RIPE NCC
RIPE NETWORK COORDINATION CENTRE

RIPE NCC

Southeast Europe Country Report

April 2020

Introduction

The Internet is a global network of networks, yet every country's relationship to it is different. This report provides an outlook on the current state of the Internet in countries in Southeast Europe. We offer an analysis of the region's current Internet number resource holdings and its history of development; examine Internet routing within the region and take a close look at its access to the global domain name system (DNS); and investigate how the global Internet reaches networks within Southeast Europe. This analysis is based on what we can observe from the RIPE NCC's measurement tools as well as a few external data sources.

We take a look at Southeast Europe as a sub-region within the RIPE NCC's service region that has its own unique opportunities and challenges, but for which the RIPE NCC has not yet provided any unique data or dedicated analysis. We present these findings in the hopes that they will inform discussion, provide technical insight, and facilitate the exchange of information and best practices regarding Internet-related developments in this unique region. This is the fourth 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 local technical communities and decision makers alike.

Defining Southeast Europe

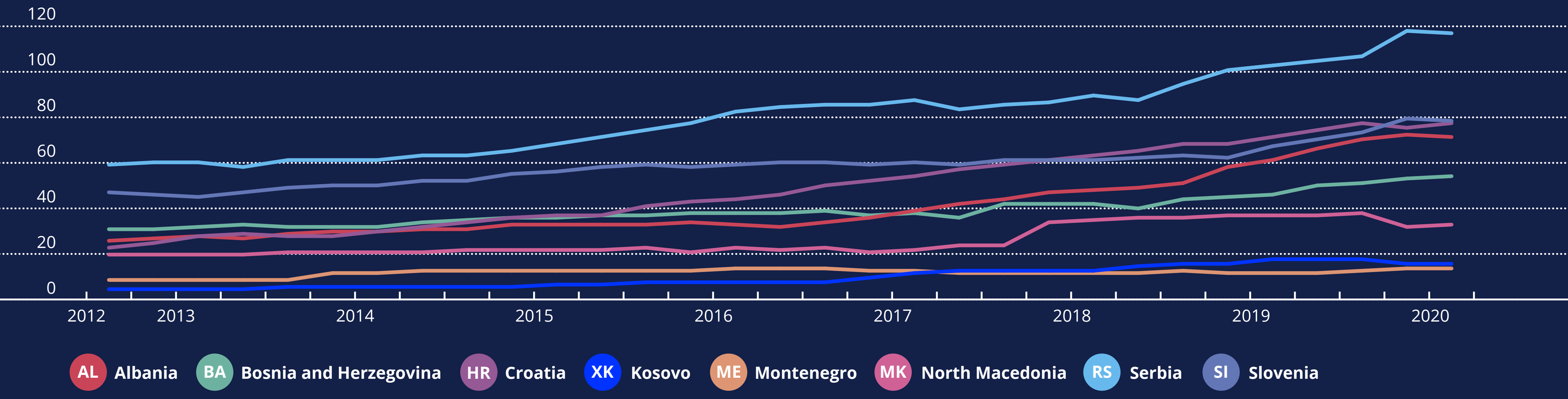
As there is no universally accepted definition of what constitutes Southeast Europe, the RIPE NCC decided to include the following for the purposes of this report: Albania, Bosnia and Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, Serbia and Slovenia.

We felt that these countries were the most comparable in terms of geography, population, technical infrastructure, market size and number of RIPE NCC members. Including some of the larger countries in the region would have skewed the results to such an extent that we felt the comparisons would have become less meaningful. We also made the decision to include Kosovo as a separate country, even though it is not represented as such in the RIPE Database. This required manually identifying Internet number resources and members from Kosovo so that we could present the most accurate data and analysis possible.

Highlights

- Although the situation is not unique to Southeast Europe, there is not enough IPv4 address space in the region to accommodate sustainable, long-term growth
- Like much of the RIPE NCC service region, Southeast Europe struggles with IPv6 deployment, which has stagnated in recent years in this region
- The IPv4 secondary market is dominated by transfers between parties within the region
- Routing within the region is generally efficient, although we observed a few anomalies that likely reflect the various peering arrangements that different networks have in place
- There is a modest amount of diversity in terms of the routes available to traffic flowing into the region

Figure 1:
Growth in the number of Local Internet Registries over time



1. Southeast Europe as seen from the RIPE NCC

Number of Providers

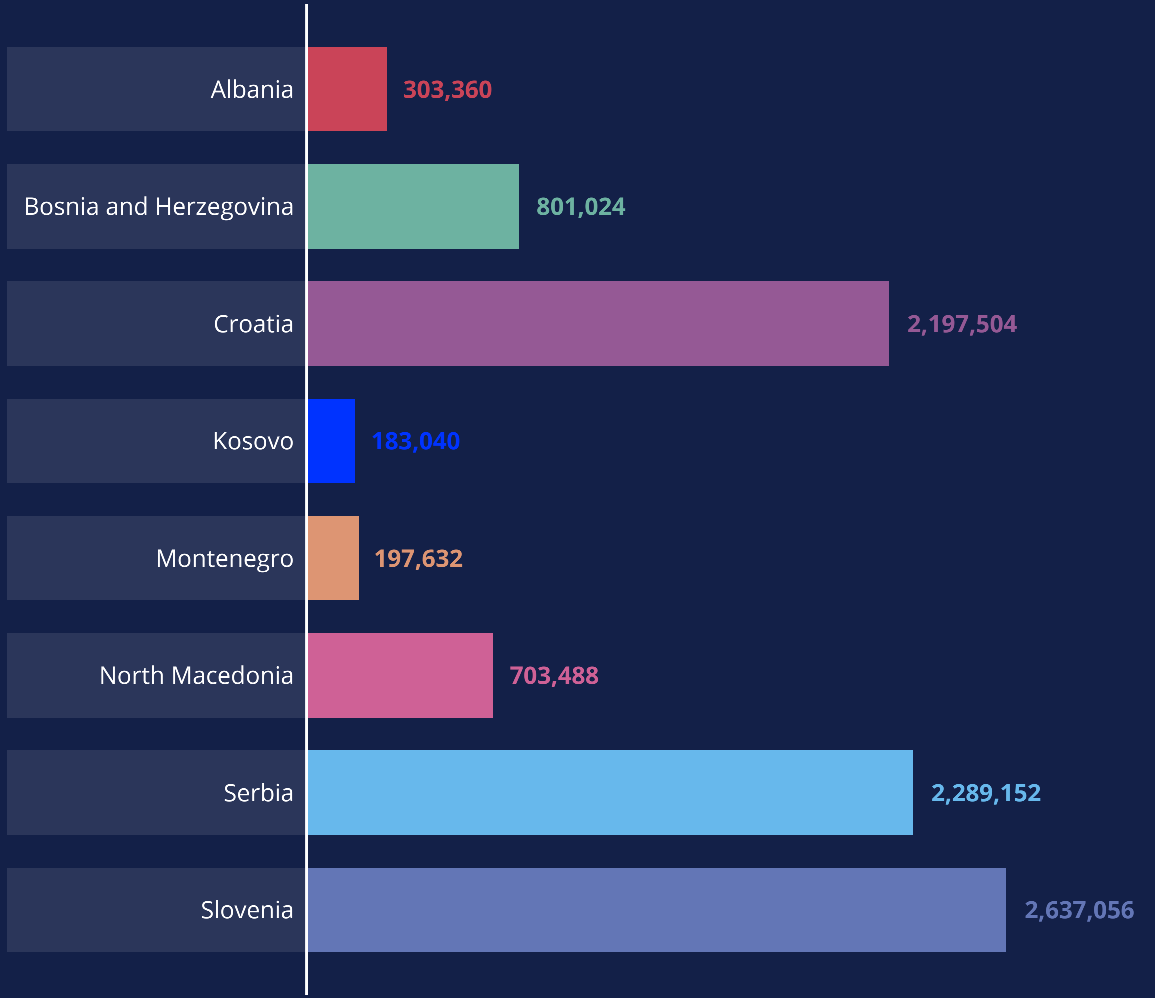
Not surprisingly, the number of Local Internet Registries (LIRs) in the different countries roughly corresponds with their populations. The exception to this is Slovenia, which has the second-highest number of LIRs despite having the fifth largest population. While we cannot be certain of the cause, it might be an indication of a more diverse market with a larger number of smaller service providers that complement the dominant access providers we see in Slovenia and other nearby markets.

RIPE NCC Members and Local Internet Registries (LIRs)

RIPE NCC members include Internet service providers, content hosting providers, governments, 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).

In general, however, an increasing number of LIRs doesn't necessarily translate into a growth in the number of Internet access providers; often, individuals, businesses or other organisations will open additional LIRs simply to receive their final allocation of IPv4 address space. Of the countries included, members in Albania and Slovenia have opened the most additional LIRs, so some of the growth shown in figure 1 for those countries can also be attributed to this effect.

Figure 2:
IPv4 address holdings by country



IPv4 Address Space in Southeast Europe

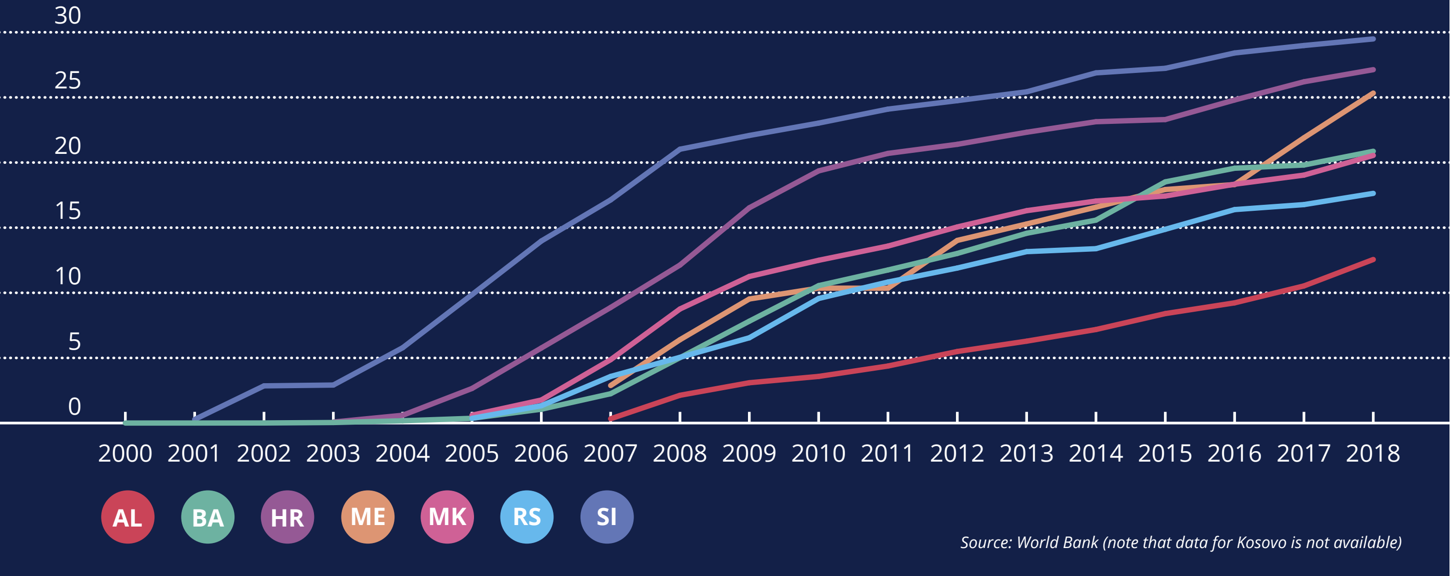
Until 2012, RIPE NCC members could receive larger amounts of IPv4 address space, based on demonstrated need. When the RIPE NCC reached the last large block of available IPv4 address space in 2012, the RIPE community instituted a policy allowing LIRs to receive a small, final allocation of IPv4 in order 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 waiting list now exists for organisations that have never received their final IPv4 allocation from the RIPE NCC. These organisations can receive an even smaller allocation when space is available (occasionally member accounts are closed and address space is returned to the RIPE NCC).

