
Incident Report on Service Disruption on 3 April 2015

1. Introduction

This report is submitted by China Unicom (Hong Kong) Operations Limited on an incident occurred on 3 April 2015 relating to a service disruption (“Incident”). We submitted a preliminary report on 10 April 2015 and this report aims to provide additional information on the Incident in order to assist OFCA’s investigation.

2. Description of the Incident

2.1 Events leading to the occurrence of the Incident

- (a) On 1 April 2015, our Network Operations Centre (“NOC”) observed that the optical board alarm was on and the optical board needed to be replaced.
- (b) At around 1:43 am on 2 April 2015, preventive HLR maintenance had been carried out and the optical board was replaced during our maintenance window which had no impact on our services. Our NOC discovered that the HLR system, which is designed with 1+1 protection, encountered system faults which caused HLR running without redundancy. As agreed with our equipment vendor, emergency maintenance would be carried out during the maintenance window the next day morning.
- (c) At around 1:30 am on 3 April 2015, the maintenance window commenced and emergency maintenance had been carried out in order to restore the 1+1 redundancy function. The emergency maintenance procedures were as follows:

Time (3 April 2015)	Actions taken	Results
0:01 am – 1:30 am	HLR database backup	Positive
1:30 am – 1:45 am	Restarted HLR ¹ then restored HA cluster ²	Positive

¹ Some confidential information has not been disclosed.

² Ditto

2:00 am – 5:30 am	Observed HLR status and found link congestion. Attempted to fix signalling link congestion.	Negative
After 5:30 am	Equipment vendor determined that service outage might extend over maintenance window and we escalated the incident to the management.	-

- (d) Until around 5:30 am on 3 April 2015, we observed that a number of our customers had lost connection from MVNO network when customers' mobile devices performed location update. The service disruption was preliminary found to be caused by the congestion of HLR signalling links. As a result, our customers' services including SMS, voice and data services were affected.
- (e) According to the HLR equipment vendor's investigation, after the HLR system resumed its redundancy function, the incoming signalling traffic was handled by the HLR system with backup for load sharing. The root cause of the Incident was not due to the HLR capacity but the congestion occurred in the signalling links in the HLR system.³

2.2 Event Log

Time and Date	Event Description
5:30 am, 3 April 2015	Our NOC observed that the HLR system critical alarm was on. The problem was immediately escalated to our network engineers and equipment vendor for investigation.
6:00 am, 3 April 2015	Our network engineers and vendor support team arrived on site and took immediate actions to solve the problem.
6:30 am, 3 April 2015	Engineers identified the problem was caused by overloading of HLR system which resulted in the new incoming signal messages abortion.
8:00 am, 3 April 2015	Engineers performed actions to restore the HLR system but such system could not take up traffic as normal after restoration.

³ Some confidential information has not been disclosed.

8:30 am, 3 April 2015	Engineers noted that the number of location update of authentication requests had exceeded the processing ability of HLR system after restoration.
9:30 am, 3 April 2015	Engineers tried different approaches to reduce incoming signalling traffic in order to decrease the loading of HLR system but no significant effect was found.
10:30 am, 3 April 2015	The congestion caused by the repeated authentication request failure deteriorated.
11:50 am, 3 April 2015	The preliminary data obtained from the system indicated that the number of affected customers had been increasing and we informed OFCA of the Incident.
12:30 pm, 3 April 2015	Our engineers and vendor support team worked out a system restoration plan to resume the services by steps, whereby the IMSI had been broken down into hundred batches. Each batch of IMSI was then resumed one by one in order to offload the number of location update authentication requests that took place at the same time into safety loading level.
2:30 pm, 3 April 2015	Around 10% of affected customer's services had resumed normal.
8:30 pm, 3 April 2015	Around 60% of affected customer's services had resumed normal.
2:30 am, 4 April 2015	All affected customer's services had resumed normal.

2.3 ⁴After the close of the maintenance window on 3 April 2015, we noticed that there was congestion but the condition was not serious. Since we could not get hold of the number of affected customers from the system, some time was spent in conducting further investigation to define the actual number of affected customers. It was not until around 11:30 am when: (i) the number of complaints received from customers increased; and (ii) the preliminary data obtained from the system indicated that 80% of our customers were affected that we could have sufficient assessment on the impact of the outage on our customers. We therefore reported the Incident to OFCA at around 11:50 am.

