Bahrain’s Internet Ecosystem Revisited

July 16, 2010

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July 2010

Executive Summary

In June 2009, the Bahrain Telecommunications Regulatory Authority (TRA) invited Renesys to perform an initial study of the Bahrain Internet Ecosystem, in order to characterize the observed relationships along the Internet-connected service providers and enterprises within the Kingdom, and to measure the stability and growth of the domestic Internet market.

Since the initial publication of the report in August 2009, the Kingdom's Internet market has continued to grow and mature. This report refreshes the initial report at the end of a full year of study, reexamining its conclusions in light of new information gathered from the Renesys network of route collectors and active measurement points.

In general, the Bahrain Internet Ecosystem continues to grow as existing providers advertise new networks. Bahrain's remoteness from major submarine cable landings and limited access to diverse paths continues to limit the diversity of international transit available to Bahrain's domestic providers, relative to the abundance of connectivity and carrier choice available at the cable landings in the UAE.

Over the last several years, Bahrain's domestic providers have had three basic carrier choices for transit to international markets: Tata, Emirates, and Flag. Batelco, the incumbent, has the highest degree of provider diversity, dividing its transit between Flag and Tata and peering with Emirates. Prior to August 2009, no other Bahraini autonomous systems purchased transit from Flag. As operator of the landing station, Batelco helped to mediate the sale of Flag transit to Lightspeed (2 August 2009) and Nuetel (10 October 2009). No additional providers have become Flag customers since October.

Most other domestic providers continue to obtain transit from the Bahrain Internet Exchange, which buys capacity from Tata and Emirates (but has no Flag connectivity). A few, such as 2Connect, also purchase some degree of connectivity direct fromTata as a complement to their BIX connectivity. These relationships have been stable over the last 12 months, suggesting that Bahrain's domestic providers continue to have relatively few connectivity alternatives.

In the first half of 2010, only one exception has become apparent: Viva (Saudi Telecom) entered the market as a mobile provider (soft launch February 2010, full launch March 2010), with substantial independent data capacity to Saudi Arabia. Because Viva uses dark fiber leased from the Gulf Cooperation Council Interconnection Authority to link Bahrain with Saudi Arabia, this arrangement represents a significant potential improvement in the path diversity available to domestic providers requiring international transit. Indeed, Viva appears to have begun providing Internet transit service to Mena Broadband on 7 June 2010. It remains to be seen whether other providers within the Kingdom will take advantage of this new path to international markets.

The significant concerns raised in the August 2009 report still stand. In particular:

- **Bahrain's Internet connectivity is adequate, but could be more diverse.** It seemed probable in late 2009 that more customers would follow Neutel and Lightspeed's lead in becoming users of Flag transit. However, there have been no additional signs of new Flag capacity utilization by Bahrain providers since then. As a result, Tata continues to be the dominant provider of international transit, with more than 90% of Bahrain's customer base on-net.

- **Batelco still does not offer domestic peering, and Batelco's customers lack transit alternatives.** The last 12 months have shown no evidence that any of Batelco's customers use their own autonomous system to purchase backup transit from another provider. It continues to be the case that packets exchanged between Batelco customers and BIX customers may travel as far as Riyadh or London before returning to Bahrain. This creates potentially serious implications for performance, stability, and security for the Kingdom's domestic Internet traffic (see also Appendix B, "Internet Transit of Key Bahrain Websites").

- **Facility carrier neutrality would increase long-term international transit diversity.** No provider has stepped up to offer carrier-neutral access to multiple international carriers in a single facility, as recommended. Gateway Gulf's plans to build out a larger Internet presence with diverse connectivity remain uncertain. Gulf Bridge International has partnered with Batelco, and Tata with the BIX, to bring new cables ashore by the end of 2011. These new paths to regional and international connectivity, along with GCCIA dark fiber, and the increasing availability of mobile broadband and smartphone-based Internet, may turn out to be the factors that unlock more lively competition within the Kingdom in 2010.

- **Until carrier diversity improves, some operators are at higher risk of suffering significant customer-facing Internet events.** The April failures of the SMW4 cable had far greater impact on Bahrain customers who were exposed to Tata's long-path routing to Europe by way of Asia and Canada. Operators who took advantage of Flag transit, by comparison, experienced significantly lower delays. Promoting multihoming, and having realtime access to monitoring information about route selection and inbound latencies during future events, could help providers make better routing decisions and minimize performance impacts on the Kingdom's consumers.

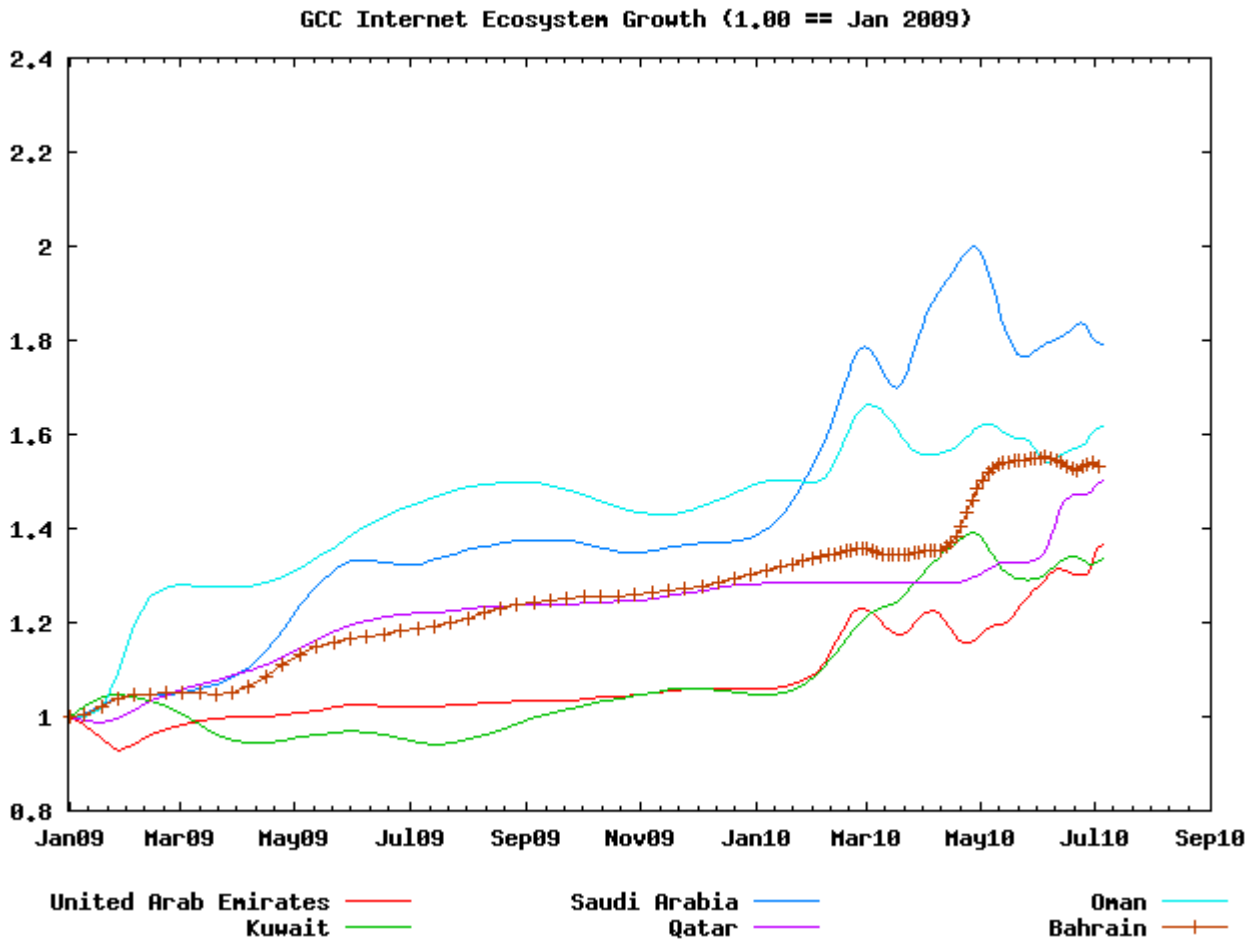
The following sections contain new data describing the state of competition and provider interconnection within Bahrain, as of July 2010.

Regional Internet Ecosystem Growth

In July 2010, Bahrain's Internet Ecosystem (measured as the sum total of all providers' overlapped customer base scores in the Renesys Market Intelligence tool) continues to grow at a rate of approximately 30% per year. Throughout 2009, this rate of growth was similar to that of Saudi Arabia and Qatar, and much faster than that of the UAE and Kuwait (where growth of the Internet Ecosystem in 2009 was barely measurable).

In 2010, with the exception of a period of rapid growth in April (when Zain and Batelco each routed significant new blocks of BH addresses), Bahrain's ecosystem growth has reverted to its 2009 growth trendline. Others in the region (including UAE, Kuwait, and Qatar) have begun to grow faster.

