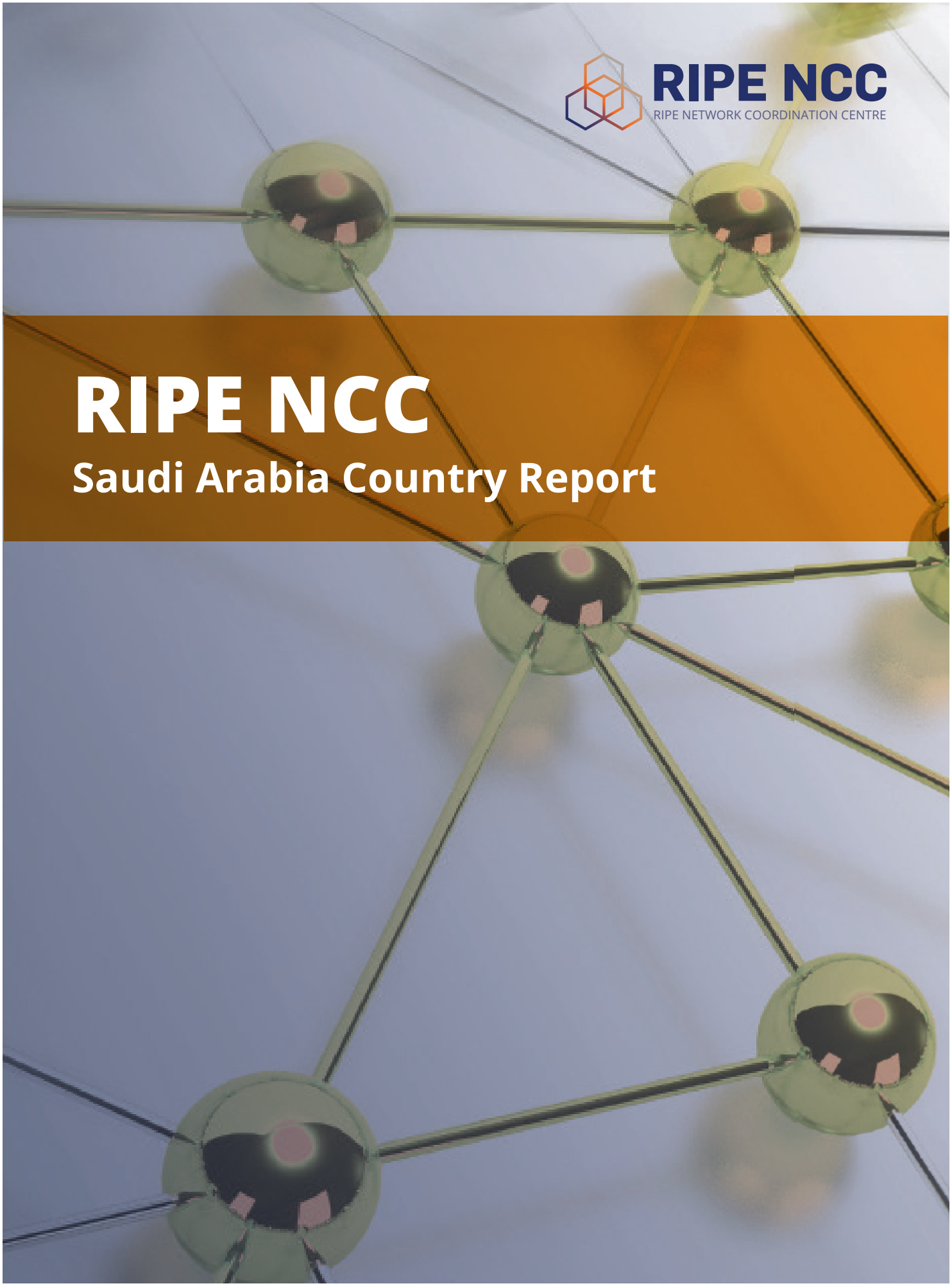


RIPE NCC
RIPE NETWORK COORDINATION CENTRE

RIPE NCC

Saudi Arabia Country Report

Date: January 2019

Introduction

This report describes the current state of Internet development in Saudi Arabia and the surrounding Arabic-speaking countries. It examines growth trends and the optimisation of Internet routing in the region and evaluates the efficiency of our K-root service, which is part of the global Domain Name System (DNS).

The report focuses on what we can observe and measure from RIPE NCC services and measurement infrastructure in the region. With a greater number of data collection points and more information sharing between stakeholders in the region, we would be able to provide an even more detailed and complete analysis of the situation in the future. To this end, the report also contains information on how all stakeholders can help support further analysis.

Growing Internet Use in the GCC

"High penetration across the board"

In recent years, the percentage of people using the Internet across the Gulf Cooperation Council (GCC) countries has continued to rise, sometimes steadily, sometimes quite sharply. If we compare the situation at the end of 2017 to the situation in 2010, we see that the proportion of people using the Internet in this group of countries has risen by an average of approximately 35%. Figure 1 provides an overview of the rise in the number of Internet users in the GCC against the backdrop of population growth.

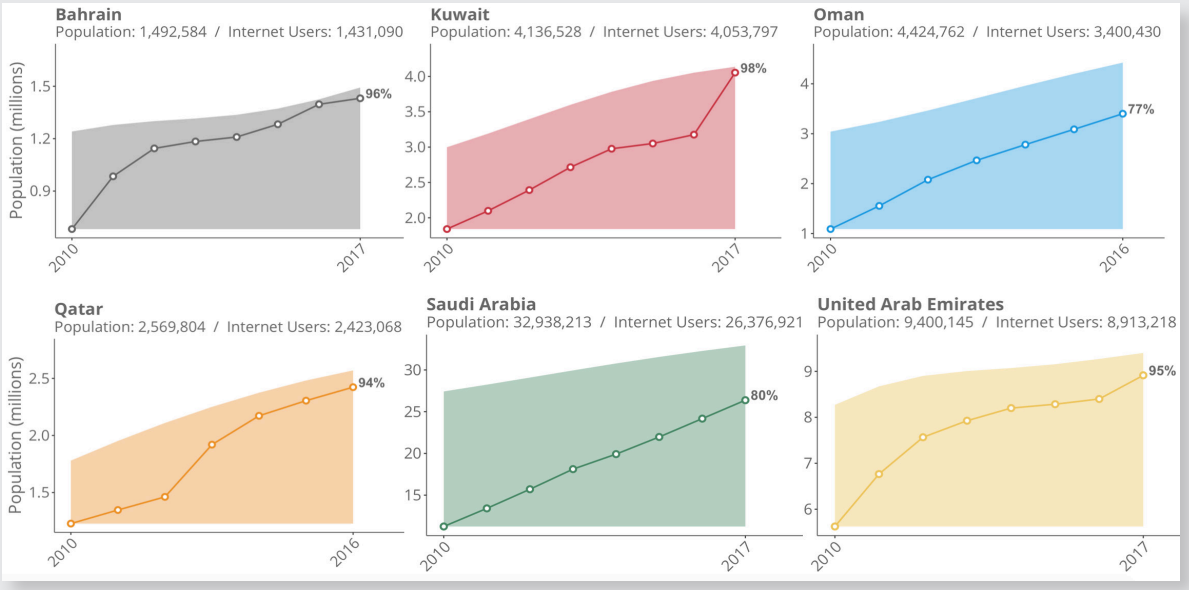


Figure 1: Growth in the number of Internet users per GCC country (indicated by dotted lines) and growth in population (indicated by shaded areas) from 2010 to the end of 2017. The figures displayed here are obtained from ITU data on Internet users by country and World Bank population data [the ITU does not as yet provide data on Oman and Qatar past 2016].

In many of the GCC countries, we see that the percentage of Internet users has now risen well over 90%, putting those countries high in the global rankings for Internet penetration. In other countries, such as Saudi Arabia, although Internet penetration is high, there is room for further growth. Indeed, future growth seems likely, with Internet penetration in Saudi Arabia having consistently risen by around 5% or more each year since 2010. So, with approximately 26.4 million Internet users in Saudi Arabia as of the end of 2017, and the likelihood of yet more growth, it is useful to consider whether the country has adequate Internet number resources to meet the growing needs of its users.

Internet Number Resources in Saudi Arabia

The exhaustion of the IPv4 address pool and slow (but accelerating) uptake of IPv6 is a defining challenge for the ongoing growth of the global Internet, and nowhere is this more true than in the Arab region. These two concurrent narratives in Internet number resource management underlie a range of trends and developments that we can see playing out in the Saudi Internet community, in the Arab region and at the global level.

