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Traffic Distribution for GRE Tunnel Bonding
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Abstract

GRE (Generic Routing Encapsulation) Tunnel Bonding as an L3 overlay tunneling mechanism is used for Hybrid Access (HA) bonding between HCPE (Hybrid Customer Premises Equipment) and HAG (Hybrid Access Gateway). The bonding performance depends upon the performance for each individual link. This document specifies a trying overflow mechanism to avoid the bonding performance downgrading due to the situation that an individual link is disrupted or its quality downgrages too much so that the bonding is no longer applicable.

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].

Status of This Memo

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1. Introduction

Service providers want to supply a higher throughput for their subscribers to provide a better customer experience, especially in those cases where customers can only be offered with a low bitrate DSL access. Bonding of fixed broadband and 3GPP access networks becomes desirable. [I-D.zhang-gre-tunnel-bonding] proposes a GRE (Generic Routing Encapsulation) tunnel bonding mechanism for bonding of DSL (Digital Subscriber Line) connection and LTE (Long Term Evolution) connection. An example of deployment scenario is illustrated in Figure 1. The Hybrid Access (HA) bonded connection is established between the HCPE (Hybrid Customer Premises Equipment), in the customer premises network, and the HAG (Hybrid Access Gateway), on the service provider's network [WT-348].

```
                 +-------+ LTE GRE Tunnel  +-------+
   +----------+    |      +-----------------+       |  Internet
   |User      +-----+ HCPE |                 |  HAG  +-----
   |Equipment|    |      +-----------------+       |
   +----------+    +-------+ DSL GRE Tunnel  +-------+
```

Figure 1: GRE Tunnel Bonding

The bonding should not be enabled if the bonding performance is worse than DSL only. This document proposes a traffic distribution algorithm named trying overflow to improve the bonding performance.

2. Terminology

2.1. Abbreviations and acronyms

BRAS: Broadband Remote Access Server

CAR: Commit Access Rate

CIR: Committed Information Rate

HA: Hybrid Access

HAG: Hybrid Access Gateway

HCPE: Hybrid Customer Premises Equipment

LTE: Long Term Evolution

2.2. Definitions

Hybrid Access: The bonding of two access paths based on heterogeneous technologies (e.g., DSL and LTE).

Hybrid Access Gateway: A logical function in the operator network implementing a bonding mechanism for customer access services.

Hybrid Customer Premises Equipment: A CPE enhanced to support the simultaneous use of both fixed broadband and 3GPP access networks.

Hybrid Access Gateway: A logical function in the operator network implementing a bonding mechanism for customer access services.

3. TCP Throughput Measurement and Issues

The Quality of Experience (QoE) on a hybrid access service depends upon the performance of each individual link. Generally, TCP Throughput (T) for a link can be measured as:

Throughput <= min (BW, WindowSize/RTT, MSS/(RTT*sqrt(p)))

While for hybrid access,

RTT = max(RTT1, RTT2)
p = w1*p1+w2*p2

Therein,

BW: maximum bandwidth

WindowSize: congestion window size

RTT: Round Trip Time; RTT1 for DSL link, RTT2 for LTE link

MSS: maximum segment size (fixed for each Internet path, typically 1460 Bytes)

p: packet loss rate; p1 for DSL link, p2 for LTE link

w: distribution factor; w1 refers to the percentage of total traffic on DSL link; w2 refers to the percentage of total traffic on LTE link.

When LTE link becomes congested, the latency may reach up to 400 ms; while the normal latency on DSL may only be 10 ms. According to the formula above, the TCP throughput for the hybrid access would be worse than DSL link only assuming p1 = p2.

4. Traffic Distribution Algorithm

Principle: Traffic distribution over DSL is prior to traffic distribution over LTE. The bonding mode would be enabled if the bonding performance is better than DSL only. Otherwise the bonding should not be enabled.

