RIPE NCC
RIPE NETWORK COORDINATION CENTRE

RIPE NCC

Internet Country Report: Cyprus, Israel and Malta

December 2021

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Introduction

The Internet is a global network of networks, yet every country's relationship to it is different. As a follow-up to our last country report that covered five of the larger countries in Mediterranean Europe, this report provides an outlook on the current state of the Internet in three smaller countries across the Mediterranean region that contend with similar issues around connectivity: Cyprus[1], Israel and Malta. We offer an analysis of these countries' market landscapes and their state of development, examine Internet routing, take a close look at their access to the global domain name system, and investigate their connections to the global Internet. This analysis is based on what we can observe from the RIPE NCC's measurement tools as well as a few external data sources.

By focusing the spotlight on these three countries in the RIPE NCC's service region, we can present a comprehensive analysis of their Internet development and potential for future growth in order to inform discussion, provide technical insight, and facilitate the exchange of information and best practices regarding Internet-related developments in this part of the world. This is the eighth such country report that the RIPE NCC has produced as part of an ongoing effort to support Internet development throughout our service region by making our data and insights available to decision makers, local technical communities and policymakers.

Highlights

- The Internet landscapes in all three countries continue to evolve, with increasing numbers of networks coming online and new investments planned for the near future
- All three countries have high levels of Internet penetration and a large amount of IPv4 per capita
- While Israel is in line with the overall world average when it comes to IPv6 deployment, Cyprus and Malta show virtually none despite holding a significant amount of IPv6 address space, and further IPv6 deployment is still needed to accommodate future growth in all three countries
- There is a good amount of interconnection and resiliency in the way networks connect with one another within each country
- The three countries have a diverse number of routes connecting them to the rest of the global Internet but are highly dependent on submarine cables for their connectivity

1 *The information in this report relates mainly to the Greek Cypriot area*

The Market and Opportunity for Growth in Cyprus, Israel and Malta

The Market Landscape

With populations of 1.2 million (Cyprus), 9.2 million (Israel) and 525,000 (Malta),[2] the countries included in this report are relatively small compared to many of their neighbours – although Israel is, by both population and area, much larger than the other two. Given this, in addition to their geographical locations, all three are heavily dependent on connections with the rest of the global Internet and ensuring that they have sufficient redundancy built into their interconnection landscapes, especially as two of the three countries are islands and, as such, are more prone to potential bottlenecks and single points of failure.

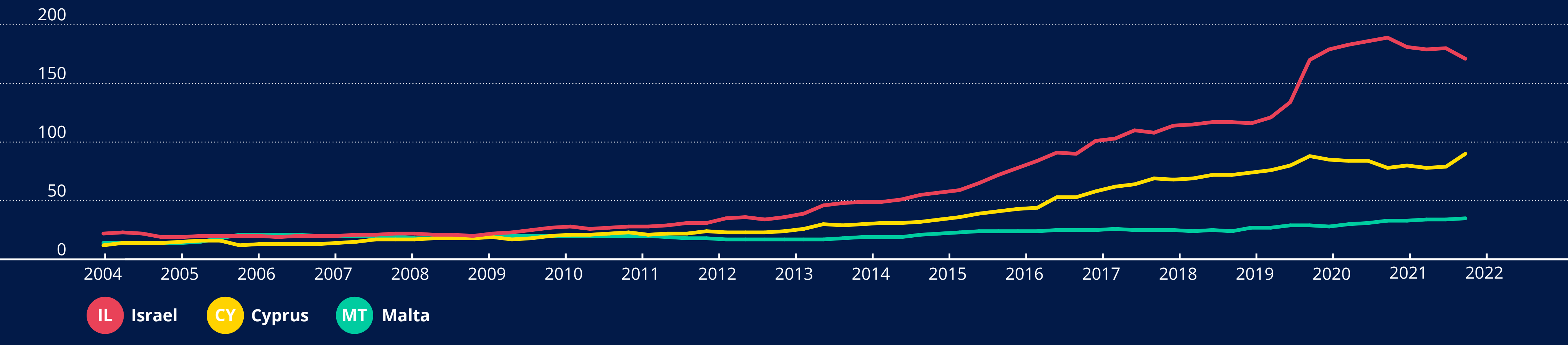
Cyprus ranks 24th out of the 28 countries included in the EU's 2020 Digital Society and Economy Index (DESI), which takes into account factors including connectivity, digital skills, e-government and more, and ranks 27th in terms of connectivity.[3] However, it scores well in fast broadband coverage, fixed broadband penetration and mobile penetration; its low score compared to the rest of Europe is based largely on fixed very high capacity network coverage and its relatively expensive fixed broadband prices. Cablenet is the only operator that offers cable broadband, but its majority owner, GO, has invested in its fixed and mobile networks in recent years. The incumbent telco, Cyta, also announced a 10-year investment in FTTP (fibre-to-the-premise) in 2018.[4] The country's financial crisis almost certainly played a role in Cyprus' relatively slow growth in the digital sphere over a number of years, but it is now making strides once again in its Internet development. There are a total of ten submarine cables connecting Cyprus to Europe, the Middle East and northern Africa.

Israel's Internet regulator historically kept connectivity and infrastructure as two separate services, with Bezeq (the incumbent) and HOT providing both infrastructure and connectivity. Other leading Internet providers include IBC and Partner Communications. As of 2018, Bezeq and HOT had a 95% share of the market.[5] In September 2021, Israel's Ministry of Communications approved an agreement between Bezeq and the country's Internet service providers that will integrate connectivity with the infrastructure and open up the market to further competition beginning in March 2022.[6] Like the island nations included in this report, Israel is highly dependent on its submarine cable connection with the global Internet, with four submarine cables connecting it to Italy, Greece and Cyprus.

Malta ranks 5th overall of all EU countries in the EU's 2020 Digital Society and Economy Index (DESI), and ranks 10th in connectivity.[7] Monaco Telecom is a major player in both Cyprus and Malta, where it operates under the Epic brand, and also took over Vodafone Malta in 2020.[8] Another major player in Malta, GO, evolved out of the state-owned incumbent Telemalta. It already owns two of the island's six submarine cables that link it with Sicily and recently launched a third, which will connect it directly to mainland Europe (at Marseille) and northern Africa (in Egypt).[9] Melita is the last of the big players in Malta, which also owns a cable link to Sicily (as does Epic). Malta has seen significant investment in its connectivity, with Melita providing 1Gb/s broadband service nationally, GO investing €100 million in fibre infrastructure, and the government offering support for a FTTP network.[10]

2 *World Bank*
3 *https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=66909*
4 *https://www.businesswire.com/news/home/20190605005753/en/Cyprus-Fixed-Broadband-Market-Statistics-and-Analyses-Report---ResearchAndMarkets.com*
5 *https://www.timesofisrael.com/slowed-down-nation-how-netanyahus-alleged-bezeq-graft-stalled-israeli-internet/*
6 *https://en.globes.co.il/en/article-israeli-isp-infrastructure-split-to-end-march-2022-1001384939*
7 *https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=66923*
8 *https://blog.telegeography.com/monaco-telecom-the-small-telco-making-its-mark*
9 *https://whoswho.mt/en/watch-go-launches-third-submarine-cable-becoming-first-operator-with-links-to-france-and-egypt*
10 *https://www.budde.com.au/Research/Malta-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses*

Figure 1:
Number of Local Internet Registries over time



Number of Providers and Other Organisations Running Their Own Networks

As the Regional Internet Registry for Europe, the Middle East and parts of Central Asia, the RIPE NCC can track the development of the local Internet over time through growth in the number of RIPE NCC members and Local Internet Registries (LIRs).

As seen in figure 1, there was little growth in the number of LIRs in any of the three countries until about ten years ago, after which point we see the numbers in both Cyprus and, to an even greater extent, Israel increase quite rapidly. This is almost certainly an effect of the change in RIPE policy that occurred after reaching the last /8 of IPv4 address space in 2012, after which time smaller organisations no longer received IPv4 from a sponsoring LIR but instead had to either become an LIR themselves, or turn to the secondary market. Although growth in Malta was much less pronounced, both Malta and Cyprus have three to four times more LIRs per capita than Israel.

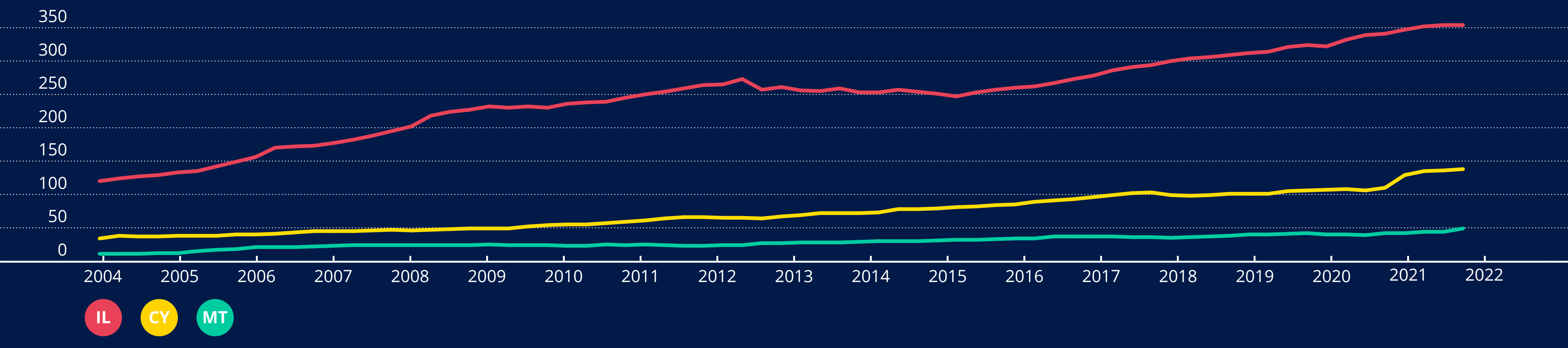
In the past year, the number of LIRs in Israel dropped by 10%, from 190 to 171 between 1 Oct 2020 and 1 Oct 2021. While 12 new LIRs opened in that period, 31 others closed. However, 21 of those that closed belonged to members holding more than one LIR account each, and the number of members in Israel actually increased by two over this 12-month period. In general, a higher number of LIRs often signals a more diversified market, with a larger number of service providers operating their own networks; however, this is not always the case.

RIPE NCC Members and Local Internet Registries (LIRs)

RIPE NCC members include Internet service providers, content hosting providers, government agencies, academic institutions and other organisations that run their own networks in the RIPE NCC's service region of Europe, the Middle East and Central Asia. The RIPE NCC distributes Internet address space to these members, who may further assign IP addresses to their own end users. It is possible for members to open more than one account, called a Local Internet Registry (LIR).

For a long time, the majority of RIPE NCC members were large Internet service and access providers. More recently,

Figure 2:
Number of networks over time



however, we've seen a significant increase in other types of organisations requiring IP addresses to run their own networks, including hosting providers, government agencies, universities, businesses, etc. As a result, an increase in the number of LIRs doesn't necessarily translate into an increase in the number of Internet access providers. However, it has allowed more organisations to exert more control over their Internet address resources and the ways in which they route their traffic.

In addition, it's possible for the same organisation to hold several LIR accounts. This practice became a significant trend after 2012, when the amount of IPv4 address space being allocated was restricted as the remaining IPv4 address pool became smaller and smaller (as explained in more detail in the IPv4 section below). Indeed, we see some evidence of this in the three countries in this report: as of October, there were 77 RIPE NCC members in Cyprus holding a total of 90 LIR accounts, 34 members in Malta holding 35 LIR accounts, and 147 members in Israel holding 171 LIR accounts.

Network Growth and Diversity

In general, a larger number of Local Internet Registries corresponds to a larger number of independently operated networks called Autonomous Systems, each of which is represented by an Autonomous System Number, or ASN. (An Autonomous System is a group of IP networks that are run according to a single, clearly defined routing policy. There are currently about 70,000 active ASNs on the Internet today.)

The number of networks in a given country is one indication of market maturity. The greater the diversification, the more opportunity that exists for interconnection among networks, which increases resiliency.

