LEBANON COUNTRY REPORT

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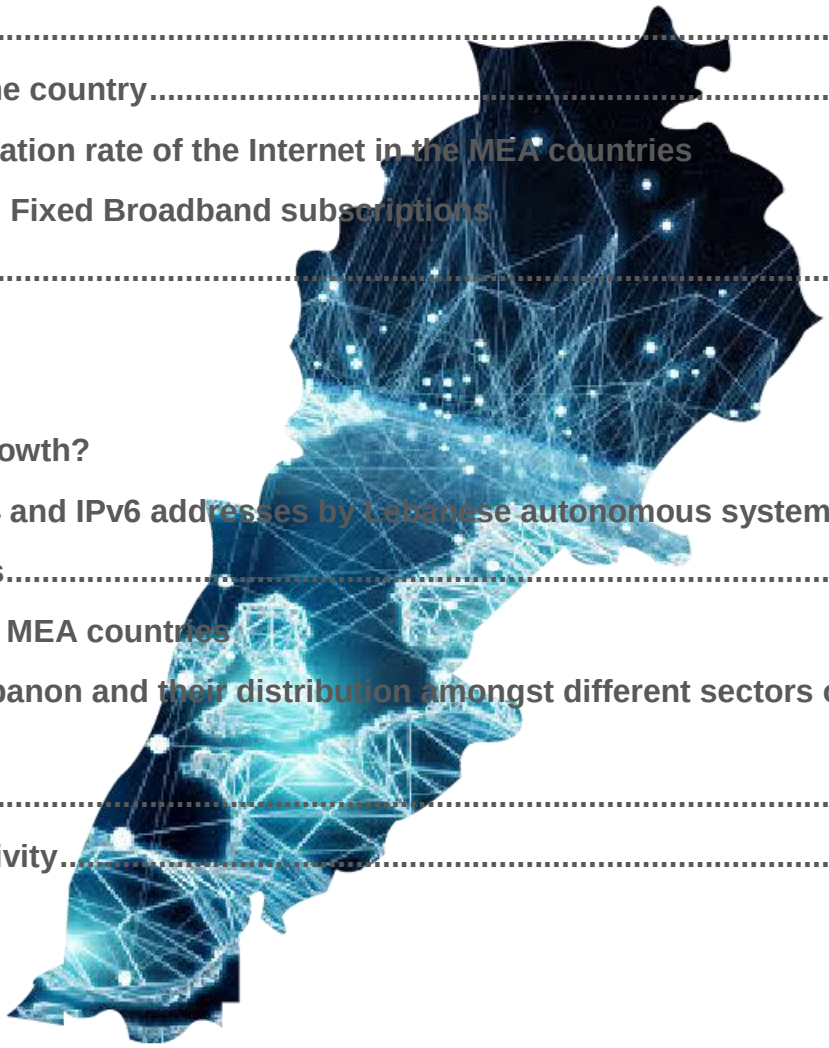

INTRODUCTION

This report aims to describe the current state of the Internet in Lebanon. It offers an analysis of growth trends and Internet routing in the country.

We will discuss the use of the Internet across the country based on data from the International Telecom Union (ITU) portraying the evolution of penetration rate of the Internet in the MEA countries as well as mobile cellular and fixed broadband subscriptions.

Then we will analyze addressing modes by touching upon LIR registered accounts to RIPE NCC determining the countries of origin of LIRs offering services in Lebanon.

Other parts of the report explore IPv4 holdings and the growth in the number of the prefixes in the Middle East which data was gathered from RIPE NCC's website. We go into the exhaustion timeline of IPv4 then we deduct a potential growth in IPv6 from the observation of the data similarly collected.

Subsequently, we visualize with interactive graphs made using the Python Plotly library (entire code will be available on Github) the distribution of IPv4 and IPv6 addresses by Lebanese autonomous systems taking away from it what autonomous systems have the biggest share of addresses.

Following this, our code will also allow us to view the results obtained from the RIPE database portraying autonomous systems' evolution in Lebanon highlighting the different sectors of activity from ISPs to banks to universities …

We then study internal routing in the country with the statistics we got from performing traceroutes between online Lebanese probes.

Finally, we highlight Lebanon's international connectivity with an interactive Sankey diagram illustrating which networks provide BGP route announcements.

