

Preliminary Report of Service Disruption on 26 February 2017

1. Introduction

On 26 February 2017, a power interruption at one mobile switching data center caused service disruption of China Mobile Hong Kong Company Limited (“CMHK”) network partially. This preliminary report provides a brief description of events that led to the occurrence of service disruption, the remedial actions taken and the improvement measures to be taken.

2. Service Disruption on 26 February 2017

2.1 Events Leading to the Occurrence of the Outage

On 26 February 2017, the industrial building, where one CMHK mobile switching data center was located, had a scheduled power maintenance. The maintenance period was from 09:00 to 18:00 between which city power for the whole building was unavailable. CMHK had received prior notice of this event from building management office. On the day, sufficient diesel fuel and vendor support was arranged to stand by on site. The diesel generator was started up manually at 08:52. The city power was off at 09:00, and mobile switching data center was powered by the diesel generator.

At 13:46, high temperature alarm was alerted in the generator (reached 90 °C). By the time on-site vendor support engineer was checking the alarm, the generator was shut down automatically at 13:48, due to high temperature protection mechanism (reached 95 °C). Under normal operation, the backup batteries of DC power system at data center should maintain the power supply for the data center. During the incident, 4 out of 5 battery banks had the output MCCB’s (Module Case Circuit Breakers) tripped. This resulted in major power outage for the

data center, and all major network equipment were shut down without power.

After cooled down of generator, on-site vendor support engineer started up the generator again. The power supply from generator was resumed at 14:14.

During the power outage between 13:48 and 14:14, limited mobile network service could be provided by the redundant network equipment at other data centers, but network quality was degraded due to network congestion. However, all prepaid services were disrupted. Some customers experienced no 2G/4G network in certain areas and attached to 3G network. Voice calls were failed in 2G/3G/4G network sometimes. Data services and VAS services including voicemail, SMS and MMS for customers in 2G/3G/4G network was partially affected, due to network congestion.

By the time when power resumed at 14:14, network equipment started to recover, but some network nodes did not resume properly after systems were powered up. The major service interruptions are mentioned below:

- a) Weak 2G/4G network coverage: Two BSC's (Base Station Controllers) and some 2G/4G cell sites were down. 2G/4G network coverage was affected. However, customers could still use 3G network. The 2G/4G network coverage was improved when we recovered the two BSC and most of the failed sites after 17:00.
- b) All prepaid services unavailable: The prepaid system could not resume after powered up. All prepaid services became unavailable. Prepaid voice and data services were resumed after prepaid system bypass was activated around 16:00.
- c) Mobile to mobile outgoing voice call failure: The redundant MNP (Mobile Number Portability) platform was failed. The malfunction of mobile number dipping caused mobile to mobile voice call failure. The outgoing call resumed gradually, after the MNP platform was recovered by 15:55.

2.2 Event History Log

Time	Event Description
26-Feb-2017	
08:52	Started up diesel generator manually
09:00	Power supply to mobile switching center was provided by generator, while city power was off.
13:46	High Temperature Alarm (90 °C) was triggered, and on-site vendor support engineer checked the generator.
13:48	Generator was shut down automatically, due to the high temperature protection mechanism (95 °C). CMHK engineer noticed power outage in the mobile switching data center. NOC noticed major network outage, and triggered internal emergency escalation procedure. Support engineers started trouble shooting.
14:14	Vendor support engineer restarted the generator after cooled down, and power was resumed for data center.
14:20-14:25	4 x MCCB's connected with backup battery banks of DC power system were found tripped. CMHK engineer switched on the MCCB's again.
14:10-14:30	CMHK frontline were briefed with the incident to answer customers' enquiries, and PR team was informed to prepare public announcement of service disruption.
13:50-14:30	Checking the affected network services: many voice call failure, prepaid service failure, and some VAS services including voicemail, PRBT, SMS, MMS were affected partially. Data service was ok.
14:30-15:30	CEO, Network Division Heads and more support engineers arrived at NOC center and the affected data center, in order to support the remedial actions for network recovery
14:30-14:40	NOC Manager informed OFCA about the major network outage
14:24	Confirmed voicemail and PRBT services were ok
14:25	Confirmed PS core nodes resumed at the affected data center
14:40	Requested core network equipment vendors to dispatch support engineers for on-site support.
15:10	Found all connections of MNP platform down, and escalated to vendor support.

15:50	Rebooted the MNP platform, and MNP dipping resumed. Mobile outgoing voice calls started to recover.
15:43	Terminated the Gy connection between prepaid system and PGW, in order to resume prepaid data service (i.e. bypassed Prepaid system).
16:23	Modified the CAMEL configuration in HLR to bypass prepaid system, and prepaid voice service was resumed.
17:15	Resumed the two failed BSC after system reload
19:45	Confirmed remaining 45 base station sites were still down. The impact on 2G/4G network coverage was minimized. Support engineers continued to recover the sites one by one.
22:20	Prepaid system was recovered, and prepaid services were gradually resumed with charging.
27-Feb	
05:30	The failed base station sites except 5 minor sites were all recovered (N.B. the 5 minor sites were all recovered by 28-Feb)

2.3 Remedial Actions taken

The diesel generator was shut down at 13:48, due to high temperature protection mechanism. It was started up again at 14:14 after cooled down. Power to mobile switching data center was then resumed. The four tripped MCCB's of battery banks were switched on again by 14:25.