As a result of only small allocations being given out since 2012, growth in the amount of IPv4 addresses has been nearly flat since that time. Regardless, the transition to IPv6 has been slow, and in the meantime, demand for IPv4 remains high.

With more than 2.6 million IPv4 addresses, Slovenia's holdings are disproportionately large compared to its population. In fact, Slovenia is the only country in the region with more IPv4 addresses than people (nearly 1.3 addresses per person), whereas the others fall in the range of one address for every two people (Croatia) to one address for every ten people (Kosovo).

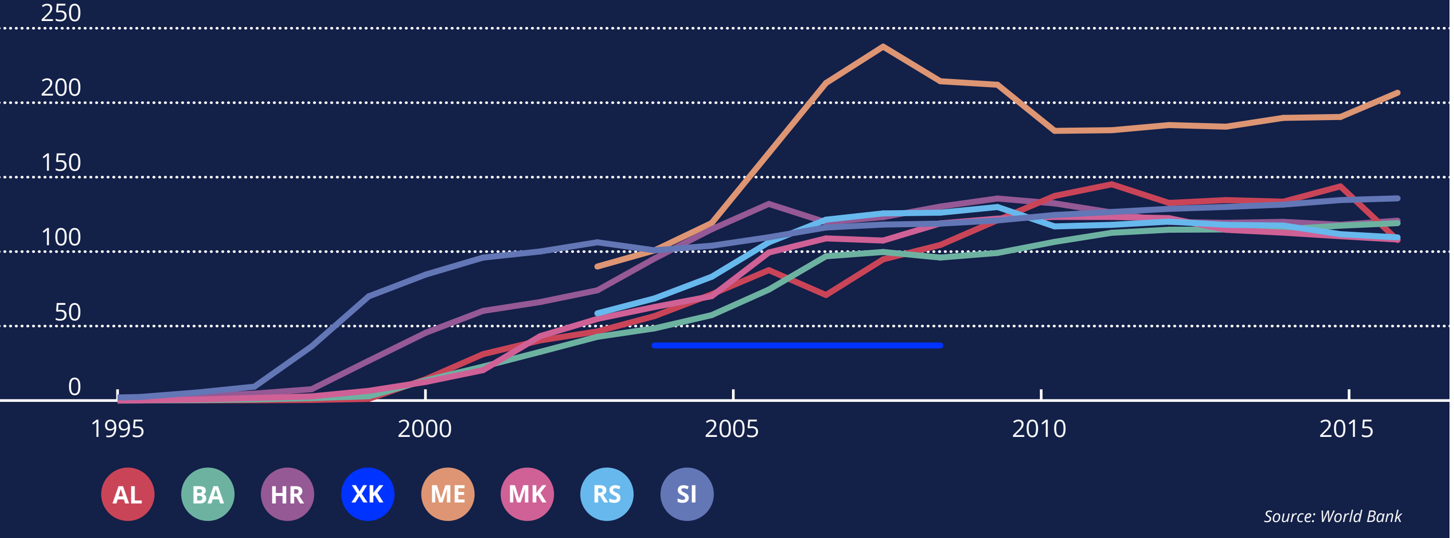
Looking at our data, some of this difference can be explained by the fact that, over time, more LIRs in Slovenia have applied for and received their final IPv4 allocations; however, that difference does not account for the full discrepancy we see here. It's more likely that Slovenia's relatively early expansion in fixed broadband beginning around the year 2000, together with a more diverse market,

Figure 3:
Fixed broadband subscriptions per 100 people over time



Source: World Bank (note that data for Kosovo is not available)

Figure 4:
Mobile subscriptions per 100 people over time



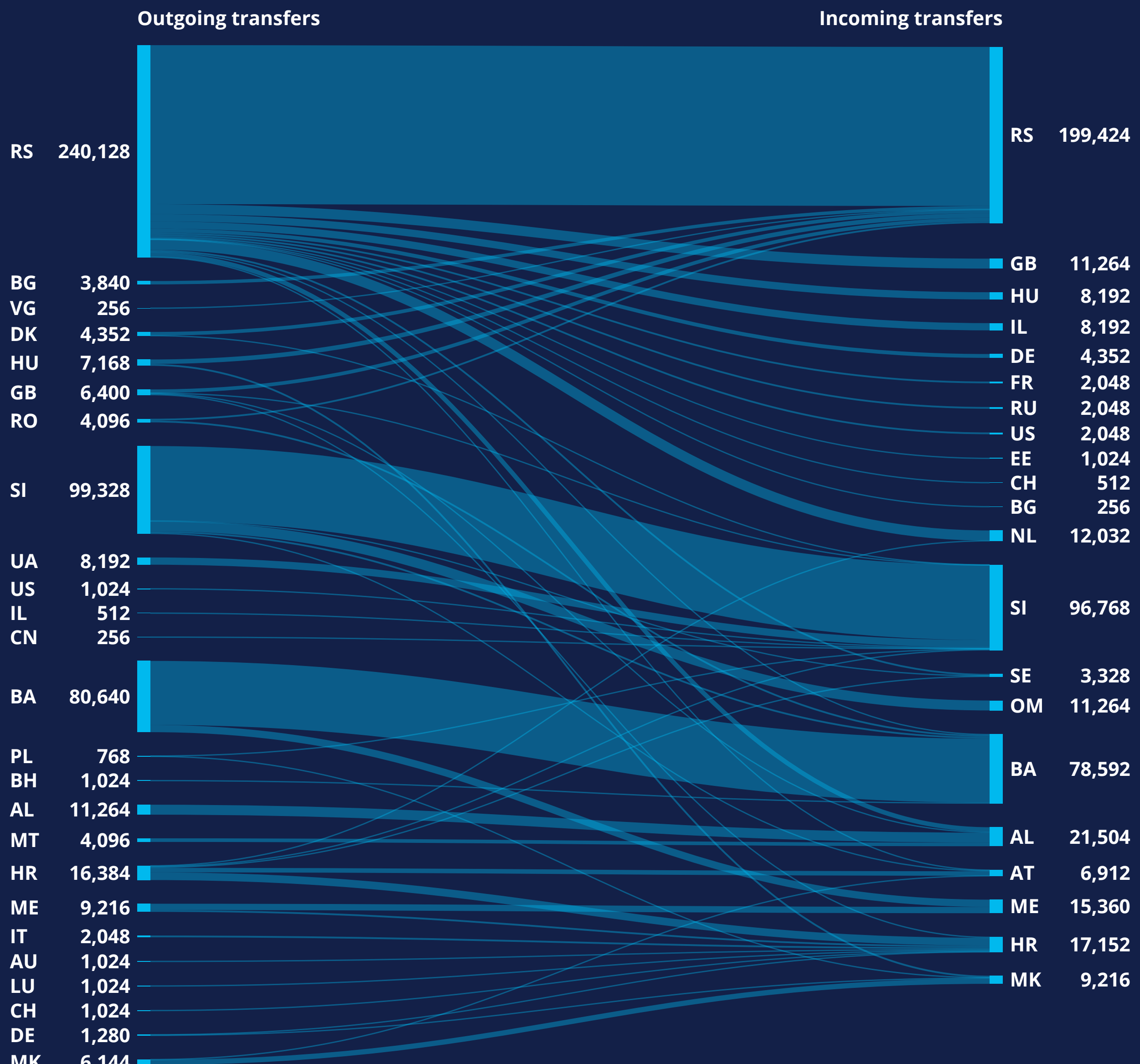
Source: World Bank

might have contributed to its larger amount of IPv4 address space over time.

It's important to note that a low address-to-population ratio doesn't necessarily mean that it will be impossible for a country to provide connectivity to all its citizens. Technical workarounds exist that allow for multiple users to share a single IP address, such as carrier-grade network address translation (CGN). Such technologies are in widespread use in mobile broadband connectivity, and, given the region's high percentage of mobile subscriptions, we don't expect this to cause any immediate restrictions on short-term growth.

However, there are well-documented drawbacks to address-sharing technologies, and in order to fully unlock the potential societal and economic benefits of further digitilisation, we highly recommend deploying IPv6 as a more sustainable long-term solution (discussed in more detail in the IPv6 section below).

Figure 5:
IPv4 transfers within, into and out of Southeast Europe between April 2013 and February 2020



