How Smooth is an ISP Changeover Process?

Waiting W. T. Fok and Rocky K. C. Chang

Abstract—For various reasons, an enterprise may change to a new ISP for network connectivity, and the ISP changeover will inevitably interrupt the normal network operations. This paper is the first to document this process and to measure the impact of ISP changeover on the network performance for HARNET which connects the eight major universities in Hong Kong. We set up a network measurement platform to monitor the performance and route changes during the one-week long migration process. Our continuous monitoring results clearly show the different phases of the migration and the impact on the end-to-end performance. Except for short periods of instability and disruptions, the entire ISP changeover process is considered quite smooth.

Index Terms—Network measurement, Network monitoring, ISP changeover

I. INTRODUCTION

Changing Internet Service Provider (ISP) does not happen often for enterprise networks, but it does happen from time to time for various reasons (e.g., lower cost and better performance). A possible barrier to migrating to a new ISP is perhaps the impact on the networks during the changeover [1]. However, there is no formal study on measuring the impacts and documenting the changeover process. This paper is the first to fill this gap by reporting a recent ISP changeover for HARNET (The Hong Kong Academic and Research NETwork) [2] which connects the campus networks of the eight major universities in Hong Kong which has over 100,000 staff and students. This study details the key steps of the changeover process and reports the results of the network measurement designed specifically for this changeover event.

Besides connecting among the eight universities, HARNET also provides Internet connectivity to the universities through (1) a designated ISP in Hong Kong, (2) HKIX, an Internet exchange hosted in a university interconnecting most networks in Hong Kong, and (3) peering to other overseas research and academic networks, such as CERNET, Internet2, and TEIN3. Since we deployed a network monitoring platform for HARNET in January 2009, we experienced three planned ISP changeovers and numerous network events, including local router faults, route discriminations and route changes, and submarine cable outages [3]. We correlate the measurements from the data plane, such as round-trip time (RTT) and packet loss events, and that from control plane, including forward and reverse path routes and BGP information, to identify the root causes [4].

In this paper, we present our measurement results and path information collected during the ISP migration. During the one-week planned network change, all of the aforementioned network connections were reconfigured one after the other. Some of them were disconnected temporarily, relying on alternate routes to recover accessibility during the short transition period, and then re-connected again. Others involved adding a new route, adjusting the incoming and outgoing routing preferences to divert traffic to the new route, and finally removing the old route. Although the ISP changeover is a planned event, we have observed that the network configuration changes create similar disruptions as those from network equipment failures and misconfigurations.

The remaining of the paper is organized as follows. Section II documents the main steps in the ISP changeover process and the expected outcomes. Section III describes our platform for monitoring the network performance during the migration. Section IV reports the measurement results and evaluates the impact of the changeover on the network availability and performance. After discussing the related works in Section V, we conclude the paper in Section VI.

II. ISP CHANGEOVER PLAN

Figure 1 illustrates the layer-3 network diagram of HARNET as of April 2015 after the changeover. Two routers CR[1|2] are hosted by each of the eight universities of HARNET to connect themselves internally and externally to two optical hubs through an optical metro network. The optical network connects to four network switches, two at each optical hub. The core routers HR* and network switches (not shown in the diagram) are hosted in optical hubs in CUHK and HKU, two members of HARNET. Routers HR[IX|1|2] are located in CUHK, and HR[3|4] in HKU. Internally, they are linked to the two network switches at the site connecting to the optical metro network. A dedicated 10 Gbps link connects HR1 and HR3 as shown in the diagram. Not shown in the diagram for simplicity, the HRIX router at CUHK is connected to a network switch at HKU to link up HRIX and HR[3|4]. Routers HR* also connect to external networks, including HKIX, ISP, CERNET, and TEIN3. The high-level HARNET network structure before and after the transition are identical except

- TEIN3 connects to HR4 in the new configuration, instead of HR3,
- ISP connects to HR1 in the new configuration, instead of HR2, and
- CERNET connects to HR2 in the new configuration, instead of HR1.

Unused connections between routers, optical networks, and switches are not shown in Figure 1.