2.4 The prolonged restoration time was due to the fact that as a mobile virtual

⁴ Some confidential information has not been disclosed.

network operator (“MVNO”), we do not have the control of MSC equipment and wireless base station which are under the control of other mobile network operators (“MNOs”) providing services to us. We are therefore unable to temporary block the excessive influx of location update authentication requests from visiting MSC immediately which is the fastest way to control the traffic according to our equipment vendor.⁵

3. Number of affected customers

We estimate that around 75,000 customers or 83% of our active customers were affected.⁶

4. Remedial actions taken

Our engineers and vendor support team worked out a system restoration plan to resume the services by steps, whereby the IMSI would be broken down into hundred batches. Each batch of IMSI would be resumed one by one in order to offload the number of location update authentication that takes place at the same time into safety loading level. All services had resumed normal at 2:30 am on 4 April 2015 when the restoration plan was fully executed. Our duty engineers were arranged to monitor the HLR system status closely until network improvement works were finished to stabilize the traffic flow.

The detailed remedial actions taken were as follows:

Time and Date	Actions taken
5:30 am – 8:30 am, 3 April 2015	Our engineers and vendors support team tried to identify the problem. ⁷

⁵ Some confidential information has not been disclosed.

⁶ Ditto

⁷ Ditto

8:30 am – 11:30 am, 3 April 2015	Our engineers and vendors support team tried different approaches to resolve the problem ⁸ in order to reduce the repeated authentication request from customers' terminal and enhance the success rate of location update requests. Unfortunately, no significant effect was found after several actions.
11:30 am – 1:00 pm, 3 April 2015	The signalling link congestion started to relieve after bypassing the messages according to different IMSI ranges. When the signalling link resumed to normal, our engineers and vendors support team tried to resume a large IMSI block but the congestion happened again. ⁹
1:00 pm, 3 April 2015 – 2:30 am, 4 April 2015	Using the plan aforesaid, the service resumed to normal gradually.
After 2:30 am, 4 April 2015	The number of signalling links had been expanded ¹⁰ .

5. Root cause analysis

¹¹During the maintenance operation, certain operation had been performed thereby resulting in a large amount of location update authentication requests during the restoration process. The number of requests had reached the maximum processing ability of the signalling links and the congestion occurred.¹²

6. Communication with the public

Soon after the coverage of affected customers was identified, we communicated with our customers, media and public on the Incident via the following channel:

6.1 Our website <http://hk.chinaunicom.com>: Pop-up announcements and up-dates were posted on our website at 11:50 am, 2:16 pm, 3:22 pm and 7:01 pm on 3 April 2015 respectively. We also informed our customers that all services had

⁸ Some confidential information has not been disclosed.

⁹ Ditto

¹⁰ Ditto

¹¹ Ditto

¹² Ditto

resumed normal at 8:27 am on 4 April 2015.

6.2 Facebook: Announcements and up-dates were posted on our official Facebook at 11:38 am, 2:04 pm, 3:10 pm and 6:49 pm on 3 April 2015 respectively. At 3:33 am on 4 April 2015, we informed our customers that our services had resumed normal.¹³

6.3 Customer hotline: We had immediately increased manpower at our customers' services hotline center to answer inquiries from customers.¹⁴

6.4 ¹⁵Some complainants alleged that they could not use our service before the start time of the Incident. While the actual cause for such service disruption is yet to be ascertained, we believe that this might be due to the network coverage problem of those complainants which is independent from the Incident.

6.5 We had received and replied to the enquiry from the following press on the Incident: Apple Daily, Sing Tao Daily, Oriental Daily, TVB and Bastille Post.

7. Improvement measures

7.1 We had been closely monitoring the HLR system in order to prevent occurrence of similar incident in the future.

7.2 The number of signalling links of the HLR system had been expanded¹⁶.

7.3 ¹⁷According to the statistics of the signalling links in the diagram below, the seizure ratio was 14.63% only.

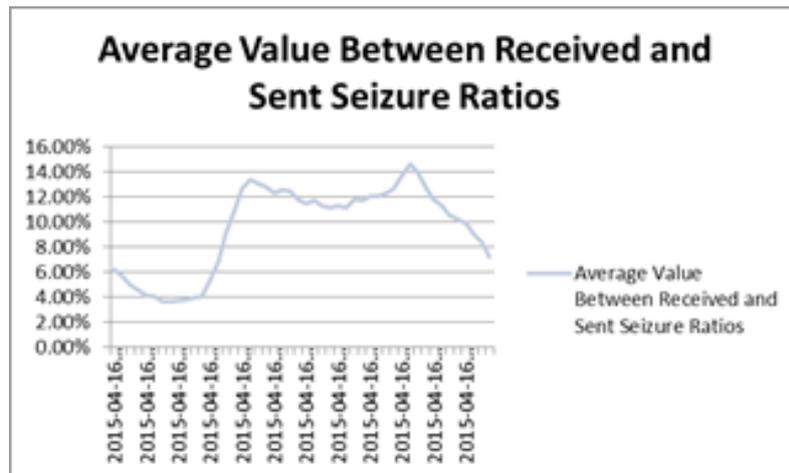
¹³ Some confidential information has not been disclosed.