Data for Kosovo is not available

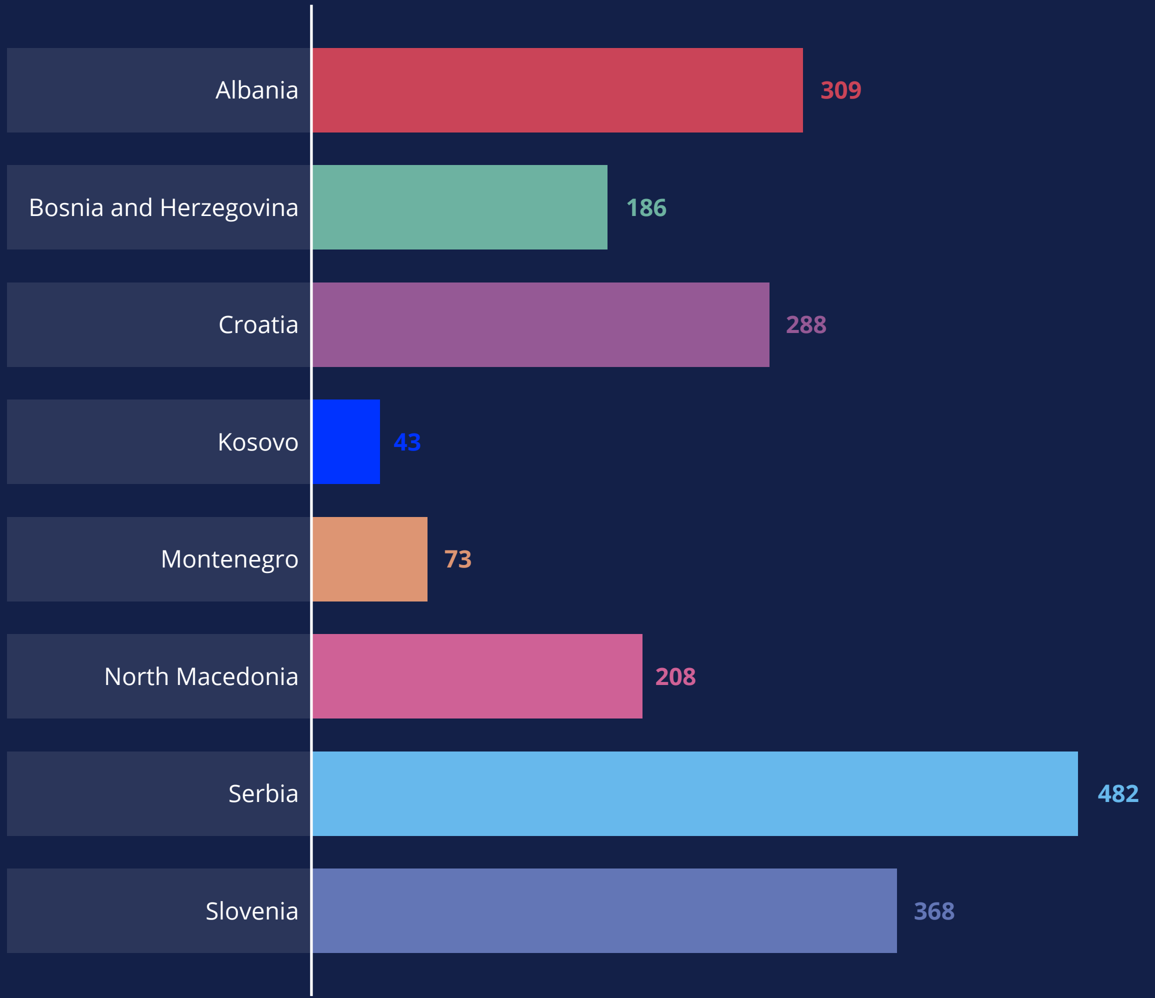
IPv4 Secondary Market

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 IPv4 has become more scarce, many providers 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.

Domestic transfers within Serbia, Slovenia, and Bosnia and Herzegovina (i.e. transfers between two different entities in the same country) dominate the transfer market. However, there have also been small amounts of IPv4 addresses transferred into the region from other countries, as well as addresses transferred out of the region. Looking at the net balance, we see Serbia exported nearly 41,000 more IP addresses than it imported. Slovenia and Bosnia and Herzegovina are also net exporters, but only by a small margin. On the other hand, Albania, Croatia, Montenegro and North Macedonia are net importers.

Figure 6:
IPv6 address holdings by country (multiples of /32)



IPv6

In the RIPE NCC Survey 2019 (which polled more than 4,000 network operators and other members of the technical community from the RIPE NCC's service region of Europe, the Middle East and parts of Central Asia), 35% of respondents in Southeast Europe cited IPv6 deployment as the biggest operational challenge they were facing (second only to network security).

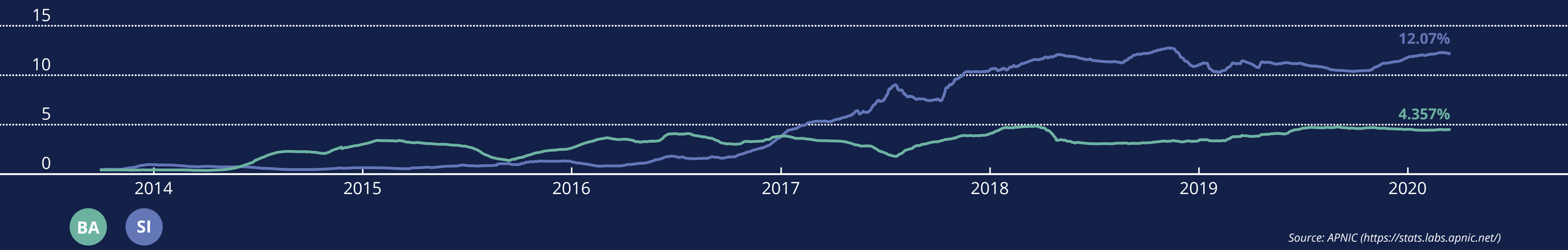
Respondents in Southeast Europe actually cited dependency on IPv4 as slightly less of a challenge in dealing with IPv4 scarcity than the overall survey average (29% compared to 35%), even though 57% said their organisation will need more IPv4 address space in the next two to three years (compared to an overall survey average of 53%). Many in Southeast Europe (60%) plan to buy IPv4 address space on the secondary market, while 40% plan to use network address translation (NAT), 39% plan on moving to IPv6, 23% have no plans for IPv6 deployment and 20% are fully deployed. In general, we don't see big differences in attitudes and planning around IPv6 in Southeast Europe compared to the other regions surveyed.[1]

It's also important to note that, even though 20% of respondents stated they are fully deployed, this doesn't mean that 20% of end users are actually able to use IPv6, as we see in the section below. In relation to crucial momentum in the market, IPv6 uptake depends on the actions of the large Internet access and service providers to include IPv6 as a default feature.

Among the countries included in this report, Serbia has the largest amount of IPv6 address space, while Slovenia has the highest amount per capita, which is not surprising given that it also has the largest number of independent Internet access providers.

1 RIPE NCC Survey 2019: https://www.ripe.net/participate/member-support/surveys/ripe-ncc-survey-2019/survey-matters-report-on-the-ripe-ncc-survey-2019

Figure 7:
Percentage of Internet users with IPv6 capability in Slovenia and Bosnia and Herzegovina



Source: APNIC (https://stats.labs.apnic.net/)

However, IPv6 deployment remains extremely low in the region (0-12%) compared to the rest of Europe. Slovenia showed some early leadership in IPv6 deployment, thanks in part to a small but active group of technical community members who convinced some of the leading access providers to enable IPv6 on their production systems as early as 2016.

However, whereas Slovenia showed a steady increase until mid-2017, with an IPv6 adoption rate of about 1 in 10 users, its deployment efforts have stagnated in recent years and it still hovers around 12% today. The biggest contributor to IPv6 efforts in the country appears to be Telekom Slovenije, 1 in 3 customers of which uses IPv6. However, this figure again reached a plateau sometime around mid-2017.[2]

Among the other Slovenian providers, ARNES, the nation's national research and education network (NREN), and T-2 have been actively deploying IPv6 for several years. Whereas ARNES has held steady at a rate of about 30% IPv6 capability for several years, T-2 recently showed a small increase from 1.6% to 5% in the first half of 2019. However, it now seems that T-2 has levelled off with an adoption rate of around 6%.

Finally, of the other major providers in Slovenia, A1 has shown a sharp increase in the first few months of 2020. At the time of writing, IPv6 usage in their network has reached 3.5% and the growth is not yet showing signs of levelling off.

The only other country in the scope of this report with an IPv6 rate of more than 1% is Bosnia and Herzegovina. Interestingly, we see the same pattern of a relatively early start in 2014, followed by a stagnation of around 4%, with no significant increase in the last three years. The only IPv6 deployment in the country that results in measurable levels comes from BH Telecom, at 16%.

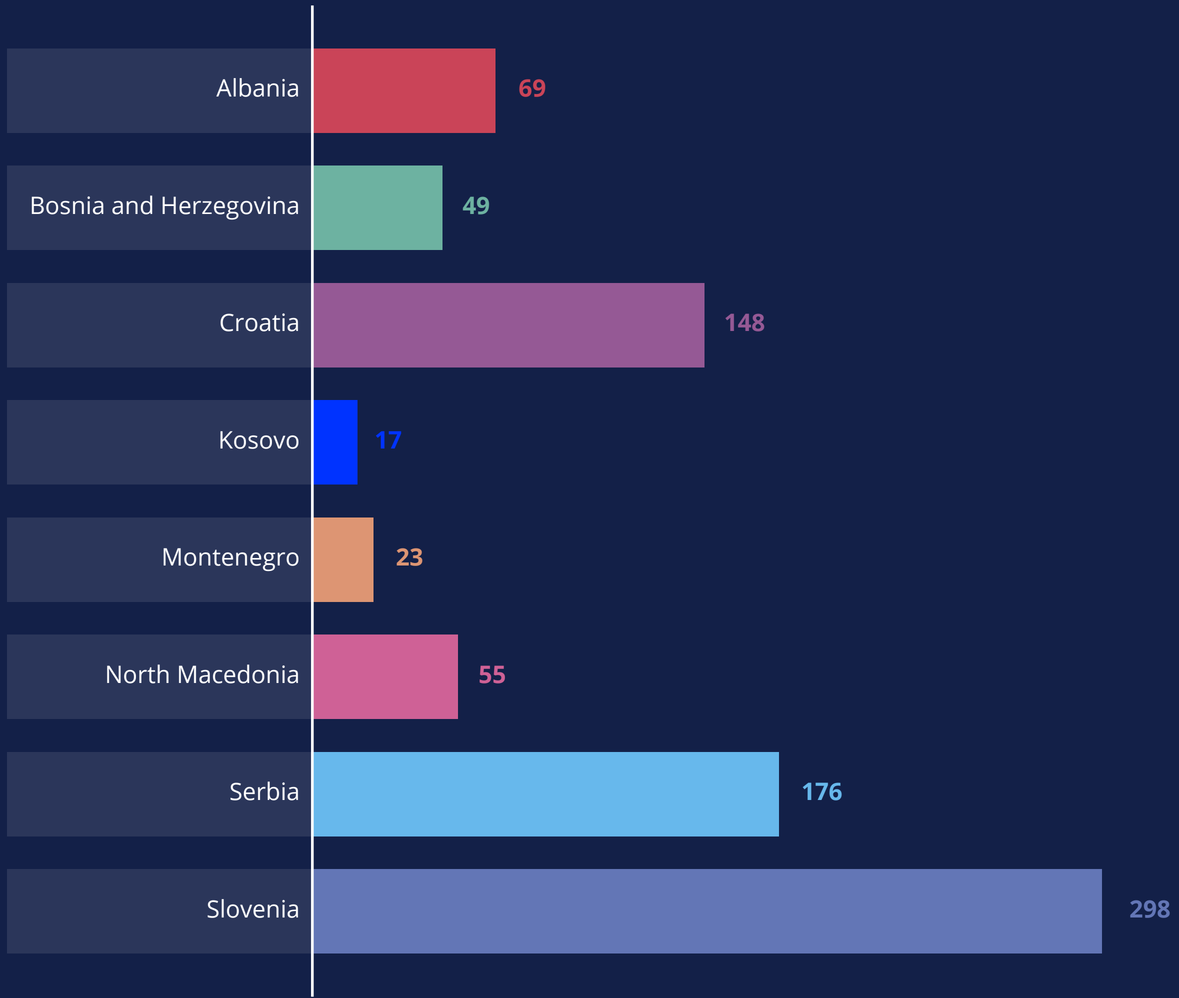
Neither Google nor APNIC measure any other significant IPv6 capability in the countries in this report. While there are no doubt factors that hinder IPv6 deployment, such as a lack of technical capability in legacy equipment that is expensive to replace, or a lack of training in IPv6 deployment, we recommend further study into which barriers currently exist in order to help overcome them.