IPv4 Exhaustion: Some Background

IPv4 exhaustion can only be understood in the broader context of the Internet landscape, which consists of a wide variety of networks, stakeholders and technologies. This scarcity will continue to pose a serious challenge to network operators around the world, as they endeavour to grow their networks in a world where IPv4 addresses are increasingly hard to obtain.

Globally, there are five Regional Internet Registries (RIRs) responsible for the allocation and administration of Internet address space to network operators in their respective regions. Of these, four are only able to offer token blocks of IPv4 (or, in the case of ARIN, nothing at all). Only AFRINIC still has IPv4 addresses available to its members, though it is not far from exhaustion either.

Figure 2: The five RIRs and their respective service regions

Anticipating this situation, the RIPE community agreed to set aside our final block of IPv4 address space for new entrants. The intention was to allow these companies to obtain a single block of 1,024 IPv4 addresses (known as a /22), which they could use to interconnect their IPv6-only networks with the IPv4 Internet. The RIPE NCC has been making allocations according to this policy since 2012. Based on the current growth in new Local Internet Registry (LIR) accounts being opened with the RIPE NCC, and with each of them entitled to a single /22 allocation, we anticipate that our remaining IPv4 addresses will last approximately another 18 months.

This approach of preserving IPv4 for new entrants has produced unexpected behaviour on the part of some networks. We have seen a significant number of companies opening multiple LIR accounts to access more IPv4 addresses, occasionally resorting to dishonest or fraudulent means to do so. The worst of this activity has been addressed through a combination of policies created by the RIPE community, changes to RIPE NCC procedures, and greater investment in due diligence and verification. These issues illustrate, though, how seriously network operators view IPv4 exhaustion and the value they place on IPv4 addresses.

At the same time, many network operators find that they are able to get more out of the limited addresses available to them through the use of address-sharing technologies (Carrier-grade Network Address Translation, or CGNAT). This is complemented by a substantial IPv4 transfer market that has emerged in the APNIC, ARIN and RIPE NCC service regions in recent years. However, the consensus is generally that these can only be short- to mid-term solutions, as questions remain about whether CGNAT can scale and about the impact it has on network operations. The inevitable conclusion is that, with several billion people still unconnected, IPv6 deployment is needed to safeguard the future growth of the Internet.

IPv4 Holdings and LIR Accounts

"Authentic growth in new members in the region"

Across the GCC countries, there are around two to three Internet users to every IPv4 address currently held by LIRs in those countries. In the face of ongoing growth in the number of Internet users, the need to bring that ratio down to something closer to one IPv4 address per user, or even to maintain the current ratio, is one of the key factors driving operators in these countries to seek more Internet address space.

In 2018, the number of LIR accounts registered with the RIPE NCC passed 20,000, across 112 countries. This is compared to roughly 8,500 LIRs in 2012. A number of different factors have been driving this growth:

- Prior to IPv4 run-out, network operators could rely on obtaining IPv4 addresses from their Internet Service Provider (ISP). This is no longer the case – their ISP may opt to charge a premium for the addresses or use them elsewhere. Operators therefore have an incentive to become LIRs, so they can be responsible for their own addresses, and are often encouraged to do so by their ISP.

- There are also country-specific business or economic factors. These might involve new networks entering a market, regulatory reforms, or changes in the political landscape.

- Organisations are taking a greater interest in ensuring resilience and redundancy in their Internet connection and having control over their data traffic flows. We have seen an

increase in the number of enterprise and banking sector operators that open LIR accounts for this reason.

There are just over 300 LIR accounts registered with the RIPE NCC from within countries in the GCC. While traditionally, RIPE NCC members were primarily Internet Service Providers (ISPs) and major telecom operators (which resulted in a handful of members per GCC country), today we are seeing a clear shift in the sectors from which RIPE NCC members are drawn. Organisations from enterprise, government and academia are now more commonly applying for their own IP resources through the RIPE NCC.

The distribution of LIRs within the GCC breaks down as follows:

Country	Number of LIRs
Saudi Arabia	125
United Arab Emirates	89
Kuwait	44
Bahrain	19
Oman	15
Qatar	14

As the graph in Figure 3 illustrates, growth in the number of LIRs varies quite markedly between countries. This sometimes reflects the number of IP addresses held by LIRs in those countries (as shown in the graph on the right). It should be noted, however, that a pre-2012 LIR could have millions of IPv4 addresses, while a newly-created LIR can only receive 1,024 addresses (in addition to any addresses it obtains via the IPv4 transfer market). The number of LIRs can also be affected by regulatory or industry changes, or by changes to the RIPE policies that govern how we distribute IP addresses and AS Numbers within our service region. These policies are developed by the RIPE community.

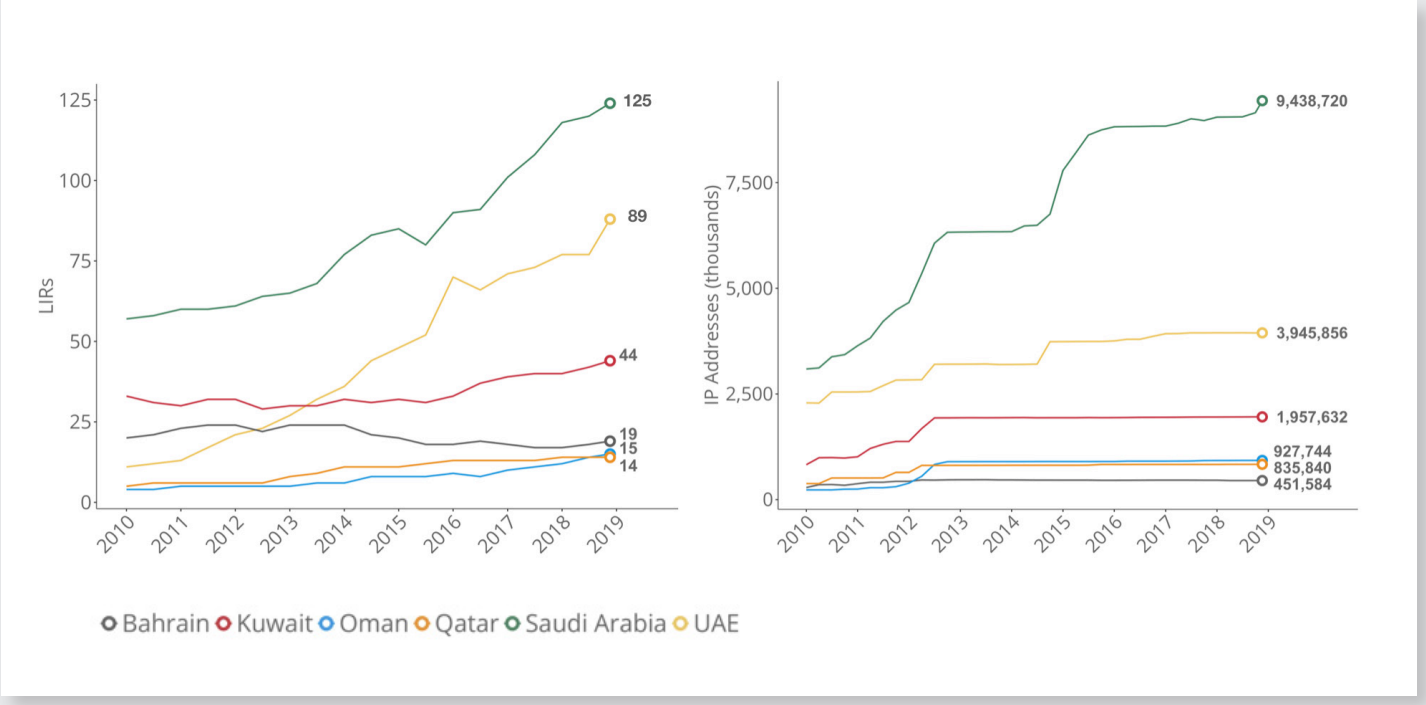


Figure 3: Growth in the number of RIPE NCC LIR accounts registered in GCC countries (left) and the number of IP addresses held by LIRs in those countries (right) since 2010.

In terms of growth in active LIR accounts:

- In Saudi Arabia, the number of LIR accounts has risen from 51 to 125 over the past decade (a 145% increase).
- The United Arab Emirates has also grown from 10 to 89 LIR accounts (a 790% percent increase).