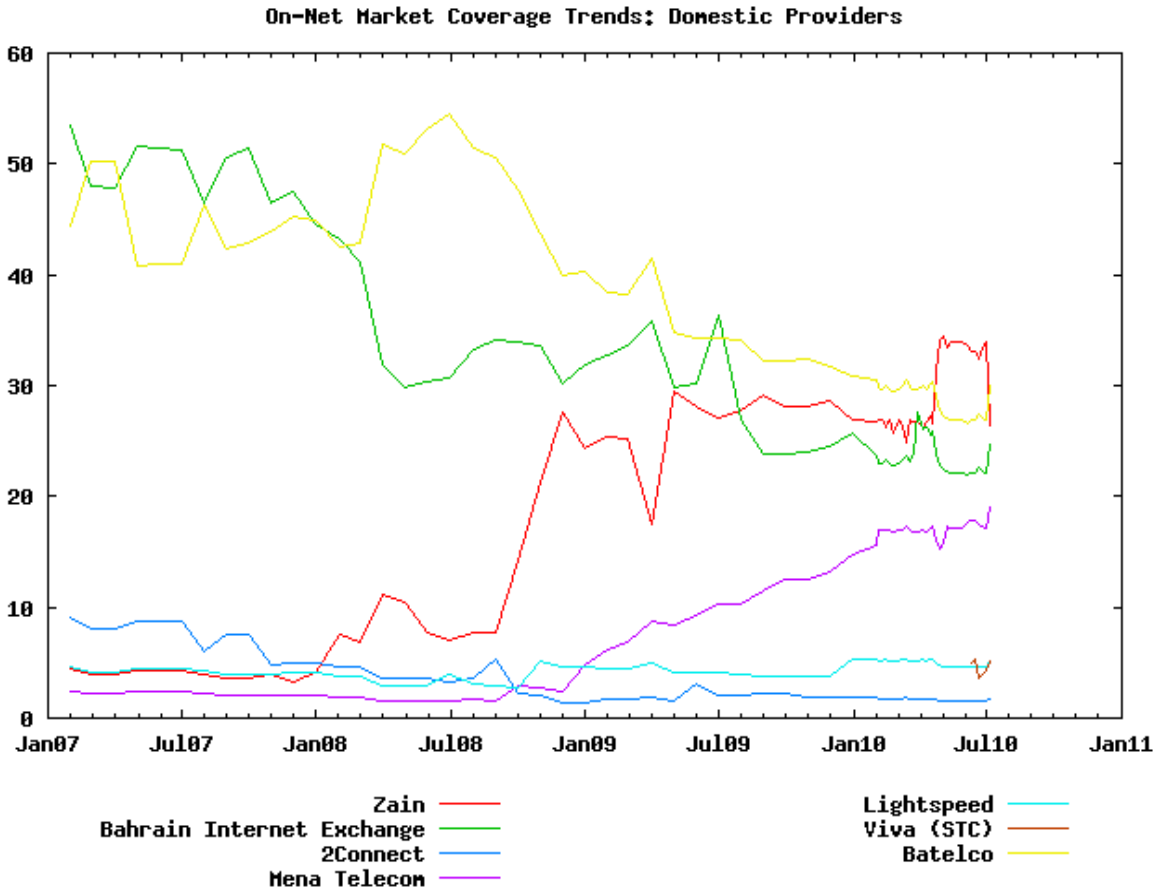
The following plot shows the relative 18-month growth of the GCC states' Internet Ecosystems over the course of 2009 and into 2010. Some of the high-frequency volatility exhibited here is the result of short-timescale fluctuations in routing patterns and traffic engineering. However, volatility trendlines have increased across all GCC countries, in comparison with the relative stability of 2009's Internet markets.



On-Net Market Coverage Trends: Domestic Providers

A provider's "on-net percentage" in a given market is the percentage of the market's total Customer Base Score (as reported by the Renesys Market Intelligence service) that is within the customer base of the given provider.

In markets with insufficient competition, the largest provider tends to have a very large percentage of the total market on-net (often 90% or more). In highly competitive markets, a relatively large pool of providers will each have somewhat lower percentages on-net.[1]



In the Bahrain market, three domestic providers (Batelco, BIX, and Zain) each have between 20 and 35 percent of the market on-net, suggesting that competitive pressures are effective and growing.

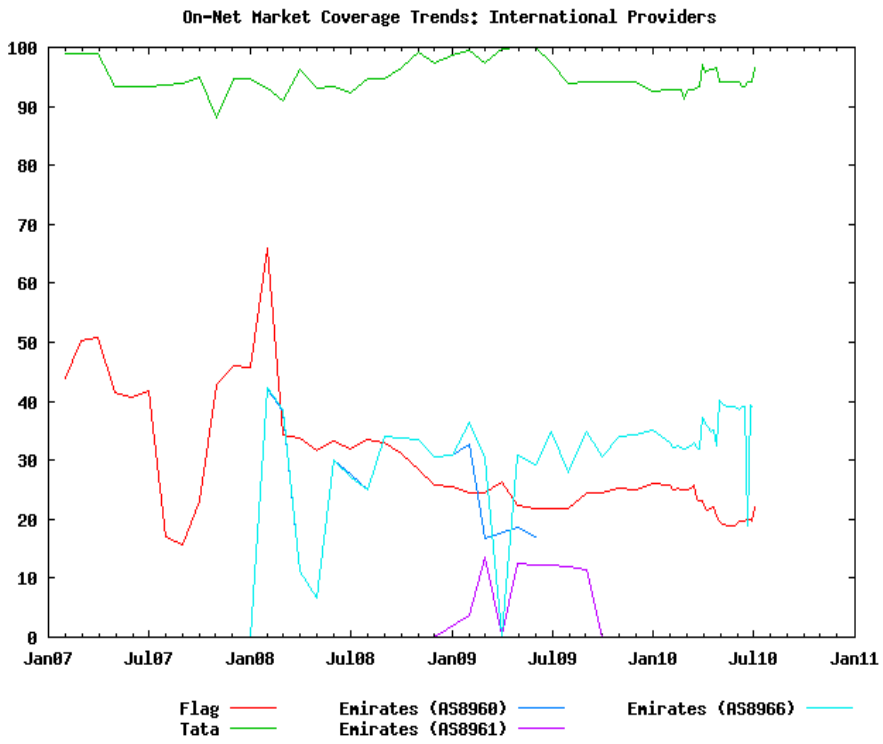
1 On-net percentages for competing providers will typically add to more than 100% because of multihoming (a given customer can be on-net with multiple providers). Country-level on-net percentage data from Renesys Market Intelligence, 1 February 2010.

As the market grows, and competitors such as Mena Telecom emerge, the on-net percentages of each the three market leaders has dropped slowly over the preceding 3 years.

There are still very few multihomed enterprises (receiving transit from more than one of these domestic providers), which is of potential concern; by this point one might expect to see some overlap in the customer bases of Batelco and the BIX, as enterprises hedge their bets (and increase their negotiating leverage) by contracting with two Bahrain providers for transit. The ultimate lack of international transit diversity, and the shortage of meaningful domestic peering, creates a fragmented domestic market with significant disincentives for an enterprise (such as a bank) to establish a second Internet connection to a competing provider.

International Providers

Similarly, the on-net percentage for an international provider in a national market is the percentage of the national customer base total that appears in that provider's customer base.



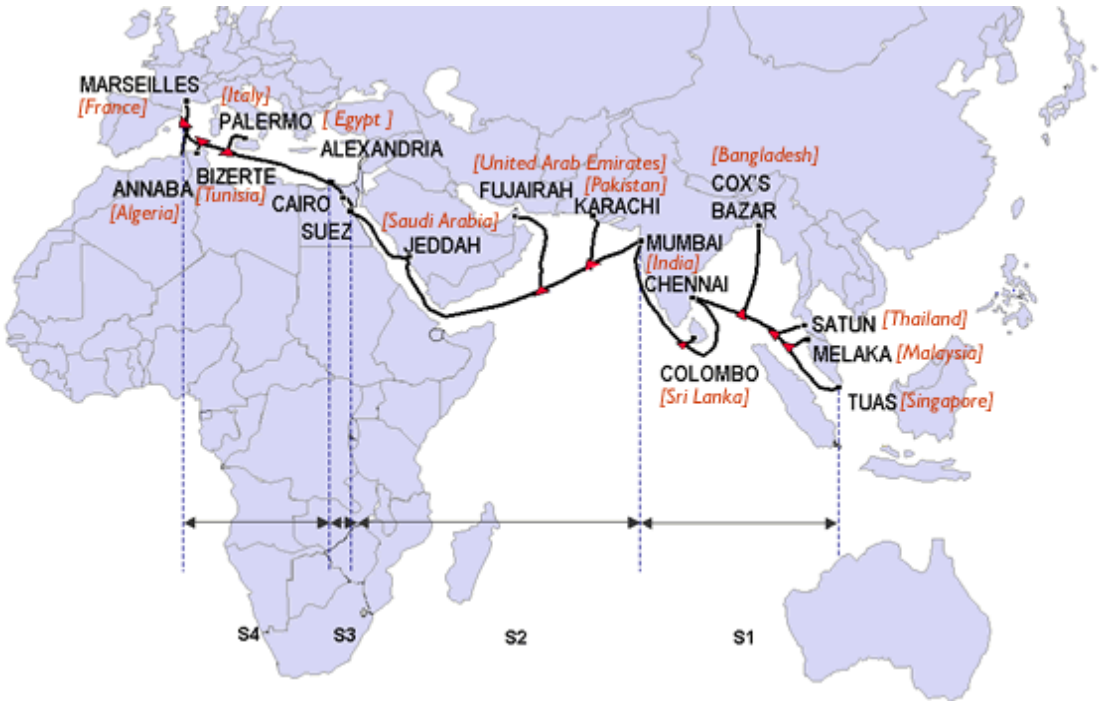
In Bahrain, Tata (AS6453) has consistently maintained a 90%+ on-net percentage for the last three years by virtue of their presence in every regional PoP. They sell to Batelco, to BIX, to Zain, and to Mena, and Tata routes are critically important to the visibility of nearly every network prefix in the Kingdom. There are no signs of this trend abating in 2010.

Flag (AS15412) quickly became an important carrier with their 2006 arrival in Bahrain, providing transit to Batelco (with more than 40% of the Bahrain market on-net). With the arrival of Emirates transit in 2008, Flag's on-net percentage fell, and continued to fall as the rest of the market expanded, while Flag added no new transit customers. The addition of Nuetel and Lightspeed Communications as Flag transit customers in August 2009 briefly halted the decline, and stabilized Flag's on-net percentage at 25%.

Increasing Flag's on-net percentage to at least 50% in Bahrain would potentially improve the overall resiliency and reliability of the Kingdom's Internet, by reducing the number of providers and enterprises who end up being wholly reliant on Tata for their international connectivity. The benefits of diversity are illustrated in the next section.

Significant Event: Sea-Me-We-4 Cable Fault (April 2010)

South East Asia – Middle East – Western Europe 4 (SEA-ME-WE 4 or SMW4) is an 18,800 kilometer long submarine cable system vital to telecommunication services between Europe, North Africa, Middle East and Asia. Although considerably shorter than its older cousin, SEA-ME-WE 3, SMW4 lands in many of the same countries and has the advantage of 128 times the capacity of SMW3.