The recent IPv4 run-out and the increasing price of IPv4 on the secondary market present barriers to new entrants to the market, and stresses even the larger incumbents' ability to accommodate future growth. Technical workarounds like network address translation (NAT) can only bridge the gap for a limited time, and present their own problems in terms of breaking end-to-end connectivity. This can negatively impact the end user's experience and has particularly negative implications for the banking industry, gamers and law enforcement. New and emerging technologies such as the Internet of Things are only going to exacerbate the need for additional IP addresses.

For all these reasons, wide-scale IPv6 deployment is the only sustainable way to ensure the Internet – and its related technologies and societal benefits – can continue to grow well into the future. The early IPv6 deployment rates we've seen in Southeast Europe demonstrate that the markets and networks have the potential to enable IPv6. Supporting an expedited transition to IPv6 would be one of the most effective ways to support the future growth of the Internet in this region.

2 APNIC: *https://stats.labs.apnic.net/ipv6/AS5603?a=5603&c=SI&x=1&s=1&p=1&w=30*

Figure 8:
Number of networks by country

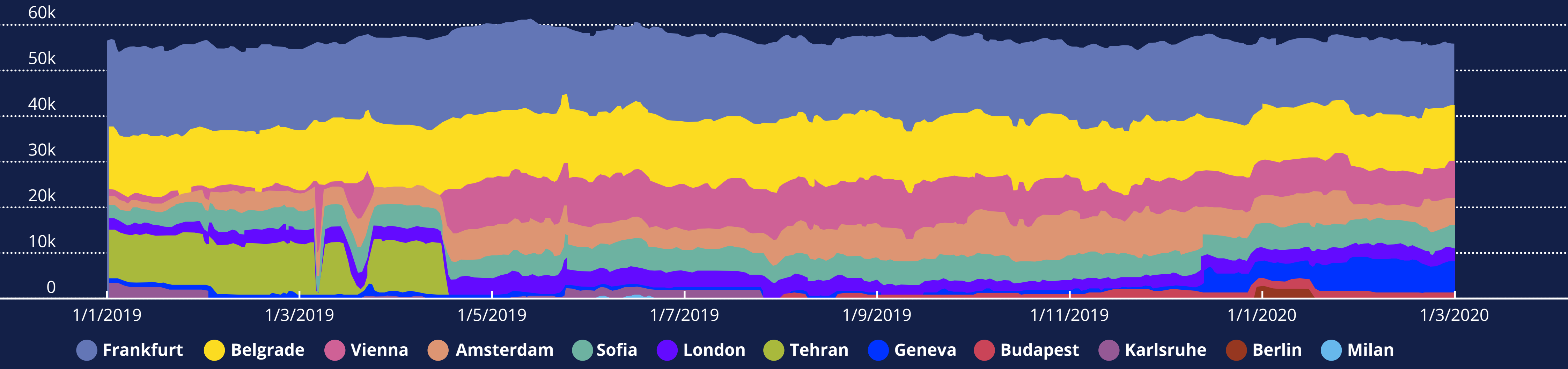


The Southeast Europe Market

As already mentioned, a larger number of LIRs generally corresponds to a larger number of IPv4 and IPv6 resources, and the same is true for the number of independent networks (called Autonomous Systems, each of which is represented by an Autonomous System Number, or ASN) that we see in each country. The exception that we see once again is that of Slovenia, which has a much higher number of networks compared to its population than the other countries in the region.

Slovenia has by far the most independent networks (ASNs), at 298 compared to the second-highest number of 176 in Serbia. Of these 298, more than 100 are operated by small businesses who obtain transit services from Telekom Slovenije while also peering with others.

Figure 9:
K-root locations reached from within Southeast Europe (IPv4)



2. Regional View of Southeast Europe

Reaching the Domain Name System (DNS)
Turning now to investigate how traffic is routed to, from and within the region, we first examine which local instances of K-root are queried from requests originating in the different countries.

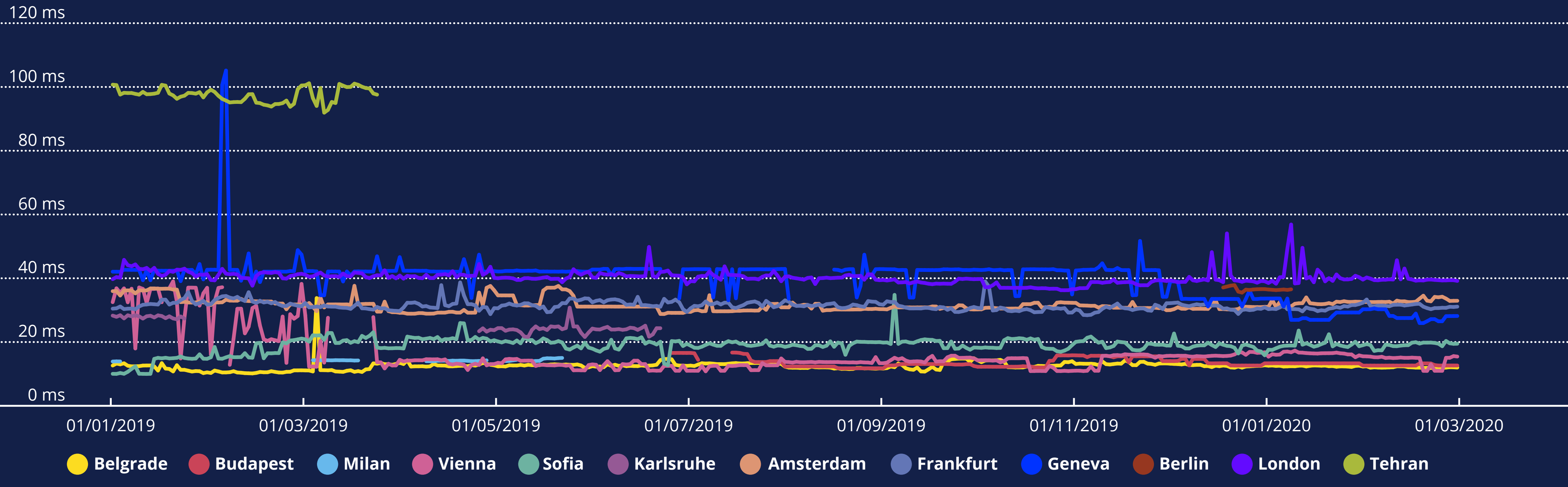
These measurements are based on the RIPE NCC's RIPE Atlas measurement platform, which employs a global network of probes that measure Internet connectivity and reachability. Note that K-root is just one of the world's 13 root name servers, and every DNS client will make its own decisions about which particular root name server to use. In cases where response times to K-root would be relatively high, it is highly likely that clients would opt for faster alternatives among the other root name servers.

Still, confining our measurements just to K-root and looking at the choices that different RIPE Atlas probes in the region make about which K-root instance to query provides some interesting results. The nature of the domain name system means that the results of these measurements are representative of how the routing system considers the various options and decides which networks and locations will provide the best results.

K-root and DNS
K-root is one of the world's 13 root name servers that form the backbone of the domain name system (DNS), which translates human-readable URLs (such as https://www.ripe.net) into IP addresses. 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.

Figure 9 shows that, in the first months of 2019, a significant number of queries were sent to the K-root instance in Tehran, Iran. Being unnecessarily far away from the originating hosts, this is obviously not ideal. From late April 2019 onward, this stopped and we see requests being routed to Vienna instead. In recent months, the requests are all sent to K-root instances in Europe, with a good distribution of servers either located directly in or close to Southeast Europe, including Belgrade, Vienna, Sofia, and Budapest.

Figure 10:
Average round-trip times to most-used K-root locations (IPv4)

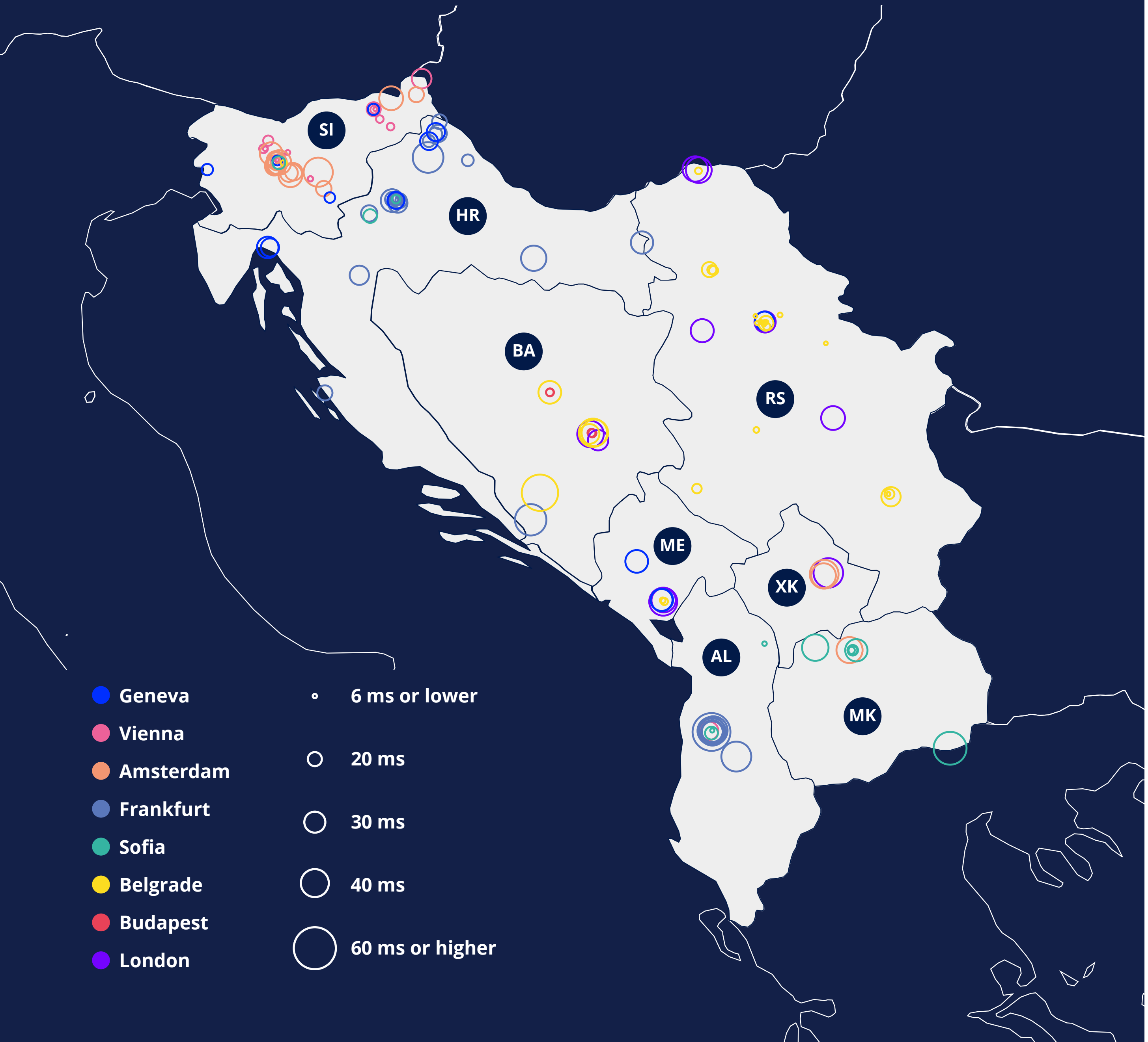


When we look at the average round-trip times per K-root location, it is clear that the Tehran instance was a suboptimal routing choice. As expected, the geographic distance added significant delays. However, the response times for all other K-root servers that were queried fell into the acceptable range, in which an end user would be unlikely to have experienced any noticeable delay.