Other examples underline the impact of regulation:

- There were 25 LIR accounts in Bahrain in 2013 compared to 19 in 2018. This change was the result of the regulator revoking the licenses of some network operators.
- An opposite example can be seen in Lebanon, which changed its regulation in 2014 to allow for the licensing of more service providers. This resulted in an increase from 50 LIRs in 2014 to 124 today (a 148% increase).

We can broadly break down the RIPE NCC membership growth into two categories:

- Growth in terms of new members (legal entities that open one LIR account), which can be read as “authentic” growth.
- Growth in terms of new or existing members that open additional LIR accounts under the same legal entity to obtain multiple IPv4 /22 allocations.

When we look at the Arab region, we mostly see authentic growth. This indicates that growth is being driven by distinct legal entities that wish to be responsible for their own IP resources. Some useful examples that illustrate this:

- Bahrain, Kuwait, Oman have no additional accounts (each LIR is a separate legal entity)
- Qatar has one additional LIR account, held by one member
- Saudi Arabia has seven additional LIR accounts, five of which are held by one member
- United Arab Emirates has eleven additional LIR accounts, five of which are held by one member

While this authentic growth indicates that organisations increasingly wish to become responsible for their own IP addresses after IPv4 exhaustion, it only tells half the story. An ISP may recommend that its corporate customers become LIRs, because it does not have enough IPv4 to provision them in the future. In this case, the new LIR becomes responsible for its own IP addresses, but in practical terms, nothing has changed – it remains a customer of the ISP. In the next section we use routing information to tell the rest of the story.

Autonomous Systems

"Businesses seeking increased control over their networks"

Another way to view Internet growth is by looking at the number of Autonomous Systems (AS) that are visible in global routing. While the technical definition differs slightly, an AS can generally be understood to be a distinct network on the Internet. AS Numbers (ASNs) are used to identify networks almost in the same way that IP addresses are used to identify specific devices. An LIR that is a traditional ISP will typically operate a single AS, though it may have more depending on the nature of its business and network requirements. There are around 63,000 independent networks on the Internet today.

Looking at the Internet landscape in Saudi Arabia and the United Arab Emirates, the number of Autonomous Systems in both countries that are visible in global routing has grown at a steady pace. At a glance, it is clear that this growth exceeds any increase relating to new ISPs or telecom operators entering the market in these countries.

While IPv4 exhaustion may have incentivised some businesses to open LIR accounts to obtain their own IPv4 addresses, this does not require them to announce their own ASN in the routing system. The fact that they are visible in the routing system indicates that greater resiliency, redundancy and control is being sought by networks within these countries.

Country	2008	2013	2018
Saudi Arabia	52	99	128
UAE	8	47	64

Number of Autonomous Systems visible in global routing

This is one more indicator that the growth we see in the region is related to actual growth and a better understanding of how to scale the local Internet. While there is still room for improvement and maturity, the growth rates in Saudi Arabia and the United Arab Emirates show that these countries are taking steady steps towards building better infrastructure and that they have a high level of awareness and understanding of the Internet ecosystem.

IPv4 address transfers

In the wake of IPv4 exhaustion, a market in IPv4 addresses emerged in the ARIN, APNIC and RIPE NCC service regions. Policies developed by the respective communities now allow for the transfer of IP addresses between operators in these three service regions. This is particularly relevant as North America (the ARIN region) appears to have the most unused addresses available for transfer.

Not all transfers involve the purchase or sale of addresses. The RIPE community has asked the RIPE NCC to report on all resource transfers, whether they are the result of mergers or acquisitions, the movement of resources between parent or sibling companies, or the direct transfer of blocks of addresses between LIRs. While many transfers undoubtedly involve money changing hands, the RIPE NCC has no role in any financial component and thus no means of differentiating between these cases.

Looking at the region, transfers have been particularly relevant for some GCC countries, where strong Internet growth coincided with the exhaustion of our IPv4 address pool. Without the ability to obtain addresses on the IPv4 transfer market, it may have been more difficult for networks in the region to achieve this growth.

Address transfers happen at the level of individual networks and according to the business needs and historical circumstances of those networks. It is therefore difficult to generalise or identify patterns. Nevertheless, we can see that the United States is currently the prime exporter of large blocks, taking the place of Romania, which was the previous leader. In both cases, historical factors meant there was an excess of addresses registered to networks in these countries that became available for market transfer.

Between the end of 2014 and the end of 2015, Saudi Arabia obtained 2.5 million addresses via the IPv4 transfer market, complementing the 6.3 million addresses that Saudi LIRs already held in the form of allocations from the RIPE NCC. Some 200,000 addresses were obtained in 2017, with a further 400,000 addresses transferred in 2018. This has brought the total number of IPv4 addresses registered in the country to 9.4 million, which equates to approximately one IP address for every three of the estimated 26.4 million Internet users in the country (80% of the total population).

Type	IPv4 Addresses	/22 equivalents (approx.)
Imports	3,120,000	3,052
Exports	8,190	8
Internal Transfers	48,130	47
Total IPv4 in Saudi Arabia	**9,400,000**	**9,137**

It is clear that IPv4 address transfers have contributed to an expansion in the number of Internet networks in Saudi Arabia. At this point, one out of three IPv4 addresses in Saudi Arabia have been obtained via transfer.

We also see that the number of IPv4 addresses leaving the country is negligible compared to the amount currently in the country (8 from a total of 9,145 /22s).

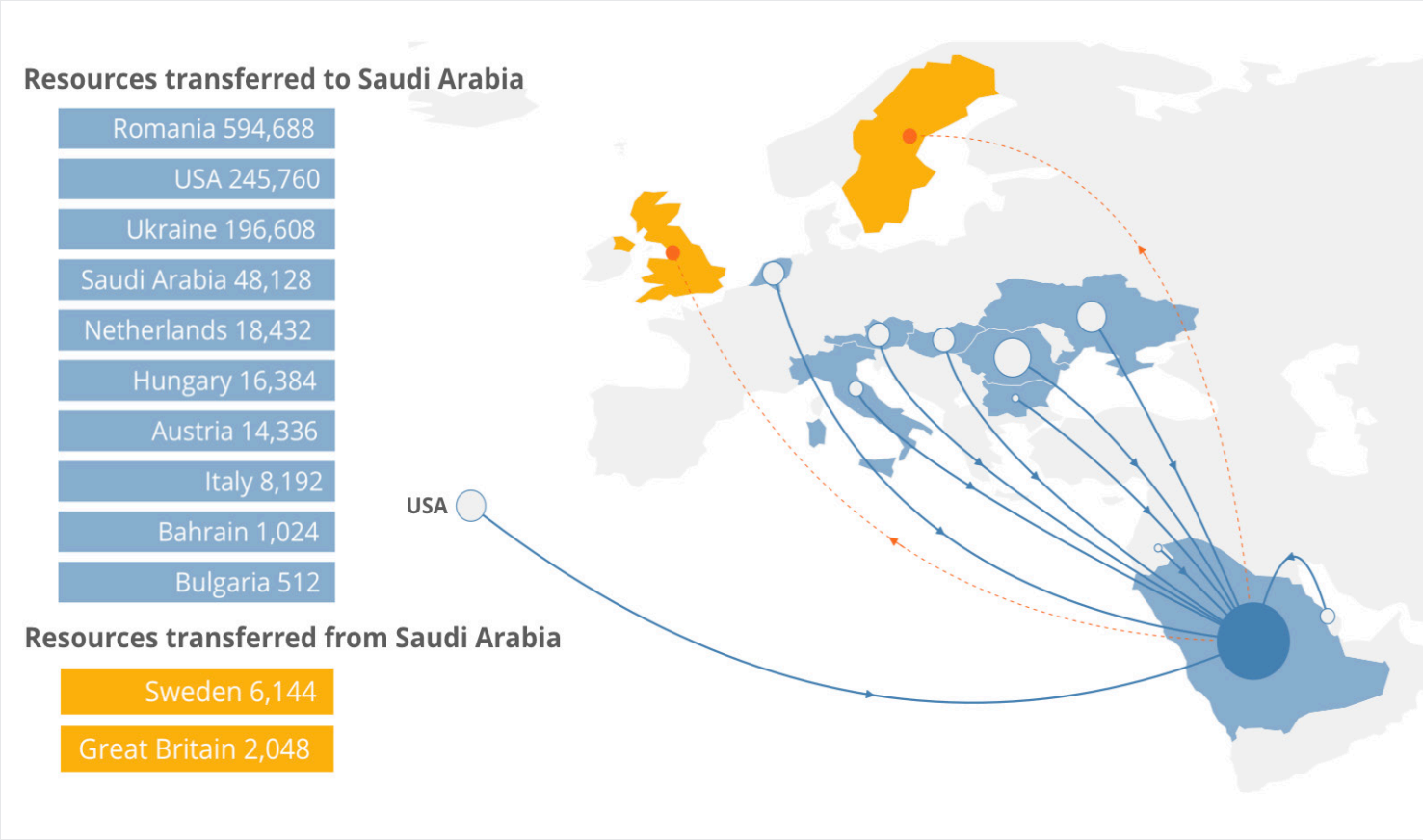


Figure 4: Transfers of IPv4 addresses to and from Saudi Arabia

When looking at the rest of the region, we can add a few additional observations: It is clear that the transfer market is well understood within the Arab region and is used when there is clear need. Given that a lot more resources have been imported into the region, the few exports there are negligible. A common scenario in many countries in the Arab region seems to be that addresses are transferred within the same country, according to the needs of the industry.

