gNB-DU ID uniquely identifies the gNB-DU at least within a gNB-CU.

5

Since this network element ID is 36 bits, e.g. only the first 32 bits are used in the element ID, which still allows identification of enough gNB-DUs for most practical networks.

10 According to another example implementation, for the element ID in Fig. 2, gNB ID is used as network element identifier, which identifies a gNB.

Since gNB ID is a bit string of size 22 to 32 bits, gNB ID can be used alternatively to the AP ID. In case gNB ID is less than 32 bits, the remaining bit
15 positions can be filled with some selected value that is not used in the identification.

According to another example implementation, for the element ID in Fig. 2, NR cell identity is used, which identifies an NR cell.

20

The F1 AP ID (and similar IDs for NG, Xn, etc.) is a 32 bit field, gNB-DU ID is 32 bits, and gNB ID is 22 bits or more up to 32 bits, so all these identifiers can be used in the host portion, either together with the TE ID or with any combination of network element IDs and logical interface IDs.

25

In other words, according to an example implementation, the host portion comprises a combination of the element ID, logical interface ID and the TE ID. According to another example implementation, the host portion comprises a combination of element IDs or logical interface IDs, without comprising the TE
30 ID.

According to at least some embodiments, for application of segment routing as GTPU replacement on F1 interface, an identifier uniquely identifying an endpoint for user plane transport may comprise a combination of e. g. gNB-DU ID and TE
35 ID . This ensures a unique ID, as a combination of element ID and TE ID is

unique. IPv6 standard defines that e.g. a logical interface ID must be unique. This condition is not fulfilled by TE ID only but it is fulfilled with the combination of the element ID (e. g. gNB-DU ID) and TE ID, as illustrated in Fig. 2.

- 5 Alternatively, the 32 bits not originating from GTPU TE ID can be randomly generated. The drawback of this approach is that, first, it still is not guaranteed to be unique (duplicate address detection is needed), and moreover, second, encoding the element ID allows the SR node also to possibly take into account which logical interface instance or network element this particular bearer belongs to.
- 10 to.

Having the element ID such as gNB-DU ID included is useful e.g. for troubleshooting or for specific processing (rule) per a particular logical interface ID. For troubleshooting, it is now clear which network element the packet flow belongs to. Regarding rules, with the element ID, it is possible to have rules specific to the particular network element.

15

As mentioned above, at least some embodiments apply to the SRv6 segment routing architecture and also to a pure IPv6 architecture, where the TE ID and the additional element ID, or a combination of element IDs and/or logical interface IDs is mapped into the host portion, to allow identification of the bearer as well as the logical interface or network element it belongs to, by transport network elements, which otherwise are not aware of individual bearers or TE IDs.

20

- 25 Regarding assigning a "network" address to an interface, loopback address of mobile network element is one of the places, so that huge IPv6 ND traffic between side router and mobile network element can be avoided.

Now reference is made to Fig. 4 illustrating SRv6 nodes and interfaces according to a mobile communications system, in which example embodiments are implementable.

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According to an example implementation, a data packet from a UE 41 is encapsulated into Ipv6 headers at a gNB 42 and forwarded to UPF1 43 via an SRv6 (N3) interface 46. The encapsulating header has, as source address, the

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gNB's address and as destination address the UPF1's address. According to an example implementation, the TE ID is encoded in the UPF1's address <UPF1::TEID>, so that the 32 least significant bits of the interface ID represent the TE ID value upwards. Similarly, for packets in downlink direction, the address of the gNB 42 has the downwards TE ID value encoded in the interface ID part of the address.

Besides, the UPF1 43 is connected with UPF2 44 via an SRv6 [N9] interface 47, and the UPF2 44 is connected with a data network (DN) 45 via an N6 interface 48.

Fig. 3 illustrates processes according to at least some embodiments. According to an example embodiment, process 1 is executed by a radio access network element (e.g. gNB 42) as transmitting entity.

According to process 1, in step S310, data packets of a session between network elements (e.g. a user equipment (e.g. UE 41) and the radio access network element (e.g. gNB 42)) of a mobile communications system are encapsulated into Ipv6 headers, each Ipv6 header comprising a source address of the transmitting entity (e.g. the gNB 42) for transmitting the data packets and a destination address of a receiving entity (e.g. the UPF1 43) for receiving the data packets, wherein a tunnel endpoint identifier (e.g. TE ID, TNL address, element ID(s), logical interface ID(s)) is encoded in the destination address. The tunnel endpoint identifier is to be used for user plane transport between the transmitting entity and the receiving entity.

In step S312, the data packets are forwarded to the receiving entity. After step S312, process 1 ends.

According to an example embodiment, the tunnel endpoint identifier (e.g. TE ID, TNL address, element ID(s)) is encoded into a host portion of an Ipv6 destination address.

According to an example embodiment, the host portion comprises a first identifier identifying at least one element of the mobile communications system,

e.g. a network element, logical interface, etc. According to an example implementation, at least one of the elements (e.g. a network elements, logical interfaces) identified by the first identifier comprises or is associated with the receiving entity.

5

According to an example embodiment, in addition to the first identifier the tunnel endpoint identifier comprises a second identifier identifying a tunnel endpoint for the user plane transport.

10 According to an example embodiment, process 2 illustrated in Fig. 3 is executed by the UPF1 43 as receiving entity.

In step S320 of process 2, a tunnel endpoint identifier (e.g. TE ID, TNL address, element ID(s), logical interface ID(s)) to be used for user plane transport

15 between the receiving entity (e.g. UPF1 43) and a transmitting entity (e.g. gNB 42) for transmitting data packets of a session between network elements of the mobile communications system (e.g. a user equipment (e.g. UE 41) and a radio access network element (e.g. gNB 42)) is assigned.

20 In step S322, the data packets which are encapsulated in Ipv6 headers are received, each Ipv6 header comprising a source address of the transmitting entity and a destination address of the receiving entity, wherein the tunnel endpoint identifier is encoded in the destination address. After step S322, process 2 ends.

25

According to at least some embodiments, endpoint addresses (SIDs) including element IDs or logical interface IDs are set based on control plane signaling as in case of GTP tunneling.

30 According to at least some embodiments, the signaling procedure is as with NG AP, so that the receiving entity assigns the TE ID that the transmitting entity shall use. For example, in Fig. 5, UPF1 55 assigns TE ID for gNB 52 to use.