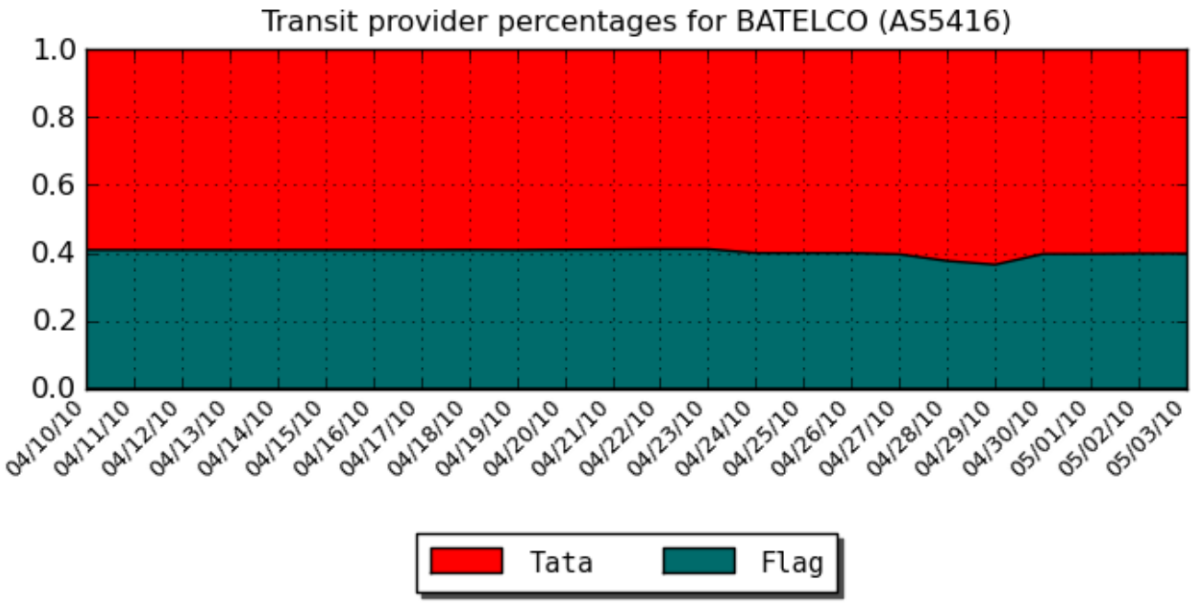


In April of 2010, SMW4 suffered a failure in the Mediterranean, slowing Internet services as repairs were untaken and less desirable routes were put into play. We looked at the impact of this event on Bahrain using passively collected routing changes (BGP updates) from our array of over 350 sensor routers around the world, and from actively collected latency measurements (traceroutes) to a large sample of the networks within Bahrain's Internet ecosystem from our London data facility. Bahrain's consumers were able to maintain connectivity during the event, although with a reduced level of performance. The worst-affected networks were those that were largely or solely reliant on Tata for transit, unable to shift traffic to the less-affected Flag cable.

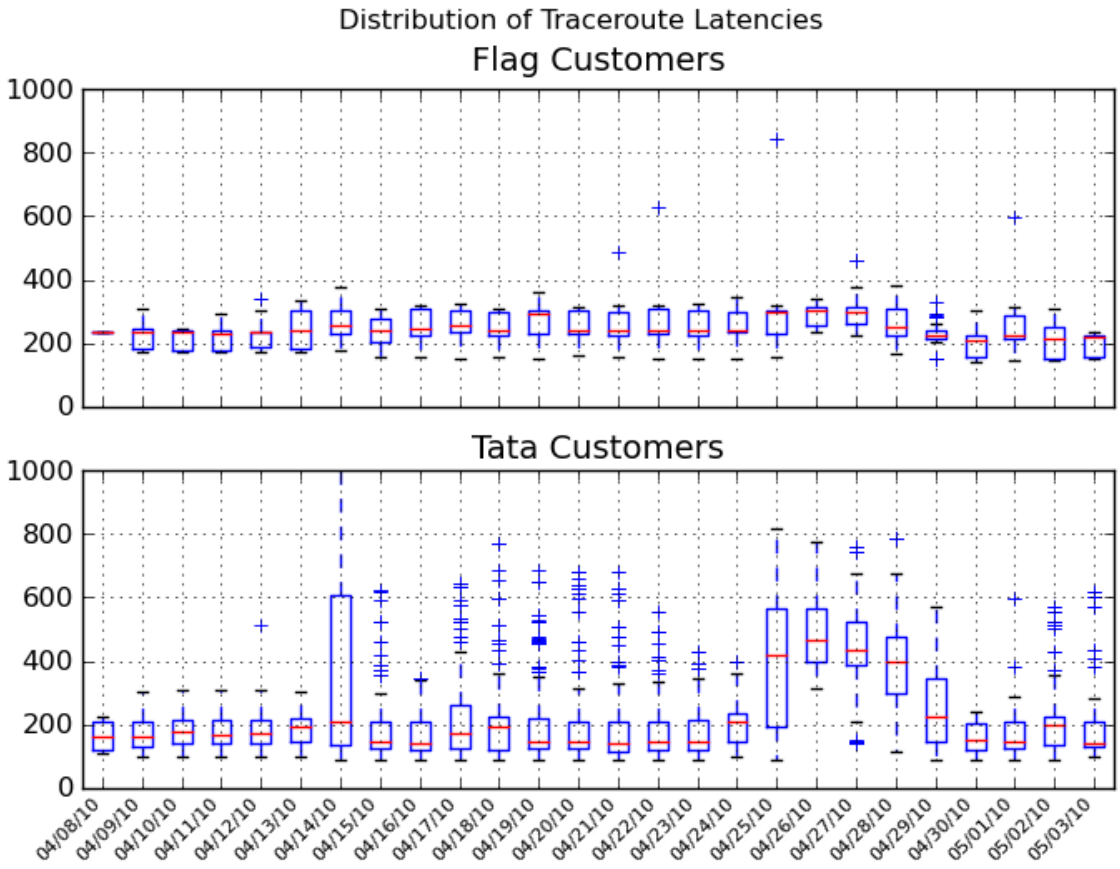
Event Overview

On 14 April 2010, SEA-ME-WE 4 suffered a shunt fault near Palermo, Italy, on the segment between Alexandria, Egypt and Marseilles. Faults of this nature refer to a short circuit between a cable's metallic core and the surrounding sea water that result from damage to the cable's insulation. With the application of sufficient additional voltage, a cable with a shunt fault can continue to carry traffic as normal, until a repair can be scheduled. Although there were various reports of slow Internet access in the region immediately after the fault, a prolonged and more substantial impact was observed when repairs were reported to have taken place (from April 24 through 29), during which time the cable was taken out of service.

If we look at the transit preferences for Batelco during the two-week period in question, one sees the relative preferences for Tata and Flag routes as basically unchanged. That is, routing preferences were not adjusted, as no actual outage took place (no BGP routes were withdrawn, and no preferences were changed).



When one looks at the latency statistics on active traceroute measurements into the Kingdom, however, one sees a different picture. The following box plots indicate both the mean and variance of the latencies on traceroutes to Bahrain networks, for two populations: customers reachable by Flag (Batelco, Lightspeed) and customers reachable by Tata (BIX, 2Connect, other operators present at the BIX).



Distribution of roundtrip packet latencies to selected Bahrain hosts, with milliseconds of delay from London on the Y-axis. Boxes frame the 2nd and 3rd quartile (25th-75th percentile) and crosses indicate outlier datapoints. Red lines indicate the mean latency on the given day; larger boxes indicate increased volatility (typically due to traffic congestion). Initial SMW4 fault occurred on 14 April, and the segment was powered down for repairs from 25 through 29 April.

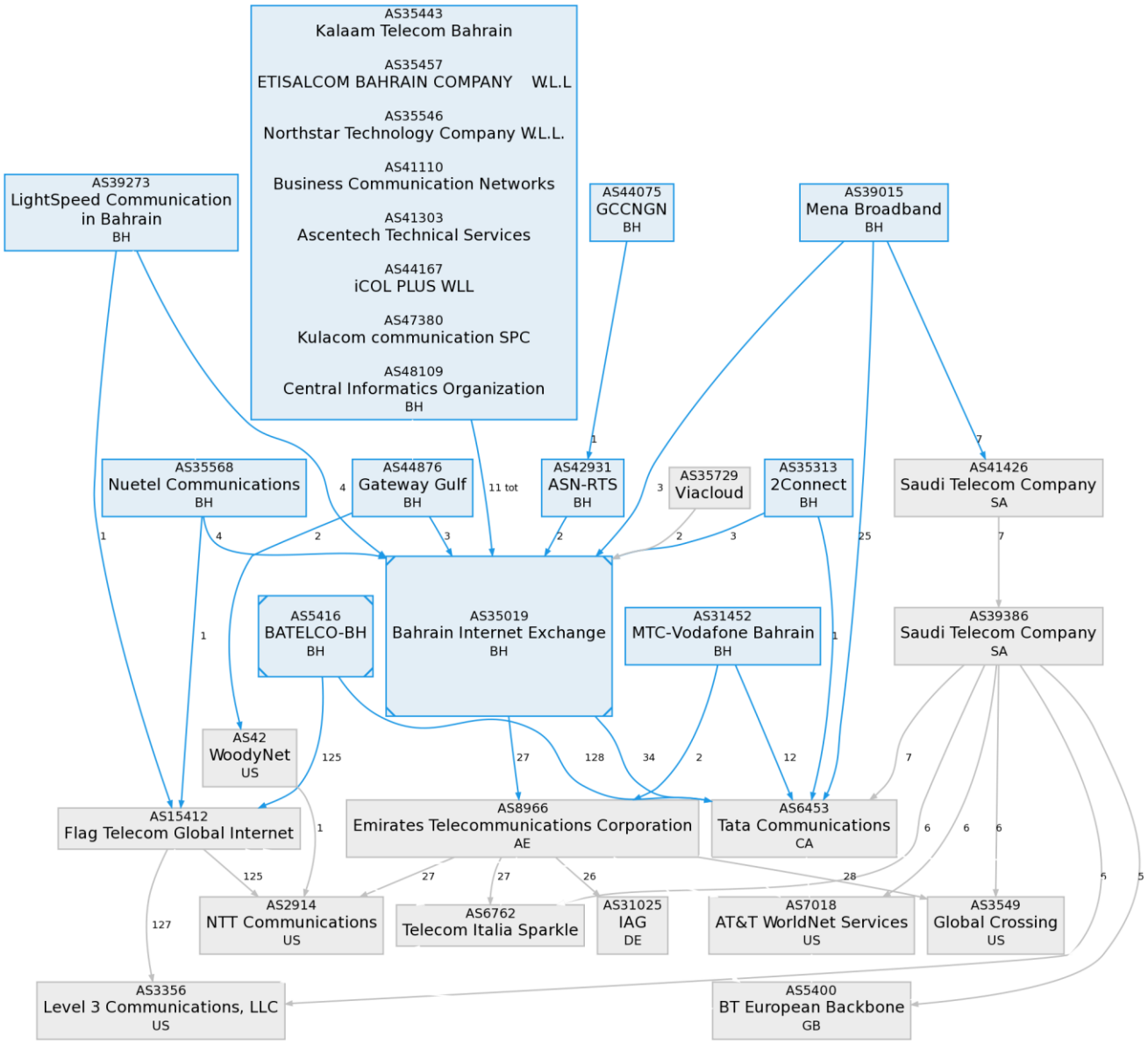
Note that the variance of latencies inbound to Flag customers (top plot) is much lower during the entire two-week period, compared to Tata customers (bottom plot). The mean latency to Flag customers is nearly constant, while mean latencies to Tata customers jump by a factor of more than 2 during the shunt fault repair window, to more than 400ms.