IPv6

"Saudi Arabia leading the region, but not the world"

It has long been understood that IPv4 exhaustion would pose a challenge to Internet growth. This is why the Internet Engineering Task Force (IETF) developed IPv6, with its enormous addressing space. However, while IPv6 was released in 1998, it was not until early 2013 that Google saw the percentage of users accessing its services over IPv6 pass the 1% threshold. Today this figure stands at around 26%.

In one sense, the failure of network operators to deploy IPv6 in the past can be viewed as completely rational behaviour. There was no real benefit in moving to IPv6 until other networks had deployed it and a network effect could emerge. It took time before vendors began to sell IPv6-capable network equipment, and many key services were not IPv6-enabled. Most network engineers were unfamiliar with IPv6 and would require training to get up to speed with the new protocol. In terms of scheduling this as a project, there were typically other projects of more immediate benefit. And of course, there were still plenty of IPv4 addresses available.

This began to change when the RIRs started allocating address space from their final blocks of IPv4 addresses. In the meantime, most of the above factors have also been addressed. Practically all network equipment sold today is IPv6-capable and many key services are now IPv6-enabled. And with the massive degree of consolidation in terms of content and services that has taken place in recent years, ISPs that switch on IPv6 typically report that as much as 70–75% of the traffic on their network immediately travels across IPv6 (as the bulk of their users are connecting to services like Facebook, Google and YouTube – all of which are IPv6-enabled).

While IPv6 deployment is widely seen by operators in the GCC countries as the solution to IPv4 exhaustion, deployment levels remain low and not nearly where we might expect them to be (based on our measurements and those conducted by others). While many networks have IPv6 configured to their upstream providers, the key component still missing is deployment to customers and end users.

By examining the routing information collected using the RIPE NCC's Routing Information Service (RIS) collectors and comparing it to the RIPE Database, we see that, while 55% of the LIRs in Saudi Arabia have received IPv6 resources from the RIPE NCC, only 21% of them are actually announcing it in global routing. This measurement does not take into account whether packets are travelling across IPv6, meaning that the real deployment figure is even lower.

It is important to acknowledge the valuable efforts of the Communications and Information Technology Commission (CITC) in raising IPv6 awareness among the different private and public sector stakeholders in Saudi Arabia. These efforts have included a biannual event to share best practices, experiences, success stories and operational challenges. The RIPE NCC partnered with the CITC early on in this initiative and has contributed with presentations and workshops run by our technical training staff.

It is largely as a result of these efforts that we have recently seen a significant move towards IPv6 adoption in Saudi Arabia. According to measurements conducted by our colleagues at the Asia Pacific Network Information Centre (APNIC), approximately 9% of Internet connections in Saudi Arabia are currently IPv6 capable. Closer inspection suggests that this is due largely to the fact that one provider network in the country, namely Saudi Telecom Company (STC), has enabled IPv6 to its fixed-line customer base all the way to its end users.

With 9% IPv6-capable connections, Saudi Arabia leads the region – most surrounding countries show less than 1% in the same APNIC statistics. Looking at the rest of the world, while Saudi Arabia is ahead of Russia (2%), China (5%) and much of Africa (0-9%), it is significantly behind North America (20-47%), Western Europe (14-48%, with some notable exceptions), Brazil (26%) and Australia (13%). Notable global leaders are India (55%), Belgium (48%) and the United States (47%).

We generally see that countries with the highest level of IPv6 penetration have deployed IPv6 on mobile networks and specifically IPv6-only mobile networks (such as in the USA and India). Most of the mobile operators in the Arab region are not ready to deploy IPv6 to their mobile customers; in fact, none of the operators in the Levant region have moved yet, and while some operators across the GCC are experimenting, Saudi Telecom Company (STC) is the closest to deploying IPv6 to their mobile subscribers.

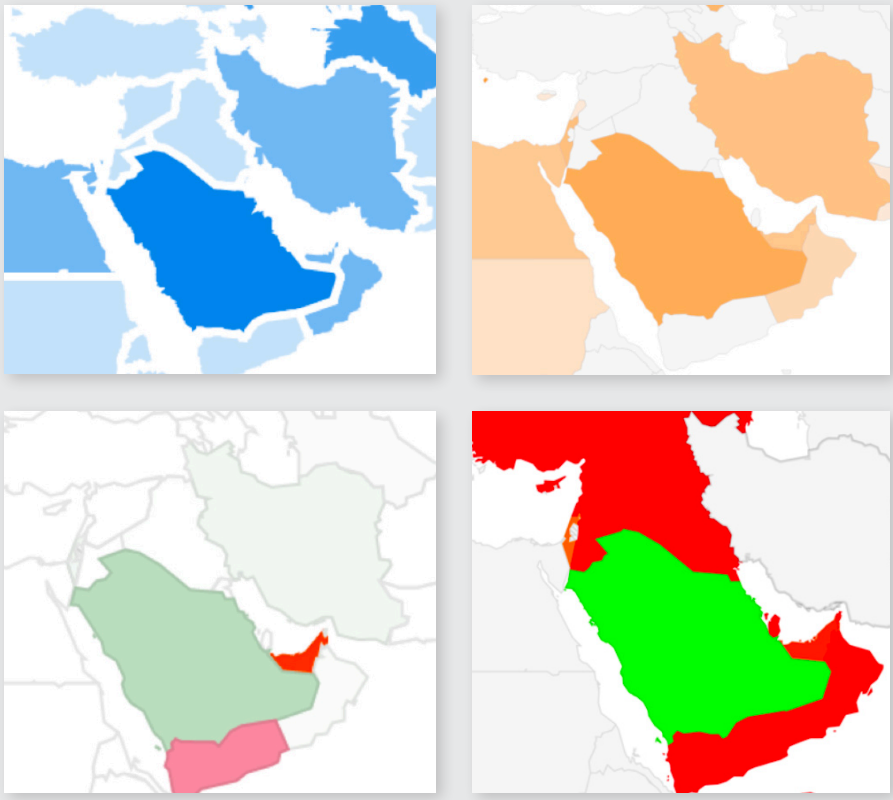


Figure 5: IPv6 deployment in the Middle East according to Facebook (top left), Akamai (top right), APNIC (bottom right), and Google (bottom left). Top row: deeper shades indicate higher deployment. Bottom row: green and red indicate higher and lower deployment, respectively.

The Internet Landscape in Saudi Arabia, the GCC and the Arab Region

The Internet in the Arab region has seen a lot of development in recent years. There are currently slightly fewer than 600 ASNs for the entire Arab region visible through our Routing Information Service (RIS), around 280 of which are in GCC countries.

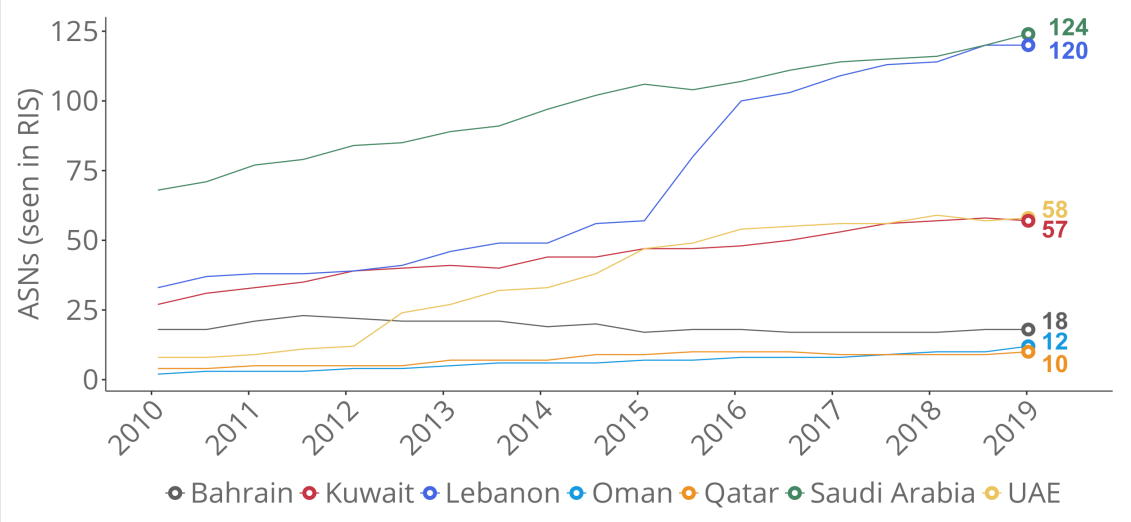


Figure 6: Growth in ASNs (seen in RIS) in GCC countries and Lebanon since 2010

If we examine the growth patterns shown in Figure 6, it is clear that Saudi Arabia has shown quite uniform growth over time, with no obvious drivers apart from organic, business-driven development.