The RIPE NCC is responsible for the allocation of ASNs in its region. This provides us with unique insight into the distribution and deployment of these networks across the Internet. Again we see Israel dominating here, but on a population basis, Malta and Cyprus have two to three times as many networks per capita. Israel shows a period of stagnation from about 2012 to 2015 followed by rapid growth. Looking at relative percentages, however, Cyprus and Malta both experienced a slightly higher rate of growth throughout the time period shown. Generally, the growth and diversity we see here is a good indication of a more mature and competitive market with a good level of choice among larger and smaller service providers.

Figure 3:
IPv4 holdings

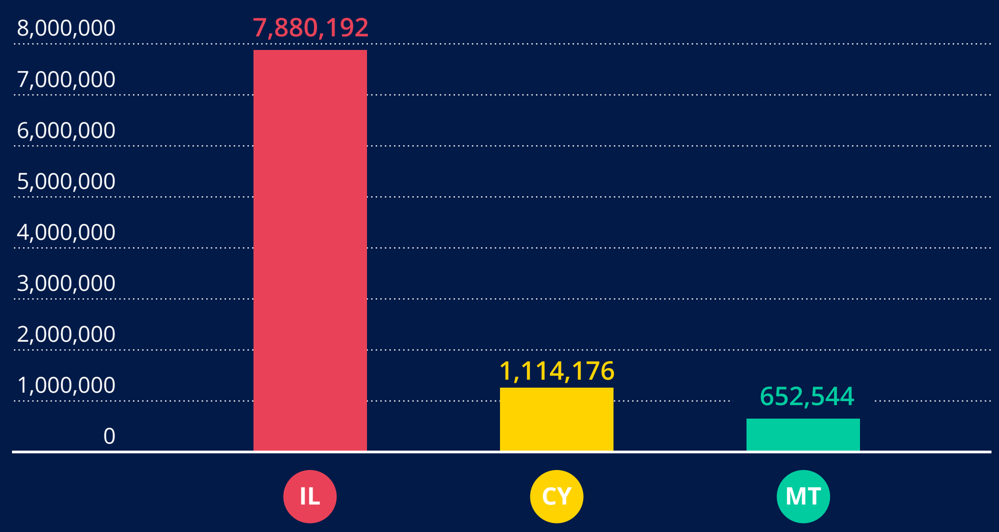
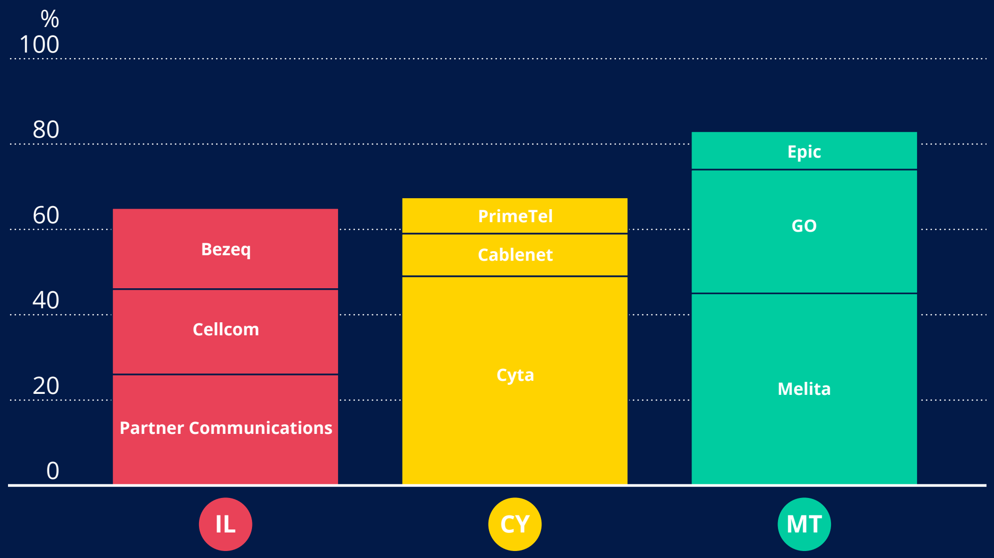


Figure 4:
IPv4 holdings by organisation



IPv4 in Cyprus, Israel and Malta

Until 2012, RIPE NCC members could receive larger amounts of IPv4 address space based on demonstrated need. When the RIPE NCC reached the last /8 of IPv4 address space in 2012, the RIPE community instituted a policy allowing new LIRs to receive a small allocation of IPv4 (1,024 addresses) in order to help them make the transition to IPv6, the next generation protocol that includes enough IP addresses for the foreseeable future. In November 2019, the RIPE NCC made the last of these allocations and a system now exists whereby organisations that have never received IPv4 from the RIPE NCC can receive an even smaller allocation (256 addresses), if available, from a pool of recovered address space (as occasionally member accounts are closed and address space is returned to the RIPE NCC).

Indeed, none of the three countries included in this report continued to accrue any significant amount of IPv4 address space after 2012. Up until that time, we saw steady growth in the amount of IPv4 allocated in Israel, with moderate growth in Cyprus that increased in the two years before the 2012 policy change, and much less growth in Malta throughout.

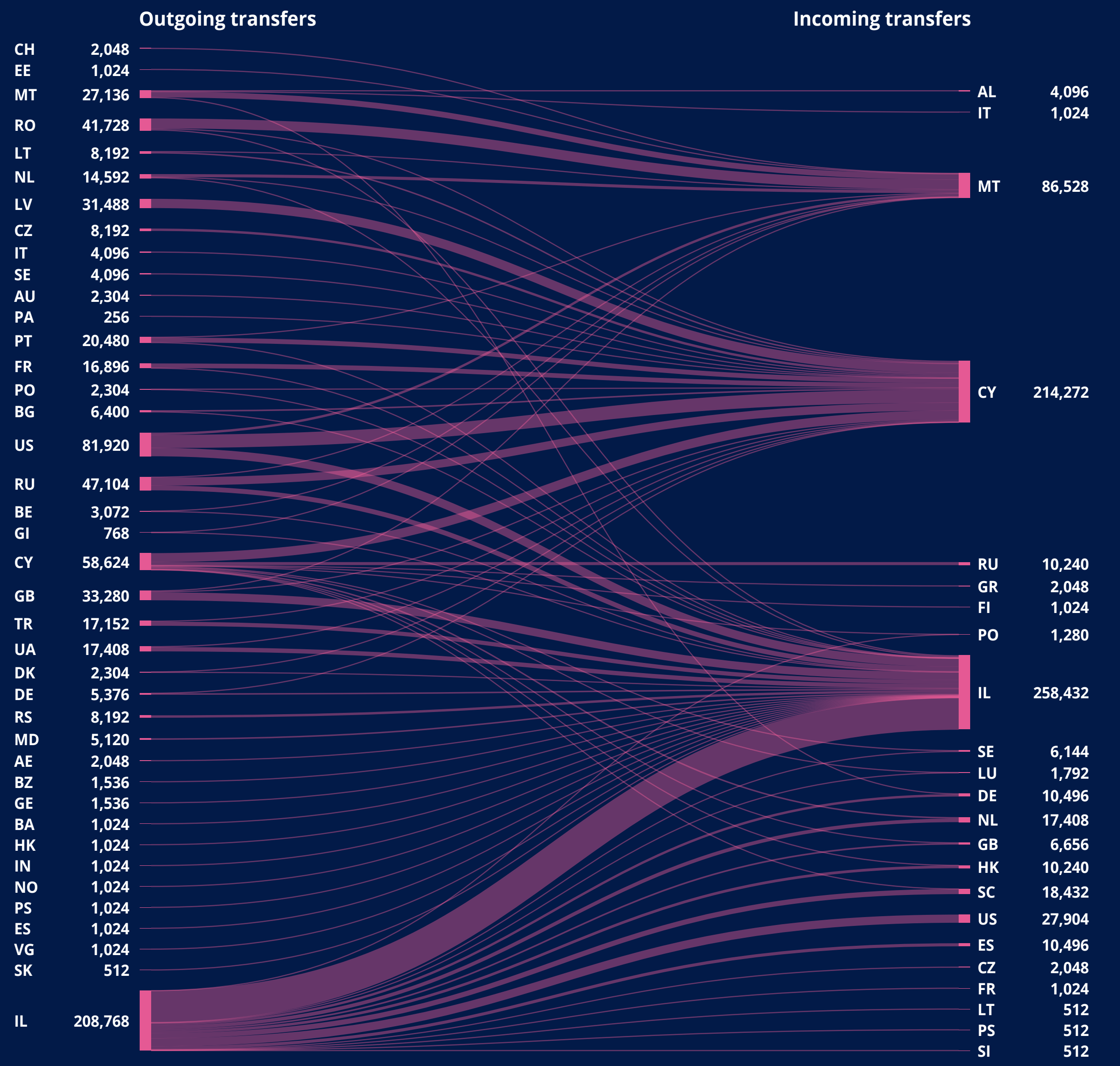
We also see more market consolidation in Cyprus and Malta than we do in Israel. In the former two, nearly half of the total IPv4 space in the country is held by a single entity. Figure 4 shows the organisations with the three largest amounts of IPv4 in each country.

IPv4 Secondary Market

To fill the demand for more IPv4 address space, a secondary market has arisen in recent years, with IPv4 being bought and sold between different organisations. The RIPE NCC plays no role in these financial transactions, ensuring only that the RIPE Database – the record of which address space has been registered to which RIPE NCC members – remains as accurate as possible.

As demand for IPv4 continues despite the dwindling pool of available space, many providers and other organisations have turned to the secondary market. Figure 5 shows the IPv4 transfers that have taken place within, into and out of each country in the region since the market became active.

Figure 5:
IPv4 transfers within, into and out of Cyprus, Israel and Malta between May 2013 and October 2021



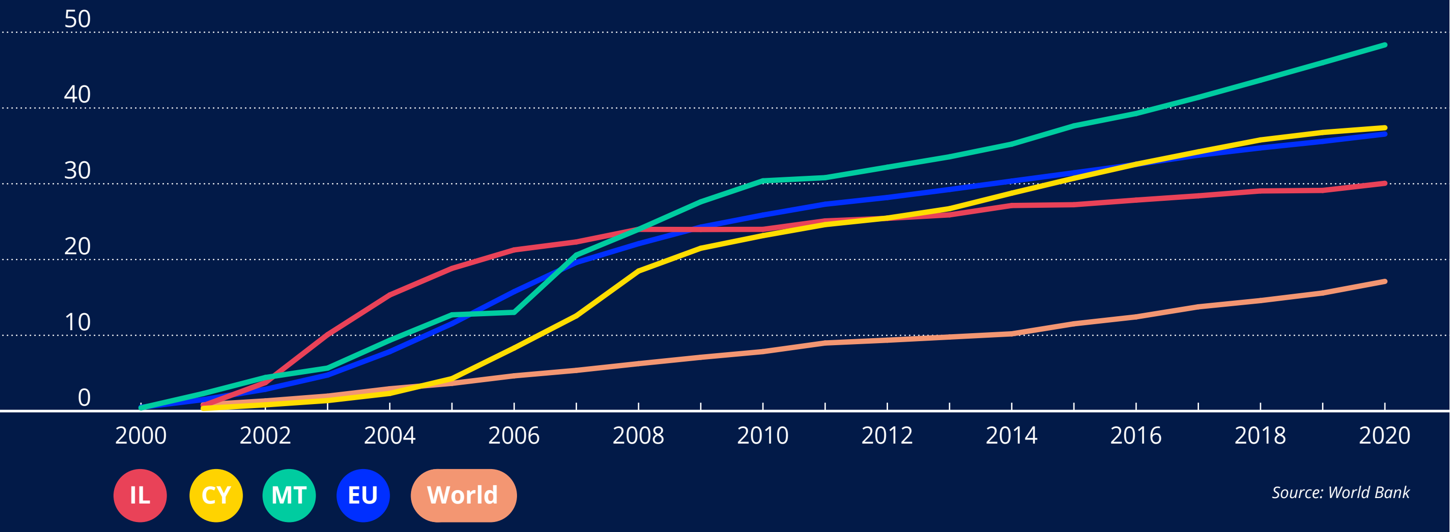
In terms of absolute numbers, we see a relatively small amount of IPv4 address space being transferred into and out of the three countries in this report, which isn't surprising given their smaller sizes. (Note that there are substantial numbers of domestic transfers, in which addresses are transferred between two parties in the same country.) However, in relative terms, both Cyprus and Malta have imported a sizable amount, corresponding to 16% and 10% of their total current IPv4 holdings, respectively.