Clearly there were two classes of Internet citizen in Bahrain during this event: those who had the foresight to acquire Flag transit, and those who did not. Operators who relied on Tata alone for primary routing during both the initial event (14 April) and the repair window (25-29 April) were subject to significantly increased congestion and latencies as a result of long-path routing to Europe by way of Asia and Canada.

Even if an operator had access to Flag routes, however, it would have been necessary for them to adjust route advertisements to favor Flag and steer clear of the Tata latency increases. We see no evidence that this took place. Having realtime access to monitoring information about route selection and inbound latencies during future events could help providers make better decisions and minimize future performance impacts on the Kingdom's consumers.

Internet Service Provider Transit Relationship Updates

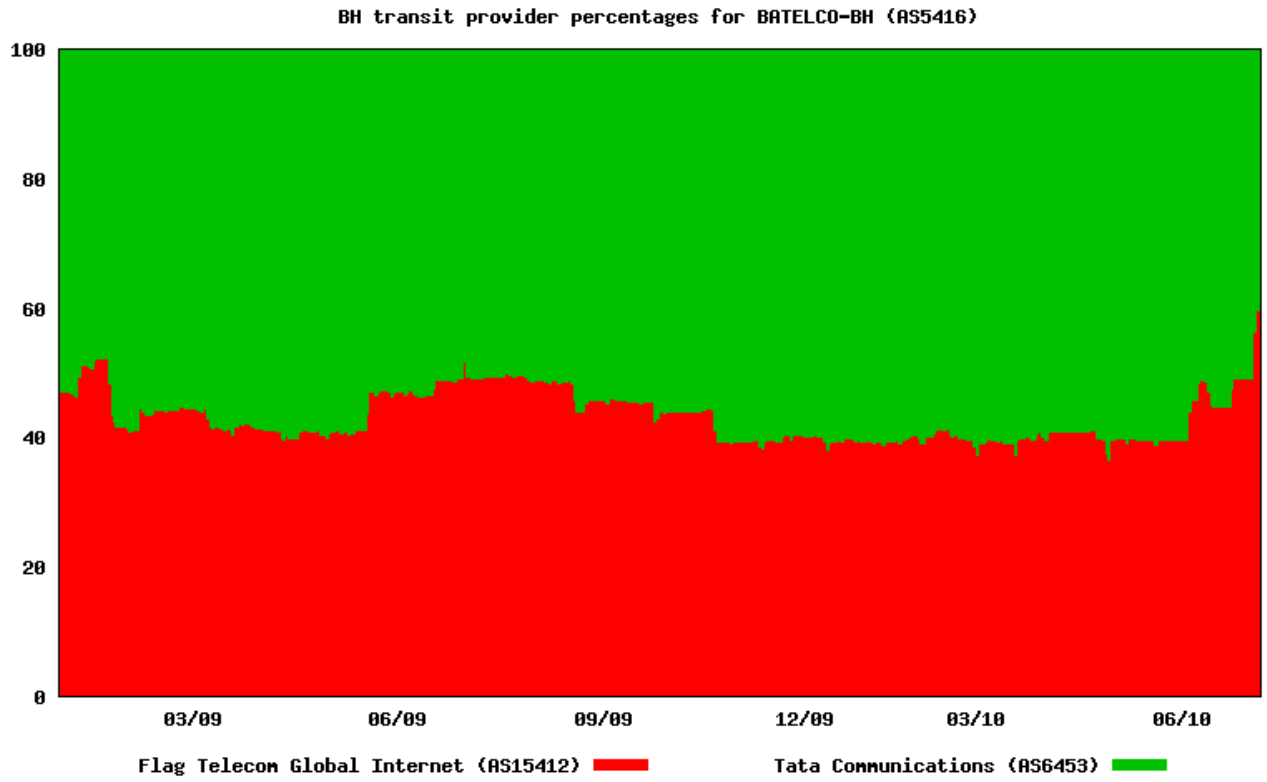
The following sections describe significant changes to service provider transit relationships in the Kingdom over the last 12 months.



Batelco (AS5416) continues to advertise its prefixes via a stable 60:40 split between Tata and Flag. Throughout 2009 and into 2010, this ratio has been significantly more stable than in previous years. In the months following the April 2010 SMW4 repair event, Batelco seems to have gradually inverted the preference, preferring Flag routes 60:40 over Tata routes (as seen in the relative transit weighting plot below).

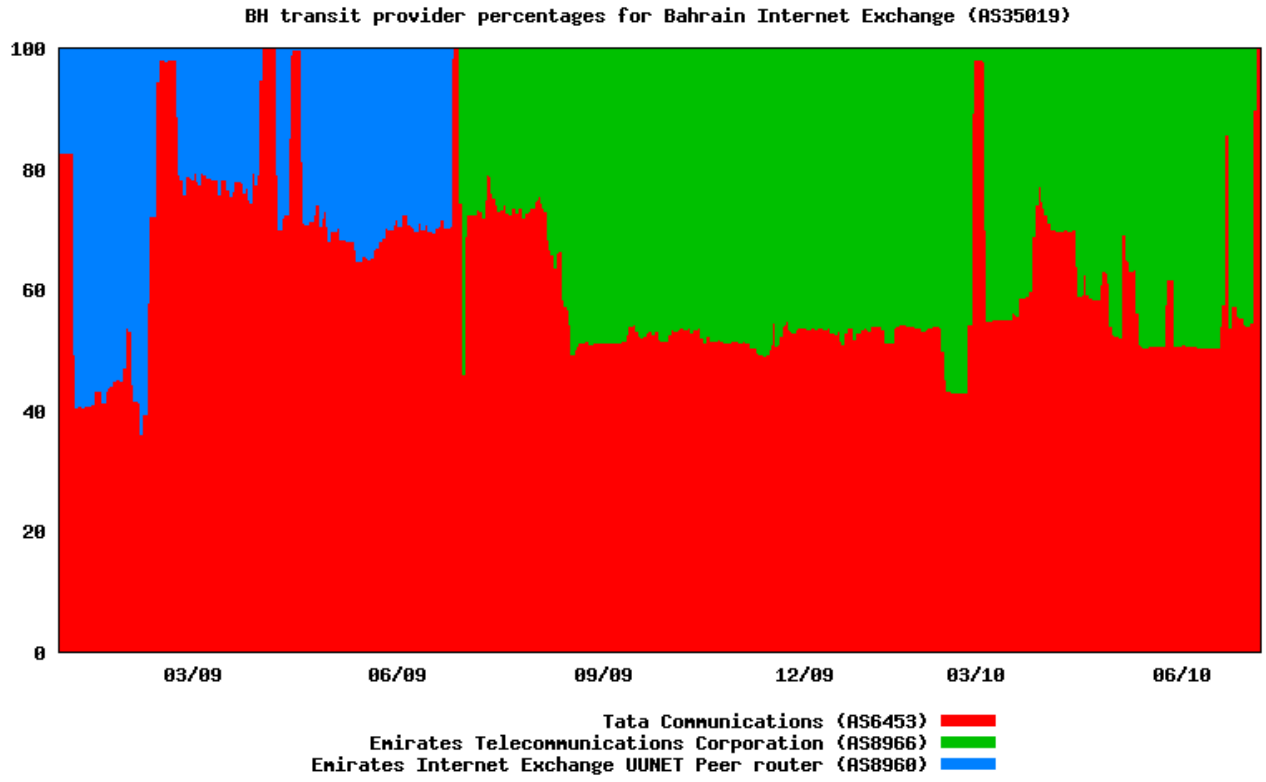
Ironically, Batelco does not appear to have significantly changed the visibility of their routes during the SMW4 outage itself. It might have made sense, given the differential impact of increased latency on Tata routes, for Batelco to attempt to increase the relative visibility of their Flag routes and minimize customer impact due to increased Tata latencies; however, the event does not seem to have affected their visible routing at the time.

Batelco continues to advertise all of its customer prefixes directly. No Batelco customer uses their own autonomous system number (ASN), and none is multihomed (has more than one provider).



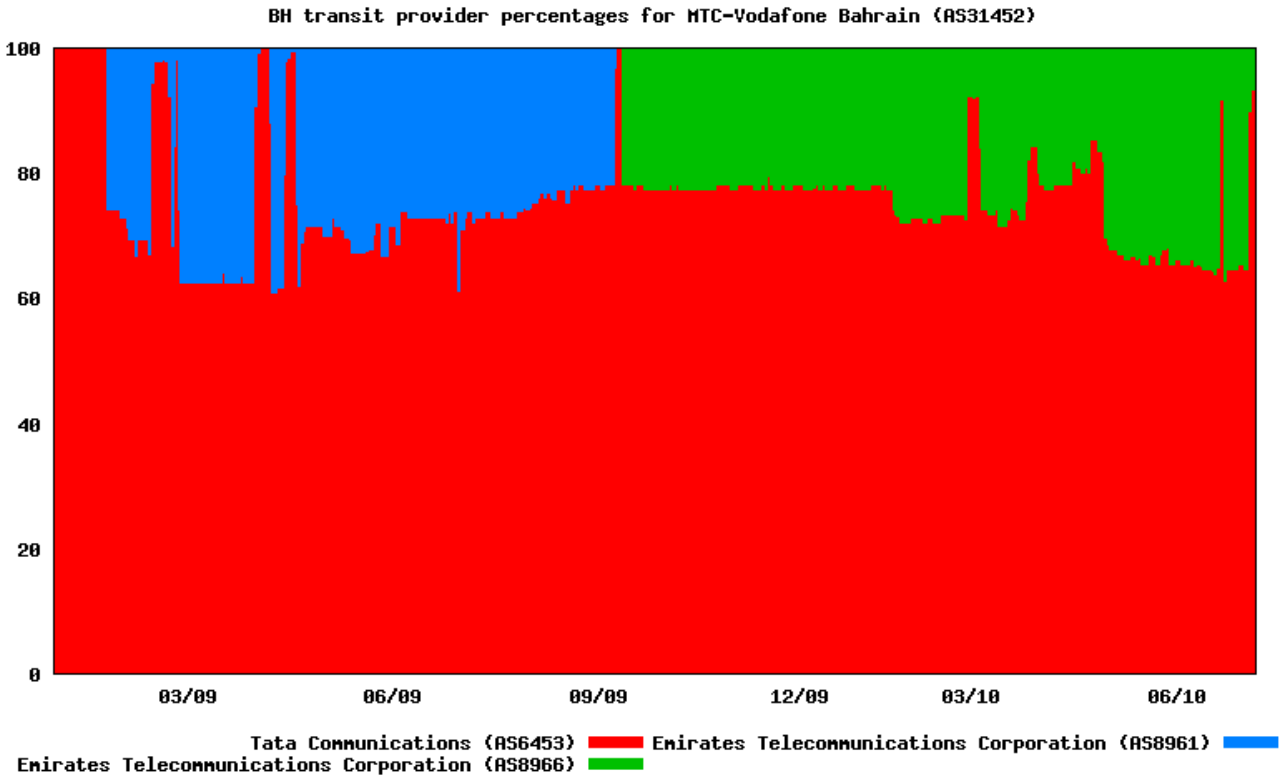
At the time of publication of the previous report, the **Bahrain Internet Exchange** (BIX, AS35019) had just lost one customer (Lightspeed Telecom, AS39273) and gained another (Gateway Gulf, AS44876). Since then, membership appears to have been stable.