At the time when power resumed at 14:14, some network equipment were found not in normal operation after system powered up. Below remedial actions had been taken to address the service impact:

- a) Weak 2G/4G network coverage in some areas: Two failed BSC were resumed successfully by 17:15 after system reload. Most of the failed cell sites were recovered, and 45 sites were still down by 19:45. The network coverage impact had been minimized. Staff continued the trouble shooting and tried to recover the remaining failed cell sites one by one. By midnight, 12 failed sites remained. Only 5 minor sites were still failed by 05:30 on 27-Feb. These 5 minor sites

were all recovered by 28-Feb.

- b) All prepaid services unavailable: The prepaid system was down, and could not be recovered immediately. Prepaid data service was resumed at 15:43 by stopping the Gy connection between Prepaid system and PGW. The prepaid voice service was resumed at 16:23 by changing the CAMEL setting in HLR to bypass prepaid system. Both bypass actions enabled Prepaid customers to use data and voice services without charging in prepaid system. The prepaid system was isolated for trouble shooting and recovery. The prepaid system was finally recovered for service by 22:20, and prepaid voice and data charging was resumed.
- c) Mobile to mobile outgoing voice call failure: The MNP platform was failed to recover after power resumed. After trouble shooting, the MNP platform was rebooted successfully by 15:55. With MNP dipping worked again, mobile outgoing voice calls were resumed gradually.

2.4 Root cause analysis

In preparation of the scheduled building power maintenance, the diesel generator had been checked twice by maintenance vendors on 7-Feb and 23-Feb respectively. Both maintenance check confirmed normal operation of the generator, without any problem identified. The generator was started up manually at 08:52 on 26-Feb and operating normally till 13:46 when high temperature alarm was alerted. The generator was then automatically shut down at 13:48 due to high temperature protection mechanism.

The capacity of diesel generator is 1200A (3 phases AC supply), and the load was lesser than 700A at the time of high temperature alarm. The reason of high temperature alarm is still waiting for maintenance vendor's incident report. Vendor had arranged a full load test on 1-Mar for further investigation.

The last preventive maintenance of DC power system and electricity at the mobile switching data center was done in 29-Dec-2016 and 7-Feb-2017 respectively. No problem was identified during the regular checks.

There are 5 banks of backup batteries installed for the DC power system, which should maintain the power supply for the data center in event of both city power and generator failure. The output of four battery banks are connected with a 570A MCCB each, which were all tripped during the incident. One battery bank is connected with a 600A fuse, which was not broken. No current discharge was suspected for this battery bank with unbroken fuse. The reason of why four MCCB's tripped but one fuse not broken is still waiting for vendor's incident report.

Some of the network equipment was not resumed properly after power resumed from the abnormal outage. We have requested all equipment vendors to provide incident reports in due course.

2.5 Number of affected customers

The power outage incident majorly affected 2G/4G network coverage, mobile outgoing voice calls and prepaid services, due to problems in some network equipment during power outage and after power resumed. The impact of no 2G/4G network coverage was minimized, as customers could attach to 3G network. Data services, mobile terminating calls, SMS and MMS services were partially affected due to network congestion and reduced network coverage in some areas.

Based on traffic statistics, network services started to resume from 15:50 and traffic was mostly back to normal level by 20:00. The voice and data traffic between 14:00 and 20:00 was decreased by 58% and 27% respectively during the incident. We need some more time to estimate the number of affected customers, and will provide the estimation in the full report later.

4. Communication with the Public

CMHK had communicated with customers, local media, and the general public about the service disruption via the following channels

on the day of the incident.

1. Retail, Corporate Sales and Hotline staff
2. Facebook
3. Media

4.1 Retail, Corporate Sales and Hotline staff

Frontline staffs were briefed about the incident for handling related enquiries from customers on 26-Feb. We had immediately adjusted manpower in Customer Services Hotline center to answer customers' enquires.

4.2 Facebook

Messages and announcements were posted in CMHK official Facebook during and after the incident, informing customers of the network service disruption and service recovery status.

4.3 Media

CMHK had kept informing the media about the latest situation and recovery status and immediately responded to their queries during and after the incident.

5. Improvement Measures

- We will perform any necessary rectification or improvement works for the generator and DC power system immediately at this data center, based on vendors' root cause analysis and recommendation. We have requested vendors to provide the incident report urgently within this week.
- We will arrange full power audit for CMHK data centers in March 2017.
- Dual power feed of MNP platform servers will be re-connected separately to UPS and DC/AC inverter of DC power system, which have independent backup batteries. The MNP platform will be replaced by new nodes with site resiliency by Q2 2017 in the planned

network migration.

- Prepaid system will be migrated to a new system with site resiliency by end 2017.
- We have already planned for migration to a new core network with improved site resiliency of network equipment including BSC by Q3 2017. The new redundant core network equipment will be located at different new data centers with more secure power facilities. We will try the best to speed up the migration, in order to offload traffic and services from this vulnerable data center as early as possible.

China Mobile Hong Kong Co. Ltd.

Date: 1-Mar-2017