Cyprus has obtained a significant portion of its imported IPv4 space from Latvia, the US and Russia. Israel's biggest contributors have been the UK, US and Russia, while Malta has imported more IPv4 from Romania than any other foreign country. The five biggest recipient organisations across all three countries, and the number of addresses they each received, include:

- Cellcom (Israel): 81,920
- LVNET (Cyprus): 67,328
- Cablenet (Cyprus): 54,272
- IPPN Holdings (Israel): 36,096
- Vodafone Malta[11]: 32,768

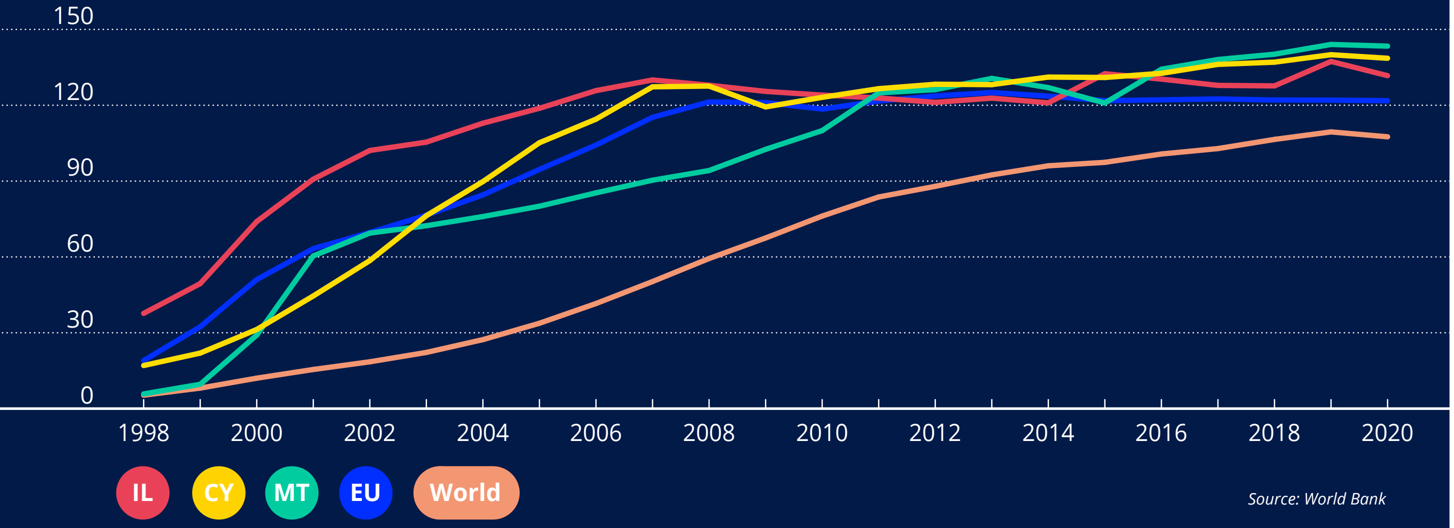
11 *Vodafone Malta subsequently rebranded to Epic*

Figure 6:
Fixed broadband subscriptions per 100 people over time



Source: World Bank

Figure 7:
Mobile subscriptions per 100 people over time



Source: World Bank

Internet Penetration and Potential for Future Growth

The three countries all have relatively high amounts of IPv4 for their populations compared to other countries in the RIPE NCC service region. In Cyprus, there are 0.92 IPv4 addresses per capita and 0.85 in Israel, while in Malta, we see the rare case of there being more addresses than inhabitants, at 1.24 addresses per person. This is generally a sign of early Internet development compared to many other parts of the world.

Given this, we would expect to see high rates of Internet penetration and use in these countries. Indeed, we see evidence of this in figures 6 and 7. (Note that fixed broadband connections are generally shared among several people in the same household, and the percentages we see in figure 6 will therefore never approach 100%.)

In terms of broadband subscription rates, we see percentages in line with much of southern Europe and well above the world average, with Malta leading the three. This isn't surprising, given Malta's small area and dense population, making it relatively easy to extend connectivity infrastructure across the island to a very high percentage of households. In 2019, an agreement between GO and Vodafone Malta also allowed Vodafone to compete in the fixed broadband market, opening up the market to further competition and reduced prices for end users.[12] According to a European Commission study from 2019 on broadband coverage in Europe, Cyprus and Malta were the only two EU countries to report 100% next generation access (NGA) coverage.[13]

When it comes to mobile subscriptions, all three are closely aligned and well above the world average. All three have also plateaued for quite some time, perhaps indicating market saturation that took place early on, which we've also

12 https://www.globenewswire.com/news-release/2020/02/14/1985252/0/en/Malta-s-Melita-Providing-Gigabit-Broadband-Service-Nationally.html
13 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=70030

Figure 8:
IPv6 holdings

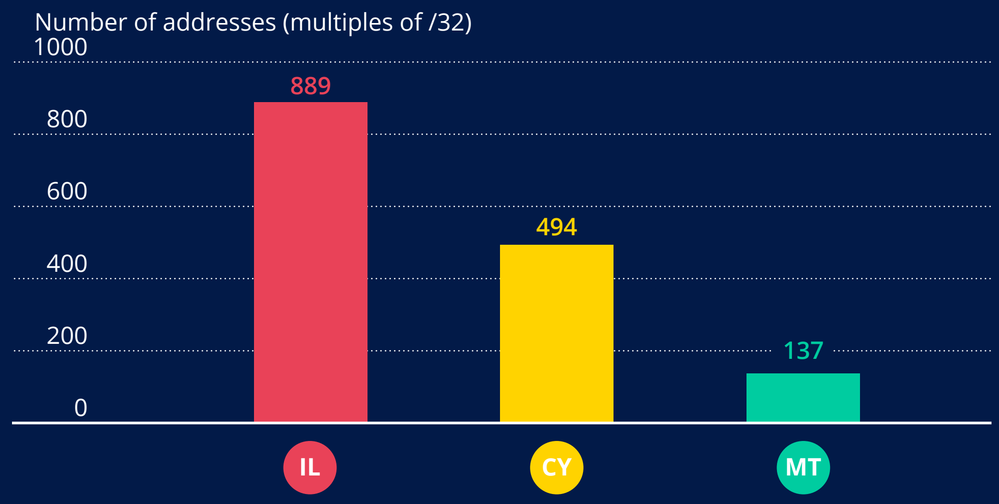
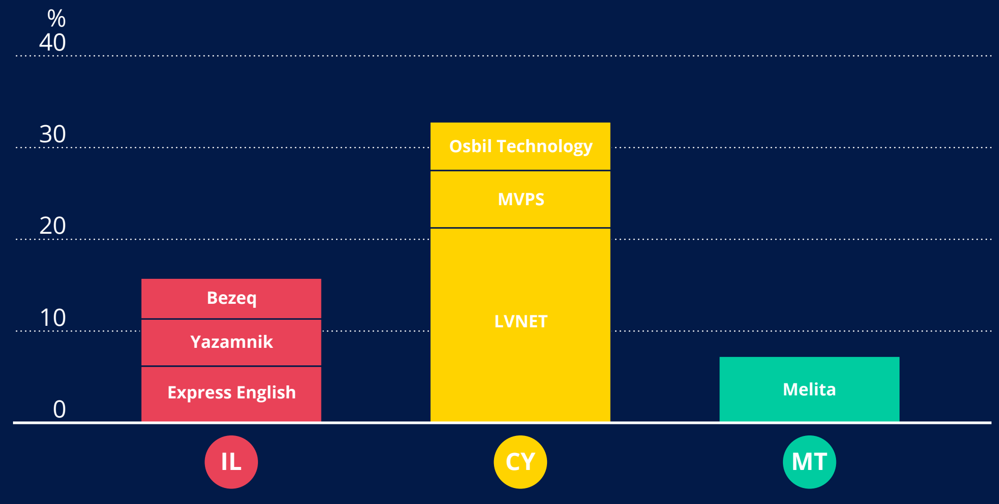


Figure 9:
IPv6 holdings by organisation



seen in other countries within Europe and the Middle East. According to one source, Israel offers the least expensive mobile data plans in the entire world.[14] However, despite Cyprus (at number 213 out of 230 countries surveyed) and Malta (at number 108) being significantly more expensive, we see very comparable mobile subscription rates in all three countries.

Although all three countries have large amounts of IPv4 address space to serve their populations, the high rates of mobile subscriptions mean that mobile operators in particular are likely relying on address-sharing techniques to serve their growing numbers of customers. Technical workarounds that allow multiple users to share a single IP address, such as carrier-grade network address translation (CGN), are in widespread use in mobile broadband connectivity. However, there are well-documented drawbacks to address-sharing technologies, and deploying IPv6 remains the only sustainable strategy for accommodating future growth – not to mention supporting emerging technologies such as 5G, the Internet of Things, smart cities and more.

IPv6 in Cyprus, Israel and Malta

Usually, we see the amount of IPv6 in a country roughly correspond to (though not equal) its IPv4; however, we see a significant deviation here, with Cyprus holding much more IPv6 space in comparison to its IPv4 holdings. Unlike IPv4, IPv6 addresses are widely available (although large allocations are based on demonstrated need), so hoarding tends not to play as much of a role in the amount of IPv6 space that organisations hold – although we have started to see this happening more recently in some cases. In Cyprus, Israel and Malta, we don't currently see widespread evidence of IPv6 hoarding.

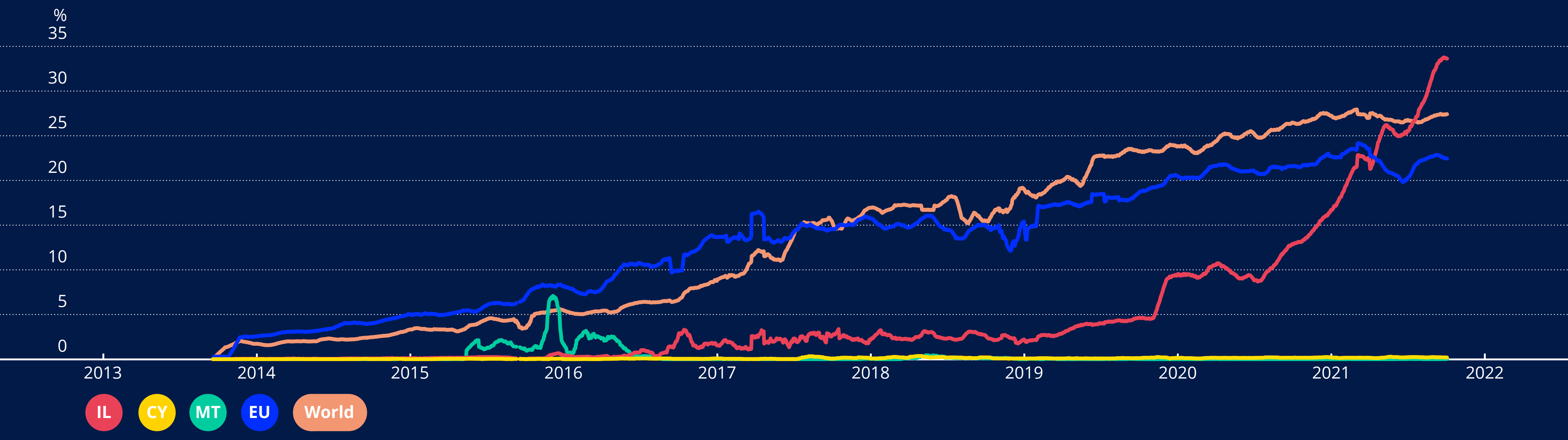
In all three countries, the first IPv6 addresses were allocated to universities at around the same point in time: in 2003 to the Israel InterUniversity Computation Center and in 2004 to the University of Cyprus and the University of Malta. IPv6 holdings in Israel show a net decrease in the last three months of our data collection as a result of a transfer of 14 /29 allocations (equivalent to 112 /32s) made by Israeli LIRs that were closing, to a single LIR registered in the Seychelles but with a postal address in Israel. It's therefore possible that these resources are still being used in Israel.