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A. HKIX Preparation

Before the transition, the HRIX router was connected internally to two HARNET core network switches (not shown in Figure 1) at 10 Gbps each, and externally to HKIX at 4 Gbps. Since the optical hub and HKIX are hosted at the same building in CUHK, the HRIX-HKIX network connections are physically short and closely monitored by CUHK. At first, a new HRIX router was installed, with new 2 x 10 Gbps connections to HKIX. After performing ping test to verify the fiber connection, the interfaces on the new HRIX router was shut down to disable the new HRIX-HKIX connection. Connections between new HRIX and network switches of optical hubs were then set up.

At this stage, since the new HRIX router was not in use, and the old router and its connection remained unchanged, no disruption was expected.

B. HKIX Migration

The BGP neighbors of the old HRIX router were shut down. Physical cables connecting HKIX networks and HRIX router were transferred from the old router to a new one. The disabled interface on the new HRIX router were re-enabled and then the BGP neighbors.

At this stage, both the re-arrangement of cables and re-configuration of BGP neighbors result in a disconnection of the HRIX-HKIX links. We therefore expect a short disruption of traffic between the HARNET members, and Hong Kong and overseas R&D networks. The outgoing traffic should be disrupted during this disconnection but resumed shortly after the cables were transferred to the new HRIX router. The incoming traffic should be subjected to short disruption too. Moreover, before the BGP announcement through the new HRIX router reaches the remote networks, the incoming traffic should then be re-routed through other links to the HARNET. Thus, the RTT is expected to fluctuate. The traffic re-routing, if through ISP, should not cause congestion or packet loss at the HARNET(HR2)-ISP link, because the utilization during the changeover is minimal.

C. TEIN3 Migration and New ISP Backup Link Installation

The HR4 router was redundant before migration. First, the hardware of HR4 was upgraded and 10 Gbps modules added. The connection between HR3 and TEIN3 was shut down. The link was then switched to HR4. After that, HR4 started announcing BGP routes for the HARNET network’s prefixes. A new port module was also to HR3, and IP address and BGP setting at HR3 were configured for the new connection between HR3 and HR4. Here ends the first part of the tasks solely for the TEIN3 migration.

Similar to the HKIX migration above, the temporary disconnection of HARNET-TEIN3 link will result in a temporary re-routing of traffic between HARNET members and remote academic networks utilizing the HARNET-TEIN3 link. RTT fluctuations are expected, but not congestion and packet loss of the alternative routes, such as HKIX and ISP.

The second stage on this day was to add a backup connection on HR3 with the new ISP’s link. An IP address was set on the new interface at HR3 which connects to the new ISP’s link. Ping test was done to verify the connection. BGP neighbor is added to the new ISP with a lower local preference and a longer AS-Path. A test subnet, where a HAR-hku node was connected, was announced to the new ISP instead of the old ISP.

We do not expect change of performance or disruption at all nodes except for the HAR-hku node. Since the HAR-hku’s subnet was announced to the new ISP instead of the old one, the incoming path was expected to change. HAR-hku should observe fluctuation of RTT and a short period of inaccessibility to remote networks utilizing TEIN3 connection.

D. CERNET Migration and New ISP Primary Link Installation

The CERNET connection at HR1 was to be relocated to HR2 in order to make rooms for connection to the new ISP. The old CERNET connection at HR1 was shut down, and the CERNET link was then switched to HR2. A new port module was inserted to HR1. Similar to the HKIX and TEIN3 migrations above, RTT fluctuations, route flip-flop and short period of inaccessibility to remote networks utilizing the CERNET connection are expected.

Fig. 1. The HARNET's network connectivity after the ISP changeover on 9 March 2015.
The second stage on this day was to add the primary connection of the new ISP to HR1. A new IP address was added to new interface on HR1 which connects to the new ISP. Similar to the ISP backup link configuration, BGP neighbor to the new ISP was added with a lower local preference and a longer AS-Path.

The new ISP primary link installation did not affect all existing connections. The lower routing preference also ensures that the link would not become effective at this stage. We therefore do not expect any special observation from all measurement nodes.