¹⁴ Ditto

¹⁵ Ditto

¹⁶ Ditto

¹⁷ Ditto



China Unicom (Hong Kong) Operations Limited

24 April 2015

Incident Report on Service Disruption on 5 April 2015

1. Introduction

This report is submitted by China Unicom (Hong Kong) Operations Limited on an incident occurred on 5 April 2015 relating to a service disruption (“Incident”). We submitted a preliminary report on 10 April 2015 and this report aims to provide additional information on the Incident in order to assist OFCA’s investigation.

2. Description of the Incident

2.1 Events leading to the occurrence of the Incident

At around 4:00 pm on 5 April 2015, we observed that there was signal link congestion in our system which may cause service disruption to our customers. Parts of our services including SMS, voice and data services were affected.

2.2 Event Log

Time and Date	Event Description
4:00 pm, 5 April 2015	Our Network Operations Centre (“NOC”) observed that the mobile system signal links encountered congestion problem. Signalling link overloading alarm had been detected. The problem was immediately escalated to network engineers and our equipment vendor for investigation.
4:30 pm, 5 April 2015	The situation of signal links congestion deteriorated. Engineers and vendor support team had immediately implemented traffic control policy and bypassed part of the traffic to improve the situation.
5:00 pm, 5 April 2015	The effect of traffic control was not significant, more traffic were therefore bypassed to avoid further deterioration.
6:00 pm, 5 April 2015	The preliminary data obtained from the system indicated that the number of affected customers had been increasing and our NOC informed OFCA that there was a service disruption in our network.
8:00 pm, 5 April 2015	Engineers applied different traffic control approaches and closely monitored the traffic of the signal links. “Tidal flow” control system was implemented in order to relieve

	congestion.
10:00 pm, 5 April 2015	Signalling link congestion relieved. The affected services had been resumed gradually.
11:30 pm, 5 April 2015	All local services had resumed normal. Part of the roaming services was still affected.
0:30 am, 6 April 2015	All affected services (including voice, data and SMS services) had resumed normal.
1:12 am, 6 April 2015	Our NOC informed OFCA that all of our service had resumed normal.

2.3 The prolonged restoration time was due to the fact that as a mobile virtual network operator (“MVNO”), we do not have the control of MSC equipment and wireless base station which are under the control of other mobile network operators (“MNOs”) providing services to us. We are therefore unable to temporarily block the excessive influx of location update authentication requests from MSC server immediately which is the fastest way to control the traffic according to our equipment vendor. ¹

3. Number of affected customers

We estimated that around 31,500 customers or 35% of our active customers were affected.²

4. Remedial actions taken

Engineers had taken immediate action to apply traffic control policies when the congestion occurred. By estimating the number of active user blocks and registration numbers in specific MSC, we had bypassed and routed the traffic towards specific MSC to ensure that the services of attached users would not be affected and overcome the traffic congestion. After several rounds of traffic control, the customer services had resumed normal at 0:30 am on 6 April 2015. Our duty engineers were arranged to closely monitor the traffic flow of signal links until network improvement works completed.

The detailed remedial actions taken were as follows:

¹ Some confidential information has not been disclosed.

² Ditto

4:00 pm – 4:30 pm, 5 April 2015	During long public holidays, the number of location update requests received was more than as usual. The influx of the requests induced the signalling links overloading. The situation of signal links congestion deteriorated when the number of requests increased continuously.
4:30 pm – 5:00 pm, 5 April 2015	Part of the traffic ³ had been bypassed and signalling link condition had been closely monitored in order to reduce the service impact on local customers.
5:00 pm – 6:00 pm, 5 April 2015	The effect of traffic control was not significant, more traffic ⁴ were therefore bypassed to avoid further deterioration.
6:00 pm – 8:00 pm, 5 April 2015	The restoration plan had been performed by breaking down the IMSI into batches and resumed one by one to relieve the congestion. ⁵ “Tidal flow” control system was implemented and the loading of signalling links was closely monitored. The successful rate of location update request increased dramatically. ⁶
8:00 pm, 5 April 2015 – 12:30 am, 6 April 2015	Apart from the actions above, engineers had also performed other operations ⁷ . The service resumed to normal gradually.

5. Root cause analysis

5.1 At around 4:00 pm on 5 April 2015, the ratio of increased traffic in a specific region was beyond our expectation and there was a large proportion of location update authentication requests within the region of Shenzhen and Hong Kong border. The traffic volume increased about 40%-100% compared to the same period of previous day and such volume reached the designed limit of our system. The cause for such increase in traffic might need to be further investigated.