Moreover, in Fig. 5, a data packet from a UE 51, which is encapsulated as
35 described above with respect to Figs. 3 and 4, is forwarded through the path

determined by the routing protocol or other IP reachability information up to the next segment, which is instantiated on the UPF1 55. Once the packet arrives to UPF1 55, the function is executed. The function is going to indicate to the UPF1 55 the specific Rule Set and the Apply Action that should be applied to that PDU.

- 5 Once the particular UPF functionality is triggered, the UPF1 55 will recover the TE ID and QoS marking from the SRv6 segment arguments.

According to at least some embodiments, signaling takes place by NG AP procedures. For each bearer/PDP context, the receiving endpoint (receiving
10 entity) assigns TE ID that the sending endpoint (transmitting entity) shall use. In NR architecture, control plane signaling delivers the endpoint information to the sending party. This control plane signaling is F1-AP, Xn-AP or NG-AP, depending on the logical interface.

- 15 An information element for the TE ID already exists in the above mentioned application protocols. As well, a TNL (Transport Network Layer) address (IPv6 address) exists. The remote endpoint (receiving entity) assigns the TE ID and the TNL address for the local endpoint (transmitting entity) to use and the control plane signaling delivers the TE ID and the TNL address to the local
20 endpoint.

Fig. 6 illustrates a PDU session resource setup for a case of a successful operation according to an example embodiment.

- 25 In Fig. 6, an AMF initiates the procedure by sending a PDU session resource setup request message to an NG-RAN node (e.g. gNB 42).

- For each PDU session the NG-RAN node stores UP transport layer information included in a PDU Session Resource Setup Request Transfer IE contained in the
30 PDU session resource setup request message and uses it as the uplink termination point for the user plane data for this PDU session.

- According to an example embodiment, the NG-RAN node reports to the AMF in a PDU session resource setup response message the result for each PDU session
35 resource requested to be setup. For example, for each successful PDU session

resource setup, a PDU Session Resource Setup Response Transfer IE is included containing UP transport layer information to be used for the PDU session and an associated list of QoS flows which have been successfully established, in a QoS Flow per TNL Information IE.

5

Process 3 shown in Fig. 3 illustrates a flowchart according to an example embodiment, which may be executed by a control plane entity of the mobile communications system, e.g. the AMF of Fig. 6.

10 In step S330, a tunnel endpoint identifier (e.g. TE ID, TNL address, element ID(s), logical interface ID(s)) to be used for user plane transport between a transmitting entity (e.g. gNB 42) for transmitting data packets of a session between network elements of the mobile communications system (e.g. a user equipment (e.g. UE 41) and a radio access network element (e.g. gNB 42)), and
15 a receiving entity (e.g. UPF1 43) for receiving the data packets is acquired, e.g. from the receiving entity.

In step S332, the tunnel endpoint identifier is forwarded to the transmitting entity via a request message requesting resource setup for a PDU session (e.g.
20 the PDU session resource setup request message in Fig. 6). After step S332, process 3 ends.

According to an example embodiment, the control plane entity receives, from the transmitting entity, a response message responding to the request message, the
25 response message including a local address of the transmitting entity and tunnel endpoint identifier for the remote endpoint to use.

As mentioned above, application protocols support information elements for both TNL address and TE ID. In this case, according to an example implementation,
30 assigning a TNL address (IPv6 address) is sufficient since the TE ID is already encoded into the host portion of that address. According to an example implementation, the remote endpoint (receiving entity) can also encode the element ID and/or logical interface ID to the TNL address. This means that the remote endpoint assigns the TNL address in the format of IPv6 address.

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In case of the architecture of Fig. 5, for the direction of gNB 52 to UPF1 55, UPF1 55 assigns the TNL address for the gNB 52 to use. This TNL address is signaled via AMF to the gNB 52. The gNB 52 sends the packet with this TNL address as the ultimate segment (e.g. indicated in segment list [0] of the SR header format shown in Fig. 1).

If there are intermediate SRv6 nodes like nodes 53, 54 in Fig. 5, according to at least some embodiments, these similarly may select the TNL address described above or may use SID without the method described above. These TNL addresses are conveyed to the gNB 52 similarly via control plane signaling or e.g. by SDN controller. The data packet sent by gNB includes all the segments in the SRv6 header, with the last segment corresponding to UPF U as the innermost.

In other words, according to an example embodiment, in step S310 of Fig. 3, the transmitting entity (e.g. gNB) includes the destination address of the UPF U into a segment list of an SR header as ultimate segment of the segment list, and includes a routing address/routing addresses of a segment routing node/segment routing nodes (e.g. C1, C2) into the segment list before the destination address (e.g. in segment list [1], segment list [2]). In step S312, the transmitting entity forwards the data packets to the receiving entity via the segment routing node(s) by using the SR header.

As mentioned above, according to the application protocols F1-AP, Xn-AP or NG-AP, apart from other fields, PDU session resource setup request contains both "Endpoint Address" and "TE ID". It means, in case of IPv6 network, "Endpoint Address" is Ipv6 address.

However, according to at least some embodiments, IPv6 is a combination of "network portion + element ID or logical interface ID + TE ID", as illustrated in Fig. 2. Hence, according to an example implementation, a format of "Endpoint Ipv6 Address" is a combination of "network portion + element ID or logical interface ID + TE ID" as part of "PDU session resource setup request/response" from the respective mobile network element. There is no need to include TE ID as separate field in "PDU session resource setup request/response".

According to at least some embodiments, TE ID is included into the IPv6 address as described above, and GTPU TE ID field is omitted.

- 5 Further, according to at least some embodiments, the IPv6 address with SRv6 for GTP-U replacement comprises a combination of "network portion + element ID or logical interface ID+ TEID".

10 Still further, according to at least some embodiments, a combination of element IDs and/or logical interface IDs is included into the host portion of the IPv6 address for uniquely identifying an endpoint for the user plane transport.

15 According to an example embodiment, when a data packet enters to an SRv6 enabled switch/router, e.g. node 53, 54 shown in Fig. 5, the following steps are performed.