E. ISP Migration

The incoming traffic were switched to the new ISP by announcing IP prefix of HARNET to the new ISP connection. The local preference of new ISP connection was raised, and the AS-Path shortened to route outgoing traffic through the new ISP.

We expect that all measurement nodes would observe outgoing paths switched to new ISP almost simultaneously, together with RTT changes in all destinations served by the ISP link. Except for the HAR-hku node, the incoming paths to all measurement nodes may take more time to switch to the new ISP, depending on the speed of propagating the new BGP announcement to remote networks. Since the ISP link may be the only available network to carry the traffic to and from these destinations, a short period of inaccessibility could be observed.

III. MEASUREMENT PLATFORM SETUP

We have deployed a measurement prober in each of the eight universities in Hong Kong for over six years. They connect directly to CR[1][2] in the campus network in Figure 1. The universities are connected to HARNET for Internet connectivity, and some of them procure additional upstream providers for load-balancing and backup connection. Two additional measurement nodes, HAR-hku and HAR-cuhk, were set up in HARNET on 1 March 2015 to compare and monitor the network performance of HARNET. HAR-[cu][ku] connect to routers HR[2][4] respectively in Figure 1. Therefore, our measurement platform has a total of 10 probers to monitor the changeover process.

We select around 50 web servers in Hong Kong, Asia, Oceania, Europe, and North America as destination of measurements. The measurements are divided into five groups, each of them is scheduled to run for 1 minute for every 10 minutes.

Our measurement tool opens a pre-set number of TCP/IP connections with random client TCP ports to the remote server in each trial. In normal setting, it first sends traceroute-like request with increasing number of TTL value to trigger ICMP responses from routers to reveals the forward path. Finally, it reuses the connections to send packet-pair probes to collect network performance metrics, including RTT, and packet loss and reordering events on both forward and reverse paths. However, this procedure causes connection timeout in some remote servers. We use an alternative approach for such servers: performing traceroute and network performance in separate trials. However, the per-destination approach did not prevent the occasional disruption of measurements from nodes at HKIEd and LU. We ignore the results of these two nodes in our analysis.

On 5 March 2015 07:30, we doubled the probing rate. We also deployed a traceroute script in seven PlanetLab nodes on 5 March 2015. For every 3 minutes, they traceroute to 19 hosts in the eight universities and HARNET. They include the web servers at the eight universities and the ten probers. The results from all measurement nodes and PlanetLab nodes were collected at a server located in one of the universities.

IV. MONITORING RESULTS

A. General Route Dynamics and Successful Measurement

We collect the forward-path routes from all ten probers during the monitoring period and count the number of distinct IP addresses appeared in all the routes for every AS. Figure 2 plots the time series of the percentage of counts for an AS (i.e., the number of counts for the AS divided by the total number of IP addresses in the routes). We show only the top 10 ASes in terms of the percentages in the figure.

![Fig. 2. Percentage of IP addresses in forward-path routes for the top ten ASes.](image)

The most significant change takes place on 9/3/2015. The value for PCCW, which was the old ISP, decreases sharply from 15% to 4%. At the same time, the values for HARNET decreases from 14% to 10%. In contrast, the value for NEWTT (New T&T Limited, now known as Wharf T&T Limited), the new ISP, increases from 0.5% to 5%. That of Flag also increases from 0.5% to 4.5%. Another sharp change, following the same trend but in a smaller scale, happens about 48 hours
later. The value for PCCW decreases to negligible, and that of NEWTT increases to 9% after the second sharp change. The increases in NEWTT and decrease in PCCW on 9/3/2015 are the result of changing the ISP from PCCW to NEWTT by raising the priority of NEWTT over PCCW. However, the total switching to NEWTT did not occur until 11/3/2015 which was responsible for the second change in the IP address counts for PCCW and NEWTT.

