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Distributed Mobility Management Handover Frequentness Analysis
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Abstract

This document analysis the handover frequentness in distributed anchor scenario.

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1. Introduction

With the Gateway in the cellular telecom core network moving downwards towards the access network and being deployed distributively, the number of gateways is increasing. Consequently, an increasing the percentage of handovers will be of inter-gateway handovers among all the handovers is also rising. Due to the fixed anchor point used by the current mobility management, the route in the access network is not optimized, ; that means there is roundabout in the access network. Such roundabout problems will aggravate with the increase of inter-gateway handovers.

2. Conventions used in this document

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].

3. Inter-GW Handover Frequentness Analysis

We use a real deployment case in a metro of China as an example for the analysis. There are seventeen RNC nodes covering the metro. If we presume the Gateways are moved downwards to the level of RNC, we can calculate the frequentness of inter-GW handover based on that of inter-RNC handover.

The frequentness of inter-RNC handover:

In certain time period of j, relocNj is the total numbers of inter-RNC handover: I relocNj = SUM(CS relocation number i + PS relocation number i) i=1

In certain time period of j, rabNj is the total number of PDP activation and call establishment in RNCs: I rabNj = SUM(CS call number i + PS call number i) i=1

Rj is the frequentness of handover in this time period: Rj = relocNj / rabNj

R is the mean handover frequentness in all the time periods: J R = (SUM Rj)/ J *100% j=1

Notes:

1) The CS calls and PS calls are counted based on the successful RAB establishment

2) Both CS relocation and PS relocation include types of UE involved and UE not involved for handover out

3) I is the number of RNC in the metro

4) J is the number of time period, which could be one hour or more.

The statistics shows that the mean frequentness of inter-RNC handover in one hour is 12.32%, that is there are 12 times inter-RNC handover per 100 times of CS calls or PS PDP activation. The highest handover frequentness could reach 15.97%. If the gateways are moved to the level of RNC, then the frequentness of inter-GW handover should be equivalent to that of inter-RNC.

3.1. The Trend of the Inter-GW Handover Frequentness

The statistics result above is based on the current deployed network. With the evolution of the mobile network, e.g. when the LTE is deployed, we can expect that inter-GW handover frequentness will increase, when comparied with current deployed network.

a. With the increment of the traffic and the user amount, the requirement of the bandwidth goes up consequently. To meet this requirement, the density of the basestation shall increase. Meanwhile, with the consideration of the limited capacity and capability of the GWs, the density of the GWs should also increase. So, in a same coverage area, there will be more GWs. As a result, the inter-GW handover frequentness will increase.

b. With the service evolution, the rate of the always online user will increase. Accordingly, the rate of the service which is started (e.g. PDP activation) and completed (e.g. PDP inactivation) under a same GW will drop. As a result, the inter-GW handover frequentness will increase.

We expect that in the near future, the value of the inter-GW handover frequentness may be doubled or even tripled to the value of current frequentness.

4. The impact of non-optimized Routing

When fixed anchor point is used, the problems of roundabout will worsen with the movement of the user. Especially, when service is deployed far from the anchor point and near the location where the user is moving to. When the anchor point locates at a different city, the impacts of roundabout become more serious, that will inevitably affect the customer experience. In the following

chapters, the impacts are appraised with a traffic model from the aspects of traffic volume, congestion and time delay, etc.

4.1. Analysis model

We use the following model for the handover analysis. In this model, the anchor is distributed in the network edge. The communication peer may be located in the backbone or in the metro network.

```
                   +----------------------+
                   |       Backbone       |
                   |+-------+ +-------+   |   +-----+
                   ||RouterB|-|RouterB|---|---| Peer|
                   |+-------+ +-------+   |   +-----+
                   +----------------------+
                     |   |           |   |
                     |   |           |   +---------------+
             /-------+   |           +-----+             |
    +-------|------------|-------+ +-------|-------------|------+
    |       |            |       | |       |             |      |
    |   +-------+    +-------+   | |  +-------+      +-------+  |
    |   |RouterA|----|RouterA|   | |  |RouterA|------|RouterA|  |
    |   +-------+    +-------+   | |  +-------+      +-------+  |
    |         \         /        | |        \           /       |
    |         ,-'' -------+      | |        ,-'' -------+       |
    |       /              \     | |       /              \     |
    |      /       Metro    \    | |      /       Metro    \     +-----+
    |      |                |    | |      |                |-----|Peer |
    |      \    Network A  ,'    | |      \    Network B  ,'     +-----+
    |       `.           _,      | |       `.           _,      |
    |        /  `-..____,,' \    | |        /  `-..____,,' \    |
    |       /                \   | |       /                \   |
    |    +------+       +------+ | |    +------+       +------+ |
    |    |P-GW1 |       | P-GW2| | |    | P-GW |       | P-GW | |
    |    |S-GW1 |       | S-GW2| | |    | S-GW |       | S-GW | |
    |    +------+       +------+ | |    +------+       +------+ |
    |                            | |                            |
    +----------------------------+ +----------------------------+
```

Figure 1: Distributed anchor handover analysis model

When the UE attaches to the network through S-GW2, the forwarding path is illustrated in the following figures.

