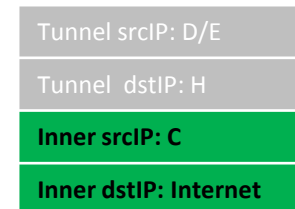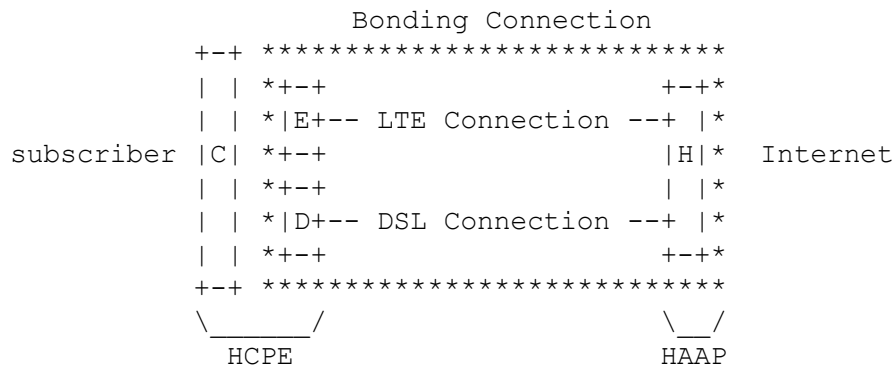# GRE Tunnel Bonding

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Overview

- GRE tunnels are set up per sub-connection.

- All sub-connections are bonded together to form a single bonding connection.

- The Home Gateway conceals the composing GRE tunnels so that the subscriber uses this bonding connection as if it is a traditional IP link.

```
                        Bonding Connection
             +-+ ***************************
             | | *+-+                    +-+*
             | | *|E+-- LTE Connection --+ |*
subscriber |C| *+-+                    |H|*  Internet
             | | *+-+                    | |*
             | | *|D+-- DSL Connection --+ |*
             | | *+-+                    +-+*
             +-+ ***************************
             _____/                  \__/
               HCPE                     HAAP
```

Tunnel srcIP: D/E
Tunnel dstIP: H
Inner srcIP: C
Inner dstIP: Internet

Subscriber's packets are tunneled

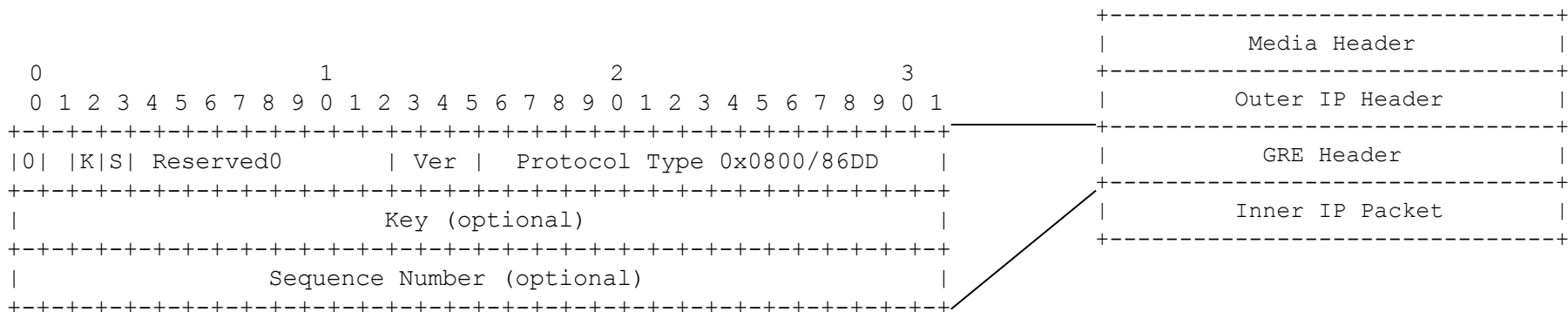# Traffic classification, distribution and recombination