Compare this to growth rates in the United Arab Emirates, where it is clear that 2012 triggered a lot of development in terms of more networks getting their own resources from the RIPE NCC, which began making allocations from a final block of IPv4 addresses.

Beyond the GCC, Lebanon saw a later boom (in early 2015) due to a change in its regulatory framework, which allowed for smaller operators in the country to register as Internet Service Providers and apply for their own RIPE NCC membership and resources.

Unlike the earlier telecom model, where each national telecom would have bilateral agreements and connections with other national telecoms, the Internet is built on networks being able to talk either directly or indirectly with all of the 63,000 networks worldwide. With around 600 visible ASNs in the Arab region and 300 in the GCC countries, it is clear that direct bilateral connections will not be able to scale to meet technical and economic challenges. This is one reason why Internet Exchange Points (IXPs) are a crucial part of how the Internet is built and structured – not only at the global or regional levels, but on a national level as well.

While it was easier (and probably cheaper in some cases) to build into the more established, well-connected IXPs (mainly in Europe and the United States), there have been more regional and national efforts in the past decade to keep domestic traffic within its respective region. This means Internet traffic does not travel halfway around the globe to reach a destination that is physically nearby, which has an impact on speed, cost, security and the overall experience for end user.

Today there are five IXPs in the region: two in the United Arab Emirates (including the largest in terms of regional and international peers, UAE-IX), two in Lebanon (including the region's oldest, Beirut IX, established in 2007), and one in Palestine. There are efforts underway to launch a further three IXPs in Saudi Arabia, Kuwait and Iraq. It is also worth noting that while Bahrain has a network operator known as Bahrain Internet Exchange Point (BIX), this operator does not currently operate as an IXP.

How Internet Traffic is Routed

So, how much of the region's traffic remains local, and how much is routed outside of national and regional borders? We use two measurement tools, the RIPE NCC's Routing Information Service (RIS) and RIPE Atlas, to look at the different paths that Internet traffic might take between two end points, including whether it remains within the country and whether it passes through an IXP. While the results are limited to those networks where we have RIPE Atlas probes, they do highlight some interesting characteristics of traffic flows in the region.

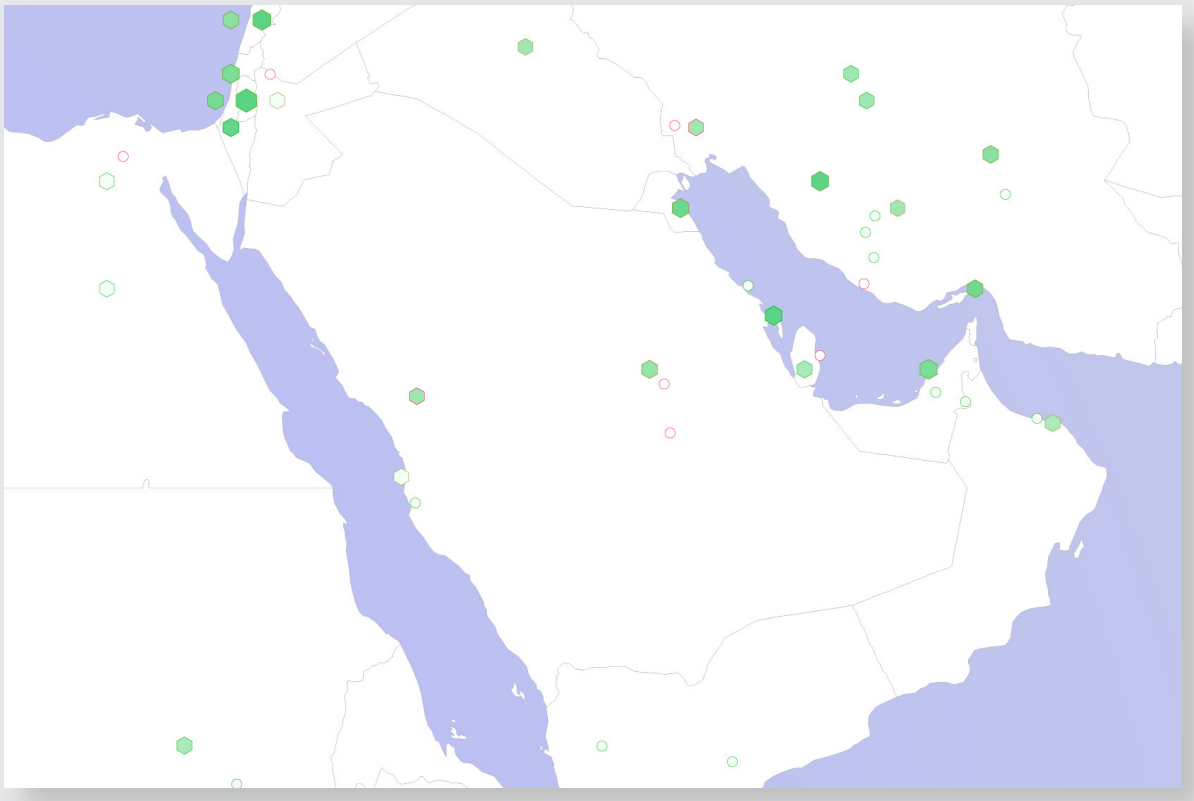


Figure 7: RIPE Atlas probes connected in the Arab region (active probes in green)

Using RIPE Atlas probes, we can look at how traffic travels between networks in a single country. Figure 8 shows the results for three countries, Saudi Arabia, UAE and Bahrain. Each chart shows the networks with RIPE Atlas probes in a given country; each entry on the two axes represents a network. The intersecting squares show how these networks exchange traffic: the darker shades of green indicate that the traffic between these networks travels through a local IXP; lighter green means that traffic is exchanged via a more direct path due to a bilateral agreement (whether commercial or fee free).

We can see that in Saudi Arabia there are currently only two networks with active probes, making it a challenge to draw useful conclusions. The UAE, on the other hand, has a larger distribution of probes across several networks, allowing for better visibility into how traffic is routed within the country - we can see that traffic between all of these networks remains within the UAE, though only some of the connections route via an IXP.

Looking to Bahrain, we see that traffic selects paths that are mainly local, despite the lack of a local, active IXP. However, the gold boxes show that traffic between some Bahraini networks actually leaves the country. This was identified as a source of concern at a 2018 meeting attended by various Bahraini stakeholders, particularly among some banking and financial institutions, which prefer their Internet traffic to remain within the country.