20 When an SRv6-capable node (e.g. C1, C2) receives an IPv6 packet, it performs a longest-prefix-match lookup on the packet's destination address by referring to the segment list of the SR header of the packet and an FIB table. This lookup can return any of the following results A, B, C or D:

Result A. An FIB entry that represents a locally instantiated SRv6 SID

1. Then a so called "My Local SID Table" of an SRv6 forwarding stack is visited. This table contains all the SRv6 segments explicitly instantiated to the node receiving the packet. My Local SID table is populated by default with all IPv6 addresses defined to this node. According to an example implementation, this is performed via 3GPP signaling.
2. At the same time, an advertised "Endpoint Ipv6 Address" is updated in "My local SID Table".
- 30 3. If the FIB entry was created by the afore-mentioned signaling and the host ID part of the packet's destination address contains a matching tunnel endpoint identifier, e.g. TE ID, the inner packet is processed as if it would have been carried over a GTP-U with the marked TE ID value.
4. The IPv6 packet is sent with the next SID (if exists) as the destination address via SRv6 routing, and the SID list is shortened.
- 35

Process 4 shown in Fig. 3 illustrates a method for use by a segment routing node (e.g. C1, C2) of a mobile communications system according to at least some embodiments.

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In S340 of Fig. 3, a data packet (IPv6 packet) is received, which has an SR header including a segment list.

10 In case a tunnel endpoint identifier (e.g. TE ID, TNL address, element ID(s), logical interface IDs) included in a host portion of a routing address included in the segment list matches with a segment identifier locally instantiated for the segment routing node, in step S342, the data packet is processed and sent with the next address of the segment list, and the segment list is shortened. After step S342, process 4 ends. According to an example embodiment, step S342
15 corresponds to above points 1 to 4.

According to at least some embodiments, the segment identifier is acquired via control plane signaling, e.g. 3GPP signalling as mentioned above.

20 Result B. An FIB entry that represents a local interface, not locally instantiated as an SRv6 SID

In this case, the IPv6 packet is forwarded to the local destination, e.g. the UPF1 55 in Fig. 5.

25 Result C. An FIB entry that represents a non-local route

In this case, the IPv6 packet is forwarded to the next hop, e.g. node 53 in Fig. 5.

Result D. No Match

In this case, the IPv6 packet dropped.

30

At least some embodiments are compliant with both 3GPP control plane architecture which comprises distributing SIDs including TE ID by 3GPP control plane, and with SRv6 architecture which comprises IPv6 address including TE ID encoded as described above in the segment list.

35

Combining element IDs/logical interface IDs or combining an element ID/logical interface ID and TE ID as described above allows for a unique value for the interface part of the Ipv6 address which is the SID.

- 5 In the following, possibilities in path selection between ingress and egress mobile network elements are described:
1. At an Ingress PE by following the IGP shortest path to the destination based on IGPs.
 2. Distributed TE:
- 10 At the ingress PE by executing a Constrained Shortest Path First (CSPF) using information obtained from traffic engineering extensions to the IGP.
3. Centralized TE (e.g. PCE)
- For example, using a CSPF at a centralized device that has knowledge of the network topology and current utilization. The computed path is then passed to
- 15 the ingress PE using any of several protocols.

Now reference is made to Fig. 7 showing a schematic block diagram illustrating a configuration of entities in which examples of embodiments are implementable.

- 20 Fig. 7 shows a transmitting entity 710, e.g. gNB 42 of Fig. 4, gNB 52 of Fig. 5, NG-RAN node of Fig. 6. According to an example implementation, the transmitting entity 710 executes process 1 shown in Fig. 3.

- The transmitting entity 710 comprises processing resources (e.g. processing
- 25 circuitry and/or virtual processing resources) 711, memory resources (e.g. memory circuitry and/or virtual memory resources) 712, which may store a program, and interfaces (e.g. interface circuitry or virtual interfaces) 713. The resources 711, 712 and interfaces 713 are coupled via a connection 714.

- 30 According to an example implementation, the transmitting entity 710 is coupled via a connection 751, e.g. an N3 interface, with a segment routing node 740, which is an SRv6-capable node such as nodes 53, 54 shown in Fig. 5.

- According to another example implementation, the transmitting entity 710 is
- 35 coupled via an N3 interface with the receiving entity 720.

According to an example implementation, the segment routing node 740 executes process 4 shown in Fig. 3.

- 5 The segment routing node 740 comprises processing resources (e.g. processing circuitry and/or virtual processing resources) 741, memory resources (e.g. memory circuitry and/or virtual memory resources) 742, which may store a program, and interfaces (e.g. interface circuitry or virtual interfaces) 743. The resources 741, 742 and interfaces 743 are coupled via a connection 744.

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According to an example implementation, the segment routing node 740 is coupled via a connection 752, e.g. an N3 interface, with the receiving entity 720, e.g. UPF1 43 of Fig. 4, UPF1 55 of Fig. 5. According to an example implementation, the receiving entity 720 executes process 2 shown in Fig. 3.

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The receiving entity 720 comprises processing resources (e.g. processing circuitry and/or virtual processing resources) 721, memory resources (e.g. memory circuitry and/or virtual memory resources) 722, which may store a program, and interfaces (e.g. interface circuitry or virtual interfaces) 723. The resources 721, 722 and interfaces 723 are coupled via a connection 724.

20

The transmitting entity 710, the segment routing node 740 and the receiving entity 720 are coupled with a control plane entity 730 via connections 753, 754 and 755. According to an example implementation, the control plane entity 730 is the AMF shown in Fig. 6. According to an example implementation, the control plane entity 730 executes process 3 of Fig. 3.

25

The terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and printed electrical connections, as well as by the use of electromagnetic energy, such as

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electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as non-limiting examples.

- 5 Further, as used in this application, the term "circuitry" refers to one or more or all of the following:
- (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and
 - 10 (b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and
 - 15 (c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

This definition of "circuitry" applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the

20 term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar

25 integrated circuit in server, a cellular network device, or other network device.

At least some embodiments are implemented by computer software stored in the memory resources 712, 722, 732, 742 and executable by the processing resources 711, 721, 731, 741, or by hardware, or by a combination of software

30 and/or firmware and hardware in any or all of the entities shown.

According to a first aspect, a transmitting entity of a mobile communications system is provided, which comprises means for encapsulating data packets of a session between network elements of the mobile communications system into

35 Internet protocol version 6 (IPv6) headers, each IPv6 header comprising a

source address of the transmitting entity for transmitting the data packets and a destination address of a receiving entity for receiving the data packets, wherein a tunnel endpoint identifier is encoded in the destination address, wherein the tunnel endpoint identifier is to be used for user plane transport between the transmitting entity and the receiving entity, and means for forwarding the data packets to the receiving entity.

According to an example implementation, the tunnel endpoint identifier is encoded into a host portion of the destination address.