We also performed reverse traceroute from seven PlanetLab nodes to 19 hosts in HARNET. Figure 3 plots the percentage of IP addresses for each host. The initial sharp decline for Internet2 (including University of Maryland) is not caused by route change, but by the different start times of the PlanetLab measurement. At around 16:00 on 9/3/2015, the values were decreased for PCCW and Level3 but increased for Cable and Wireless and NewTT. Clearly this is also the result of the ISP changeover at that time. The other fluctuations are apparently not related to route changes. Some diurnal ones may come from load-balancing paths. The reverse-path route changes due to the changeover are therefore consistent with the forward path’s.

The three failed measurements occurred at around 07:00, 10:30, and 12:20. For each of these paths, only one measurement failed during the period. There was neither forward-path route change nor TTL value change. As a result, we cannot conclude whether these short disruptions are due to the HKIX preparation.

C. HKIX Migration

During the planned HKIX migration period at 22:00-22:30, there was no disruption. However, during period (1) 00:10-00:50 and (2) around 03:00 on 5/3/2015, several disruptions were reported by our measurement. They are presented in Table II with 1 and 2 to represent the two time periods. Besides MingPao, TP1RC and NCU, the destinations also include PCCW (www.pccw.com), KRN (www.kreonet.net), APJP (www.jp.apan.net), and TWG (www.twgrid.org).

In addition, a temporary outgoing route change for several paths was observed from 22:20 to 00:00. The traffic was redirected to other networks during the HKIX connection downtime and routed back through HKIX at around 00:00. These paths can be grouped into several categories.

\begin{itemize}
  \item (Sources from CUHK) CUHK uses dedicated connection to HKIX because of the short proximity. They were therefore not affected by the HKIX migration.
  \item (Hong Kong) 10 paths to 2 destinations in Hong Kong were re-routed to the secondary ISPs: PCCW ISP (6), WTT (2), NTT (1), and HGC (1).
  \item (TEIN3) 9 paths to 3 TEIN3 destinations (TEIN3, URENNES, BERLIN) via HKIX were re-routed to the TEIN3 paths through HR3.
  \item (CERNET) 7 paths to 2 CERNET destinations (PKU, SHNet) via HKIX were re-routed to the CERNET paths through HR1.
\end{itemize}

\begin{table}[h]
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\begin{tabular}{|c|c|c|c|c|c|}
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 & PCCW & MingPao & TP1RC & NCU & KRN & APJP & TWG \\
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HKU & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
CUHK & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
PolyU & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
CityU & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
HKBU & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
UST & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
HAR-hku & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
HAR-cuhk & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\
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\end{tabular}
\caption{Disruption Observed in HKIX Migration during (1) 00:10-00:50 and (2) around 03:00 on 5/3/2015.}
\end{table}
• (Internet2) 12 paths to 3 Internet2 destinations (Internet2, MIT, Stanford) were re-routed to TEIN3 (6), PCCW (5), and WTT (1).
• (Asia R&D Networks) 17 paths to 4 destinations (TP1RC, NCU, KREONET, APANJP) were re-routed to TEIN3 (9), PCCW (7), and WTT (1).
• (China) 5 paths to a destination in China were re-routed to PCCWs during the period.

Figure 5(a) illustrates the forward paths from all nodes to MingPao, one of the destinations in Hong Kong that can be accessed through HKIX. The solid lines represent the primary outgoing paths and dash lines the alternative paths during the period. As mentioned above, CUHK did not observe route change due to its close proximity with HKIX. HAR-hku and HAR-cuhk did not have access to HKIX, and they accessed MingPao through HARNET’s old ISP (PCCW) that had no interruption during the period. HKU, PolyU, and HKBU accessed MingPao through their secondary ISPs (NTT, HGC, and WTT), respectively. UST and CityU, on the other hand, opted HARNET’s ISP as the second best path and accessed it through the ISP link. Figure 5(b) shows the forward path from all nodes to a PCCW destination in Hong Kong. The original paths are the same as that for MingPao. But for the alternative paths, HKU and PolyU accessed it through PCCW instead of their own secondary ISPs as in MingPao’s case.

Figure 6 shows the RTT from CityU to MingPao and PCCW. It clearly shows that the RTT increased during the temporary route change between 22:00 and 00:00, and both RTT and forward route reverted back at 00:00. Immediately after that, the measurement failed for 40 minutes since 00:10. This 40-minute outage occurred only between CityU and HKIX destinations. It should be caused by the routing configuration or connection problem between CityU CR1 and the HRIX routers.