As we would expect given their geographic proximity, servers in Belgrade, Sofia and Vienna were reached in the shortest amount of time, and it's a sign of a healthy system that these are the preferred choice of many of the requests we measured.

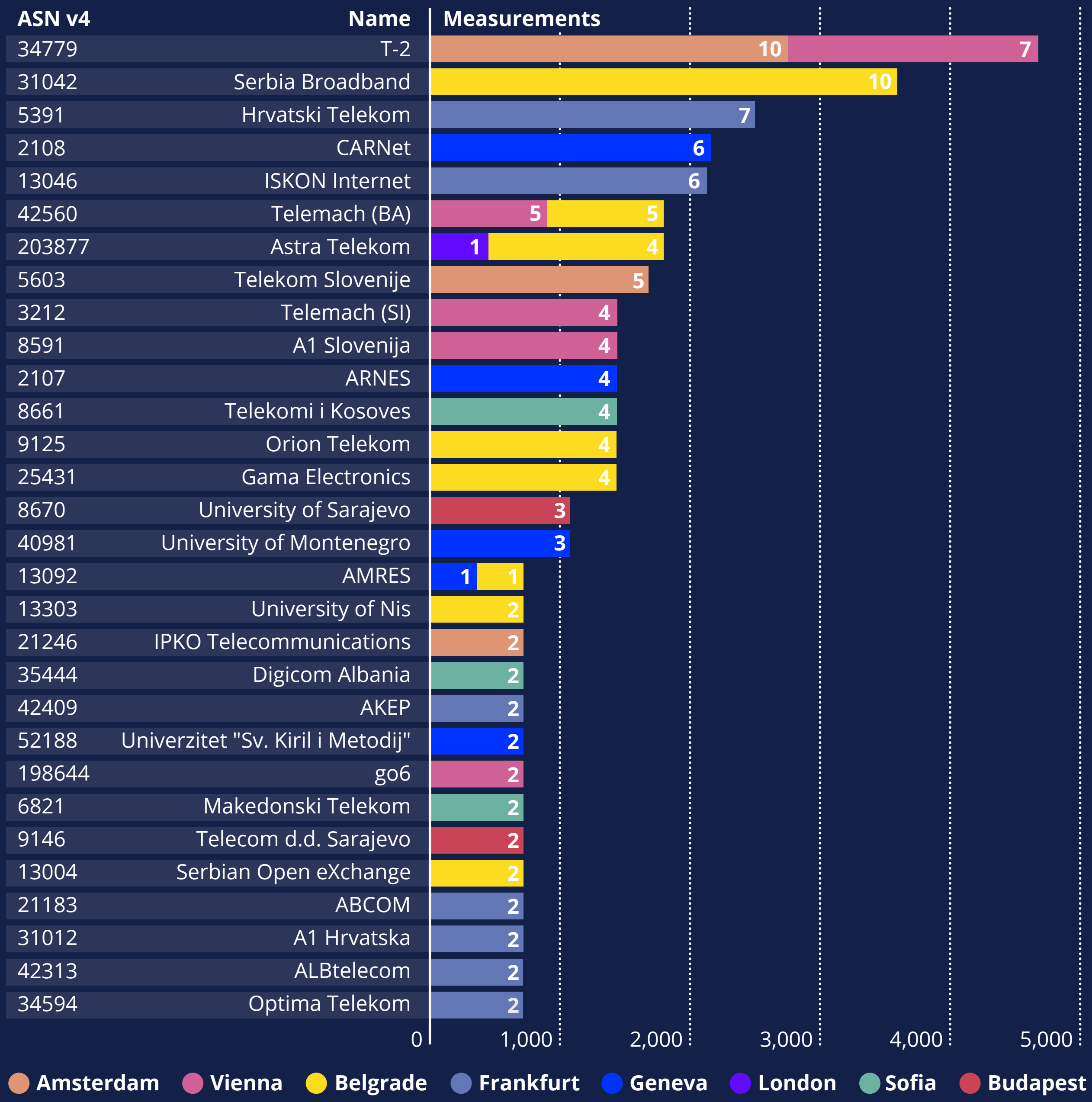
Looking at some historic data, we found that the probes that selected Tehran were mostly based in a number of different networks in Slovenia. While we lack substantial data, we expect that the selection of Tehran as a preferred path originated in a network in Slovenia and subsequently got passed on via bilateral peering arrangements as a preferred option.

Figure 11:
K-root locations reached from vantage points throughout Southeast Europe (IPv4)



Looking at individual countries in the region, we can see a clear geographical distinction between the queried K-root instances depending on the location of the originating request. Requests originating in the northern part of the region tend to be sent to K-root servers in the north, although it's interesting to note, for example, the division between requests originating in Slovenia, which tend to be sent to Vienna and Amsterdam, and those originating in Croatia, which are largely routed to Frankfurt.

Figure 12:
K-root locations reached from different networks throughout Southeast Europe (IPv4)



Peering Arrangements

These types of distinctions are almost certainly the result of the peering arrangements that exist between the different providers operating in the different countries – a trend that becomes more obvious when we look at the distribution of requests after grouping them by network, rather than by country, as many local providers operate under larger international conglomerates.

With some exceptions, most networks have a preference for a particular K-root instance. Traditionally, the Border Gateway Protocol (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 generally what we see in figure 12, where all probes in a particular network end up querying the same root-server instance.

However, this does not explain the diversity of locations we see in the preferred K-root instances. Routing processes should select the “shortest” path, but as we can see from the data, the nearest instance from a routing perspective might not be the nearest geographically.

Based on distance, the closest K-root instance for much of the region is likely the one hosted at the Serbian Open eXchange (SOX) in Belgrade. Other nearby instances can be found in Geneva, Sofia, Bucharest, Athens, Vienna and Budapest, and while some of these are indeed used, we also see some networks opting for more distant options including Frankfurt, Amsterdam and even London. When we look at how and where these particular networks interconnect, we find plausible explanations for almost all of these selections.

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.

The K-root-server in Geneva is hosted at CERN, which has a connection with the GÉANT network that further connects the European research and education networks (NRENs). Looking at figure 12, we can see that CARNet, ARNES and the University of Montenegro all prefer the K-root instance in Geneva, which is very likely because these networks all connect to the GÉANT network.

The one exception here is the University of Sarajevo, which is not connected to GÉANT but instead makes use of BH Telecom as an upstream provider. It should not come as a surprise that the two measurements we were able to make in the BH Telecom network (not pictured) also prefer the instance in Budapest, where it has a connection to the Budapest Internet Exchange – the site of a K-root instance. This behaviour is exactly what we would expect, whereby BH Telecom prefers the route they have via the Internet exchange point in Budapest and in turn passes this information downstream to the university, where BGP decided that this is the best route available.

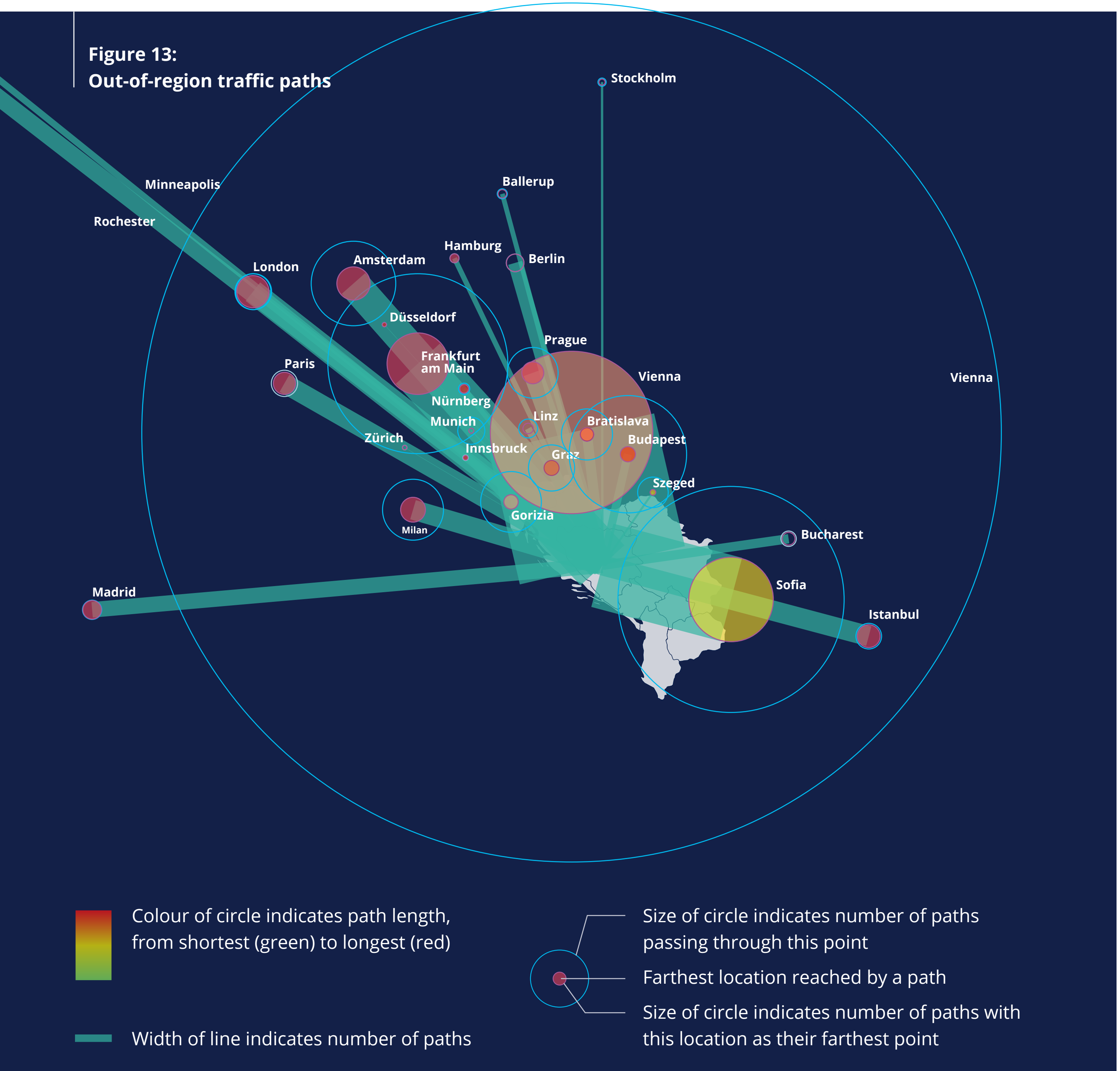
Hrvatski Telekom, a subsidiary of Deutsche Telekom, has a connection to the DE-CIX Internet exchange, where a K-root instance is also hosted. Because the network identifies that particular route as the best available, it is likely to get passed on to downstream customers such as ISKON, which also prefers the Frankfurt instance.