BIX has continued to purchase transit through Tata and Emirates. The transit mixture has approximated 50:50 since September, although it has tended to shift in favor of Tata for short periods of time (red spikes in plot below).



Zain (AS31452) continues to maintain Emirates as a 25% secondary provider, with primary transit through Tata. This arrangement has also been very stable over the last 12 months, although, like the BIX, Zain has heavily favored Tata in the first days of July 2010.

Like BIX, which migrated from Emirates' AS8960 to AS8966 in July 2009, Zain migrated from AS8961 to AS8966 in September 2009. These changes reflect internal changes in Emirates' network architecture and probably did not affect the flow of traffic or Bahrain customer experience once the transition was complete.

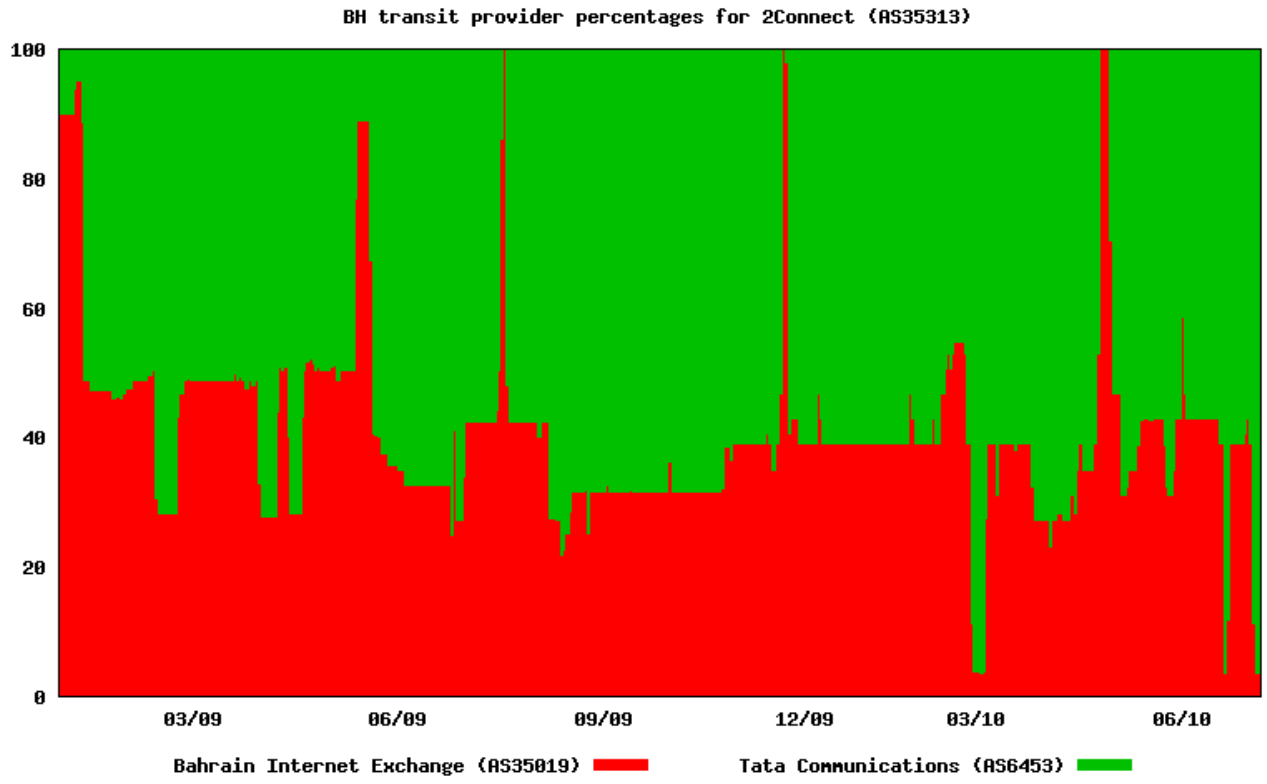


2Connect (AS35313) continues to split transit approximately 60:40 between Tata (AS6453) and BIX (AS35019).

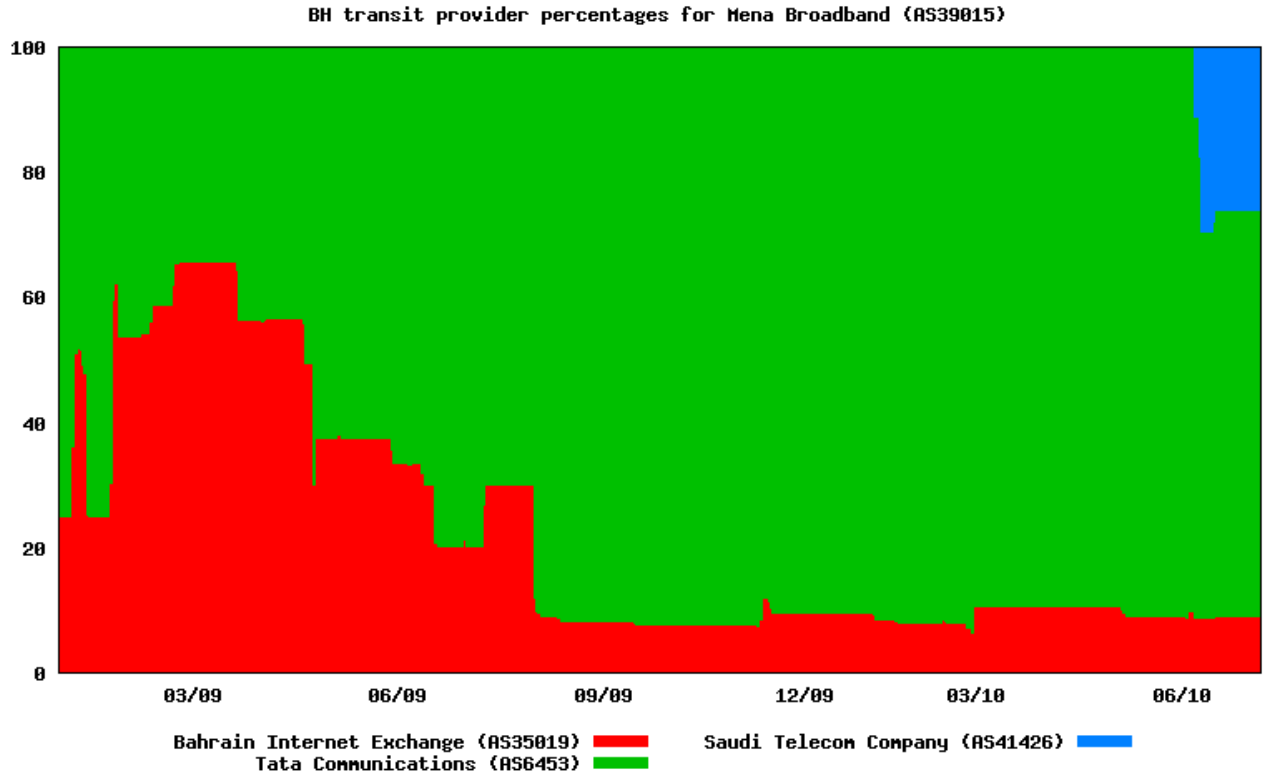
They did have one multiday Tata outage (21-23 November 2009, visible in the following plot as a red spike) during which time they were solely reliant on the BIX. No other Tata customers (BIX, Batelco, Zain) seem to have been affected, so this probably involved 2Connect's circuit alone.

Note that 2Connect tends to shift traffic to the BIX only when the BIX shifts traffic away from Tata (creating a mirror-image in Tata utilization, compared to previous plot). The reason for this is simple: when the BIX offers a route through Tata, 2Connect's direct Tata route is shorter (and preferred in BGP). When that route is taken away, the BIX shifts to Emirates, and 2Connect tends to follow by shifting traffic away from Tata towards BIX.

In June 2010, 2Connect announced their intention to host an instance of the I Root server, the first such installation in the Kingdom, and only the second such installation in a GCC state. The extent to which domestic consumers will be able to access this instance is still unclear, however. Domestic providers who do not peer at the BIX, and who have no transit or peering relationship with 2Connect, are more likely to steer their customers to use other (presumably European) I-root instances instead.