This would be the first detailed report done for Lebanon. We hope to provide technical insight and make the data available to the local community and decision makers. Hence, supporting the internet development in the country.

1. INTERNET USE ACROSS THE COUNTRY

Evolution of penetration rate of the Internet in the MEA countries

The percentage of people using the Internet across the Middle Eastern countries has been increasing quite steadily in most of them and at a rapid rate in some others (i.e UAE, Lebanon). Figure 1 shows that Lebanon places in the middle.

In 2001, the penetration rate was extremely low (less than 10%) and began to increase rapidly between 2008 and 2013. However, this evolution slowed down around 2014. This may be due to the government cutting off access to mobile Internet services in Arsal in the northeast of Lebanon in 2014 for political reasons. This shutdown lasted around three years. Moreover, in July 2015, there was a breakdown of several thousand telephone and Internet lines in Beirut due to the waste incineration.

In 2017, Lebanon's penetration rate reached 78% which gives room for future growth and investment.

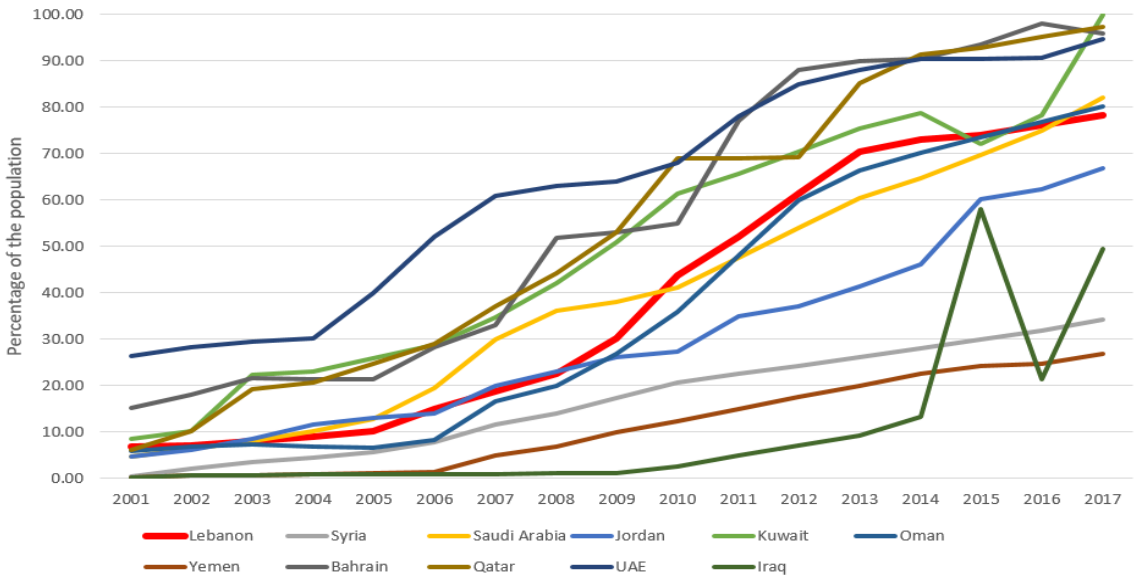

Figure 1: Growth of Internet users (in percentage) in the Middle East from 2001 to the end of 2017
Source: ITU (International Telecommunication Union)

Mobile Cellular and Fixed Broadband subscriptions

The same global curve of evolution previously noted can be seen in the mobile cellular subscriptions as Figure 2 records an important increase in the end of 2008. This evolution stagnates after 2011.

Concerning the fixed broadband subscription, it has slightly increased all through 2014. However, what is more noticeable is its drastic decrease in 2018 (0.14%). This could be explained by the kickoff of the 4G data service in 2013 and people leaning more towards mobile cellular.

Furthermore, a large gap in percentages is noticed between fixed broadband and mobile cellular. In fact, there are much more mobile subscriptions than fixed. This is due to the many benefits offered by mobile cellular such as higher latency (30 to 50 Mbps in 2015) and portability.