A similar pattern emerges between Serbia Broadband and several of the Telemach networks, which are all part of the same group. Serbia Broadband itself has a connection to the Internet exchange in Belgrade and, as expected, uses the instance located there. Telemach Slovenia has a connection to the Vienna Internet Exchange and measurements show that they clearly prefer the path to Vienna. Downstream from these two networks, we find Telemach in Bosnia and Herzegovina. Confronted with the information passed on by both upstream networks, we see how instead of making a choice, the BGP considers both options equal and as a result we see traffic balanced across both available paths.

Additionally, a similar case of load balancing becomes apparent within the T-2 network, which has a presence at a number of Internet exchanges, including NL-ix in Amsterdam and VIX in Vienna. Here as well, from our measurements in their network, we see both paths in use and a distribution across the K-root instances in Vienna and Amsterdam.

Not every network uses these equal paths simultaneously, which is an option that the network operator has to enable. By default, BGP will use a tie-breaker algorithm and pick only one, storing the other path in memory to be used as a backup. This is likely what we see happening in Telekom Slovenije, which has connections to both AMS-IX in Amsterdam and DE-CIX in Frankfurt, but which clearly prefers the instance in Amsterdam.

Figure 13: Out-of-region traffic paths



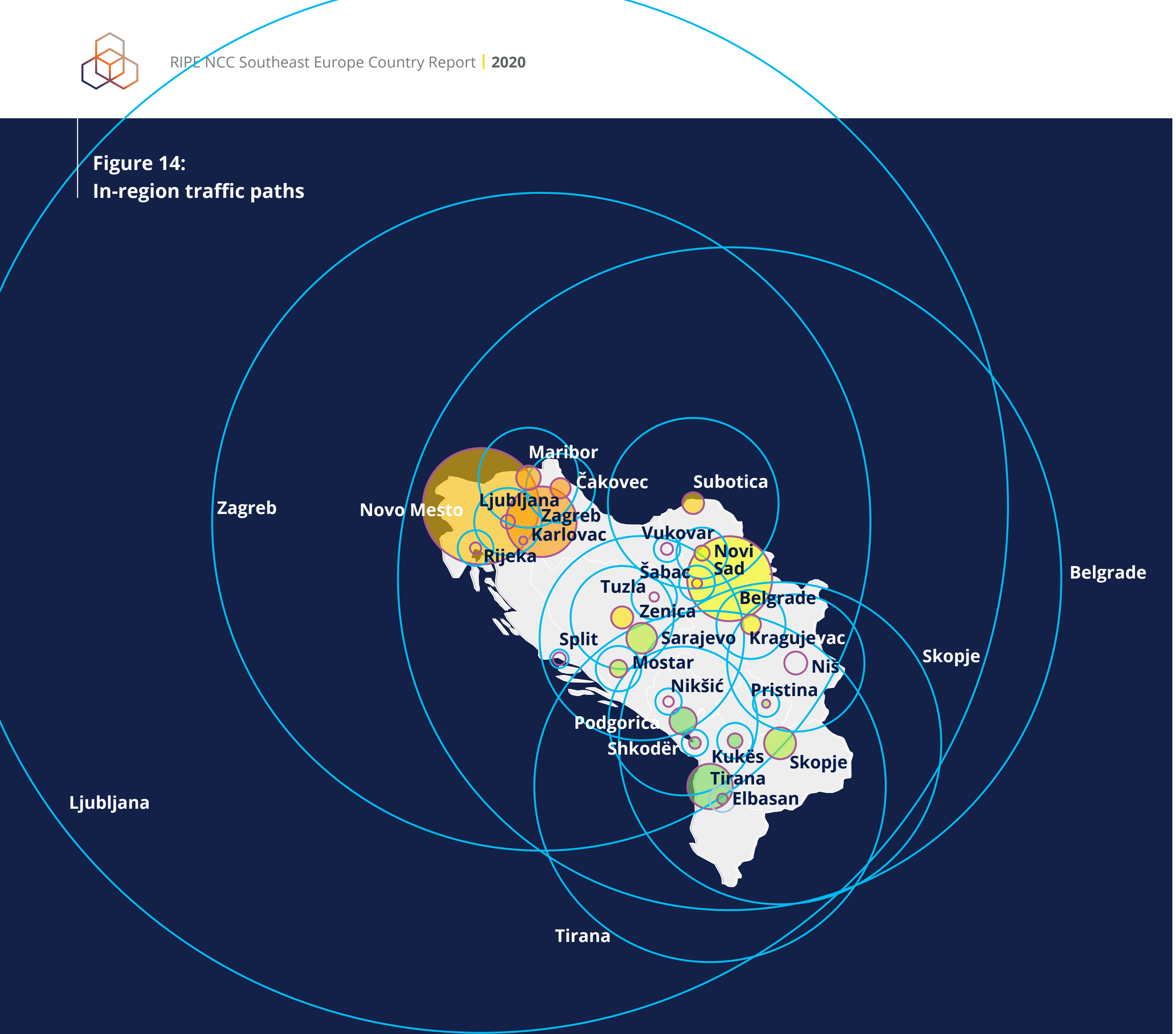
How Regional Traffic is Exchanged

We can also use the RIPE Atlas measurement network to investigate how some of the networks in the region 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 region. Because those measurements disclose the IP addresses of the routers involved, we then used RIPE IPmap to geolocate those network resources.

Figure 13 shows the results of these measurements. Ideally, paths should travel in a straight line from end user to end user, in order to reduce round-trip times. In reality, however, this is almost never feasible. We can clearly see that, although a lot of traffic is exchanged locally within the region, there is still a significant amount of traffic exchanged in more distant locations. As we already saw from the DNS measurements, a number of networks maintain connections to Internet exchange points in Northwest Europe, such as AMS-IX in Amsterdam, DE-CIX in Frankfurt and LINX in London. We also see VIX, the Vienna Internet Exchange, playing a large role. This is likely due in part to proximity, but probably also a result of the fact that the A1 Telekom Austria network is active in the region.

This behaviour of routing packets a long way to an exchange point, only to have them travel back to a destination close to the origin, is referred to as "tromboning". The farther a path extends from the origin/destination, the more inefficient the path is. The delay that this introduces might be so minimal as to not even be noticeable to an end user, but it generally increases costs for the network operator. More importantly, the additional distance travelled unnecessarily increases the risk of disruptions and often creates additional dependencies on external suppliers, many of which reside in foreign jurisdictions.

Figure 14:
In-region traffic paths



Colour of circle indicates path length, from shortest (green) to longest (red)

Width of line indicates number of paths

Size of circle indicates number of paths passing through this point

Farthest location reached by a path

Size of circle indicates number of paths with this location as their farthest point

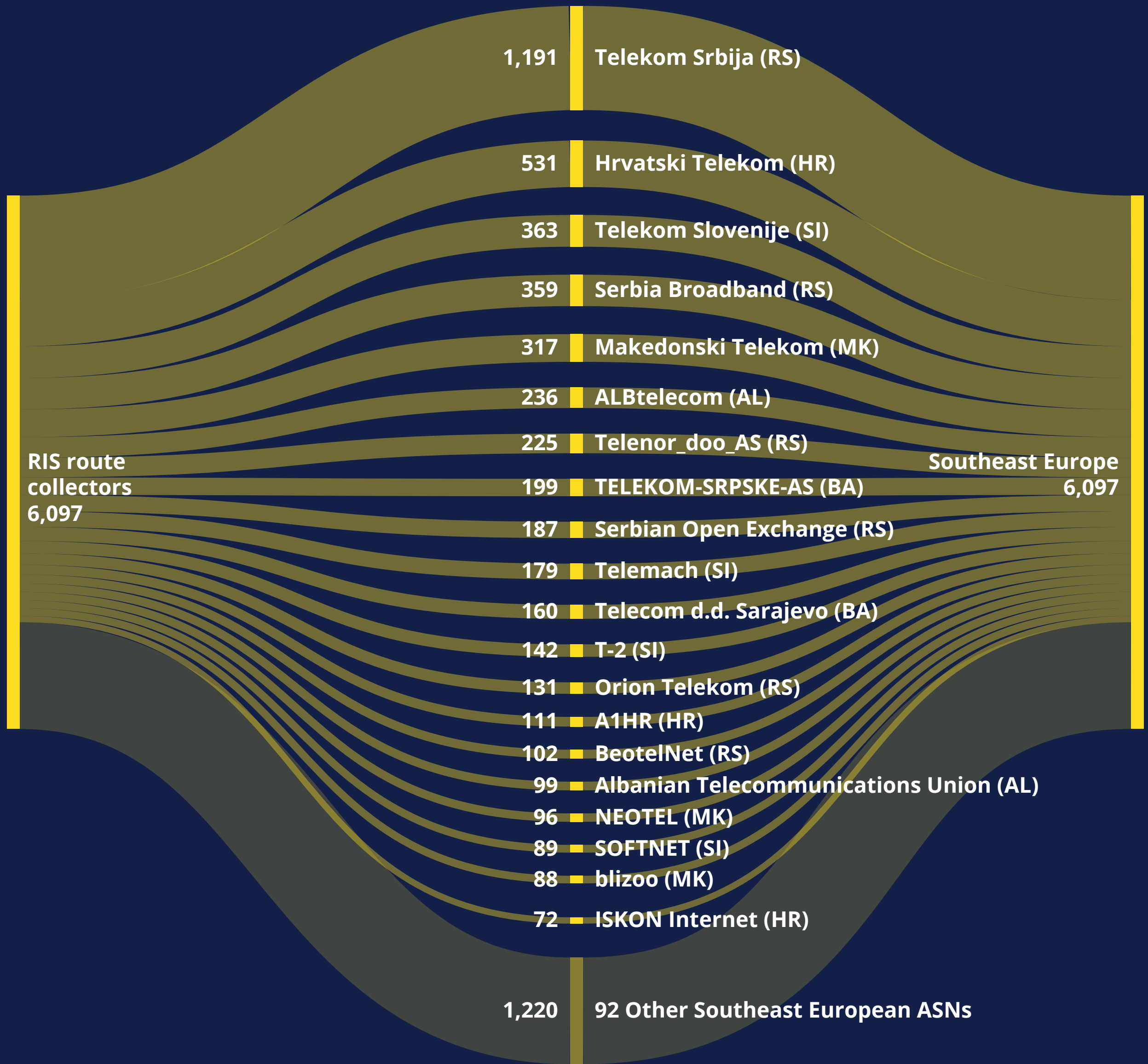
Over the years, several local Internet exchange points (IXPs) have been established to mitigate these effects and encourage the local exchange of Internet traffic. Some of these IXPs have been operating for a decade or longer, while others were established more recently.