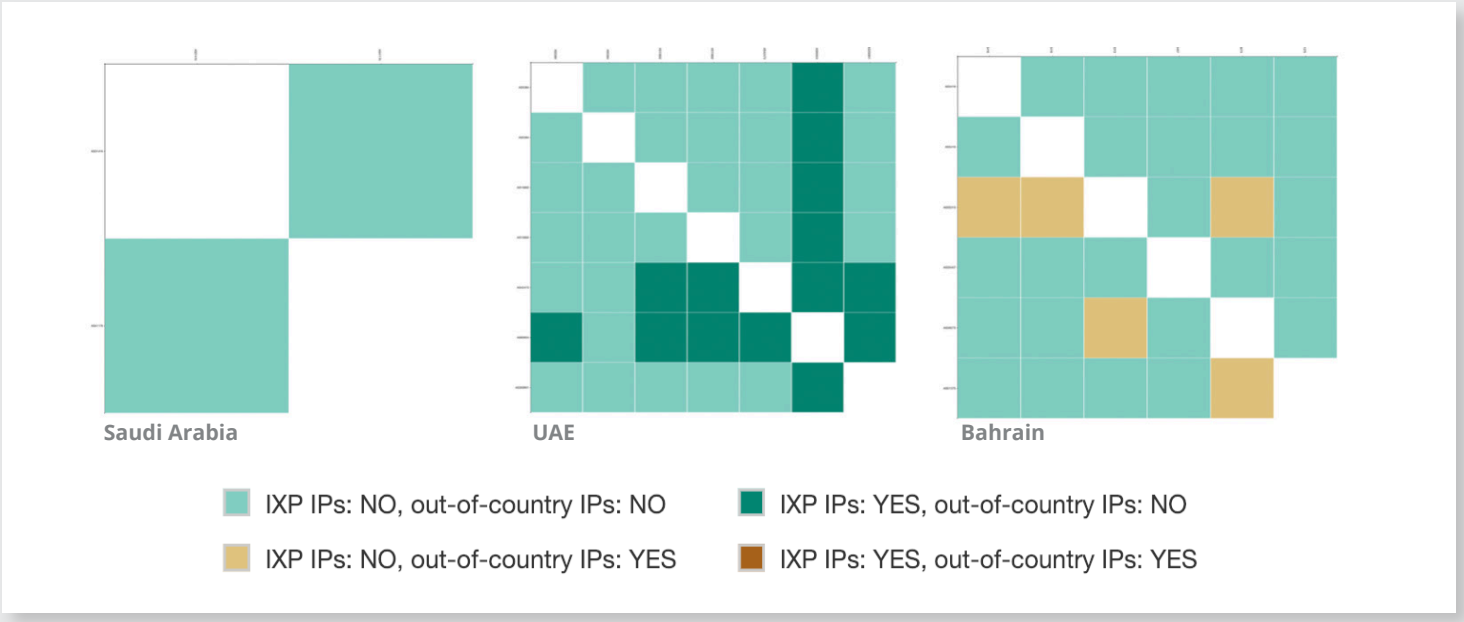


Figure 8: Grids indicating how domestic Internet traffic is exchanged by networks in Saudi Arabia, UAE, and Bahrain.

Looking at the RIPE Atlas data in a different way, Figure 9 illustrates just how traffic from networks in the Arab region is routed. It is clear that significant traffic flows are going through Marseilles, Paris, Frankfurt, London and Amsterdam - no surprise, as the biggest Internet Exchange Points in the world are located in these cities.

It is also clear that IXPs have not yet reached their full potential in the Arab region, and there are several reasons behind this:

- The captive nature of the market in the Middle East can cause some operators to adopt a "lose-lose" strategy and forgo the benefits of peering at an IXP to keep their competition from benefiting as well.

- Some regulations prevent operators from exchanging traffic in neighbouring countries.
- Pressure from former monopoly incumbents that prefer to see the rest of the local and regional market as customers and not as peers.
- Overpricing the last mile and interconnects to the point that exchanging traffic in other regions is much cheaper than doing so locally.

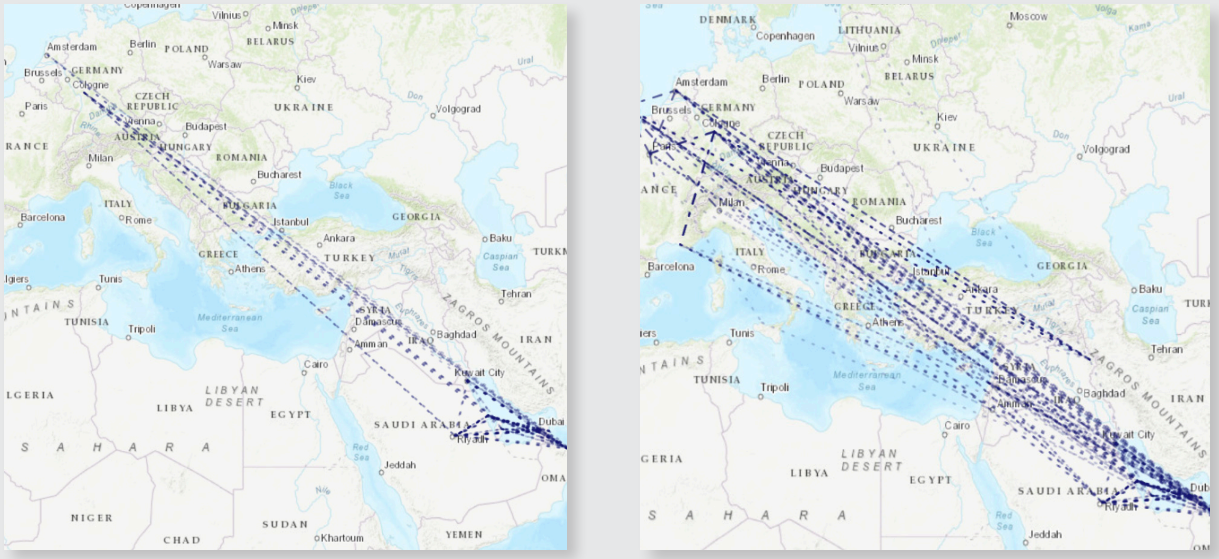


Figure 9: IPv4 traffic patterns for the Arab region (left) and the GCC more specifically (right). The data indicates that traffic passing between end points in these countries does not always remain local, but instead passes through IXPs and networks in several other countries.

Taken together, these points have weakened the role of IXPs in the region, leading them to focus more on serving international content to local networks than on improving routing to keep traffic domestic.

Despite the fact that there are several decisions and declarations on keeping traffic regional (e.g. the League of Arab States and GCC have both weighed in on this issue), we still see Arab traffic making its way to Europe.

The good news is that, based on the data that we can see and illustrated in Figure 10, IPv6 traffic is far more likely to stay within the region. However, the fact that there are far fewer networks running IPv6, and fewer still running it to their end users (where we could use RIPE Atlas to measure the connection) means that this is a rough conclusion based on relatively small amounts of data.

Figure 10: IPv6 traffic patterns for the GCC.

Overall, the data indicates a need for increased efforts:

- More routing optimisation for IPv4 is still needed throughout the region.
- More IPv6 routes are needed in the region (either through peering or transit relationships).
- Internet Exchange Points (IXPs) can play a huge role, but this can only be achieved if all stakeholders see this as a mutually beneficial project and enter into it with a "win-win" mentality. IXPs mandated and established through legislation and regulation often fail to realise their potential because participants are simply trying to comply with the bare minimum regulatory requirements.

The RIPE NCC is keen to deploy more RIPE Atlas probes and anchors to act as measurement points within the region so that we can provide a more comprehensive picture of what's happening, what's working well and what could be improved. In Bahrain, for example, the government included RIPE Atlas in their national Internet Quality of Service project, which has allowed us to provide fuller reporting on the state of routing and peering than for any other country in the region.

The View From K-Root

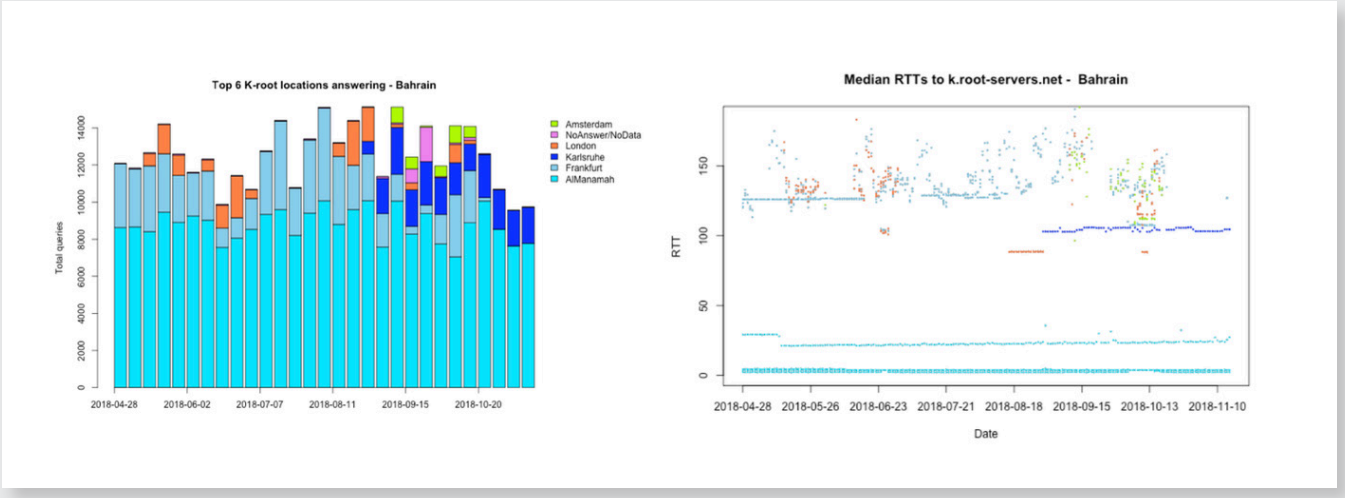
Apart from IP address space, another major element in the broader Internet landscape is the Domain Name System (DNS), and at the heart of the DNS is the root server system. The RIPE NCC operates K-root, one of the 13 Internet root name servers. The K-root service consists of a distributed set of servers that use IPv4 and IPv6 anycast: these servers announce the same IP prefixes from multiple locations around the world, allowing ISPs to choose which of the routes available is best suited for their needs.