- An "offloading" bonding mechanism
  - Using coloring mechanism (RFC 2697 and RFC 2698).
  - Yellow packets are routed through the LTE GRE tunnel and green packets are routed through the DSL GRE tunnel.
  - As such, packet-based traffic distribution is supported.
  - At the egress, packets are reordered according to their sequence numbers.
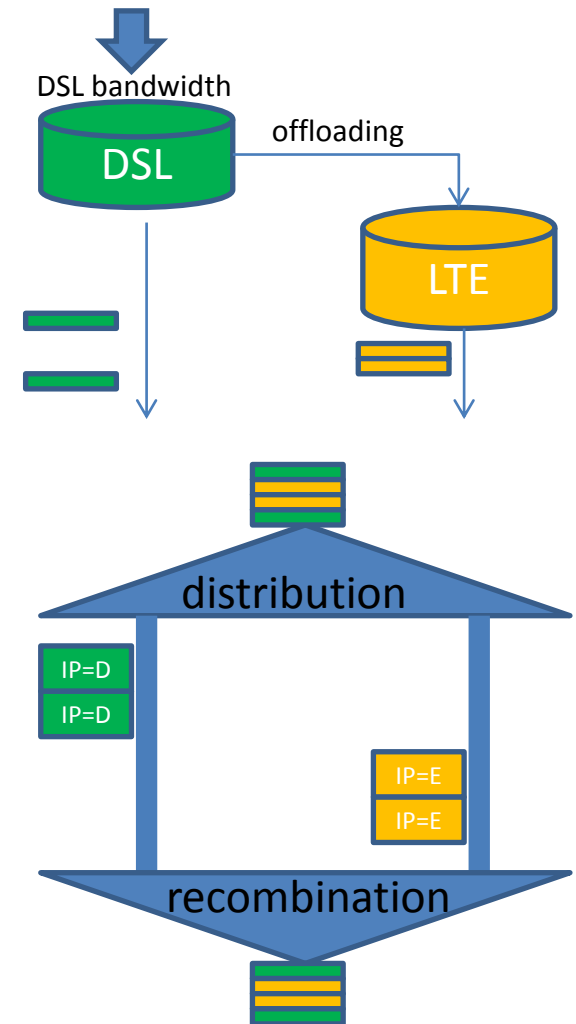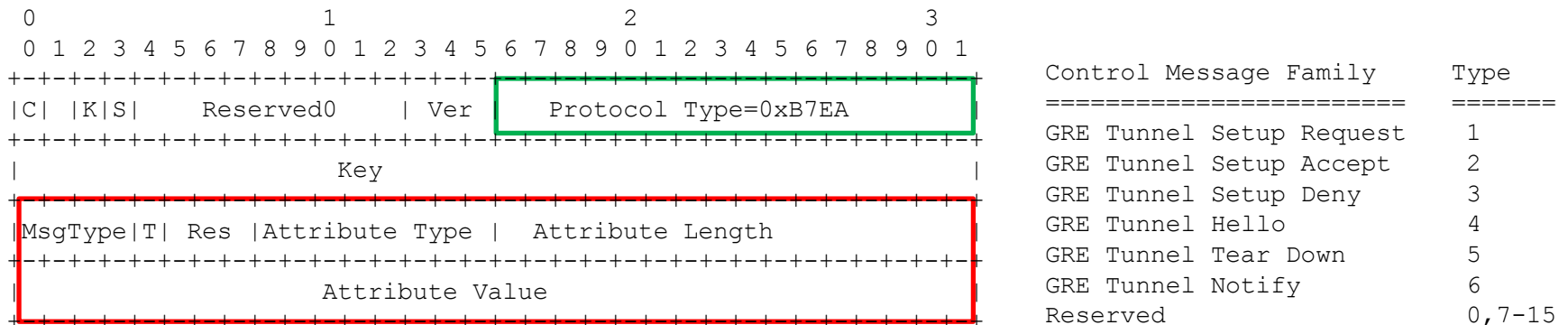
Data Plane

- GRE header defined by RFC 2890 is used.
- For the purpose of packet reordering, each packet through the bonding connection gets a sequence number.
- Both IPv4 (Protocol Type = 0x0800) and IPv6 (Protocol Type = 0x86DD) are supported.
- This provides an L3 overlay: the users' IP packets (inner IP) are encapsulated in GRE which is in turn carried over IP (outer IP).