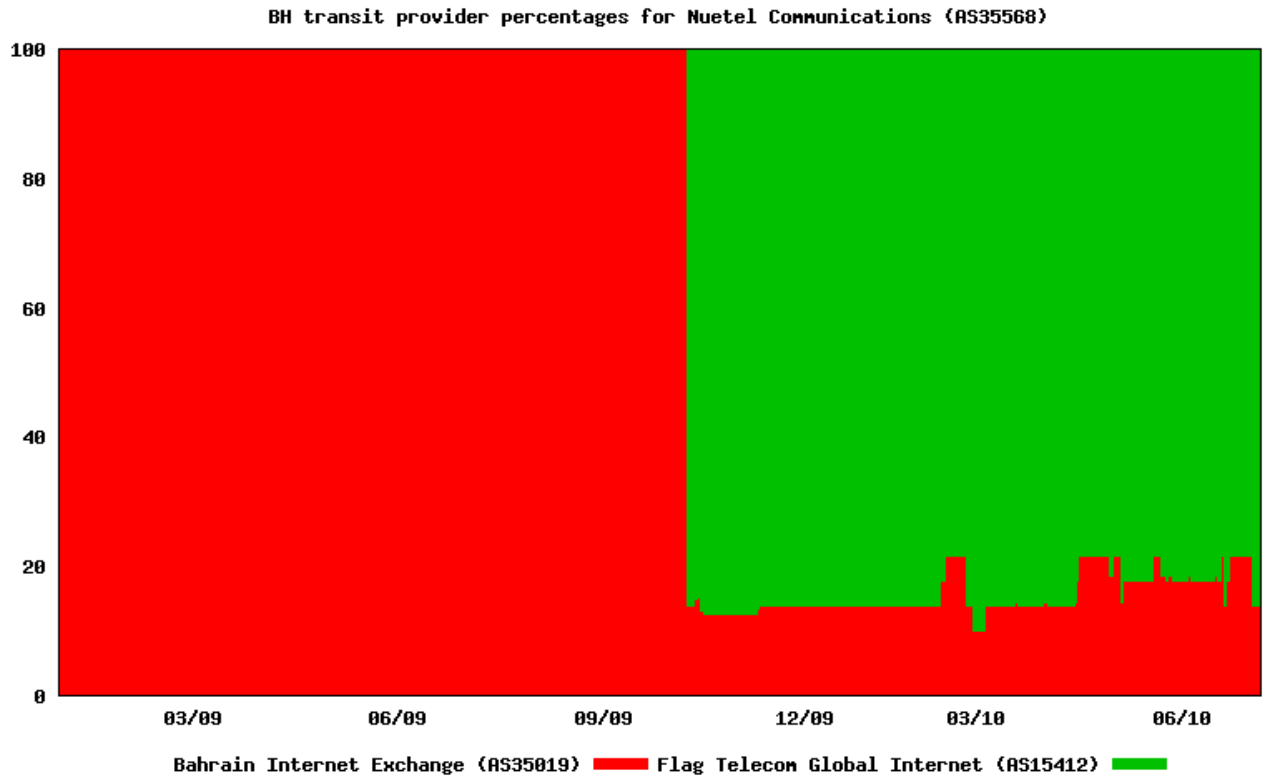


Mena Telecommunications (AS39015) maintains a minority transit reliance on BIX, but 60% of their networks are transited through a direct relationship with Tata. Since June 2010, another 20% are transited through a new IP transit relationship with Viva STC (AS41426), who appear to be providing IP transit to Mena over their GCCIA leased fiber to Saudi Arabia.

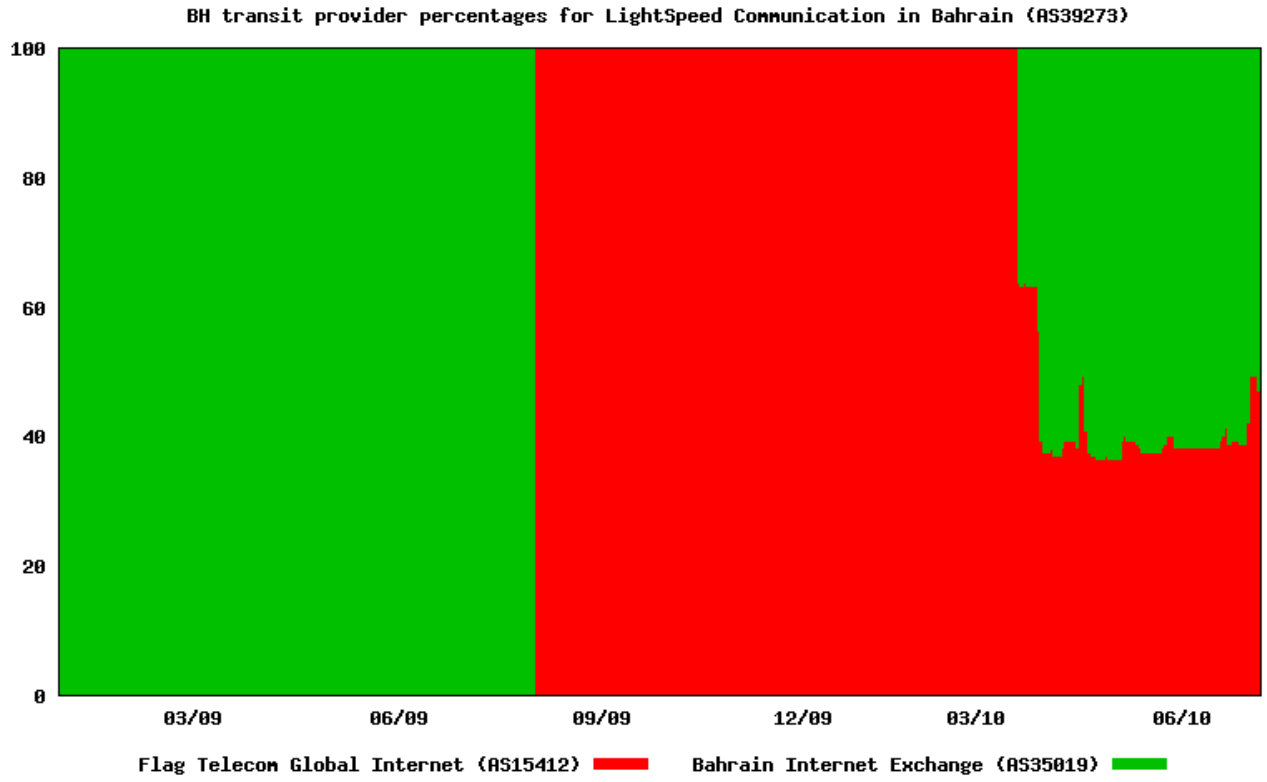


Nuetel (AS36658) transits just 15% of their networks through the BIX, with the remainder being transited by their new connection to FLAG (AS15412).

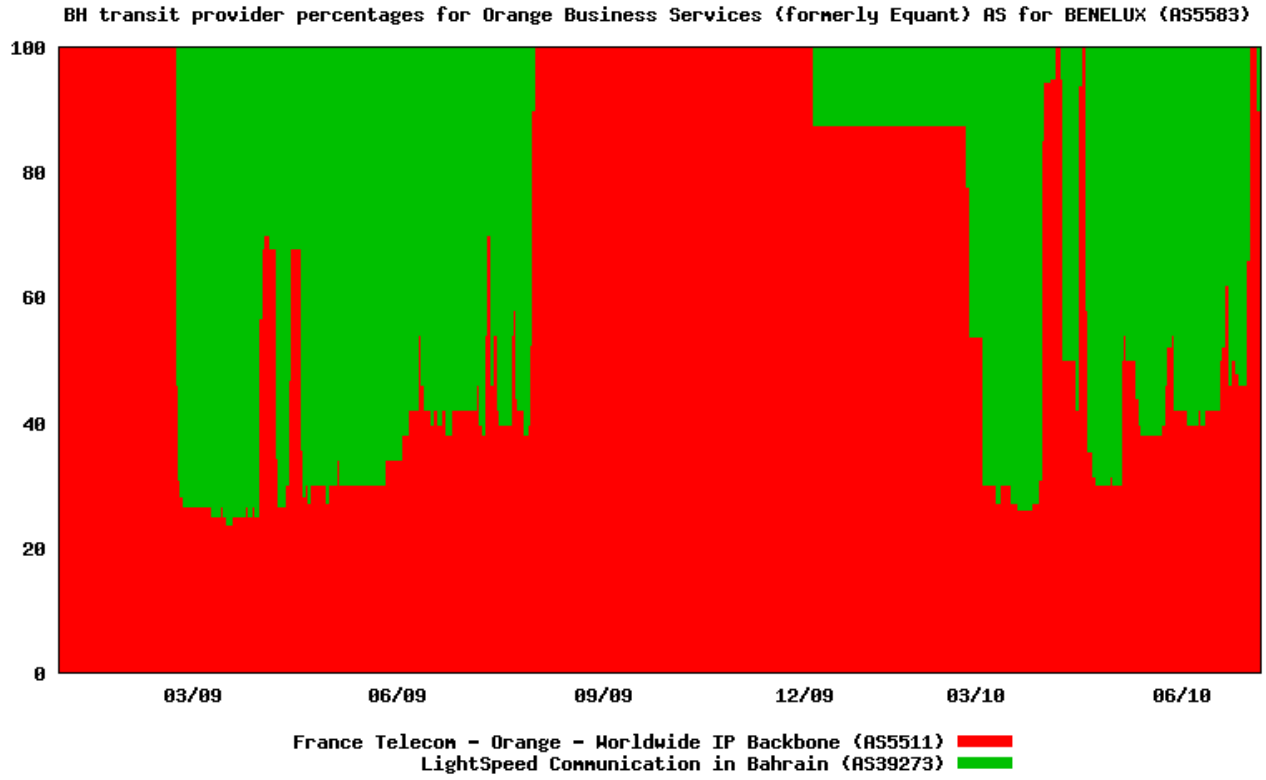
Nuetel was one of two providers to pick up new Flag transit during the summer of 2009, the other being Lightspeed Communication.



Lightspeed Communication spent 6 months relying totally on a single-homed relationship with Flag for their transit requirements, having shifted from the BIX to Flag on 1 August 2009. In April 2010 they brought their BIX transit back online, and now rely on BIX for approximately 60% of their routed transit.