According to an example implementation, the tunnel endpoint identifier comprises at least one of a first identifier identifying at least one of an element of the mobile communications system and a logical interface of the mobile communications system and a second identifier identifying a tunnel endpoint for the user plane transport.

According to an example implementation, the transmitting entity further comprises means for including the destination address into a segment list of a segment routing (SR) header.

According to an example implementation, the means for forwarding forwards the data packets to the receiving entity by using the SR header.

According to another example implementation, the means for forwarding forwards the data packets without the SR header to the receiving entity.

According to another example implementation, the means for forwarding forwards the data packets to the receiving entity via at least one segment routing node by using the SR header, wherein the destination address is included as ultimate segment of the segment list of the SR header.

According to an example implementation, the transmitting entity further comprises means for including at least one routing address of the segment routing node into the segment list before the destination address.

According to an example implementation, the routing address contains a tunnel endpoint identifier.

5 According to an example implementation, the transmitting entity further comprises means for acquiring the destination address and the tunnel endpoint identifier of the receiving entity from a request message requesting resource setup for a packet data unit (PDU) session.

10 According to an example implementation, the transmitting entity further comprises means for acquiring the routing address of the segment routing node from a request message requesting resource setup for a PDU session.

15 According to an example implementation, the transmitting entity further comprises means for acquiring the destination address and/or the routing address via control plane signaling.

20 According to an example implementation, the transmitting entity further comprises means for acquiring the destination address and/or the routing address via management plane.

According to an example implementation, the transmitting entity further comprises means for acquiring the destination address and/or the routing address via a software defined networking (SDN) controller.

25 According to an example implementation, the source address and the destination address and/or the routing address are IPv6 addresses, wherein the destination address and/or the routing address comprises a network portion and a host portion including the tunnel endpoint identifier.

30 According to an example implementation, the transmitting entity comprises the transmitting entity 710 of Fig. 7.

35 According to a second aspect, a receiving entity of a mobile communications system is provided, which comprises means for assigning a tunnel endpoint identifier to be used for user plane transport between the receiving entity and a

transmitting entity for transmitting data packets of a session between network elements of the mobile communications system, and means for receiving the data packets which are encapsulated in IPv6 headers, each IPv6 header comprising a source address of the transmitting entity and a destination address of the receiving entity, wherein the tunnel endpoint identifier is encoded in the destination address.

According to an example implementation, the receiving entity comprises the receiving entity 720 of Fig. 7.

According to a third aspect, a control plane entity of a mobile communications system is provided, which comprises means for acquiring a tunnel endpoint identifier to be used for user plane transport between a transmitting entity for transmitting data packets of a session between network elements of the mobile communications system and a receiving entity for receiving the data packets, and means for forwarding the tunnel endpoint identifier to the transmitting entity via a request message requesting resource setup for a PDU session.

According to an example implementation, the control plane entity comprises means for receiving, from the transmitting entity, a response message responding to the request message, the response message including a local address of the transmitting entity and tunnel endpoint identifier for the remote endpoint to use.

According to an example implementation, the control plane entity comprises the control plane entity 730 of Fig. 7.

According to a fourth aspect, a segment routing node of a mobile communications system is provided, which comprises means for receiving a data packet having an SR header including a segment list, and means for, in case a tunnel endpoint identifier included in an host portion of a routing address included in the segment list matches with a segment identifier locally instantiated for the segment routing node, processing the data packet, sending the data packet with the next address of the segment list as new destination address and shortening the segment list.

According to an example implementation, the segment routing node comprises means for acquiring the segment identifier via control plane signaling.

- 5 According to an example implementation, the means for sending send the data packet to the new destination address by using the SR header.

According to another example implementation, the means for sending send the data packets without the SR header to the new destination address.

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According to an example implementation, the segment routing node comprises the segment routing node 740 of Fig. 7.

- 15 It is to be understood that the above description is illustrative and is not to be construed as limiting. Various modifications and applications may occur to those skilled in the art without departing from the true spirit and scope as defined by the appended claims.

CLAIMS

1. A method for use by a transmitting entity of a mobile communications system, the method comprising:

5 encapsulating data packets of a session between network elements of the mobile communications system into Internet protocol version 6, IPv6, headers, each IPv6 header comprising a source address of the transmitting entity for transmitting the data packets and a destination address of a receiving entity for receiving the data packets, wherein a tunnel endpoint identifier is encoded in the
10 destination address, wherein the tunnel endpoint identifier is to be used for user plane transport between the transmitting entity and the receiving entity; and
 forwarding the data packets to the receiving entity.

15 2. The method of claim 1, wherein the tunnel endpoint identifier is encoded into a host portion of the destination address.

20 3. The method of claim 1 or 2, wherein the tunnel endpoint identifier comprises at least one of a first identifier identifying at least one of an element of the mobile communications system and an interface of the mobile communications system and a second identifier identifying a tunnel endpoint for the user plane transport.

25 4. The method of any one of claims 1 to 3, further comprising:
 including the destination address into a segment list of a segment routing, SR, header.

30 5. The method of claim 4, wherein the forwarding comprises:
 forwarding the data packets to the receiving entity by using the SR header.

6. The method of claim 4, wherein the forwarding comprises:
 forwarding the data packets without the SR header to the receiving entity.

7. The method of claim 4 or 5, wherein the forwarding comprises:

forwarding the data packets to the receiving entity via at least one segment routing node by using the SR header, wherein the destination address is included as ultimate segment of the segment list of the SR header.

- 5 8. The method of any one of claims 4, 5 and 7, further comprising:
including at least one routing address of the segment routing node into the segment list before the destination address.
9. The method of claim 8, wherein the routing address contains a tunnel
10 endpoint identifier.
10. The method of any one of claims 1 to 9, further comprising:
acquiring the destination address and the tunnel endpoint identifier of the receiving entity from a request message requesting resource setup for a packet
15 data unit, PDU, session; and/or
acquiring the routing address of the segment routing node from a request message requesting resource setup for a PDU session; and/or
acquiring the destination address and/or the routing address via control plane signaling; and/or
20 acquiring the destination address and/or the routing address via management plane; and/or
acquiring the destination address and/or the routing address via a software defined networking, SDN, controller.
- 25 11. The method of any one of claims 1 to 10, wherein the source address and the destination address and/or the routing address are IPv6 addresses, wherein the destination address and/or the routing address comprises a network portion and a host portion including the tunnel endpoint identifier.
- 30 12. A method for use by a receiving entity of a mobile communications system, the method comprising:
assigning a tunnel endpoint identifier to be used for user plane transport between the receiving entity and a transmitting entity for transmitting data packets of a session between network elements of the mobile communications
35 system; and

receiving the data packets which are encapsulated in Internet protocol version 6, IPv6, headers, each IPv6 header comprising a source address of the transmitting entity and a destination address of the receiving entity, wherein the tunnel endpoint identifier is encoded in the destination address.