We see even less market consolidation when it comes to IPv6 than we did with IPv4. Figure 9 shows the organisations with the largest IPv6 holdings in each country (note that we only show the single organisation with the largest holding in Malta, as every other top ten organisation in the country holds an equal amount of space).

Interestingly, LVNET, the organisation holding the most IPv6 space in Cyprus (and the fourth-largest amount of IPv4

14 https://www.cable.co.uk/mobiles/worldwide-data-pricing/

Figure 10:
IPv6 deployment over time



in the country), has a street address in Latvia but is legally based in Cyprus. All but 1,024 of its 68,352 IPv4 addresses were obtained via a total of 64 transfers from LIRs based in Latvia, Russia and France.

It's worth noting that just because organisations hold large amounts of IPv6 address space does not mean they have actually deployed IPv6 and that the addresses are in use. Some networks might hold a large amount of address space without using it (possibly having presented plans for future growth when requesting large allocations), while others might be able to serve their entire customer base with a relatively small allocation.

Despite the IPv6 address space held by Cyprus and Malta, we see only 0-0.2% IPv6 deployment in these two countries, while Israel, at 30-37%, is in line with the world average of 28-37%.[15] Israel's IPv6 capability has risen steadily over the past two years as a result of the country's Ministry of Communications requiring Internet service providers to support IPv6, as announced in July 2019.[16] According to APNIC's measurements, Israel's IPv6 capability increased from 4.8% in November 2020 to 34.4% in October 2021. All major Internet service providers contributed to this, albeit at different times and rates. (Note that we do not have any information about the temporary spike that APNIC measured in Malta's IPv6 capability from 2015-2016, as seen in figure 10.)

Governments, regulators, Internet exchange points (IXPs) and local network operator groups (NOGs) all have a role to play in IPv6 deployment. As seen in Israel, these factors can contribute significantly to a country's overall Internet development and the ability to transition to the next generation protocol.

15 Note that exact figures differ between organisations, which use different measurement methodologies. Sources: APNIC: https://stats.labs.apnic.net/ipv6
Facebook: https://www.facebook.com/ipv6
Google: https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption
16 https://www.gov.il/en/departments/news/02012020_1

Domestic and International Connectivity

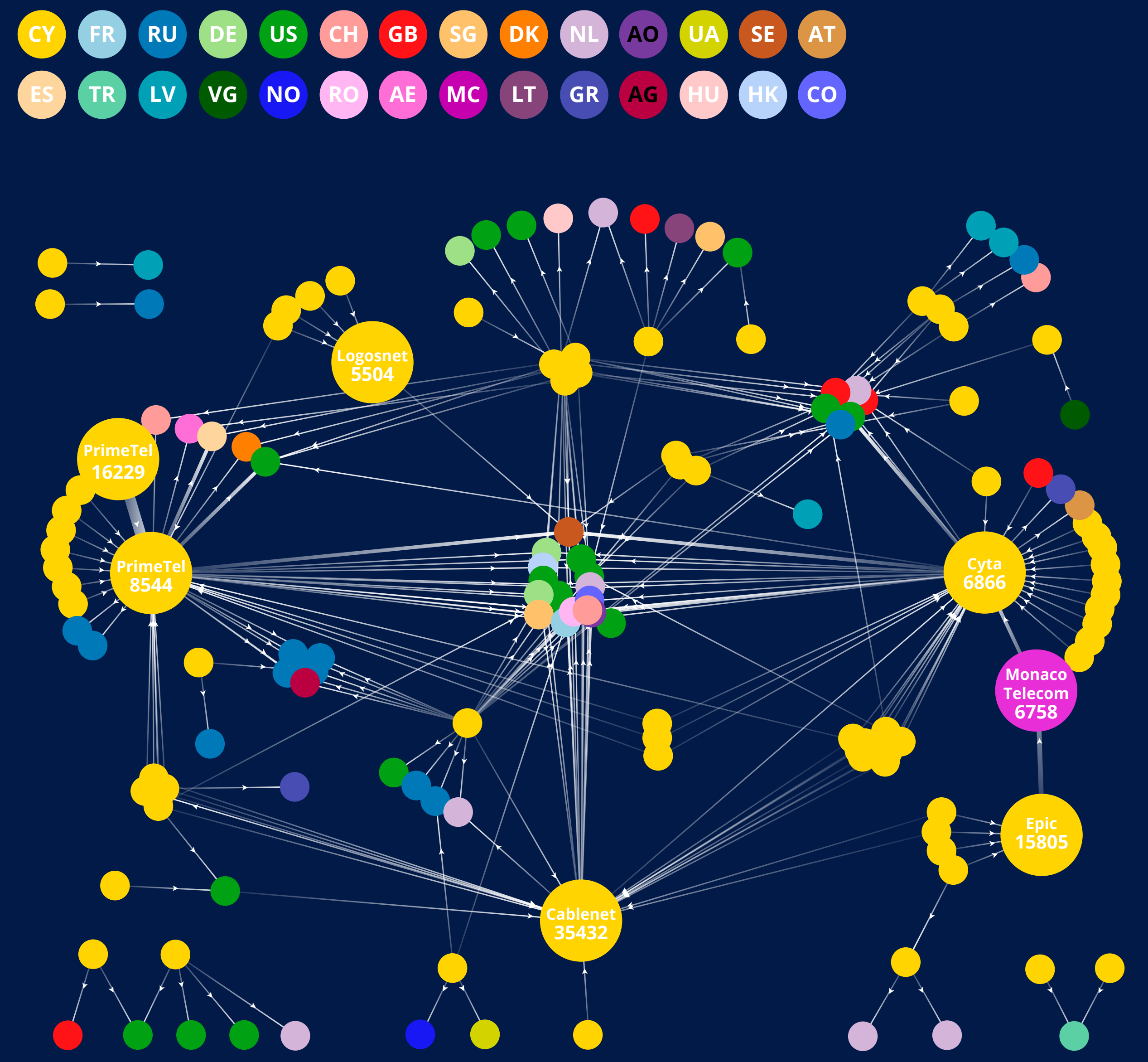
Domestic Connectivity Between Networks

To understand the relationships that exist between different networks, we can investigate the interconnections within each of the countries using data from the RIPE NCC's Routing Information Service (RIS), which employs a globally distributed set of route collectors to collect and store Internet routing data. This shows us the available paths that exist between networks (as opposed to actual paths taken).

For each country, we plot how the routes propagate from one network to another (arrows indicate the direction of BGP flow, which is opposite to traffic flow) up to the point where the path reaches a foreign network. For each path, we discard the first few hops that detail how routes propagate through international networks; our focus is on routing inside each country and the connections to the outside world. The nodes in each figure are colour-coded according to the country in which the network (ASN) is registered, and the width of the lines is determined by the number of paths in which we see the connection between the different ASNs. Note that we only label the ASNs that we specifically mention in the text and have made them larger to make them easier to identify, but the size doesn't correspond to the size of the network in any way. Also, the position of the different networks doesn't correspond to any kind of geographical layout; instead, these figures are merely a visual representation of the interconnections between the networks in each country.

Due to the nature of Border Gateway Protocol (BGP) and RIS route collection processes, our view is limited to the routes followed by international traffic. We will only observe peering relationships between two service providers in a country when one or both partners announce the other's routes to a third party that further propagates the route. Most notably, we will not see peerings at regional IXPs, where the intention is to keep local traffic within the country or region. Nevertheless, graphing the connections that we can detect provides valuable insight into domestic connectivity.

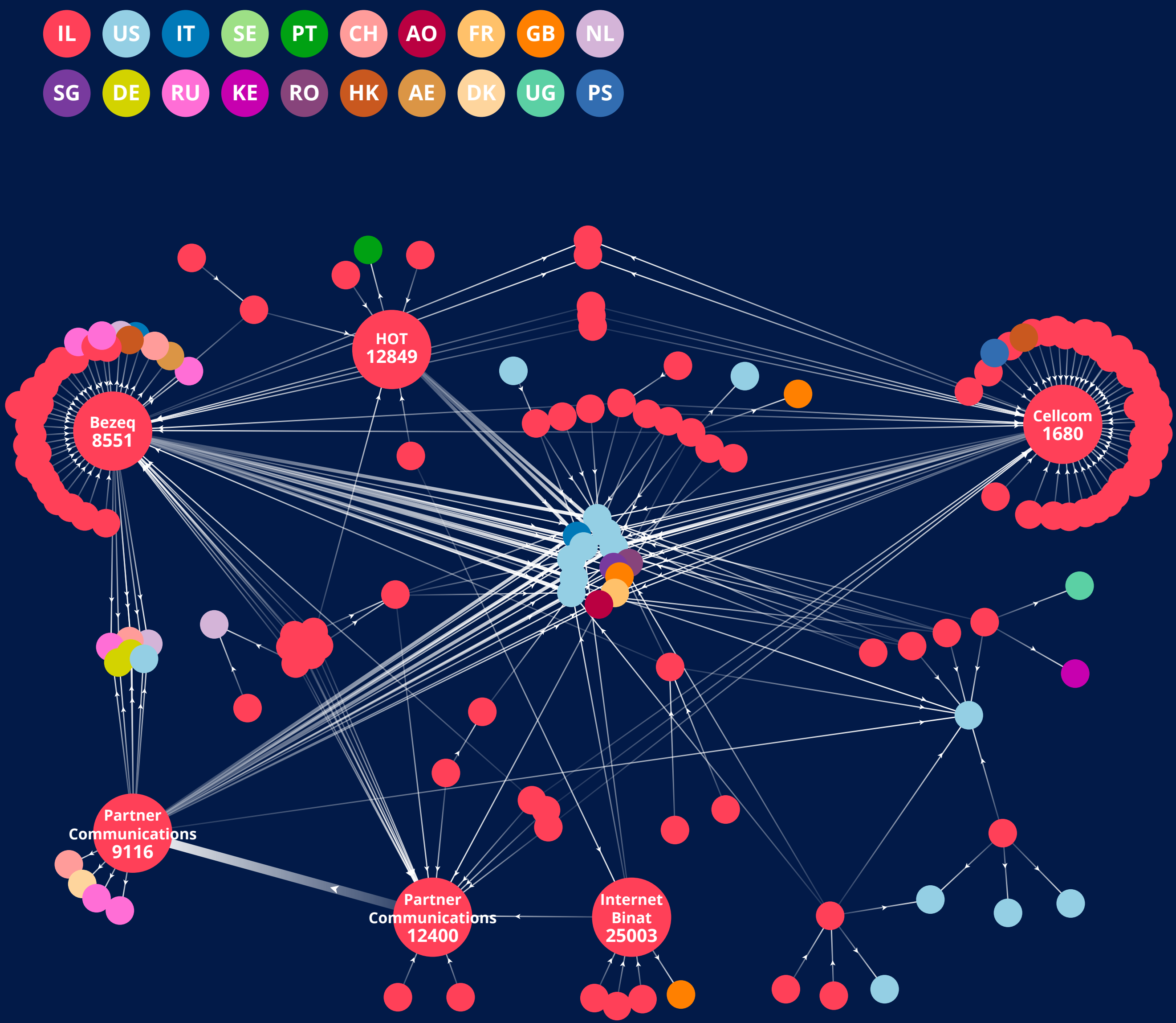
Figure 11:
Connectivity between networks in Cyprus



In Cyprus, we see the important role that PrimeTel (AS8544) and Cyta (AS6866) play in providing connectivity to the country. Many networks connect to one of these two providers, both of which have a wealth of international connections thanks to their presence at major IXPs. PrimeTel also has a second network (AS16229) that connects a substantial number of networks and relies fully on the main PrimeTel network (AS8544) for its connectivity. We also see how a significant number of the networks that connect to PrimeTel or Cyta have a second connection to Cablenet (AS35432), a third provider with a variety of international connections.