![Hong Kong Internet eXchange (HKIX)](image)

Fig. 5. Primary and secondary forward routes to MingPao and PCCW during the HKIX migration.

**Fig. 6.** RTT measurements from CityU to MingPao and PCCW through HKIX.

### D. TEIN3 Migration

Our measurement observes temporary re-routing during the TEIN3 connection migration on 5/3/2015. Traffic going through TEIN3 link via HR3 was routed to other links at around 22:25 on 5/3/2015. After around 4 hours 50 minutes, the traffic was routed back to the TEIN3 link at around 03:15 on 6/3/2015 via HR3 and HR4.

![TEIN3 Migration](image)

Fig. 7. RTT and TTL of the HAR-hku-BERLIN measurement during the TEIN3 migration.

Despite some measurement failures, we still observe 12 paths subjected to short disruptions during the transition period, and 13 paths experienced longer disruptions. The 13 paths were all sourced from HAR-hku and to destinations through the ISP and TEIN3 networks. The disruption period was around 6 hours 50 minutes, between 23:20 on 5/3/2015 and 07:10 on 6/3/2015. Figure 7 presents the RTT and TTL values for one of the 13 paths, HAR-hku-BERLIN. The initial change of TTL value in Figure 7(b) coincides with the
re-routing of forward path at around 22:25 on 5/3/2015. It signals the disconnection of the TEIN3 network, and re-routing of outgoing and incoming traffic through ISP via backup links. The disruption between 23:20 on 5/3/2015 and 07:30 on 6/3/2015 was due to the operator’s negligence of connecting the prober back to the router.

E. CERNET Migration

The CERNET migration was performed similar to the TEIN3 migration but with less paths affected. Table III presents the route change observed between 22:30 on 6/3/2015 and 00:50 on 7/3/2015, which lasted for 4 hours 20 minutes. The two destinations are PKU (www.lib.pku.edu.cn) and SHNet (www.shnet.edu.cn).

Except for the paths experiencing measurement disruptions before the transition, only short disruptions were observed in four paths. Similar to the HAR-hku node for TEIN3 paths, the paths sourced from HAR-cuhk node to destinations through CERNET were re-routed to ISP during the transition period. Figure 8 presents the RTT and TTL values of HAR-cuhk-PKU path. The temporary change of RTT and TTL between 22:30 on 6/3/2015 and 00:50 on 7/3/2015 coincides with the forward-route change.

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TABLE III: ROUTE CHANGE OBSERVED IN CERNET MIGRATION BETWEEN 22:20 ON 6/3/2015 & 00:00 ON 7/3/2015.

F. ISP Link Installation and Migration

The ISP link installations were completed after the TEIN3 and CERNET migrations. They were not utilized by the HARNET members until the migration. We did not observe relevant disruption or performance change.

The ISP migration, which was planned to take place at 16:00 on 9/3/2015, was actually performed at around 16:10 according to the forward route change observed by us. No disruption was observed around the transition time. Figure 8 presents the RTT and TTL of the CUHK-ausnews path. The permanent change of RTT and TTL at 16:10 on 9/3/2015 coincides with the forward route change observed.

V. RELATED WORK

Although there is no previous work on studying the impact of ISP changeover, Wang et al. conducted active measurement on controlled route changes and end-to-end network performance [6]. They found that routing changes contribute to end-to-end packet loss significantly. Huang et al. used routing information to detect and identify network disruptions [5]. They proposed a multivariate analysis technique on dynamic routing information to detect node and link disruptions.

VI. CONCLUSION

In this paper we presented the detailed ISP changeover plan and the measurement result during the migration. We have set up a measurement platform to monitor route changes and end-to-end performance change during the entire changeover period. We reported the impact of the changeover in each major step of the changeover. Except for short intervals of instability and disruptions, the ISP changeover is considered quite smooth.

![Fig. 8. RTT and TTL of CUHK-ausnews measurement during the ISP migration.](image)

REFERENCES


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