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13. A method for use by a control plane entity of a mobile communications system, the method comprising:

acquiring a tunnel endpoint identifier to be used for user plane transport between a transmitting entity for transmitting data packets of a session between
10 network elements of the mobile communications system and a receiving entity
for receiving the data packets; and

forwarding the tunnel endpoint identifier to the transmitting entity via a request message requesting resource setup for a PDU session.

15 14. The method of claim 13, further comprising:

receiving, from the transmitting entity, a response message responding to the request message, the response message including a local address of the transmitting entity and tunnel endpoint identifier for the remote endpoint to use.

20 15. A method for use by a segment routing node of a mobile communications system, the method comprising:

receiving a data packet having an SR header including a segment list; and
in case a tunnel endpoint identifier included in an host portion of a routing address included in the segment list matches with a segment identifier locally
25 instantiated for the segment routing node, processing the data packet, sending the data packet with the next address of the segment list as new destination address and shortening the segment list.

16. The method of claim 15, wherein the sending comprises:

30 sending the data packet to the new destination address by using the SR header.

17. The method of claim 15, wherein the sending comprises:

35 sending the data packets without the SR header to the new destination address.

18. The method of any one of claims 15 to 17, further comprising:

acquiring the segment identifier via control plane signaling.

5

19. An apparatus for use by a transmitting entity of a mobile communications system, the apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform:

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encapsulating data packets of a session between network elements of the mobile communications system into Internet protocol version 6, IPv6, headers, each IPv6 header comprising a source address of the transmitting entity for transmitting the data packets and a destination address of a receiving entity for receiving the data packets, wherein a tunnel endpoint identifier is encoded in the destination address, wherein the tunnel endpoint identifier is to be used for user plane transport between the transmitting entity and the receiving entity; and forwarding the data packets to the receiving entity.

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20. The apparatus of claim 19, wherein the tunnel endpoint identifier is encoded into a host portion of the destination address.

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21. The apparatus of claim 19 or 20, wherein the tunnel endpoint identifier comprises at least one of a first identifier identifying at least one of an element of the mobile communications system and an interface of the mobile communications system and a second identifier identifying a tunnel endpoint for the user plane transport.

30

22. The apparatus of any one of claims 19 to 21, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to further perform:

including the destination address into a segment list of a segment routing, SR, header.

35

23. The apparatus of claim 22, wherein the forwarding comprises:

forwarding the data packets to the receiving entity by using the SR header.

24. The apparatus of claim 22, wherein the forwarding comprises:

5 forwarding the data packets to the receiving entity without the SR header.

25. The apparatus of claim 22 or 23, wherein the forwarding comprises forwarding the data packets to the receiving entity via at least one segment routing node by using the SR header, wherein the destination address is included
10 as ultimate segment of the segment list of the SR header.

26. The apparatus of any one of claims 22, 23 and 25, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to further perform:

15 including at least one routing address of the segment routing node into the segment list before the destination address.

27. The apparatus of claim 26, wherein the routing address contains a tunnel endpoint identifier.

20

28. The apparatus of any one of claims 19 to 27, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to further perform:

25 acquiring the destination address of the receiving entity from a request message requesting resource setup for a packet data unit, PDU, session; and/or

acquiring the routing address of the segment routing node from a request message requesting resource setup for a PDU session; and/or

acquiring the destination address and/or the routing address via control plane signaling; and/or

30 acquiring the destination address and/or the routing address via management plane; and/or

acquiring the destination address and/or the routing address via a software defined networking, SDN, controller.

29. The apparatus of any one of claims 19 to 28, wherein the source address and the destination address and/or the routing address are IPv6 addresses, wherein the destination address and/or the routing address comprises a network portion and a host portion including the tunnel endpoint identifier.

5

30. An apparatus for use by a receiving entity of a mobile communications system, the apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform:

10

— assigning a tunnel endpoint identifier to be used for user plane transport between the receiving entity and a transmitting entity for transmitting data packets of a session between network elements of the mobile communications system; and

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— receiving the data packets which are encapsulated in Internet protocol version 6, IPv6, headers, each IPv6 header comprising a source address of the transmitting entity and a destination address of the receiving entity, wherein the tunnel endpoint identifier is encoded in the destination address.

20

31. An apparatus for use by a control plane entity of a mobile communications system, the apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform:

25

acquiring a tunnel endpoint identifier to be used for user plane transport between a transmitting entity for transmitting data packets of a session between network elements of the mobile communications system and a receiving entity for receiving the data packets; and

30

forwarding the tunnel endpoint identifier to the transmitting entity via a request message requesting resource setup for a PDU session.

32. The apparatus of claim 31, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to further perform:

receiving, from the transmitting entity, a response message responding to the request message, the response message including a local address of the transmitting entity and tunnel endpoint identifier for the remote endpoint to use.

- 5 33. An apparatus for use by a segment routing node of a mobile communications system, the apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform:
- 10 receiving a data packet having an SR header including a segment list; and
in case a tunnel endpoint identifier included in an host portion of a routing address included in the segment list matches with a segment identifier locally instantiated for the segment routing node, processing the data packet, sending the data packet with the next address of the segment list as new destination
15 address and shortening the segment list.
34. The apparatus of claim 33, wherein the sending comprises:
sending the data packet to the new destination address by using the SR header.
- 20 35. The apparatus of claim 33, wherein the sending comprises:
sending the data packets without the SR header to the new destination address.
- 25 36. The apparatus of any one of claims 33 to 35, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to further perform:
acquiring the segment identifier via control plane signaling.
- 30 37. A non-transitory storage medium storing a program that causes a computer to execute the method of any one of claims 1 to 18, when the program is run on the computer.