Although every country in the region now has a local IXP, unfortunately we do not have enough RIPE Atlas probes or other data points to draw any conclusions about their effectiveness. However, if we filter out the paths that go outside the region, we get some insight into how traffic is exchanged locally within the region.

Figure 14 includes only the traffic paths that stay within the region, to examine where traffic is being exchanged locally. The role of IXPs in Ljubljana, Zagreb and Belgrade become more obvious here, where we see a lot of traffic being exchanged. But we also see many smaller concentrations around the other capitals. This could be a result of traffic being exchanged at the IXPs located there, but indicates that at least a portion of the traffic gets exchanged between operators at the local level.

It's worth noting that these figures are based on measurements that were taken at a particular point in time and therefore offer only a snapshot of the situation; however, measurements taken at any time would likely offer very similar results.

Figure 15:
Providers announcing Southeast European prefixes as seen by RIS route collectors



3. External View of Southeast Europe

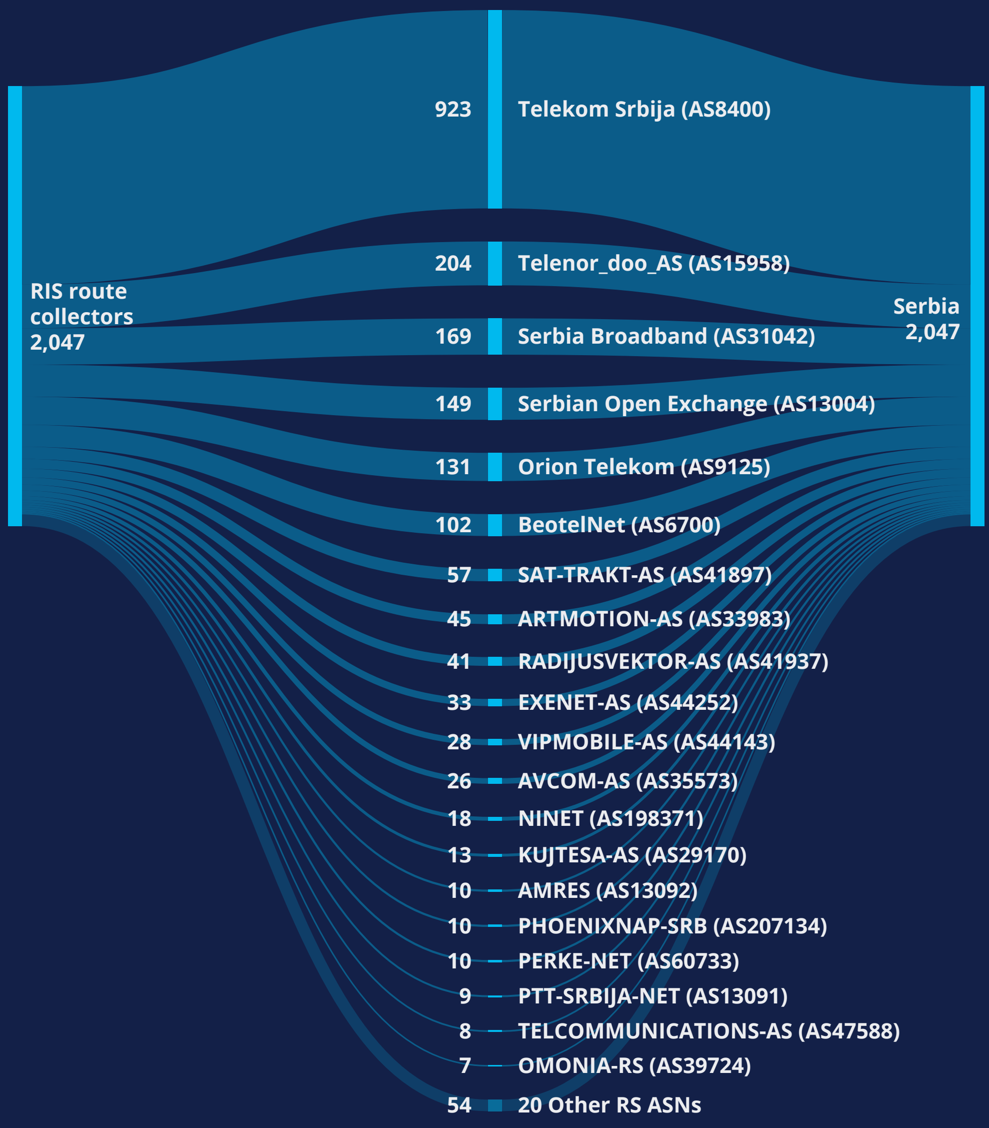
Turning now to look beyond regional traffic paths, we examine the paths available to traffic flowing into and out of Southeast Europe from the global Internet. To investigate how the rest of the Internet reaches networks in Southeast Europe, we look to the RIPE NCC's Routing Information Service (RIS), which uses a number of BGP data collectors to provide an overview of what other networks perceive as the best or shortest path to IP prefixes originating in the region.

In total, there are about 4,000 prefixes (i.e. blocks of IPv4 addresses) in the routing table that are located in the region. For each of these, we identified the first Southeast European network (ASN) encountered in paths from the RIS route collectors and counted the number of unique prefix/ first-ASN combinations, which totalled just over 6,000.

This gives an idea of which operators provide transit to international traffic entering Southeast Europe. If every prefix from the region had one unique entry point, the total number of paths would equal the number of prefixes. In practice, we see roughly 50% more, suggesting that some networks have more than one upstream provider announcing their IP prefixes (or parts thereof) – which in turn indicates a relatively modest amount of diversity in the number of paths into the region.

Indeed, the important role that the local incumbents still play in the region is immediately evident, with a number of (former) state telecommunications operators providing transit into the region, including Telekom Srbija, Hrvatski Telekom, Telekom Slovenije, Makedonski Telekom and ALBtelecom (the only provider in the top six here that isn't a (former) state operator is Serbia Broadband).

Figure 16:
Providers announcing Serbian prefixes as seen by RIS route collectors



We do see a number of "other" Southeast European networks, which together account for a significant fraction of transit into the country. This could be a sign of further diversity; however, these smaller networks could themselves be customers of a limited number of large, internationally operating, non-Southeast European transit networks.

Figures 16, 17 and 18 show the different operators providing transit into Serbia, Albania and Croatia (as a few examples of individual countries in the region[3]). We see some differences among them, yet all show a significant level of market consolidation, with a heavy reliance on a small number of larger providers.

This is certainly not unique to these countries or the region – similar concentration is taking place all over Europe and even on a global level. But there is concern, both in the Internet community as well as among policymakers, about the negative effects this consolidation can have on innovation and market resilience.

3 Figures for the other countries covered by the report are available at:
https://labs.ripe.net/Members/suzanne_taylor_muzzin/ripe-ncc-country-report-southeast-europe

Figure 17:
Providers announcing Albanian prefixes as seen by RIS route collectors

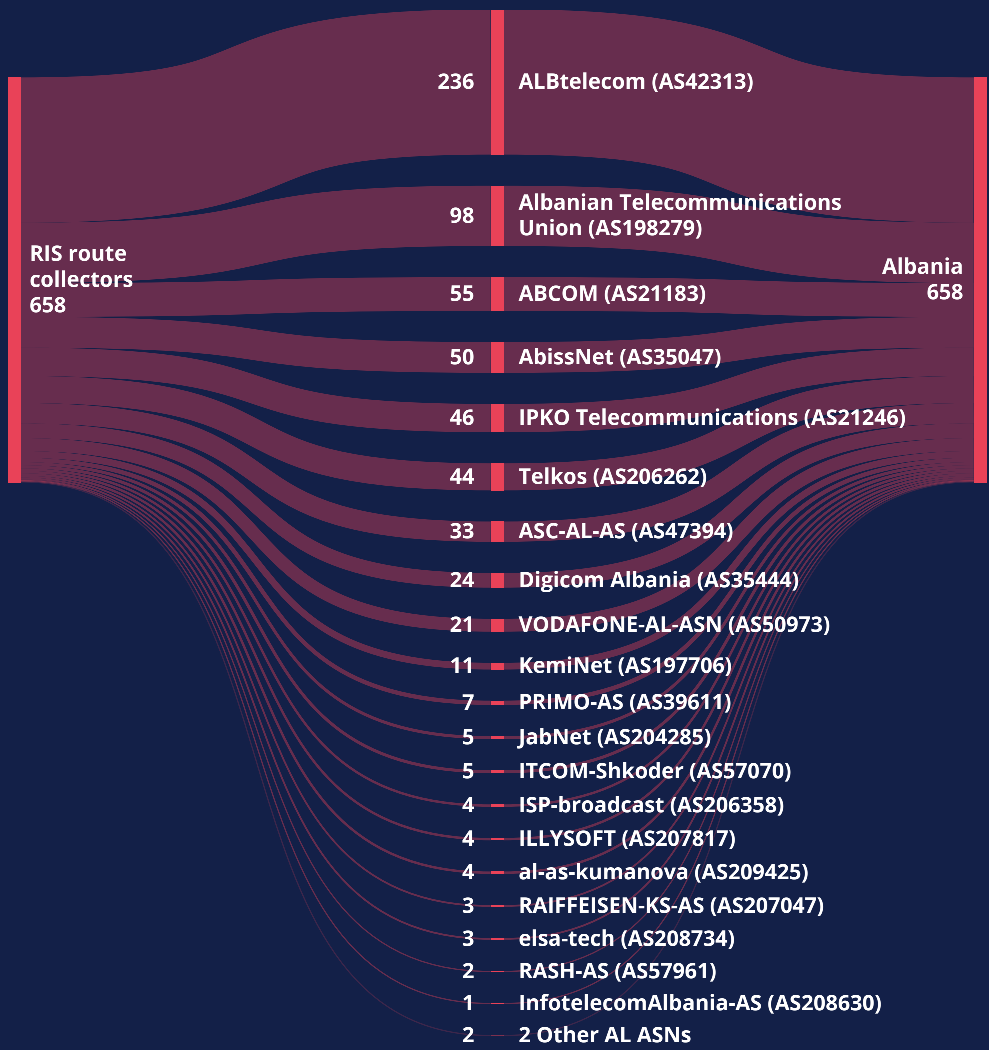


Figure 18:
Providers announcing Croatian prefixes as seen by RIS route collectors