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0| |K|S| Reserved0      | Ver |   Protocol Type 0x0800/86DD    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Key (optional)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Sequence Number (optional)                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
+-------------------------------+
|          Media Header         |
+-------------------------------+
|        Outer IP Header        |
+-------------------------------+
|           GRE Header          |
+-------------------------------+
|        Inner IP Packet        |
+-------------------------------+
```
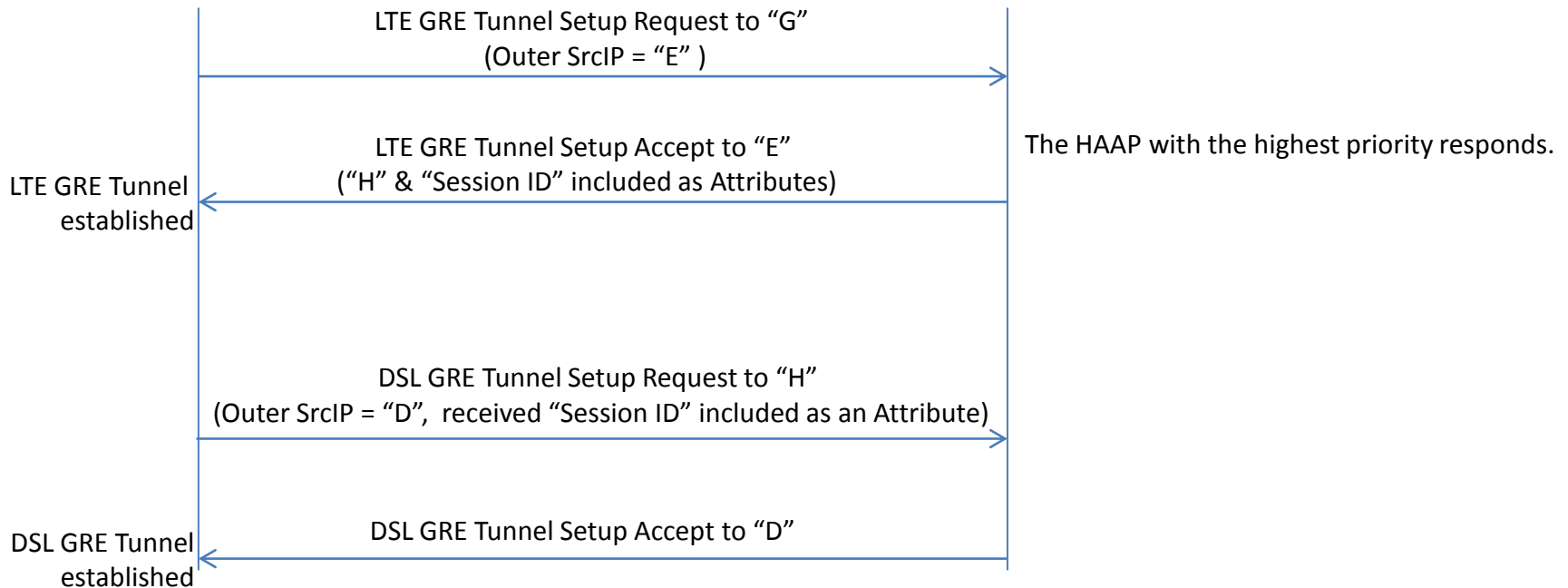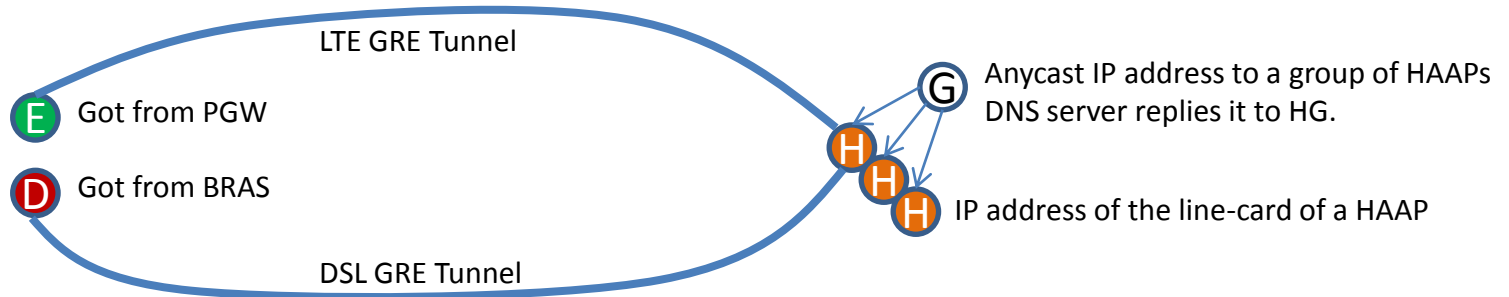
Control plane: the GRE Channel

- A new GRE protocol type (#0xB7EA) for the GRE Channel is assigned by IEEE. This channel is used as the control plane of the GRE-Tunnel-Bonding solution.
- A family of Message Types are defined.
- So, control messages will also be encapsulated as GRE packets! And, they are transmitted in the same tunnels as data packets.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|C|  |K|S|    Reserved0    | Ver |     Protocol Type=0xB7EA      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              Key                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|MsgType|T| Res |Attribute Type |   Attribute Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Attribute Value                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Control Message Family	Type
========================	======
GRE Tunnel Setup Request	1
GRE Tunnel Setup Accept	2
GRE Tunnel Setup Deny	3
GRE Tunnel Hello	4
GRE Tunnel Tear Down	5
GRE Tunnel Notify	6
Reserved	0,7-15

Tunnel establishment, example

LTE GRE Tunnel

E Got from PGW

D Got from BRAS

DSL GRE Tunnel

G Anycast IP address to a group of HAAPs
DNS server replies it to HG.

H
H
H IP address of the line-card of a HAAP

LTE GRE Tunnel Setup Request to "G"
(Outer SrcIP = "E")

LTE GRE Tunnel Setup Accept to "E"
("H" & "Session ID" included as Attributes)

The HAAP with the highest priority responds.

LTE GRE Tunnel
established

DSL GRE Tunnel Setup Request to "H"
(Outer SrcIP = "D", received "Session ID" included as an Attribute)

DSL GRE Tunnel Setup Accept to "D"

DSL GRE Tunnel
established

Thanks!