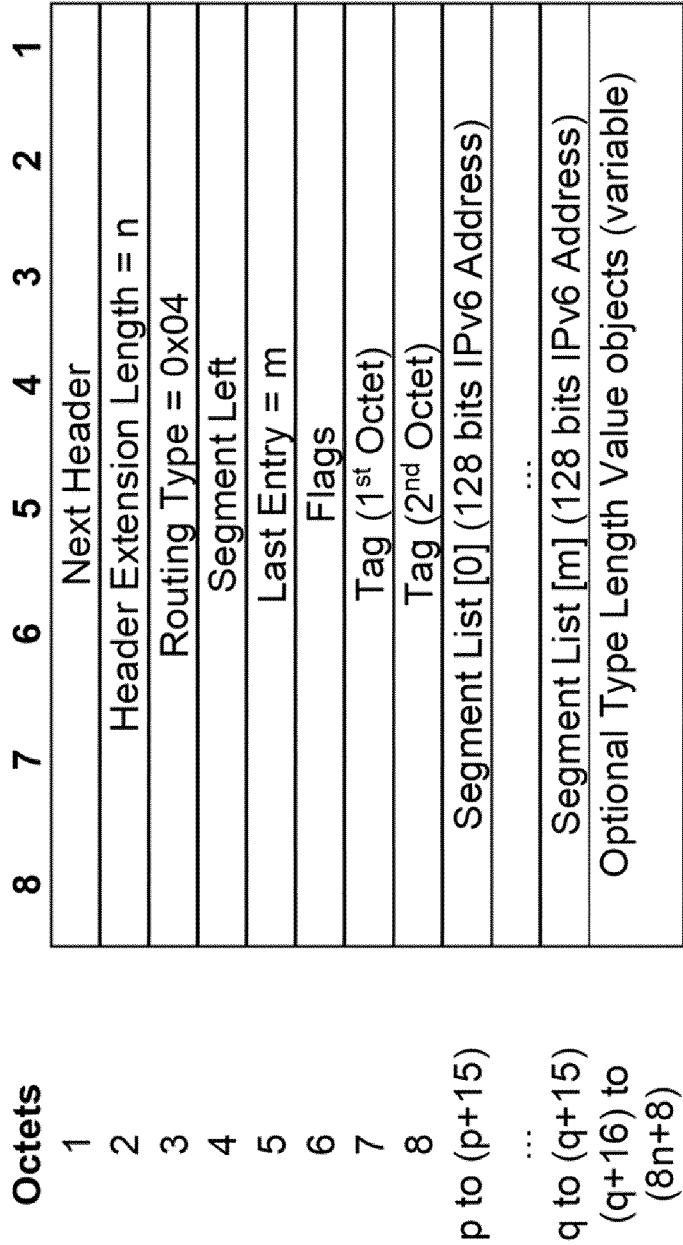


Fig. 1

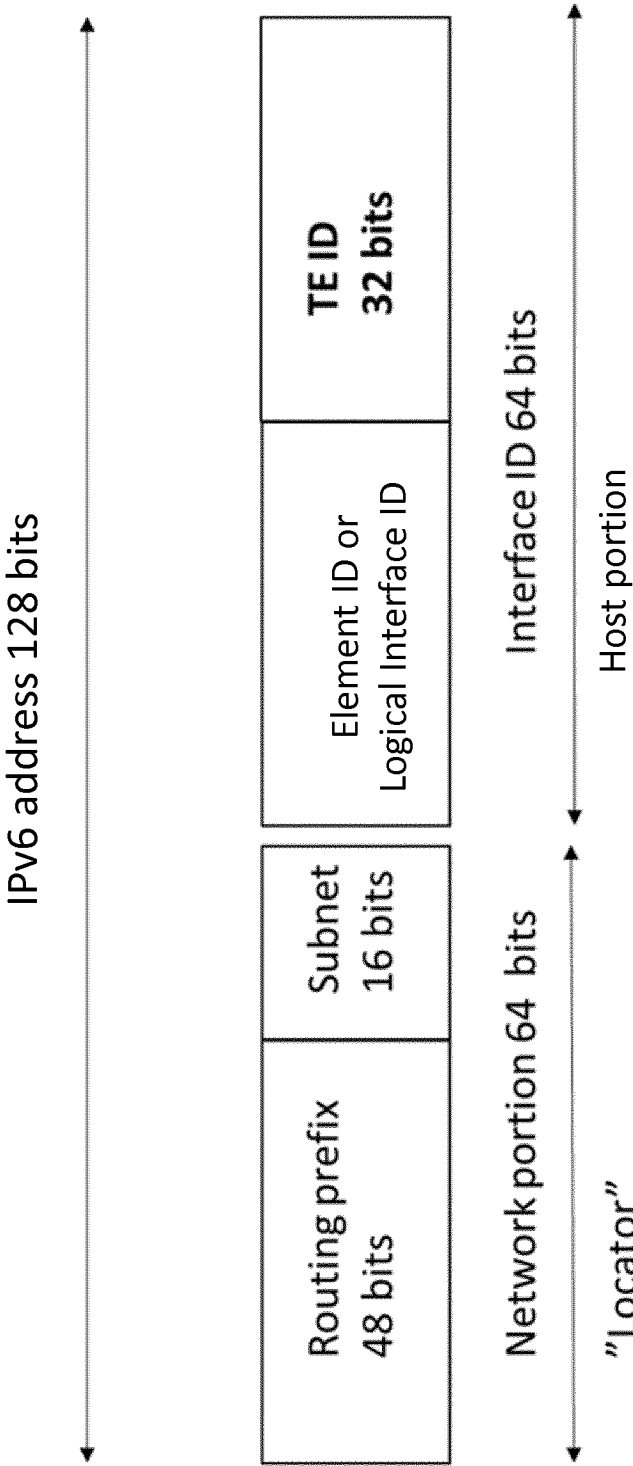


Fig. 2

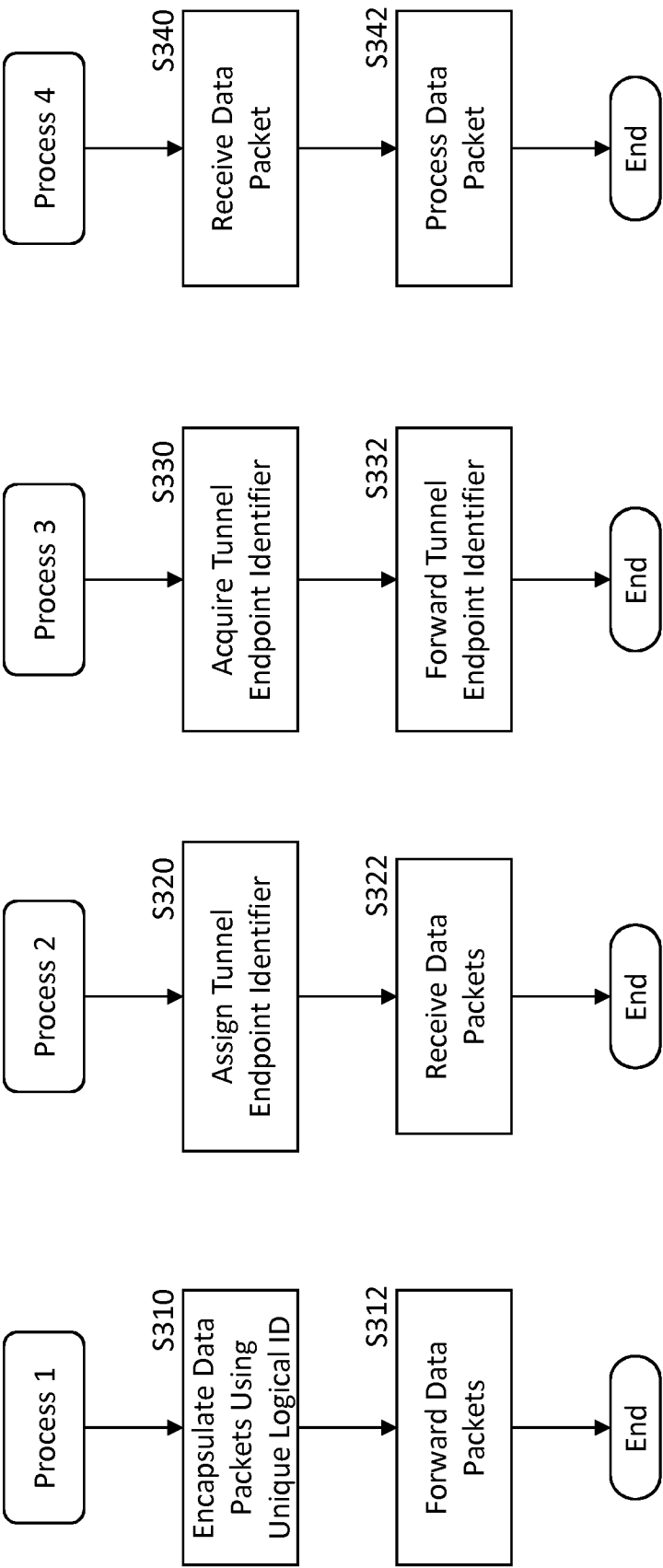


Fig. 3

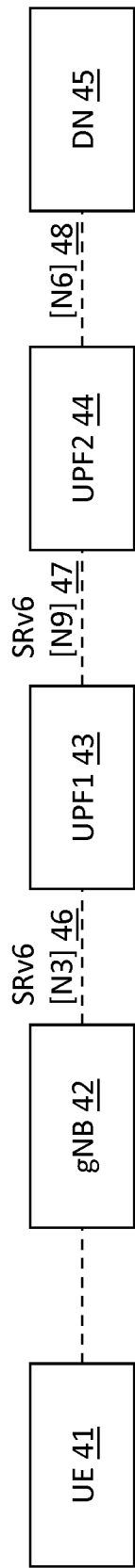


Fig. 4

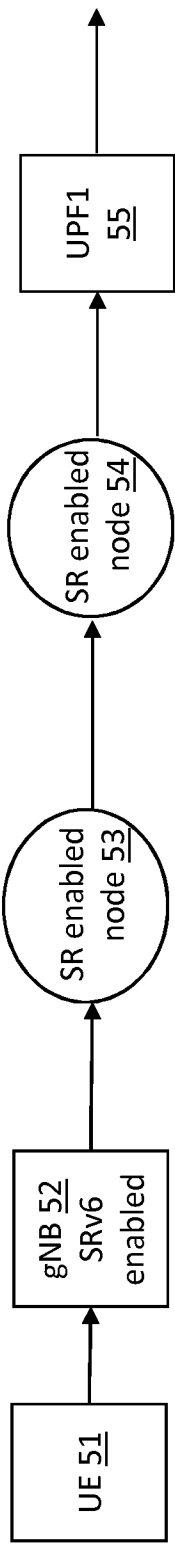


Fig. 5

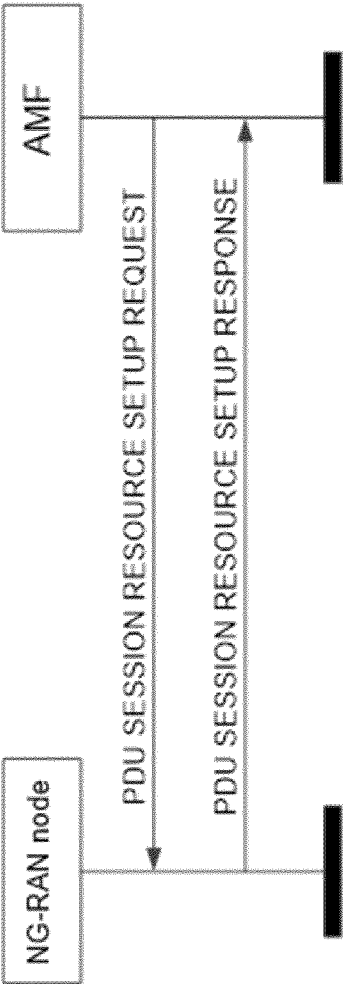


Fig. 6

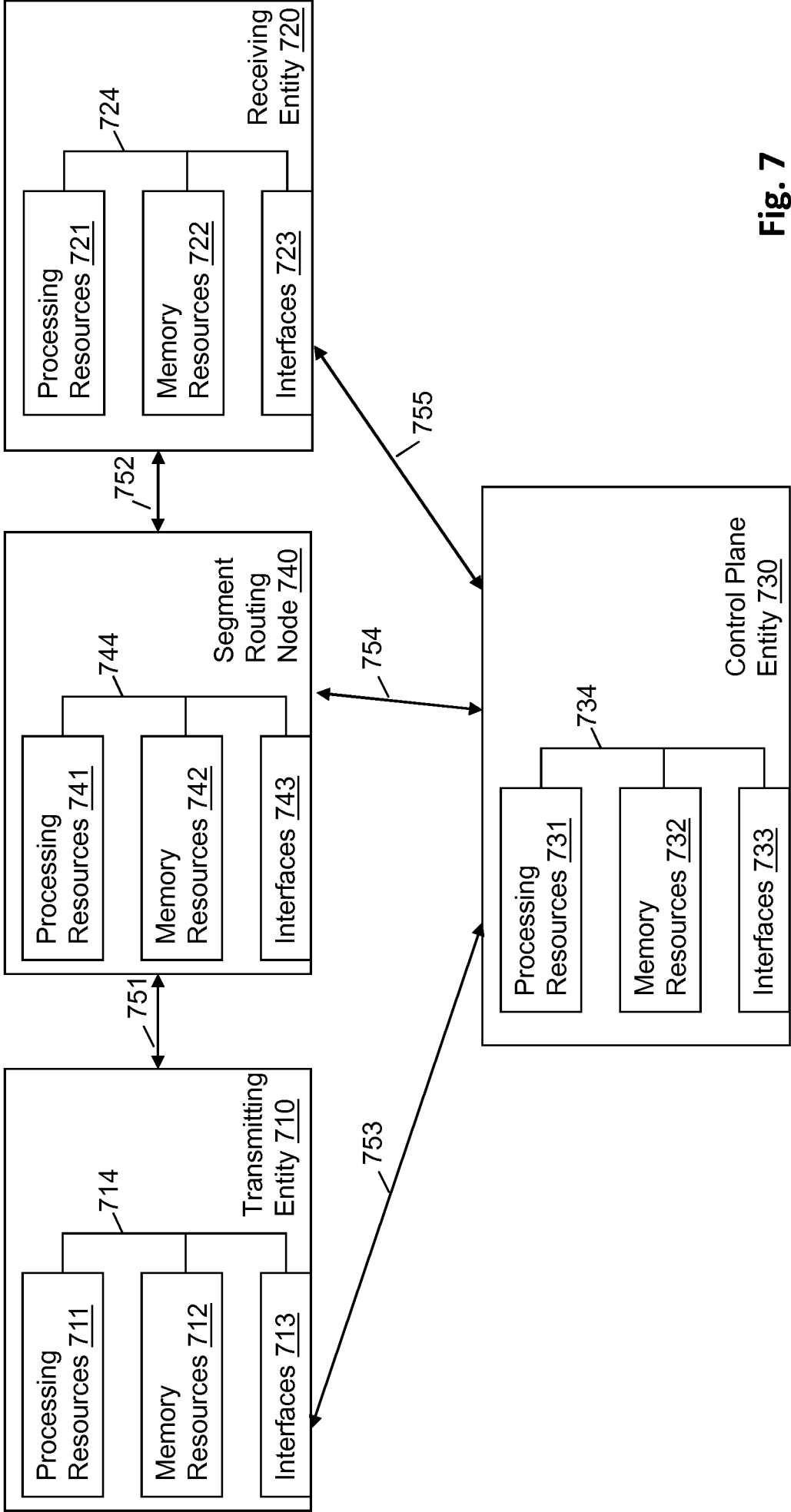


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/056829

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L12/46 H04L12/721 H04W40/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	"3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Study on User Plane Protocol in 5GC. (Release 16)", 3GPP DRAFT; 29892-100, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. TSG CT 8 March 2019 (2019-03-08), XP051688692, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fct/TSG%5FCT/TSGC%5F83%5FShenzhen/Docs/CP%2D190060%2Ezip [retrieved on 2019-03-08] 5.1 Architectural Requirements for Use Plane; -/--	1-14, 19-32,37



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

30 October 2019

Date of mailing of the international search report

07/11/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Martin Bueno, Teresa