5.2 Due to the sudden and unexpected increase in traffic, the mobile core system had therefore experienced high utilization and resulted in signalling link congestion. The traffic congestion happened within a very short period of time and the number of successful location update rate dramatically degraded to 65%.

³ Some confidential information has not been disclosed.

⁴ Ditto

⁵ Ditto

⁶ Ditto

⁷ Ditto

During the recovery process, our engineers tried to reduce the traffic by apply different approaches in order to secure the uninterrupted services of attached users. “Tidal flow” control system was implemented in order to relieve congestion and as a result, the recovery time was longer than expected.

- 5.3 After the outage occurred on 3 April 2015, we had expanded the number of signalling links⁸ in order to avoid the traffic congestion in the future.⁹ Unfortunately, the traffic congestion happened again in the afternoon of 5 April 2015. The service resumed normal again after the implementation of restoration plan. After further investigation with equipment vendor, it was found that although we had expanded¹⁰ signalling links after the incident on 3 April 2015, the signalling link loadings were not balanced and therefore rendered the¹¹ additional links ineffective during service peak hours and resulted in traffic congestion.
- 5.4 In the early morning of 6 April 2015, all affected customer’s services had resumed normal.¹² After system parameter configuration, the load balancing problem had been resolved.

6. Communication with the public

Soon after the coverage of affected customers was identified, we communicated with our customers, media and public on the Incident via the following channel:

- 6.1 Our website <http://hk.chinaunicom.com>: Pop-up announcement was posted on our website at 7:24 pm on 5 April 2015. We also informed our customers that all services had resumed normal at 1:35 am on 6 April 2015.
- 6.2 Facebook: Announcement was posted on our official Facebook at 6:50 pm on 5 April 2015. At 1:30 am on 6 April 2015, we informed our customers that our services had resumed normal.¹³
- 6.3 Customer hotline: We had immediately increased manpower at our customers’ services hotline center to answer inquiries from customers¹⁴.

⁸ Some confidential information has not been disclosed.

⁹ Ditto

¹⁰ Ditto

¹¹ Ditto

¹² Ditto

¹³ Ditto

¹⁴ Ditto

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- 6.4 ¹⁵Some complainants alleged that they could not use our service before the start time of the Incident. While the actual cause for such service disruption is yet to be ascertained, we believe that this might be due to the network coverage problem of those complainants which is independent from the Incident.
- 6.5 We had received and replied to the enquiry from Oriental Daily on the Incident.

7. Improvement measures

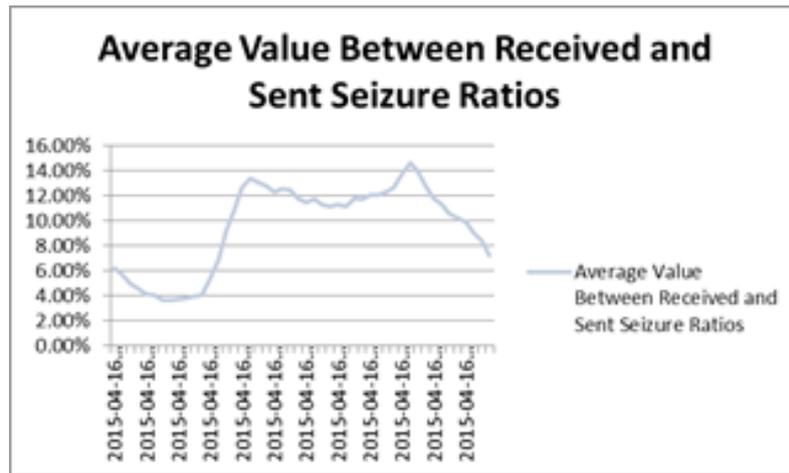
- 7.1 We have implemented the following measures to prevent occurrence of similar incident in the future:
- increased the number of signal links; and
 - closely monitoring of the HLR system.
- 7.2 Our 3G core mobile platform has been in use for more than 8 years¹⁶. We had already purchased a new system to replace 3G core platform. The new 4G core mobile platform had been installed and tested in the end of March 2015. The new system had been in a trial running state and the processing power is 4 times of the existing platform. ¹⁷Due to these 2 incidents, we had rescheduled the cutover plan and our target date of completion will be postponed to mid-May 2015. We are confident that the root cause of the Incident can be fully resolved after the migration to the new 4G system.
- 7.3 ¹⁸According to the statistics of the signalling links between HLR and CNP in the diagram below, the seizure ratio was 14.63% only.

¹⁵ Some confidential information has not been disclosed.

¹⁶ Ditto

¹⁷ Ditto

¹⁸ Ditto



China Unicom (Hong Kong) Operations Limited

24 April 2015