Most of the networks that don't connect to either PrimeTel, Cyta or Cablenet have arranged for their own international connectivity, and some employ multihoming to increase redundancy. Logosnet (AS5504) and Epic (AS15805) also provide connectivity to other networks in Cyprus, but in much smaller numbers compared to the top three. Interestingly, Epic's only upstream provider, its parent company, Monaco Telecom (AS6758), is seen to rely in turn on Cyta for its connectivity. This is not the full picture, however; Monaco Telecom also has connections to other major international transit providers, which are out of scope in this diagram, as the focus here is on organisations based in the country. Still, it is uncommon to see a "foreign" network in the path between two of the larger networks within a country.

Figure 12:
Connectivity between networks in Israel

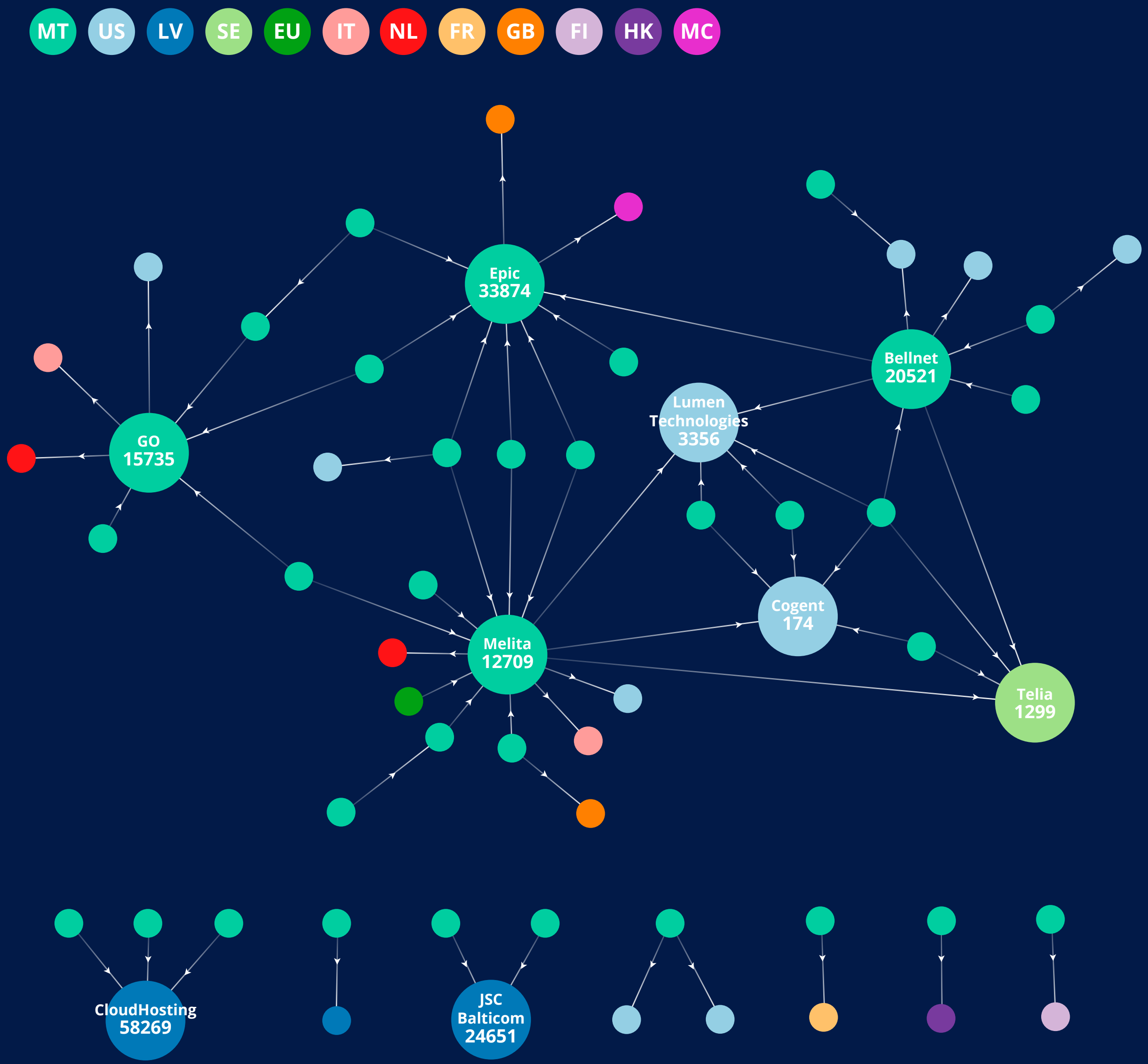


Because Israel has more than 200 networks that appear in the routing tables, we had to restrict figure 12 to the 250 most frequently observed segments in the BGP paths. Although this omits the less prominent connections, the overall structure for the country remains the same, and we can clearly see a very hierarchical structure appear with very clearly defined clusters. Most networks in Israel are connected via Bezeq (AS8551), Cellcom (AS1680) or Partner Communications (AS12400). Many are single-homed to one of these providers, but we also see a significant number of networks that connect to two of the three.

The figure also shows how Bezeq, Cellcom and Partner Communications have many international peering partners and transit providers in common. Partner Communications in fact operates with two networks; the first (AS12400) connects all the domestic networks, while the second (AS9116) has only international connections and is the sole upstream provider for AS12400.

HOT (AS12849) and Internet Binat (AS25003) are seen connecting domestic networks as well, but in far smaller numbers and with less diversity in their international connectivity.

Figure 13:
Connectivity between networks in Malta



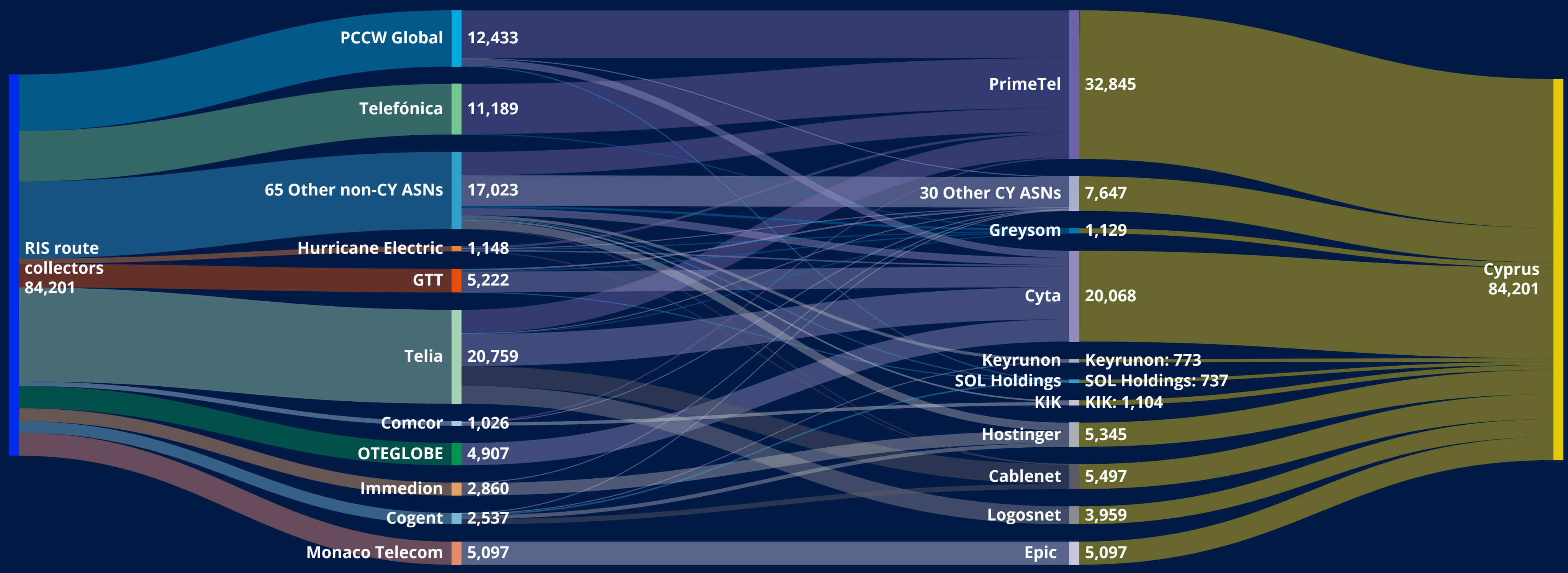
In Malta, GO (AS15735), Epic (AS33874), Bellnet (AS20521) and Melita (AS12709) play an important role in connecting other networks to the rest of the Internet, and some organisations are multihomed to two of these providers. Others connect directly to major US-based transit providers, like Lumen Technologies (AS3356)[17] and Cogent (AS174), either exclusively or in addition to peering with one of the main players in Malta. Telia (AS1299) is also the upstream for four different Maltese networks.

Next to this, we also observe 10 networks without a connection to any of the big four or their transit providers, which is unusual. Five of these are held by the same organisation, MyFatDigital, and connect to two organisations in Latvia: CloudHosting (AS58269) and JSC Balticom (AS24651). It's possible that MyFatDigital, though incorporated in Malta, is in fact operating from Latvia.

A visualisation of domestic Internet connectivity, like we see in these figures, should resemble a deeply interconnected web, with a large distribution of paths and interconnections that lack clear choke points or bottlenecks. Indeed, this is generally what we see in Cyprus, Israel and Malta, where domestic networks tend to be multihomed to more than one of the major providers – although we also see the unusual case of a number of networks in Malta that aren't connected to any other networks within the country.

17 Level 3 was acquired by CenturyLink, now Lumen Technologies

Figure 14:
Cyprus' international connectivity

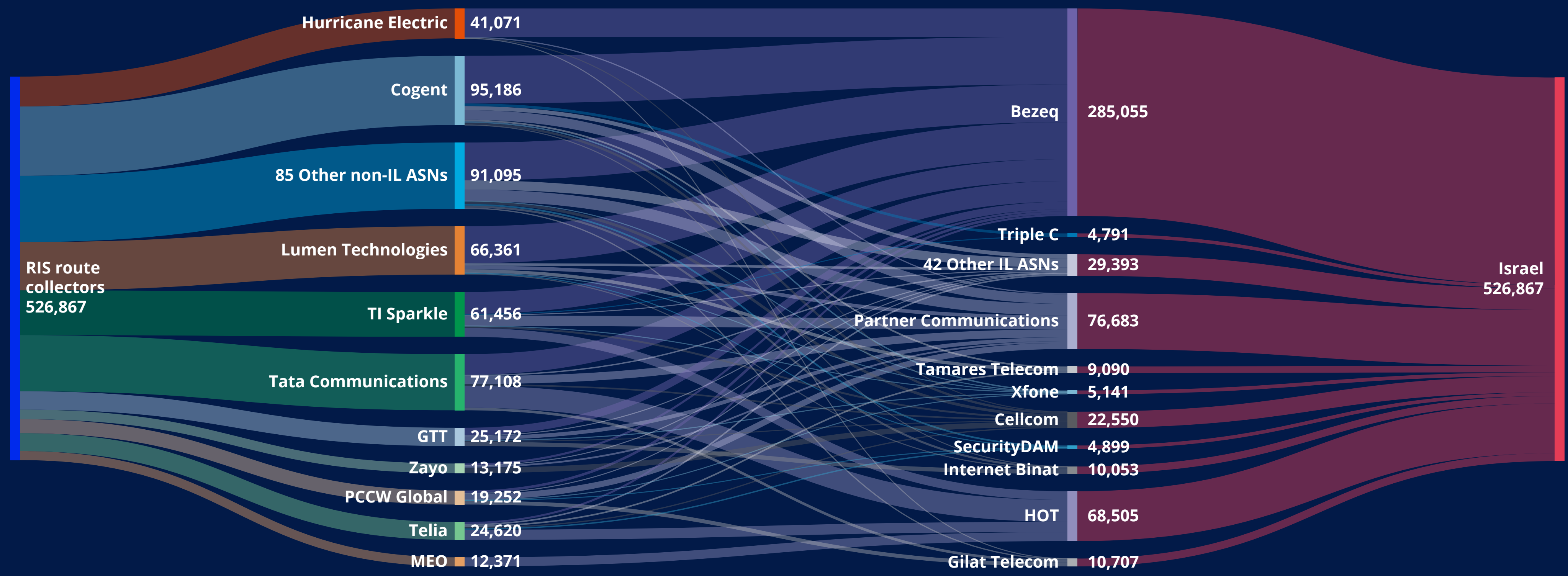


International Connectivity

Extending our view, we now look beyond domestic connectivity to examine how the three countries connect to the rest of the world. To investigate this, we again turn to the RIPE NCC's Routing Information Service (RIS). We look at the routes collected by RIS for IP networks in each country and identify the last foreign and first domestic network encountered in these paths. This gives us an overview of which operators provide international connectivity into each country. The numbers listed in these figures are the number of routes that include each network.