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/056829

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	page 8 - page 9 5.2 Key Issues for User Plane Protocol; page 12 6. Candidate user Plane Protocols 6.1 GTP-U; page 13 6. Candidate user Plane Protocols 6.2 Segment Routing IPv6 (SRv6); page 19 - page 28 ----- MATSUSHIMA SOFTBANK C FILSFILS M KOHNO P CAMARILLO CISCO SYSTEMS S ET AL: "Segment Routing IPv6 for Mobile User Plane; draft-ietf-dmm-srv6-mobile-uplane-04.txt", SEGMENT ROUTING IPV6 FOR MOBILE USER PLANE; DRAFT-IETF-DMM-SRV6-MOBILE-UPLANE-04.TXT; INTERNET-DRAFT: DMM WORKING GROUP, INTERNET ENGINEERING TASK FORCE, IETF; STANDARDWORKINGDRAFT, INTERNET SOCIETY (, no. 4 11 March 2019 (2019-03-11), pages 1-28, XP015131799, Retrieved from the Internet: URL:https://tools.ietf.org/html/draft-ietf-dmm-srv6-mobile-uplane-04 [retrieved on 2019-03-11] 3. Motivation 4. A 3GPP Reference Architecture; page 5 - page 7 5.2 Enhanced Mode; page 9 - page 11 ----- -/--	15-18, 33-36

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/056829