There are four K-root servers located in GCC countries: two in Kuwait City, one in Manama and one in Doha (there is also a server in Beirut, as well as instances in Europe, North and South America, Asia and Australia). There is a significant distribution of other root name instances in the region as well - the only country currently without a single instance is Syria.

Although the average Internet user doesn't end up querying a root name server very often (this information is cached further down in the DNS hierarchical structure), being able to query a server that is closer (in terms of network topology and geographical distance) ensures better resiliency and can improve response time.

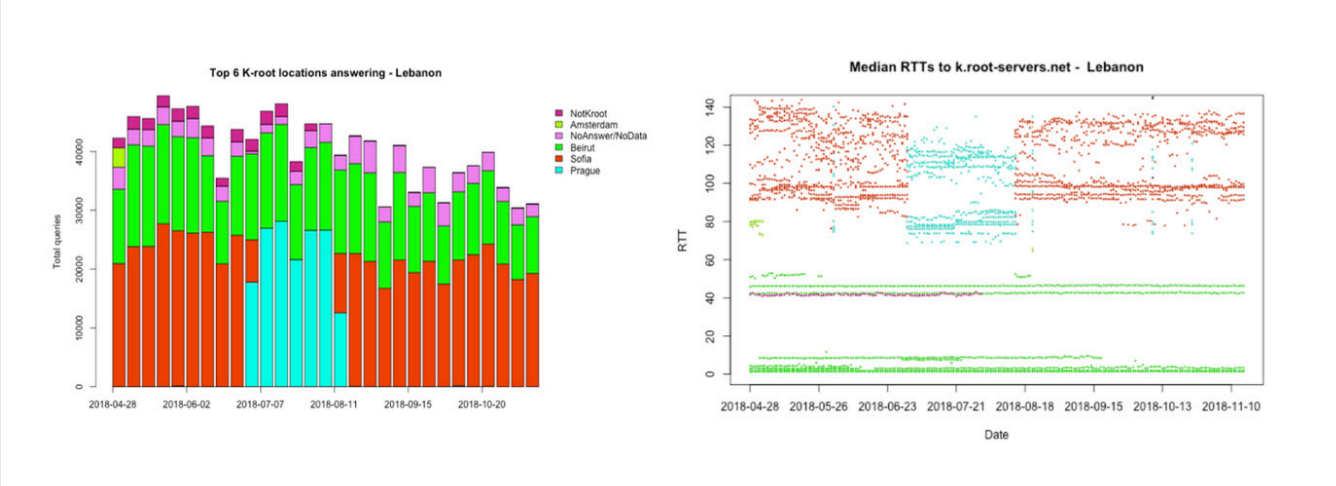
We use K-root reachability and response times to measure whether hosting this critical infrastructure in the region increases its efficiency and whether operators in the region prefer to use local K-root servers or those hosted in other regions. In the figures below we look at results for IPv4 queries from measurement points in a number of Arab countries for the past seven months. The results of these tests are subject to the number of measurement points within the country and their distribution among different networks, which may or may not host a K-root server.

Bahrain



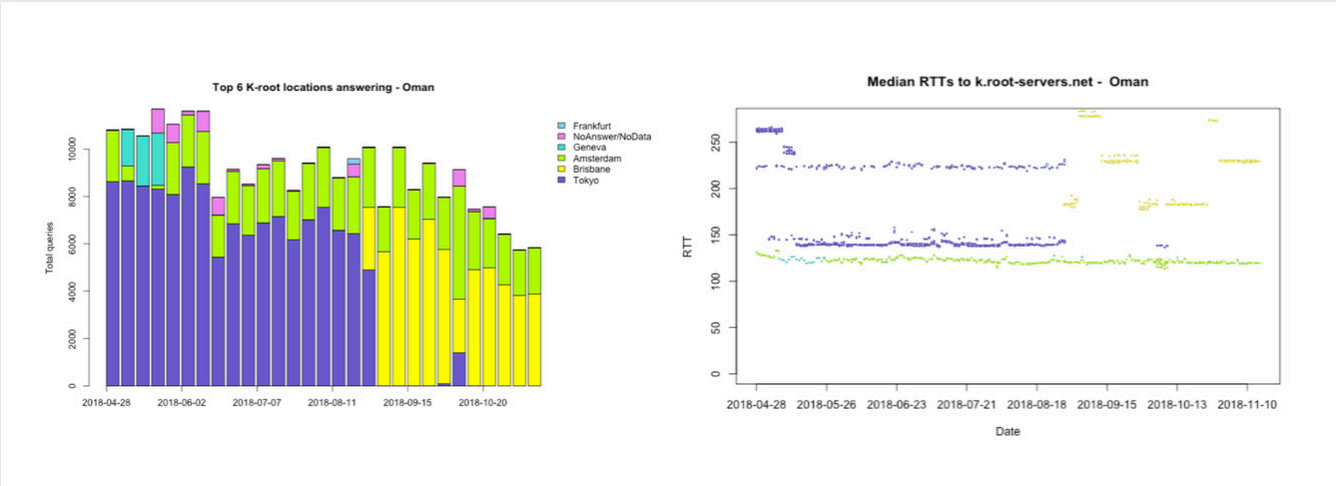
We can see that most Bahraini operators prefer the local server, as expected. Unfortunately, we still see that some prefer servers in Germany and the United Kingdom. The difference in round-trip time (RTT) is highly significant, suggesting that those with higher RTTs would get their responses from one of the 12 other root name servers (rather than a K-root server). Better peering and interconnection within the country could improve this situation.

Lebanon



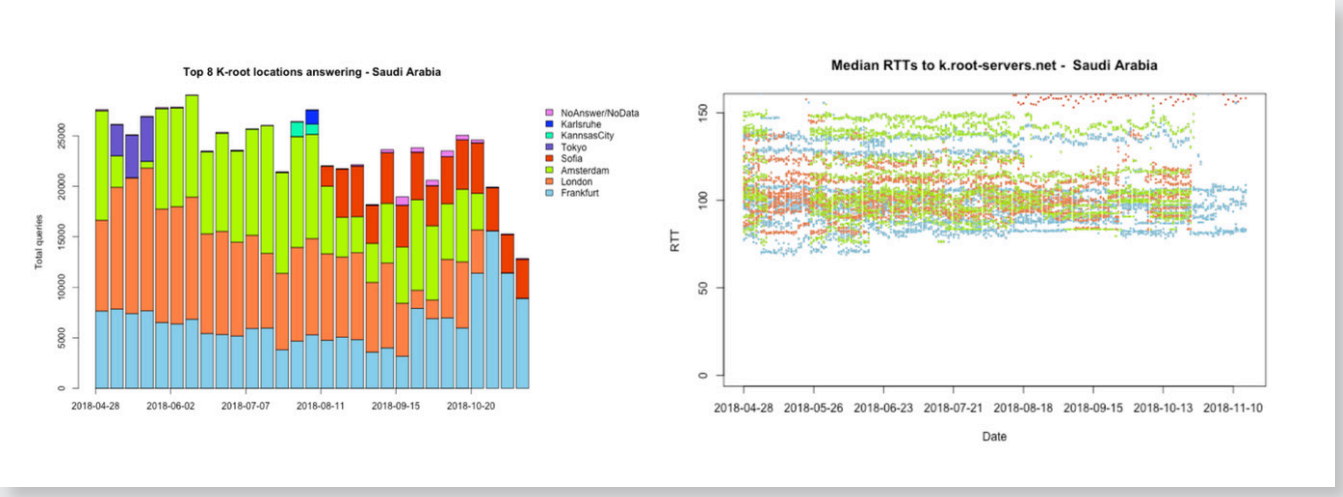
In Lebanon, which also hosts a K-root server, we see that servers in Bulgaria and the Czech Republic are both preferred over the local server. In this case, despite the existence of an IXP in the country, it is clear that operators are not sharing routes, as some experience response times of a few milliseconds while other experience more than 100ms.