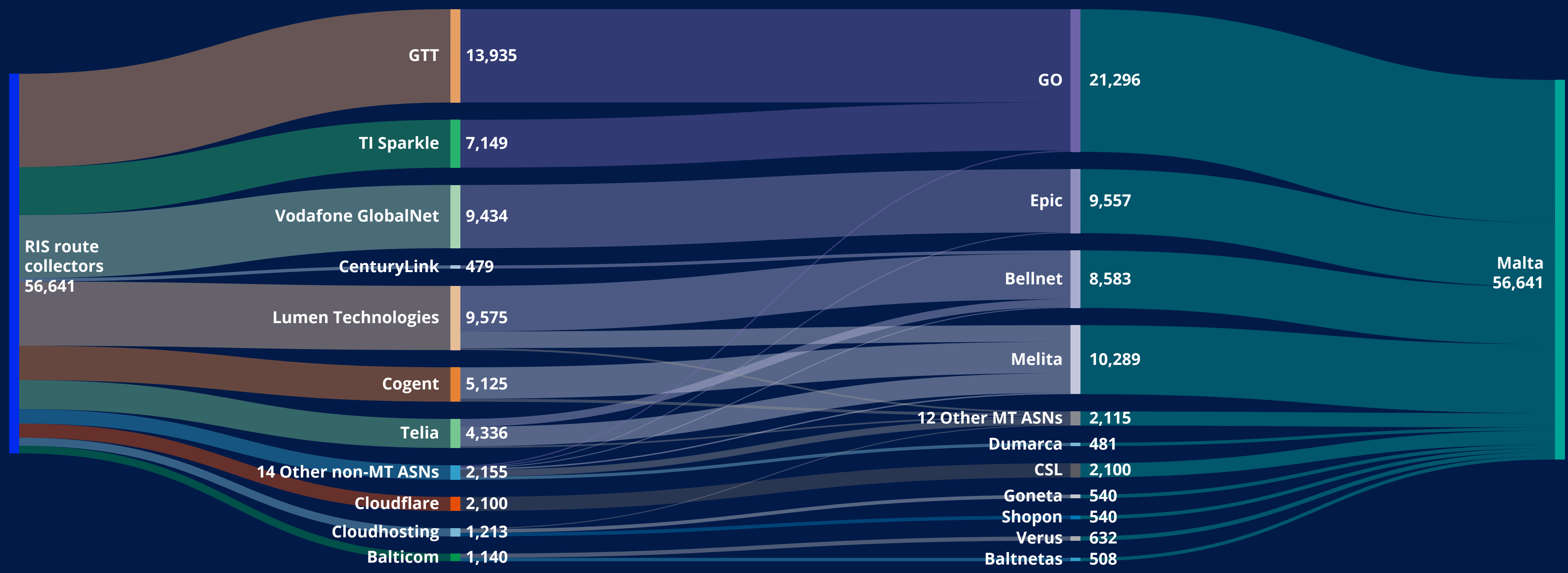
For its international connectivity, Cyprus relies heavily on PrimeTel and Cyta, both of which receive transit from at least three other upstream providers. Cablenet has two upstream providers (Telia and Cogent), while Logosnet fully depends on Telia. Epic is also seen to have a single upstream provider, Monaco Telecom; given that Epic is a subsidiary of Monaco Telecom (in both Cyprus and Malta), this is understandable. It also is quite possible that this part of Monaco Telecom's infrastructure is located on the island of Cyprus, as hauling traffic back across the Mediterranean Sea to Monaco before further distributing it from there would be suboptimal.

Figure 15:
Israel's international connectivity



In Israel, the main entry points are Bezeq, Partner Communications, Cellcom and HOT. All have good diversity in upstream providers, though they mostly rely on the same subset of transit providers. All four use Tata Communications and TI Sparkle, while three use Cogent, Lumen Technologies, Hurricane Electric and GTT, in different permutations. Figure 15 illustrates how we see about half of the paths to IPv4 networks in Israel pass through Bezeq. This is because, compared to Partner Communications and Cellcom, Bezeq breaks up its address space into many smaller prefixes that it announces in BGP, so we measure a higher number of total announcements. However, the total number of IPv4 addresses covered by these announcements is of the same order of magnitude as what Partner Communications and Cellcom each have in the routing table.

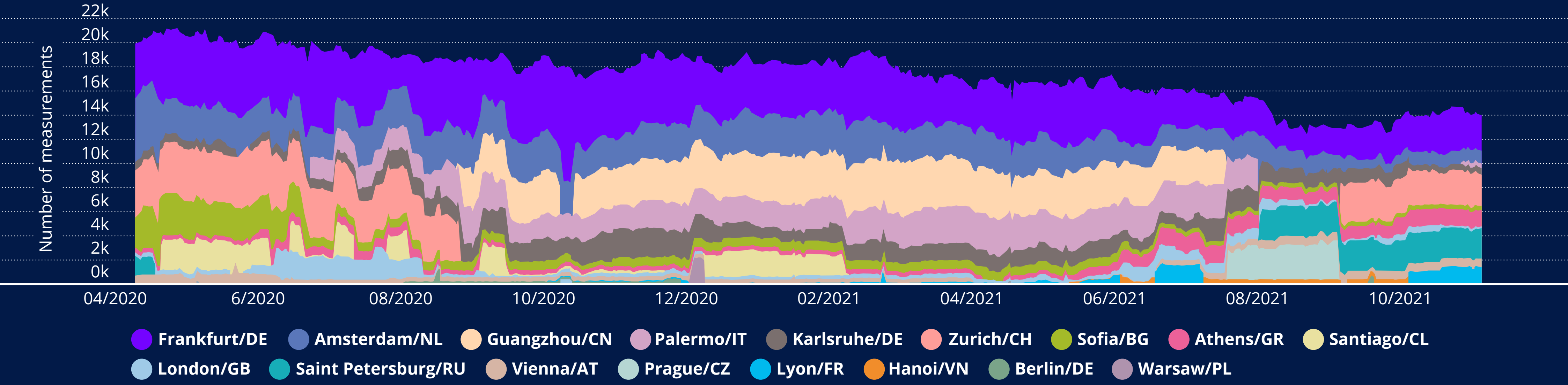
Figure 16:
Malta's international connectivity



In Malta, the main providers are also multihomed, though to a lesser extent than in Cyprus. Whereas Melita has three upstream providers (Lumen Technologies, Cogent and Telia), GO has two main upstream providers (GTT and TI Sparkle), and Epic (formerly Vodafone Malta) almost exclusively relies on Vodafone's global backbone network for transit.

In general, the higher the number of different available paths we see into and out of a country, the better. This is because relying on a small number of dominant domestic providers to provide the vast majority of the connections into and out of a country creates the potential for bottlenecks and single points of failure, negatively impacting that country's Internet stability, regardless of how many upstream connections it has. In the three countries included in this report, and particularly in Cyprus and Israel, the visualisations paint a positive picture. However, while they show BGP resiliency, it's important to keep in mind that, on the IP level, traffic exchange with the major international players may well happen at foreign IXPs – the physical paths to which may be less diverse than BGP peerings, given the countries' reliance on a relatively small number of submarine cable connections.

Figure 17:
K-root locations reached from within Cyprus, Israel and Malta (IPv4)



Domain Name System, Traffic Paths and Routing Security

Reaching the Domain Name System

Turning now to investigate how traffic is routed to, from and within Cyprus, Israel and Malta, we first examine which local instances of K-root are queried from requests originating in the different countries. This gives us some insight into how the routing system considers the various options and decides which networks and locations will provide the best results.

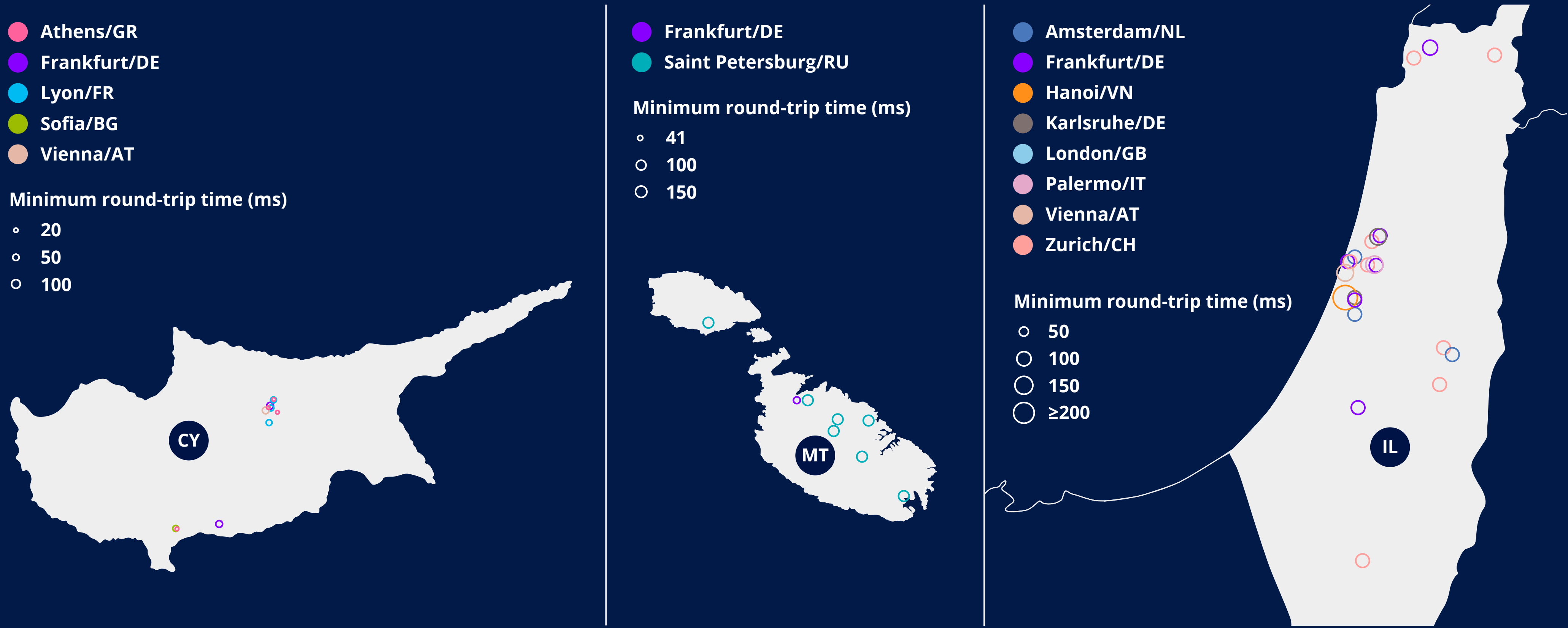
These measurements are based on the RIPE NCC's RIPE Atlas measurement platform, which employs a global network of probes to measure Internet connectivity (see the section on RIPE Atlas at the end of the report for more information about how to get involved).

K-root and DNS

K-root is one of the world's 13 root name servers that form the core of the domain name system (DNS), which translates human-readable URLs (such as https://www.ripe.net) into IP addresses (such as 193.0.6.139). The RIPE NCC operates the K-root name server. A globally distributed constellation of these root name servers consists of local "instances" that are exact replicas. This set-up adds resiliency and results in faster response times for DNS clients and, ultimately, end users.