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	BOGINENI VERIZON A AKHAVAIN HUAWEI CANADA RESEARCH CENTRE T HERBERT QUANTONIUM D FARINACCI LISPERS NET A RODRIGUEZ-NATAL G CAROFIG: "Optimized Mobile User Plane Solutions for 5G; draft-bogineni-dmm-optimized-mobile-user-plane-01.txt", OPTIMIZED MOBILE USER PLANE SOLUTIONS FOR 5G; DRAFT-BOGINENI-DMM-OPTIMIZED-MOBILE-USER-P LANE-01.TXT; INTERNET-DRAFT: DMM, INTERNET ENGINEERING TASK FORCE, IETF; STANDARDWORKINGDRAFT, INTERNET SOCIETY (ISOC) 4, RUE DES FALAISES CH- 1205 GENEVA, SWITZE, no. 1, 29 June 2018 (2018-06-29), pages 1-65, XP015127176, [retrieved on 2018-06-29] 5. Data Plane Architecture models for N9; page 23 - page 28 6.1 Locator based - SRv6; page 41 - page 43 -----	1-37
T	"LTE; Interface between the Control Plane and the User Plane nodes (3GPP TS 29.244 version 15.3.0 Release 15)", ETSI TECHNICAL SPECIFICATION, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE (ETSI), 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS ; FRANCE , vol. 3GPP CT, no. V15.3.0 9 October 2018 (2018-10-09), pages 1-195, XP014330001, Retrieved from the Internet: URL:http://www.etsi.org/deliver/etsi_ts/129200_129299/129244/15.03.00_60/ts_129244v150300p.pdf [retrieved on 2018-10-09] 5.5 F-TEID Allocation and Release; page 40 6.3 PFCP Session Related Procedures 6.3.2 PFCP Session Establishment Procedure; page 60 -----	