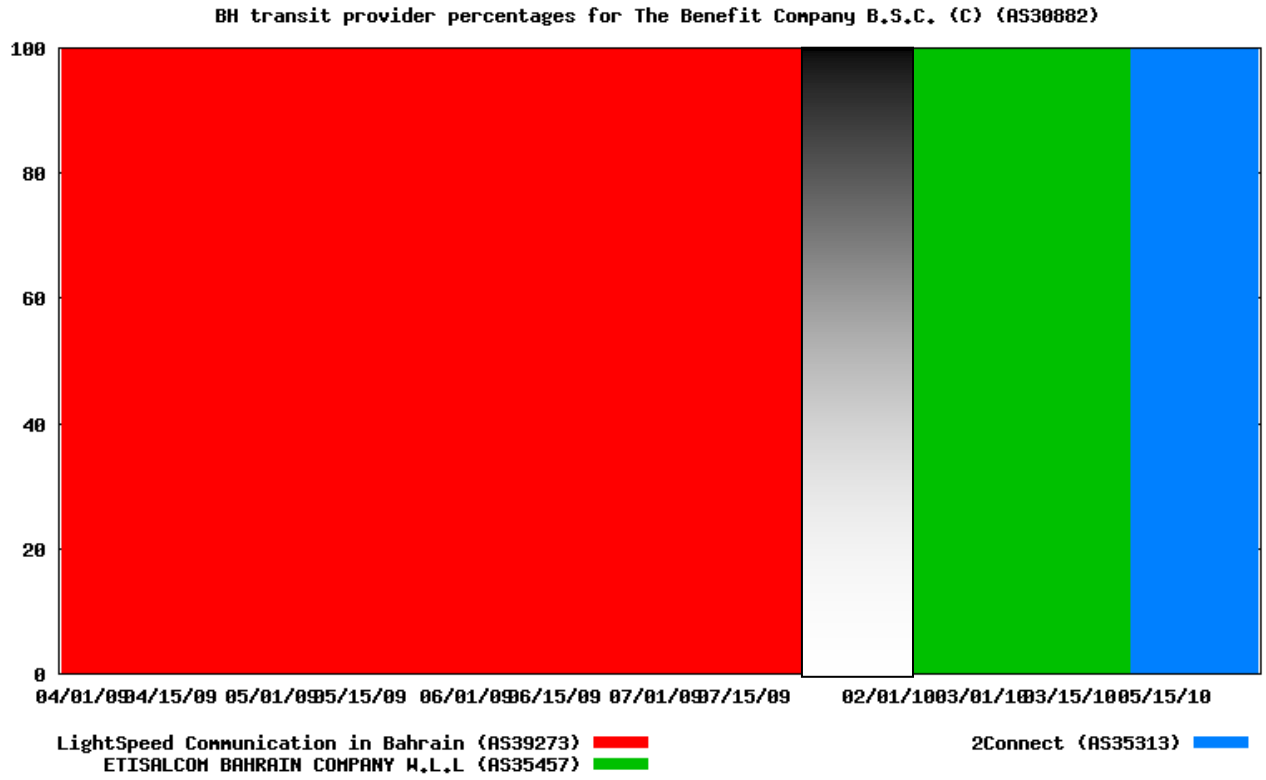


Orange Business Services (AS5583), which depended on Lightspeed to transit its Bahrain prefixes, was briefly left without Bahrain transit, choosing instead to single-home with France Telecom (Orange, AS5511). In 2010, however, they are once again transiting Lightspeed for at least some of their prefixes.



The Benefit Company B.S.C. (AS30882), which had relied on Lightspeed for its transit through 2009, abruptly gave its single network prefix (79.171.240.0/24) to Lightspeed to transit via Flag on 1 August 2009, and stopped using their own autonomous system.

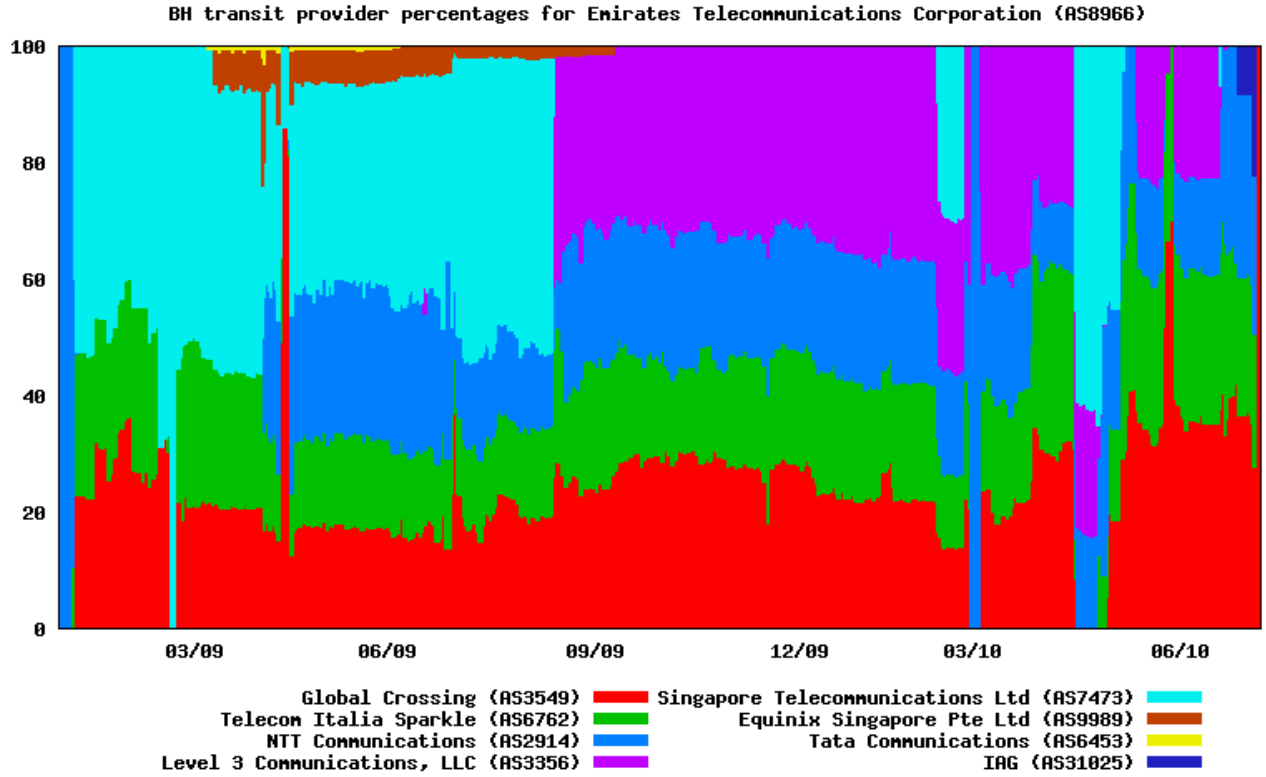
They reappeared on 26 January 2010, single-homed to Etisalcom Bahrain WLL (AS35457), which was in turn single-homed to the BIX. In April they transitioned yet again, singlehomed to 2Connect.



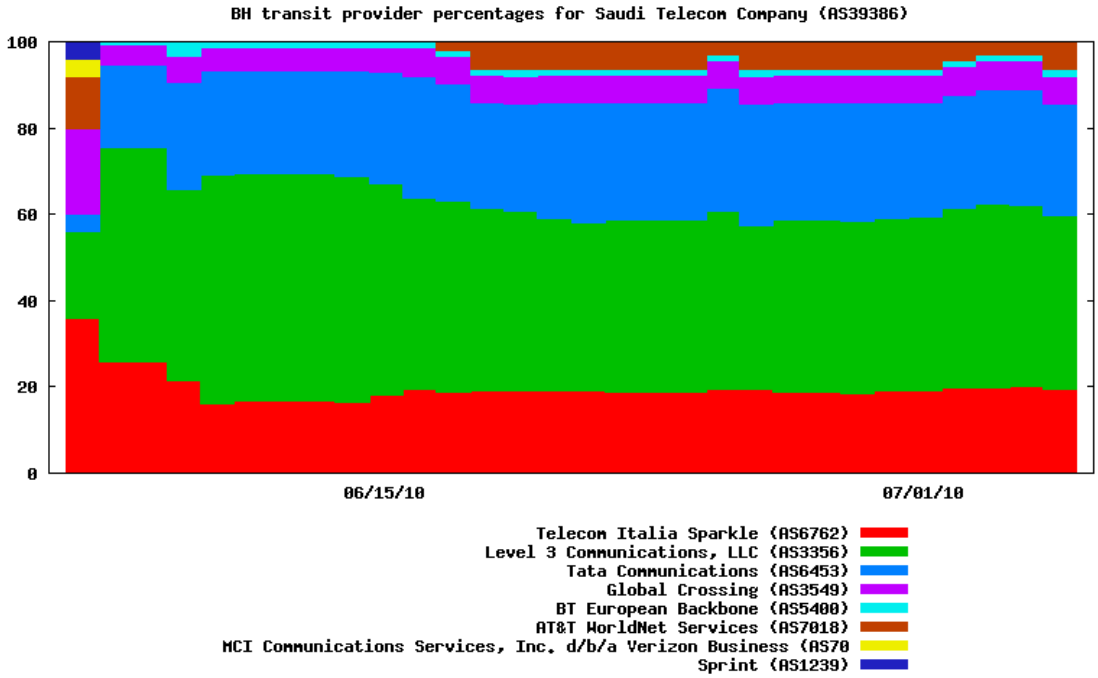
Emirates Telecom dropped Singapore Telecom (AS7473) for transit in August 2009, leaving a stable four-way diverse mixture of Level3, NTT, Sparkle, and Global Crossing to carry the traffic. In February, freshly motivated by Singtel's resale of cheap Tinet transit, Emirates added Singtel back to the mix.

In July 2010, as in August 2009, there is a clear difference between the high-order diversity available to a carrier at the cable landing (in a highly competitive carrier-neutral environment), and the low-grade diversity available in the Kingdom.

In 2010-2011, significant reductions in the price per megabit of Internet connectivity in Bahrain will probably be impossible without radically increasing the number of carriers available at a domestic interconnection point such as the BIX. Of course, the remaining variable to be examined is Viva's entry into the market, in March 2010.



Finally, in March 2010 **STC Viva** launched as the Kingdom's third mobile licensee. Saudi Telecom's Bahrain operations primarily use assigned resources within a single network prefix (84.235.0.0/17) advertised by a single autonomous system (AS41426). AS41426 (Viva) receives transit from STC (AS39386, 10%) and SaudiNet (AS25019, 90%). The STC investment brings a level of upstream international transit diversity to Bahrain that is similar to that of Emirates, as seen in the following transit provider plot.



Saudi Telecom's Bahrain operations primarily use assigned resources within a single network prefix (84.235.0.0/17) advertised by a single autonomous system (AS41426). AS41426 (Viva) receives transit from STC (AS39386, 10%) and SaudiNet (AS25019, 90%).

A small amount of additional transit is provided by Flag; traceroutes confirm that this transit is being provided from the Flag facility in Bahrain ("bah001.flagtel.com (85.95.25.154)") rather than Jeddah, and is only being provided to the two smallest networks (84.235.96.0/22 and 84.235.100.0/22, representing the Hoora and Tubli facilities). The percentage of transit is low enough that this is probably backup transit, intended for disaster recovery in case the leased GCCIA fiber beside the Causeway is interrupted.

Initially, while these Flag-backed prefixes included two /22 subnets that are plausibly reserved for handset addressing, they did **not** include other blocks (for example, 84.235.107.0/24) used for routing infrastructure within Bahrain at the Hoora and Tubli facilities. In case of damage to the GCCIA fiber beside the Causeway, it is possible that transit to Viva's mobile network would not have gracefully failed over to the Flag cable as intended, resulting in a service interruption. Fortunately, on June 16th, the remaining /24 infrastructure block appeared with Flag transit, resolving the potential issue.