Oman



Oman is a very interesting case, as it assumes that Japan and Australia are closer than Qatar, Bahrain and Kuwait. By looking at the RTTs, it is highly unlikely that K-root is used much by networks in Oman.

Saudi Arabia



Finally, in Saudi Arabia, we also see a preference for instances that are out of the GCC and Arab regions, resulting in high RTTs; however, as this analysis is based on K-root statistics, it is necessarily incomplete. There are other root name servers in the region that may give different results (for example, L-root, which is operated by ICANN, has a significant number of servers in the region, including at least three in Saudi Arabia). It is highly probable that Saudi Arabia is served from those servers more than K-root. We plan to extend the scope of these DNS measurements in the future to provide a more complete picture of all root name servers.

From the data above, however, we can infer the following:

- There is an opportunity to improve interconnectivity, both within countries and across the region, through more and better routing and better-connected IXPs. If the region's ISPs peer with one another and exchange routes, the chances of the routing protocol preferring a more local K-root server become much higher.

- There is an opportunity to install more K-root servers in the region, which would enhance resiliency and could improve response times. You can learn more about hosting a K-root server and peering with K-root here: https://www.ripe.net/analyse/dns/k-root

Conclusions

Based on the different data we've collected about the current Internet landscape in Saudi Arabia and its surrounding region, we can draw the following conclusions:

- The Internet in Saudi Arabia is going through a period of growth and diversification – we see growth both in the number of LIRs being established and in the number of IPv4 addresses registered to Saudi LIRs in the RIPE Database.
- While Saudi Arabia is currently the world's largest importer of IPv4 addresses via transfers, it has also shown that there is a clear strategy to use these IPv4 addresses to help with their IPv6 adoption.
- While there have been significant efforts to prepare the Saudi Internet community for IPv6 adoption, IPv6 networks have not significantly contributed to Internet growth in the country to date. This is due to the fact that IPv6 connectivity has not yet reached end users, with the exception of Saudi Telecom Company (STC) customers.
- Current routing and traffic management practices are hindering the efficient operation of networks in many countries throughout the region. Root server preferences, local peering and a focus on local traffic routing may be effective levers in gaining additional efficiency and saving on operational costs.

While these conclusions remain quite high level, they point toward various opportunities for active improvement via cooperative efforts on the part of operators and the public sector.

The launch of the Saudi Internet Exchange Point will contribute to improved traffic routing in the country, and a community focus on peering and transit in the Middle East Network Operators Group (MENOG) will also help achieve this goal.

The RIPE NCC is working with stakeholders from the Saudi public and private sectors to provide technical training to network operators in order to support the region's technical development.

The RIPE NCC can also contribute by providing data and making tools available to local users that can provide region-specific information about resources and operations, providing a real-time picture of Internet connectivity. Increasing the number of RIPE Atlas probes in Saudi Arabia and other GCC countries would greatly strengthen the data that is available to operators and the public sector.

About the RIPE NCC

The RIPE NCC serves as the Regional Internet Registry for Europe, the Middle East and parts of Central Asia. As such, we allocate and register blocks of Internet number resources to Internet service providers (ISPs) and other organisations.

The RIPE NCC is a not-for-profit organisation that works to support the open RIPE community and the development of the Internet in general.

Although based in Amsterdam, the RIPE NCC has staff based across our service region and an office in Dubai to better understand and serve the needs of members and other stakeholders in this part of our service region.

Data Sources

The information presented in this report and the analysis provided is drawn from several key resources:

RIPE Registry

This is the record of all Internet number resources (IP addresses and AS Numbers) and resource holders that the RIPE NCC has registered. The public-facing record of this information is contained in the RIPE Database, which can be accessed from www.ripe.net.

RIPE Atlas

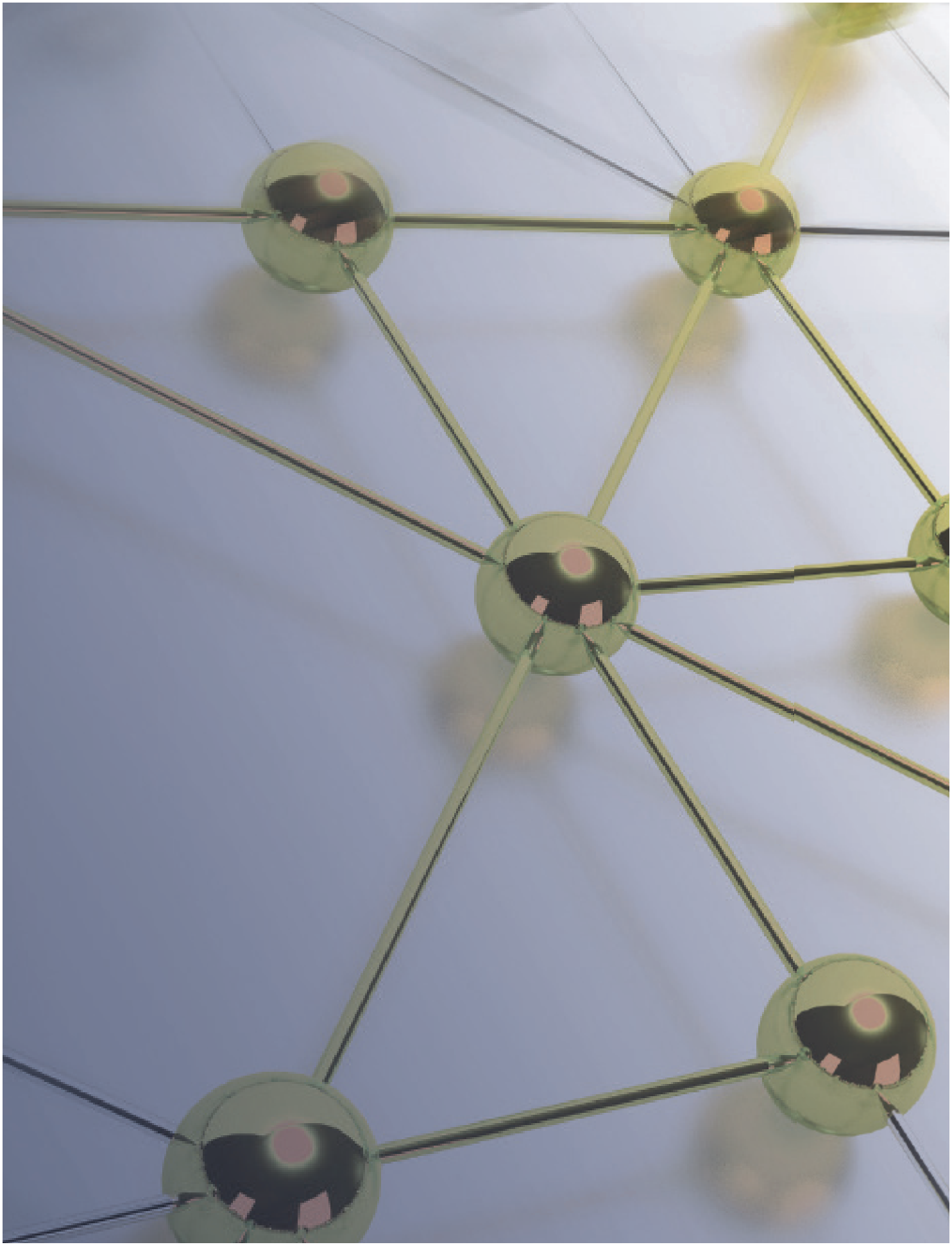
RIPE Atlas is the RIPE NCC's main Internet data collection system. It is a global network of hardware devices, called probes and anchors, that actively measure Internet connectivity. Volunteers around the world connect these devices to their home networks or data centres. Anyone can access this data via Internet traffic maps, streaming data visualisations, and an API. RIPE Atlas users can also perform customised measurements to gain valuable information about their own networks.

Routing Information Service (RIS)

The Routing Information Service (RIS) collects and stores Internet routing data from locations around the globe. It was established in 2001. More information is available at:
https://www.ripe.net/ris

The data obtained through RIPE Atlas and the Routing Information Service is the foundation for many of the tools that we offer, and the RIPE NCC is very interested in getting more RIPE Atlas probes connected in the Arab region and finding a network operator willing to host a RIS collector.

For more information on how you can contribute or be a part of this important work, see:
https://atlas.ripe.net/get-involved/



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