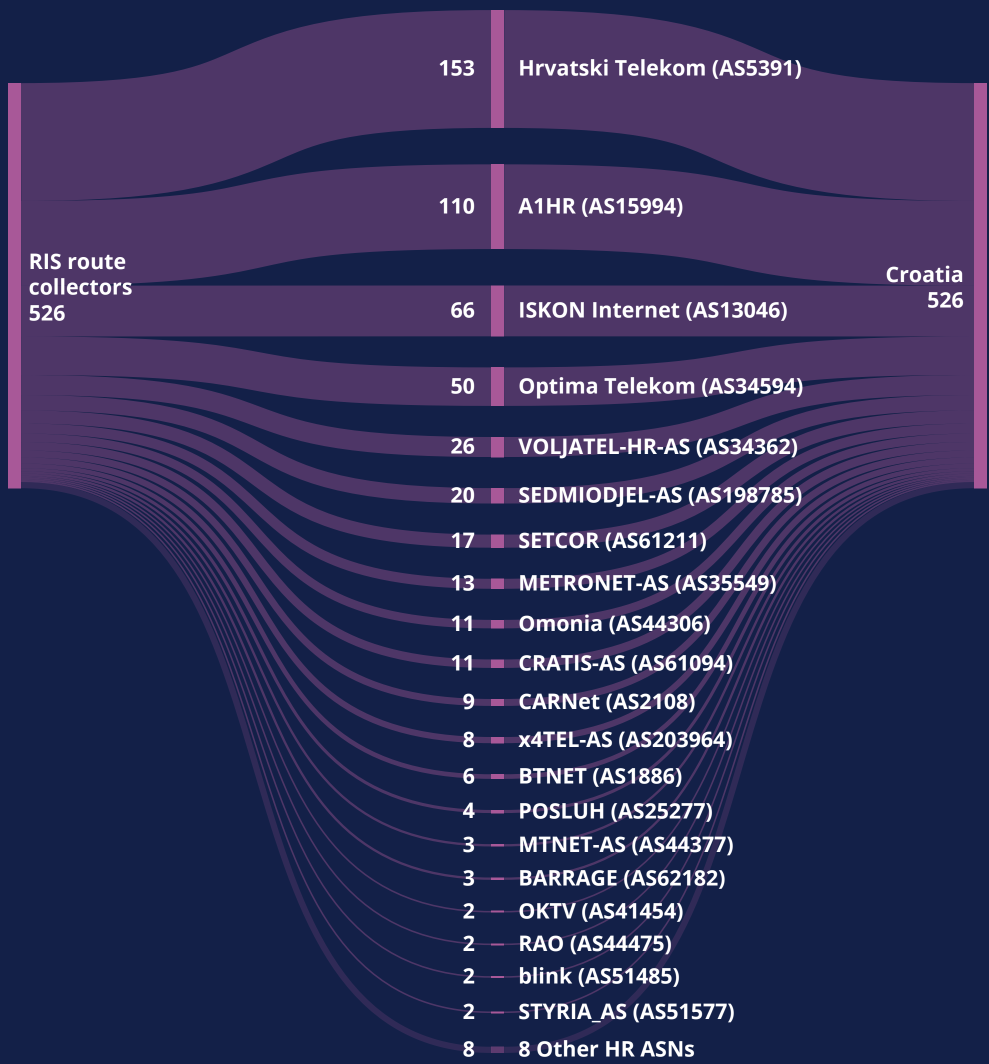


Figure 19:
Upstream operators providing connectivity into Serbia as seen from Brazil

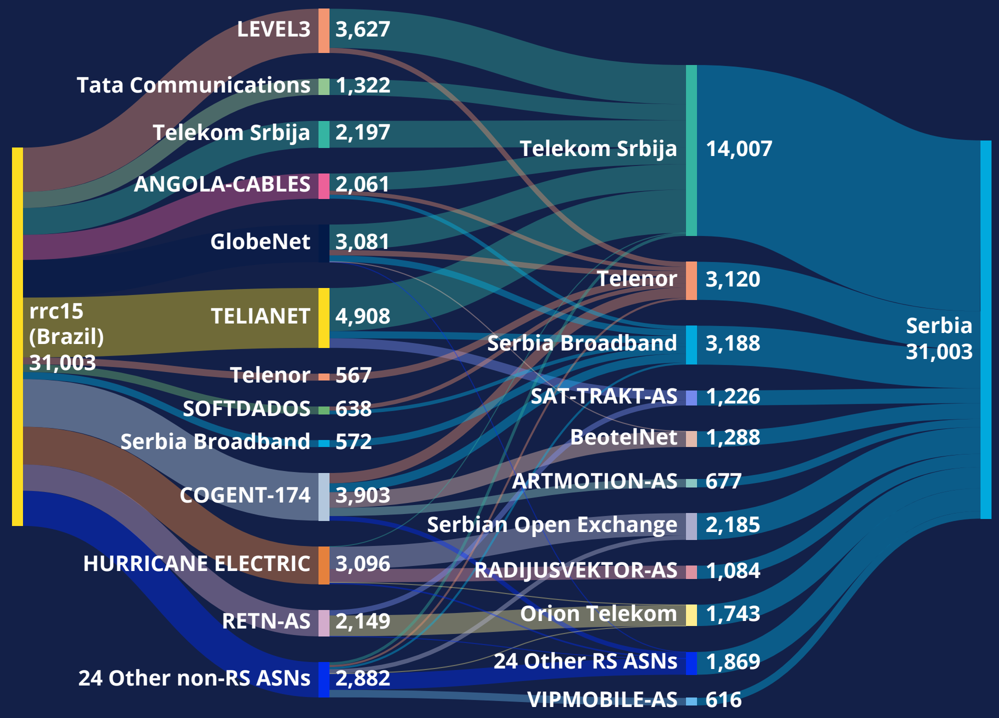
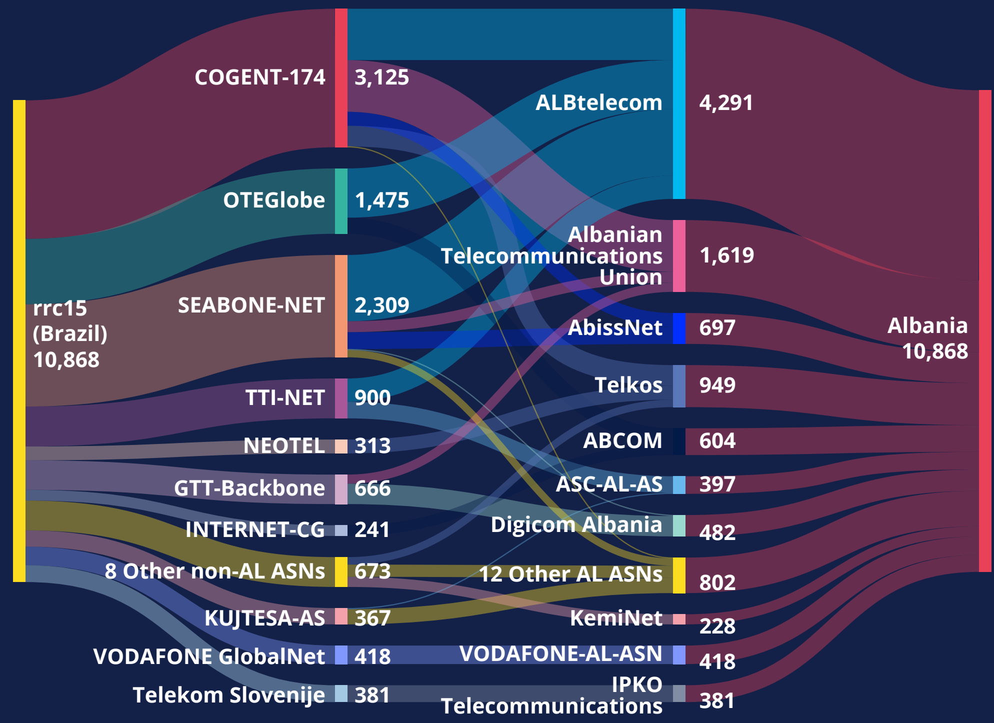


Figure 20:
Upstream operators providing connectivity into Albania as seen from Brazil



Using a similar method, we next identify the immediate upstream operators of the networks (ASNs) that provide international connectivity into Serbia and Albania, as two examples from the region, from our route collectors in Brazil (as an example of a distant location).

Looking at all the available paths from Brazil to the Serbian prefixes, we identify the last foreign ASN and the first Serbian ASN, and count more than 31,000 combinations.

Telekom Srbjia is seen in almost half of the paths into the country, and relies on parties such as Tata, Telianet and Level3 for a significant proportion of the international traffic – but it may also be providing transit to customers with their own ASN.

An interesting observation here is that we still see a role for Telenor, which has sold its local operations, but still plays a role in some of the routing to and from those networks.

Using the same approach for Albania, we see similar patterns emerge, but with a totally different set of operators involved. The local incumbent is still responsible for a significant number of the paths, but at the same time we see less diversity in the upstream providers.

More importantly, in comparison to the situation in Serbia, we see a number of local providers connecting to the same set of upstream providers. Providers like Cogent, OTE and Seabone provide connectivity not only to ALBtelecom, but other providers such as ATU. The presence of Seabone and OTE might be related to the various submarine cables that have a landing point in Albania and link the country directly to Italy and Greece.

Conclusion

The Internet industry is still developing in Southeast Europe, where the (former) state telecommunications operators still exert a lot of influence and there are smaller numbers of independent providers than we see in some other parts of Europe.

In addition, a number of out-of-region operators, such as Deutsche Telekom and A1 Telekom Austria, have a presence in the region, as reflected in the peering arrangements that become visible when looking at how traffic is routed within – and out of – the region. However, these peering arrangements don't have a major influence on end users in terms of response times, with the vast majority of round-trip times to the domain name system well within acceptable ranges.

The Southeast European landscape benefits from a modest amount of diversity when it comes to available routes into the region, although we again see the dominant role played by incumbents.

It's worth noting that all of the observations in this report are based on active paths, and there is likely an entire "hidden" world of backups that would automatically take over in the case of any disruptions. This redundancy provides the system with more resiliency.

As is the case in much of the world, the increasing shortage of IPv4 will become a bigger hurdle in connecting the remaining households that don't yet have fixed broadband access and in supporting future growth. To fully take advantage of the benefits promised by digital societies and economies, as well as to be able to support the roll-out of 5G and the development of IoT and other emerging technologies, the region should focus its efforts on encouraging IPv6 deployment.

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, which can be accessed from https://www.ripe.net

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 at ways to get more RIPE Atlas probes connected and to find network operators willing to host RIS collectors. 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