Appendix A. Service Provider Rankings: Bahrain

The Renesys Market Intelligence service ranks autonomous systems according to the number and size of the network prefixes whose traffic they carry into a given geographic region.

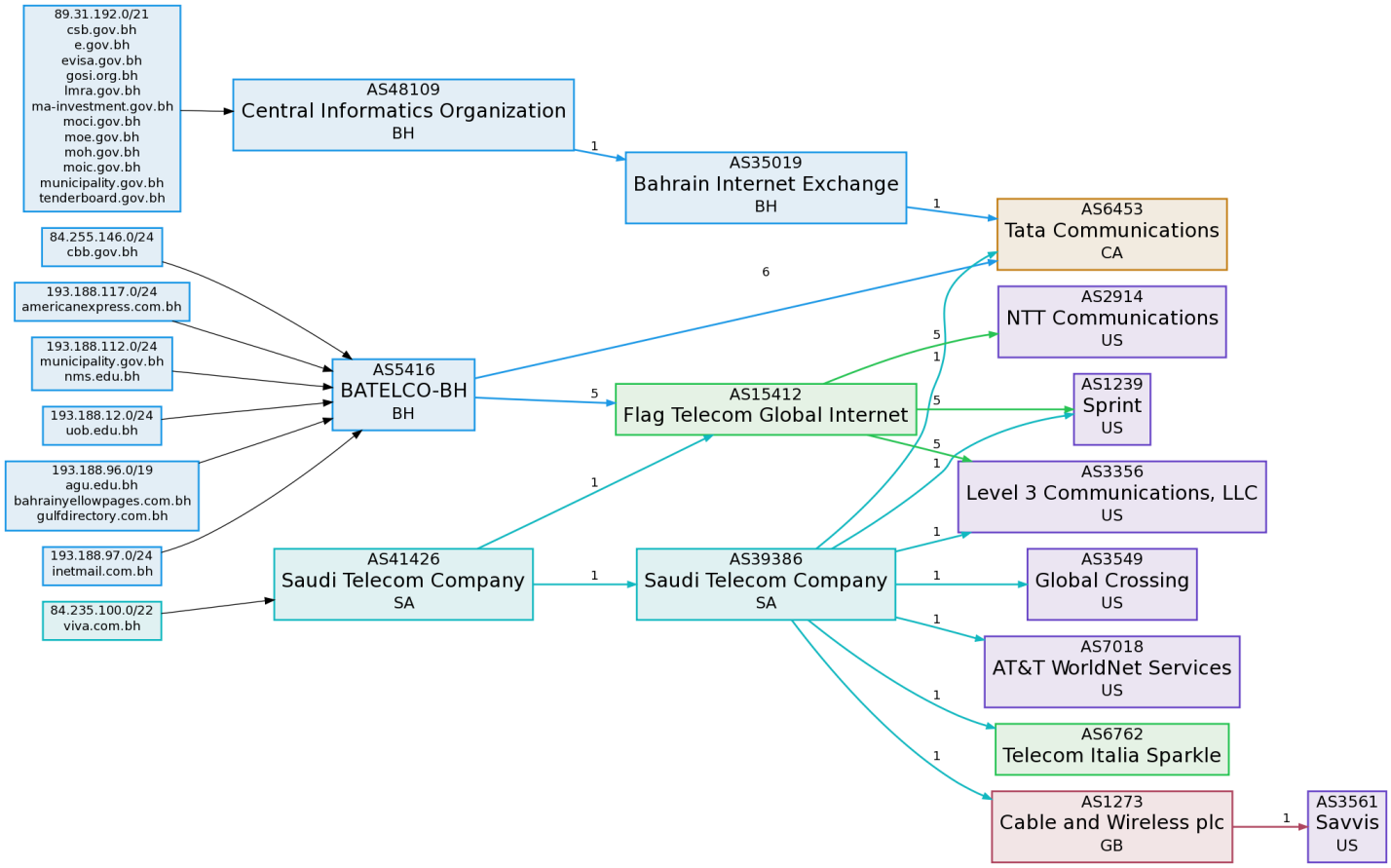
The July 2010 Retail Customer Base rankings are reproduced below. “Retail transit” of a prefix is defined as origination of that prefix, or transit on behalf of an autonomous system who originates that prefix. Because Tata (AS6453) provides direct transit to the originated prefixes of both Batelco and the BIX, they top the retail rankings.

Bahrain Internet Index Ratings

Customer Base: Retail — Bahrain

1		Tata Communications	6453
2	↑ 1	BATELCO-BH	5416
3	↓ 1	MTC-Vodafone Bahrain	31452
4		Bahrain Internet Exchange	35019
5		Flag Telecom Global Internet	15412
6	↑ 1	Mena Broadband	39015
7	↑ 1	Saudi Telecom Company	41426
8	↑ 1	LightSpeed Communication in Bahrain	39273
9	↑ 1	Business Communication Networks	41110
9	↑ 1	ASN-RTS	42931
10	↑ 1	2Connect	35313
11	↑ 1	ETISALCOM BAHRAIN COMPANY W.L.L	35457
12	New	GCCNGN	44075
12	↑ 1	Orange Business Services (formerly Equant) AS for BENELUX	5583
12	↑ 1	Northstar Technology Company W.L.L.	35546
13	↑ 1	Kalaam Telecom Bahrain	35443
14	↑ 1	Gateway Gulf	44876
15	↑ 1	WoodyNet	42
16	↑ 1	Nuetel Communications	35568
17	↑ 1	Kulacom communication SPC	47380
17	↑ 1	Ascentech Technical Services	41303
17	↑ 1	Central Informatics Organization	48109
17	↑ 1	iCOL PLUS WLL	44167
18	↑ 1	Viacloud	35729
19	↑ 1	754th Electronic Systems Group	1733
20	↑ 1	DoD Network Information Center	27064
20	↑ 1	DoD Network Information Center	5237

Appendix B. Internet Transit of Selected Bahrain Websites



This diagram illustrates schematically how many of the most popular Bahrain websites[2] connect to the Internet. Arrows flow from customers to providers, with the Bahrain websites arranged on the left side, and global Internet transit carriers along the right side.

Note that Batelco does not peer (exchange domestic traffic) with other operators at the Bahrain Internet Exchange. As a result, it is possible that traffic from some BIX-dependent netblocks (for example, the government ministries at the upper left) may actually have to leave the country, travel as far as Riyadh or London, and return to Bahrain in order to reach content sites hosted by Batelco (such as the webmail gateway, www.inetmail.com.bh).

For reasons of performance, stability, and security, domestic traffic should not leave the Kingdom. It should instead settle domestically, either at a common exchange point such as the BIX, or through appropriate bilateral interconnections between domestic operators.

[2] as identified on 7 July 2010 by Alexa's web rankings: **http://www.alexa.com/topsites**

Appendix C. Routing Terminology

Internet routing has developed its own terminology over time, which may not be familiar to the nonexpert. This section provides context for some of the terms used in this report.

- **Prefix (or "network"):** a sequence of IP addresses that an enterprise may use to identify machines that it attaches to the Internet (computers, routers, etc.)
- *Example: 77.92.160.0/19, which is a contiguous block of 8 million IP addresses belonging to Rawabi Telecommunications and Software.*

- **Border Gateway Protocol (BGP):** the software protocol used to establish Internet connections between different organizations.

- **Autonomous System:** An organization that has applied for an Autonomous System Number (ASN), in order to be allowed to advertise its own prefixes in the global routing table.
- *Example: Batelco (ASN 5416), or the BIX (ASN 35019).*

- **Border Router:** networking equipment deployed at the edge of an organization's network, in order to establish connections to other organizations by exchanging BGP messages with them.

- **Advertise (or "Announce") a Prefix**: An organization that wants other people to be able to reach its prefixes must **announce** them to its transit providers and peers. It does this by configuring its border routers to send BGP messages describing networks it knows how to reach, and listen for BGP messages that announce other people's networks.

- **Path to a prefix, ASPath:** each BGP announcement contains an **autonomous system path:** a sequence of one or more autonomous systems who passed on the announcement, representing the "best path" to the announced prefix.

- *Example: a BGP announcement containing the ASPath **"7473 8966 35019 39273 30882"** indicates that the best path to the prefix goes from Singtel (AS7473), to Emirates Telecom (AS8966), to the Bahrain Internet Exchange (AS35019), to Lightspeed Telecom (AS39273), and finally on to Benefit Company (AS30882), in that order.*

- "**Having a Route":** when a router hears another router announce a path to a prefix, it enters it into its routing table, and is then said to "have a route" to that prefix. If the new route is an improvement over its existing route, it will re-announce that improved route to all of its other neighbors. Amazingly, a new or improved route to any prefix generally propagates to all of the routers worldwide through re-announcement within 15 seconds.

- **Transit, Transit Provider:** When an autonomous system signs a contract to carry another enterprise's traffic to and from the global Internet, it is serving as a Transit Provider (i.e., "selling transit" to the other party).
- *Example: FLAG (AS15412) and Tata (AS6453) both sell transit to Batelco.*

- **Peering:** when two autonomous systems agree to exchange traffic between their customers, instead of each having to pay a transit provider to carry that traffic between them, they are said to be peering. If no money changes hands, it's **settlement-free peering** (the usual case).
- *Example: Batelco (AS5416) and Emirates Telecom (AS8966) peer with each other at the EMIX. Traffic between a Batelco customer and an Emirates customer changes hands "for free," rather than being sent to a paid transit provider, such as FLAG. Most Bahrain autonomous systems (other than Batelco) peer with each other at the BIX.*

- **Reachable, Unreachable (or "Outaged'):** If a router has a route to a given prefix, that prefix is **Reachable** from its perspective; if it no longer has a route, the prefix is **Unreachable**. When a network prefix becomes unreachable (that is, it is no longer being announced to any transit provider), it is no longer connected to the Internet.

- **Instability:** When the routes to a prefix change very quickly (often because a physical link is very congested, or "flapping" in and out of service), the prefix is said to be Unstable. A route to it may exist, but traffic may not be flowing smoothly because link quality is poor.

- **Global Routing Table:** the ideal routing table consisting of all the known “best paths” to all of the prefixes on earth, from all of the border routers on earth. Renesys builds an approximation of this ideal global picture by connecting to hundreds of organizations' border routers and synthesizing a continuous map of their routes at one-second granularity.