CAR (Committed Access Rate) with two token buckets is used to distribute traffic flows on HA-compliant nodes.

```
+-------+  (RTT2, p2, T2)       +-------+
|       |  LTE GRE Tunnel       |       |
|       +-----------------------+       |
| HPCE  |                       |  HAG  |
|       |          +-----+      |       |
|       +----------+BRAS +------+       |
+-------+          +-----+      +-------+
            DSL GRE Tunnel
            (RTT1, p1, T1)
```

Figure 2: Deployment Scenario

1. Start DSL only, and measure RTT1, p1 and T1 periodically; get <RTT1_min, p1_min>, <T1_max, RTT1_t1max, p1_t1max>. Here RTT1_t1max refers to the RTT when the throughput reaches maximum (T1_max) in a period. Likewise, p1_t1max refers to the p when the throughput reaches maximum (T1_max) in a period.

2. Estimate the usage of DSL according to RTT1 and P1; If there’s no congestion (i.e. RTT1=RTT1_min and p1=p1_min), bonding is not enabled.

3. If DSL is congested (i.e. RTT1>RTT1_min or p1>p1_min), start the "trying overflow" procedure (detailed in Section 5).

   1) The bonding mode is on. Tentatively distribute a small amount of traffic onto the LTE link at the initial stage, assuming CIR2 = LTE_MIN (minimum committed access rate). LTE_MIN is configurable and its default value is 64Kbps.

   2) Measure the throughput of the bonded links (T12) periodically.

      a) If T12 < T1_max and the DSL link is not congested, the bonding mode should be off.

      b) If T12 < T1_max and the DSL link is congested, the bonding mode is open, the CIR adjustment (i.e. decreasing) of the DSL link is triggered.

      c) Otherwise, the bonding mode is on. Set CIR1 = T1_max, the overflow traffic is distributed to LTE tunnel.

         i. If the DSL link is not congested and T12 is increasing rapidly, the CIR adjustment (i.e. increasing) of the DSL link is triggered.

5. Trying Overflow Mechanism

The "Trying Overflow" mechanism is implemented using the token bucket mechanism on, as shown in Figure 3.

```
           |
           |CIR2=LTE_MIN
           |
          \|/
       +---+----+
       +--------+
       |        |  Mark color
       |Trying  |  (Yellow, #1)
       |Overflow+---------------------+
       |Bucket  |                     |
       |        |                    \|/
       +---+----+                 +---+----+
           |Mark color            +--------+ Mark color
           | (Green)              |        | (Yellow, #2)
          \|/                     |        +--------------+
      +----------+                |DSL     | CIR1=T1_max  |
      |Forward to|                |Bucket  |             \|/
      |LTE tunnel|                |        |         +----------+
      +----------+                +---+----+         |Forward to|
                          Mark color  |              |LTE tunnel|
                           (Green)   \|/             +----------+
                                 +----------+
                                 |Forward to|
                                 |DSL tunnel|
                                 +----------+
```

Figure 3: Trying Overflow

o Trying Overflow Bucket: In this step, all the incoming traffic will be distributed to the trying overflow bucket. Its CIR can be set to LTE_MIN.

HA node has no knowledge of the quality of the LTE tunnel at first. If the LTE tunnel is congested, the bonding may impair the customer experience. So trying overflow is performed. If the trying is successful, then it means the LTE tunnel can be used for bonding.

The green packets will be distributed into the LTE tunnel, while yellow packets of #1 will be put into the DSL bucket.

o DSL Bucket: Its CIR can be set to T1_max. The green packets will be distributed into DSL tunnel, and yellow packets of #2 will be distributed into LTE tunnel.

Theoretically, if the LTE tunnel is suitable for bonding, the bonding TCP throughput T12 will increase continuously; and will exceed T1_max immediately. Yellow packets of #2 can be continuously observed obviously in a period of time.

6. Overbooking Considerations

DSL bandwidth can be overbooked on the BRAS (Broadband Remote Access Server). Overbooking may cause long delay or high packet loss rate.

When bandwidth downgrading happens on the BRAS due to overbooking, the CIR of the DSL link needs to be decreased. At that time, the bonding performance is worse than using DSL only and the DSL link is congested.

When the bandwidth is restored, the CIR of the DSL link needs to be increased. At that time, the bonding performance improves, and the congestion on the DSL link can be relieved.

7. Security Considerations

TBD.

8. References

8.1. Normative References

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