For the case that the communication peer is located in backbone, the forwarding path is illustrated as the following figure.

```
  +----+   +-----+   +------+   +-------+   +-----------------+
  |UE  |-->|P-GW2|   |      |   |       |   |                 |
  |    |   |S-GW2|-->|Metro |-->|RouterA|-->|Metro to Backbone|
  +----+   +-----+   +------+   +-------+   +-----------------+
                                                              |
                                               +-------+   +-------+
                                               |  Peer |<--|RouterB|
                                               +-------+   +-------+
```

Figure 2: Forwarding path when peer is located in backbone network

For the case that the peer is located in metro network, the forwarding path is illustrated as following figure.

```
               +----+   +-----+   +------+   +-------+
               |UE  |-->|S-GW2|-->|Metro |-->| Peer  |
               |    |   |P-GW2|   |      |   |       |
               +----+   +-----+   +------+   +-------+
```

Figure 3: Forwarding path when peer is located in metro network

Whe the UE moves to S-GW1's serving area and handover to S-GW1 from S-GW2, the data forwarding path is illustrated as the following figures. In this scenario, if we use current mobility solution, the anchoring point should be still at P-GW2.

For the case that the peer is located in backbone network, the forwarding path is illustrated as following figure.

```
  +----+   +-----+      +------+      +-------+        +------- +
  | UE |-->|S-GW1|----->|Metro |----->| P-GW2 |------->|Metro  |
  +----+   +-----+      +------+      +-------+        +--------+
                                                              |
               +----+   +-------+   +------------------+   +-------+
               |Peer|<--|RouterB|<--| Metro to backbone|<--|RouterA|
               +----+   +-------+   +------------------+   +-------+
```

Figure 4: Forwarding path when peer is located in backbone network after handove

For the case that the peer is located in metro network, the forwarding path is illustrated as following figure.

```
+----+  +-----+  +------+  +------+  +------+  +----+
|UE  |->|S-GW1|->|Metro |->| P-GW2|->|Metro |->|Peer|
|    |  |     |  |      |  |      |  |      |  |    |
+----+  +-----+  +------+  +------+  +------+  +----+
```

Figure 5: Forwarding path when peer is located in metro network

It is assumed that the traffic to the backbone network is 60% of the total traffic and the traffic to metro network is 40% of the total traffic.

4.2. Traffic load Analysis

Based on the above handover model, the un-optimized routing is summaried in the following table.

Traffic	peer in Backbone	peer in Metro	average
Before handover	1 volume within metro. 1 volume between metro and backbone 1 volume within backbone	1 volume within metro. 0 volume between metro and backbone 0 volume within backbone	1 volume within metro. 0.6 volume between metro and backbone 0.6 volume within backbone
After handover	2 volume within Metro. 1 volume between metro and backbone 1 volume within backbone	2 volume within metro. 0 volume between metro and backbone 0 volume within backbone	2 volume within metro 0.6 volume between metro and backbone 0.6 volume within backbone

Figure 6: Traffic Analysis result for non-optimized routing

From this analysis result, it can be concluded that the non-optimized routing will result in 100% traffic load increase in metro network.

4.3. Congestion Probability Analysis

We assume that the congestion probability in metro network is X, the congestion probability between metro network and backbone is Y, based on the above analysis model, we have the following result.

congestion probability	peer in backbone	peer in metro	average
Before handover	1-(1-X)*(1-Y)	X	0.6*[1-(1-X)*(1-Y)]+0.4*X
After handover	1-(1-X)*(1-X)*(1-Y)	1-(1-X)(1-X)	0.6*[1-(1-X)(1-X)*(1-Y)]+0.4*[1-(1-X)*(1-X)]

Figure 7: Congestion Probability Analysis result for non-optimized routing

From the above result,we can conclude that the congestion probability will increase after handover. If X=3%, Y=3%, the congestion probability after handover will increase 2.86%.

4.4. Delay Analysis

The delay from UE to peer consists of three parts:delay within metro network: T1, the delay between metro to backbone:T2, the delay within backbone:T3. Based on the above model, we have the following analysis result.

Delay	Peer in Backbone	peer in Metro	Average
Before handover	T1+T2+T3	T1	T1+0.6(T2+T3)
After handover	2*T1+T2+T3	2*T1	2T1+0.6(T2+T3)

Figure 8: Delay Analysis result for non-optimized routing

From the analysis result, we can conclude that the delay within metro will increase 100% due to the non-optimized routing after handover.

5. Conclusion

According to the inter-gateway handover frequentness calculation model and based on the data gathered from the deployed network, an average of 12% of service sessions perform inter-gateway handover (e.g. handover from S-GW2 to S-GW1) in every survey cycle. The inter-gateway handover leads to non-optimal routing and brings some impactions as following:

Traffic load: referring to figure 6, a lot of wasted volume deliveres in the metro network. The operator's valuable bearer resource is wasted. According to the Global Mobile Data Traffic Forecast by CSISO, in 2015 the global mobile data traffic will be 6.3EB. That means the wasted volume will be 0.75EB in 2015.

Congestion: Many mobile users will suffer from a higher congestion probability than the average. The increased congestion probability is X*(1-X)*(1-0.6X), in which the X is the average congestion probability in metro network and the Y is the average congestion probability between the metro network and backbone network. For example, when X is 10%, Y is 10%, then the average congestion probability is 15.4%. Then these mobile users have to bear the congestion probability of 23.86%.

Delay: Many users will suffer from much more traffic delay. The increased traffic delay is one time of the average delay in the metro network.

6. Security Considerations

TBD

7. IANA Considerations

None

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