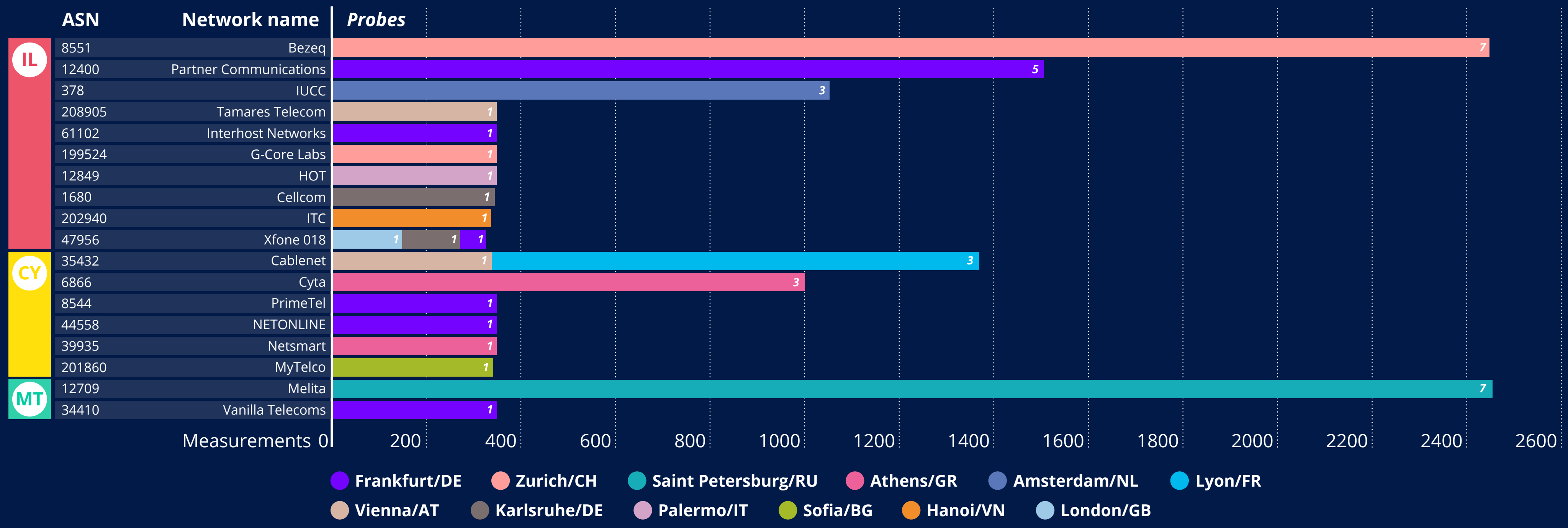
There are no K-root instances hosted in Cyprus, Israel or Malta. As a result, it's not surprising to see these countries reaching instances at some of the major exchange points farther afield in figure 17, including Frankfurt, Amsterdam, Palermo and Zurich. However, the heavy use of a K-root instance in Guangzhou, China for a period between August 2020 and June 2021 is somewhat surprising, as this location is quite distant from both a geographical and topological point of view. This example also demonstrates how dynamic the domain name system is, as this instance was suddenly used and then abruptly dropped off. We also see some other very distant K-root instances being reached, for example in Vietnam and Chile, although these were reached far less often than the instance in China.

Figure 18:
K-root locations reached from vantage points in Cyprus, Malta and Israel



We also looked into which K-root instances were queried by RIPE Atlas probes in the three countries on a given day, as shown in figure 18. From a geographical point of view, most of the chosen locations were not the closest ones. Only on Cyprus do we see a sizable percentage of the probes reaching nearby K-root instances in Athens and Sofia.

Figure 19:
K-root locations reached from different networks in Cyprus, Israel and Malta (IPv4)



We can also investigate which K-root instances were reached by probes in different networks in each of the three countries. Traditionally, the BGP decision-making process would ensure that once a particular path has been identified as being the best option, there is consistency across all the routers that are part of that particular network. Indeed, this is very much what we see in figure 19, where all the probes in almost every network end up querying the same K-root instance. However, there are a couple of prominent cases in which we see networks favouring a K-root instance much farther away than the closest (geographical) option.

In Malta, for example, all seven probes in Melita's network in July 2021 switched from querying the instance in Palermo to Saint Petersburg instead. Unsurprisingly, the round-trip times nearly doubled, from approximately 50ms to 90ms.

In Israel, ITC has been using the even more distant instance in Hanoi, Vietnam since May 2021, a switch from the equally far away instance in Guangzhou, China. With round-trip times between 250ms and 350ms, these are clearly suboptimal choices. Bezeq also reached the instance in Guangzhou from August 2020 to July 2021 before switching to Zurich in the last few months. Although geographical distances to other instances like Athens and Sofia may be even shorter, they could, in fact, result in longer response times depending on the location(s) where Bezeq connects to international transit providers. From a routing perspective, the shortest path from a network in Cyprus, Malta or Israel might well be through an exchange point in Zurich, Frankfurt or Amsterdam. However, making use of local IXPs is generally preferred.

Border Gateway Protocol and Anycast

The K-root name server, like many other DNS servers, uses a technique called anycast whereby each individual instance of K-root is independently connected to the Internet via a local Internet exchange point or any number of upstream networks available at its location. Each instance communicates using the Border Gateway Protocol (BGP), which is designed to select the best path out of all the available options. Initially, the most important criterion here is path length, and the system will choose the path with the lowest number of intermediary networks. However, network operators can override the BGP decision-making process, often for reasons relating to costs or ownership. It is not uncommon for networks to prefer routes that may be longer but are less expensive due to peering arrangements via an Internet exchange point or a parent company.

We should note that these results, while considered generally representative, offer only a snapshot of measurements made on a single day in October 2021. Given BGP's dynamic nature, results can change constantly due to subtle changes in routing.

It's also worth remembering that these results are for K-root only, and every DNS client will make its own decisions about which particular root name server to use. In cases where response times to K-root would be relatively slow, it's likely that clients would opt for faster alternatives among the other root name servers.

To investigate this further, we ran similar measurements for L-root, one of the other root name servers (operated by ICANN). Surprisingly, we found that the situation wasn't very different: most probes still queried an instance that, geographically at least, was a suboptimal choice. However, when combining the data from K-root and L-root, we saw that probes that reached a distant instance for one of the root servers made a better choice for the other.

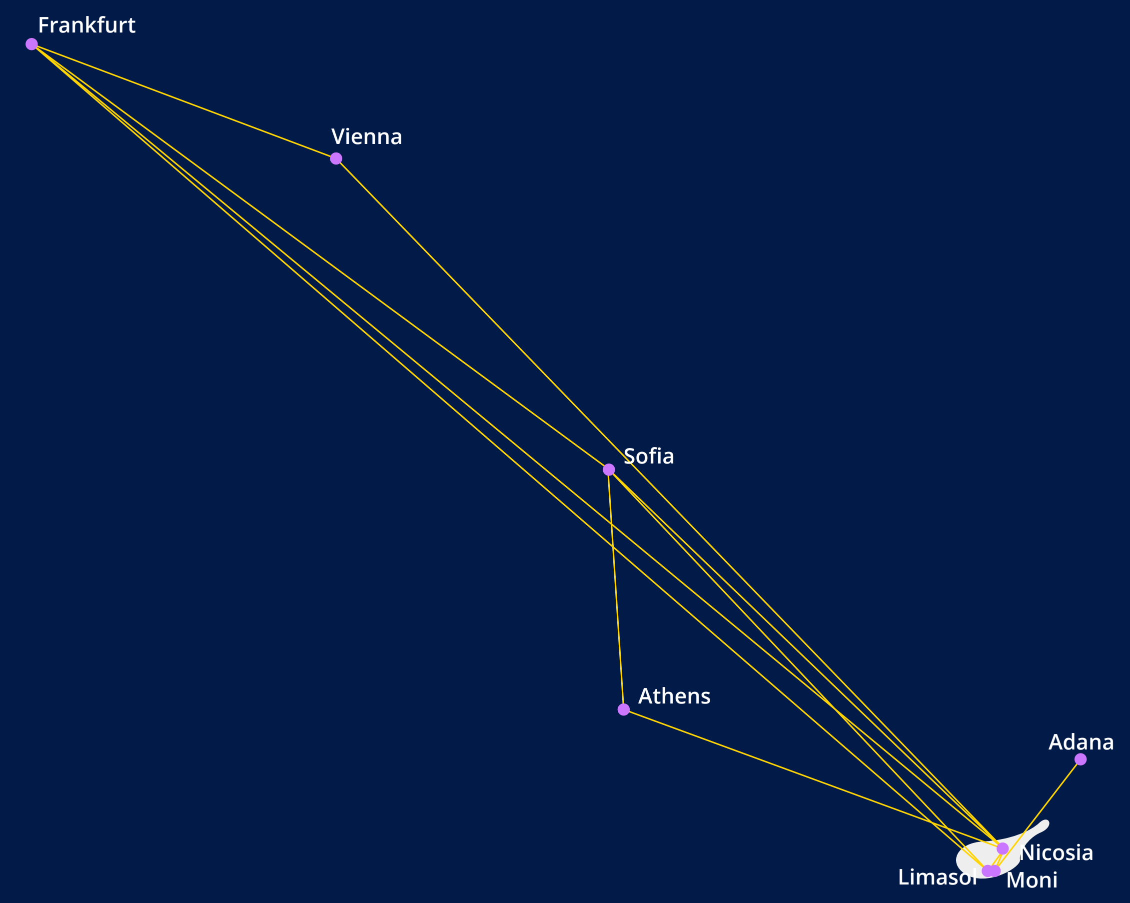
In Malta, for example, where Melita queried the K-root instance in Saint Petersburg, it selected the L-root instance in Latina, Italy, resulting in the shortest round-trip times. In Israel, the InterUniversity Computation Center selected an L-root instance in Uruguay, but reached a K-root instance in Amsterdam. Because the DNS root zone has 13 root name servers, several of which employ anycasting, DNS clients are likely to receive timely answers from at least one of these servers. Even a clearly suboptimal choice for just one of the anycast servers will have no effect on overall response times.

Regional Traffic Exchange

Again using data from the RIPE Atlas measurement network, we can investigate how some of the networks in the three countries exchange traffic with each other, and get some indication of where those exchanges take place. For this experiment, we performed traceroutes from each RIPE Atlas probe to every other probe in the country, for each of the three countries. Because those measurements disclose the IP addresses of the routers involved, we then used RIPE IPmap to geolocate those network resources. This gives some insight into the paths *available* to traffic, although it does not directly measure traffic itself.

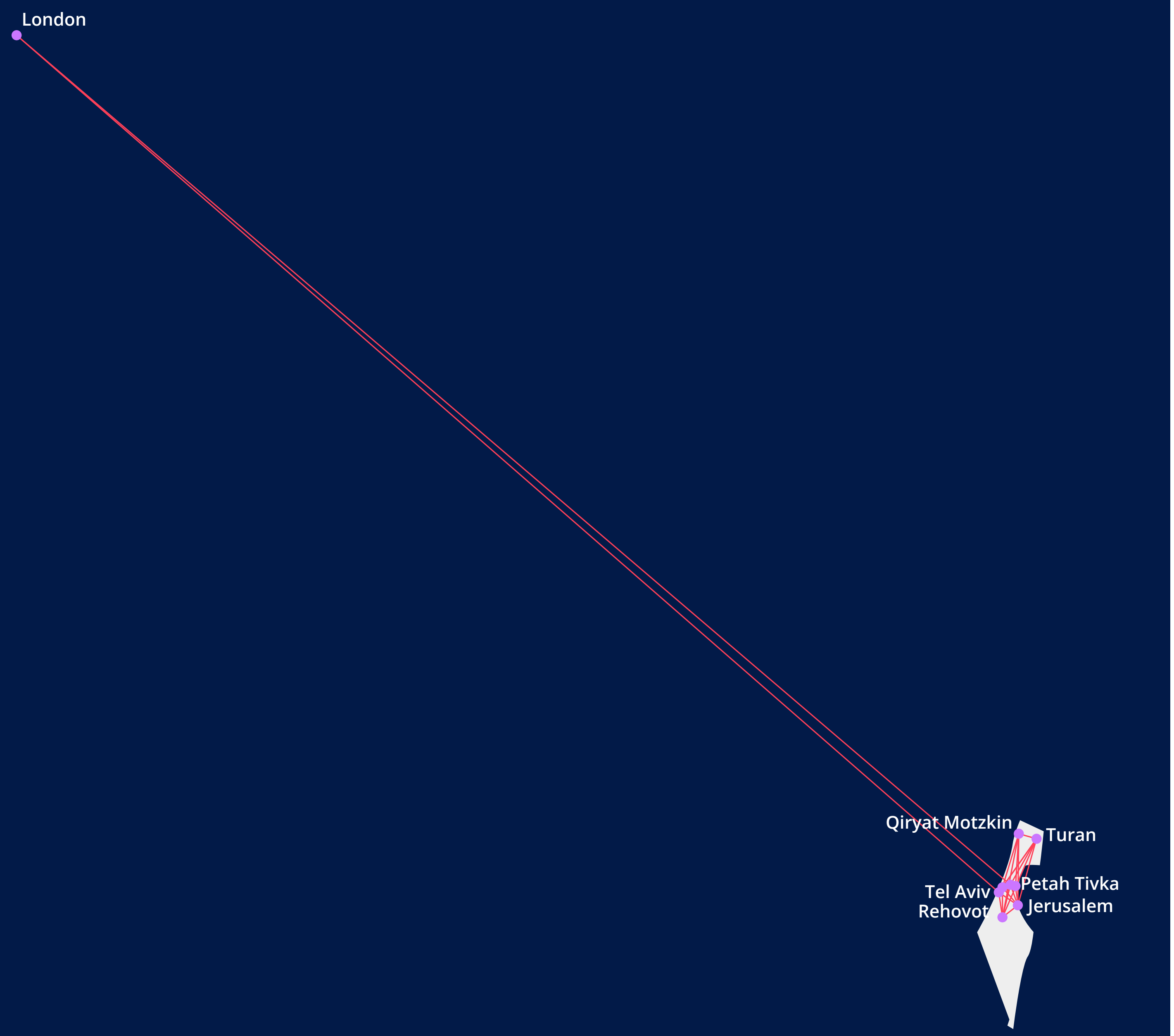
Routing packets a long way to an exchange point, only to have them travel back to a destination close to their origin, is referred to as "tromboning". The farther a path extends from the origin and destination, the more inefficient the path is. In addition, these detours generally increase costs for the network operator and, more importantly, the additional distance travelled unnecessarily increases the risk of disruptions. It also creates additional dependencies on external providers, which could have regulatory implications.

Figure 20:
Paths between origin and destination in Cyprus (IPv4)



In Cyprus, we see some paths taking a long detour all the way to Frankfurt. These paths exist between probes on different sides of the United Nations buffer zone, between a network in the northern part of the island and other networks in the south. We do not observe very long paths between networks in the southern part of the island, although some do extend to Bulgaria and Greece, where different networks interconnect.

Figure 21:
Paths between origin and destination in Israel (IPv4)



In Israel, the majority of paths between RIPE Atlas probes stay in the country, although a few pass through London. We also see some extending to Amsterdam when we look at IPv6.

Unfortunately, Malta has RIPE Atlas probes in only two of the country's networks. As such, we do not have enough data to report on the available paths. We would encourage readers in Malta to learn more about how to host a RIPE Atlas probe at the end of this report.

It's worth noting that the impact of the longer routes we see here, which would result in longer response times, is impossible to ascertain directly because it depends on how much traffic is actually flowing across them, which is not something we can measure. Instead, we can only discover which route traffic would take if a device in one network wanted to reach a device in another network within each country.

Although each of the countries has an active IXP, the lack of data for these countries also makes it difficult to say with any certainty how much the local IXPs are being used, although we clearly see some evidence of this.

Figure 22:
IPv4 address space covered by RPKI

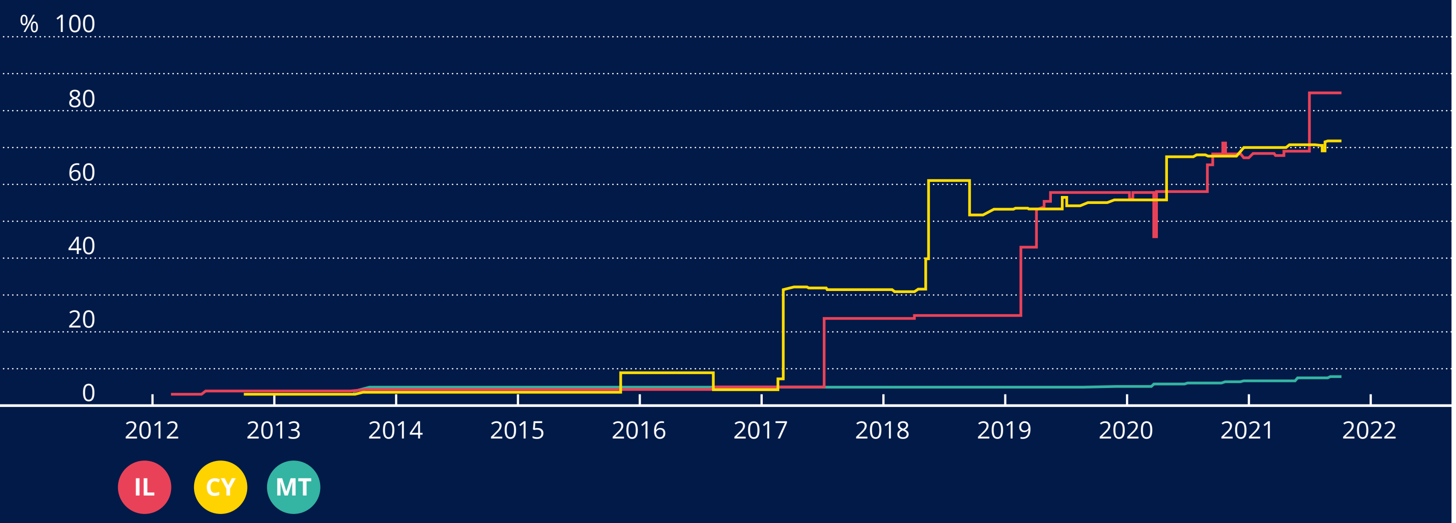
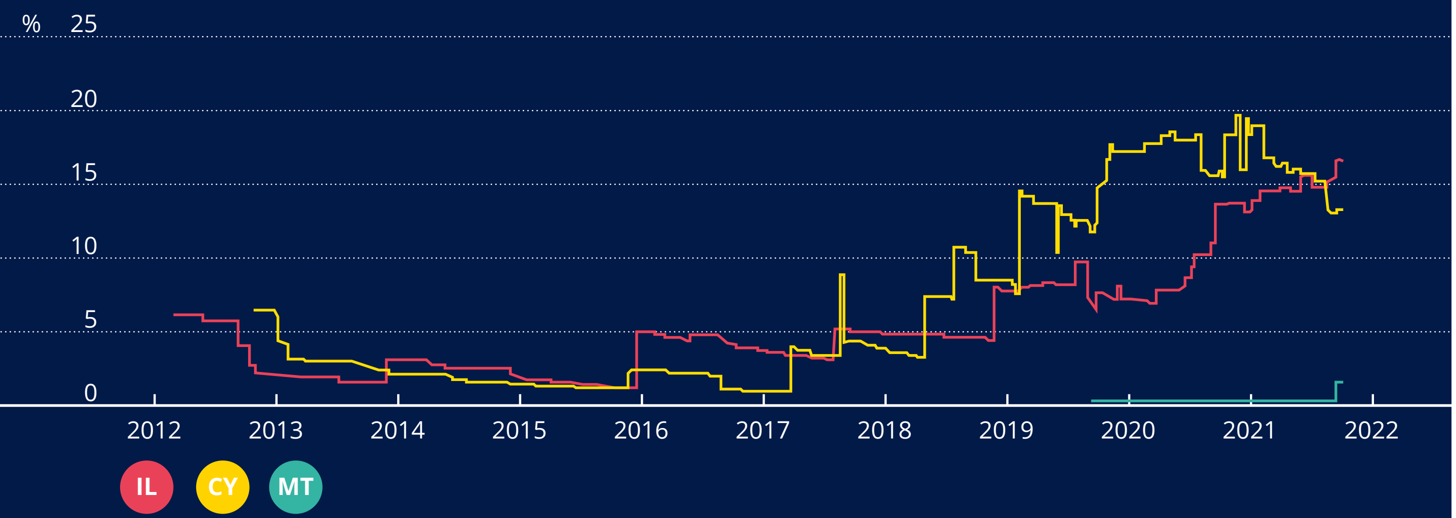


Figure 23:
IPv6 address space covered by RPKI



Routing Security

Beyond looking into the different routes available to traffic originating in the region, we can also investigate routing security in the three countries by looking at how effectively IP address space is protected by Resource Public Key Infrastructure (RPKI), a security framework that helps network operators make more secure routing decisions.

RPKI uses digital certificates called ROAs (Route Origin Authorisations) to prove a resource holder's right to announce IP prefixes (i.e. certifying that the resources were allocated or assigned to the resource holder by a Regional Internet Registry). This helps avoid the most common routing error on the Internet: the accidental announcement of an IP prefix by someone who is not the legitimate holder of that address space. Using the RIPE NCC's RIPEstat tool – which provides all available information about IP address space, ASNs, and related information for hostnames and countries – we can see what percentage of a country's address space is covered by ROAs.

We can see that Malta has very little IPv4 or IPv6 address space covered by ROAs, while Cyprus and Israel have each made strides in recent years to secure their routing using RPKI.

Conclusion

Cyprus, Israel and Malta all have a long history of Internet development that is reflected today in their competitive markets and high penetration rates. Infrastructure and market development continue, with significant ongoing and future investment projects planned.

The networks in each of the three countries benefit from a good level of interconnectivity, and this redundancy provides the overall system with resiliency. This is an especially pertinent issue for Cyprus, Israel and Malta, as all three countries are either islands themselves or rely on connections with islands for their international interconnection, and are particularly vulnerable to bottlenecks or single points of failure as a result. However, we also see that the three countries have a large and diverse number of connections to the global Internet via their upstream providers, which helps mitigate this risk and reduces the potential for disruptions or outages.

Routing is generally optimised, resulting in fast response times, and we see some evidence that local exchange points are being used in order to keep domestic traffic local. However, there are also a few routing anomalies in which quite distant exchange points seem to be favoured over local options, which unnecessarily increases costs, foreign dependencies and risk of disruption. Similarly, routing decisions to access the domain name system occasionally send requests to quite distant root name server instances, although we tend to see this balance out when considering more than one root name server.

In comparison with one another, the three countries offer an interesting portrait of the potential influence of regulation: Israel's Ministry of Communications' IPv6 requirement for Internet service providers had an immediate and significant impact on IPv6 uptake in the country, while the other two remain at nearly zero capability despite their relatively large amounts of IPv6 address space. Despite high levels of mobile use in all three countries and relatively high IPv4 per capita rates, all three countries – but especially Cyprus and Malta – will need to further invest in IPv6 deployment in order to meet the demands of future growth and emerging technologies. With a relatively small number of players, these countries could make large strides in a relatively short amount of time, given the required commitment from the major network operators.

It's worth noting that all of the observations in this report are based on active paths, and we cannot know what "hidden" world of backups exists that would automatically take over in the case of any disruptions. Whatever redundancy does exist would provide the system with even more resiliency.

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.

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.
https://www.ripe.net/manage-ips-and-asns/db

RIPE Atlas

RIPE Atlas is the RIPE NCC's main Internet measurement platform. It is a global network of thousands of probes that actively measure Internet connectivity. 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.
https://atlas.ripe.net

Routing Information Service (RIS)

The Routing Information Service (RIS) has been collecting and storing Internet routing data from locations around the globe since 2001.
https://www.ripe.net/ris

The data obtained through RIPE Atlas and RIS is the foundation for many of the tools that we offer. We are always looking to improve our measurement platforms by expanding the diversity of networks they cover and would like to have RIPE Atlas probes or RIS peers in networks that aren't already included. Please see the RIPE Atlas and RIS websites to learn more.

Other RIPE NCC tools and services

- RIPEstat: https://stat.ripe.net/
- RIPE IPmap: https://ipmap.ripe.net/
- K-root: https://www.ripe.net/analyse/dns/k-root