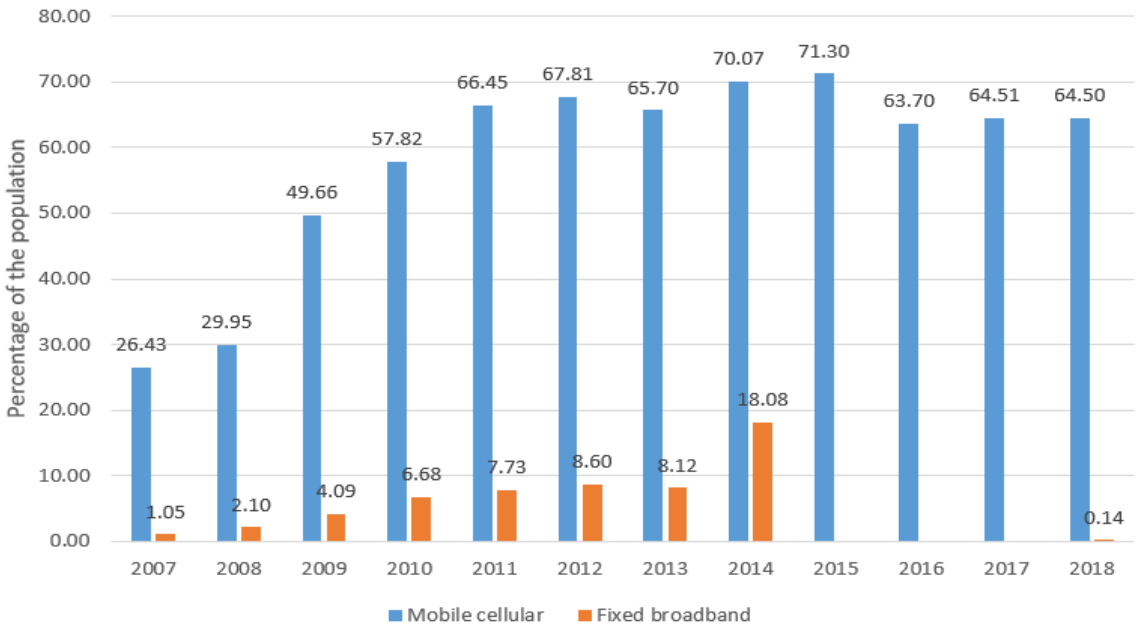

Figure 2: Evolution of mobile cellular and fixed broadband subscriptions (in percentage) in Lebanon from 2007 to 2018. No data was available for the years 2015 to 2017
Source: ITU (International Telecommunication Union)

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Mobile cellular works by connecting to a mobile network with a SIM card. Fixed line broadband, on the other hand, is the Internet connection delivered via your phone line or through the provider's network of cables.

2. ADDRESSING MODES

LIR Accounts

First, a quick glance at Figure 4 shows that in most of the Middle East countries, the number of LIRs increases at a constant rate between 2017 and 2019.

Nonetheless, it is important to acknowledge that although the number of LIR is quite a good indicator of a growing Internet market in the concerned countries, it is not always the case. Indeed, in the era of an IPv4 hunting, multiplying the LIRs is very often a way for the Internet landscape stakeholders (ISPs, tech companies, and various other autonomous systems) to acquire more IPv4 /24 address blocs despite RIPE NCC's policies that have had the tendency to slow down this market since 2012. In the same logic, some ISPs have subsequently encouraged the network operators, whom they are the providers of, to become LIRs themselves to avoid the near future situation where they could not continue to fulfill their demand in IPv4 addresses. It is then noteworthy to recall that an already existing LIR from 2012 or probably before that benefits from a very large IPv4 stock while a newly registered one (after 2012) would be limited to the to the acquisition of only 256 addresses (equivalent to one /24 block) from RIPE NCC.

On another note, some growing autonomous systems in the public and private sectors, such as banks, network operators or governments, manifest a growing likelihood to gain greater control, responsibility and independence over their traffic flow which encourages them to become LIRs themselves so they can manage more efficiently their own IP blocs.

Second, Turkey (TR) and Iran (IR) draw attention by their significant dominance in LIR accounts' abundance. This is the logical consequence of the advance they already had in 2010 in terms of IPv4 allocated spaces: they had respectively around 150 and 40 IPv4 /16 prefixes, when Lebanon (LB), Qatar (QA) or Jordan (JO) barely had 10 IPv4 /16.

Concerning Lebanon, another factor that played in favor of the LIRs numbers' uprising is the changing in regulation in 2014 that allowed for the licensing of more service providers. The latter modification initiated an increase that will reach around 204% in 6 years, making the number of LIRs on the Lebanese soil jump from 50 in 2014 to 152 in 2019.

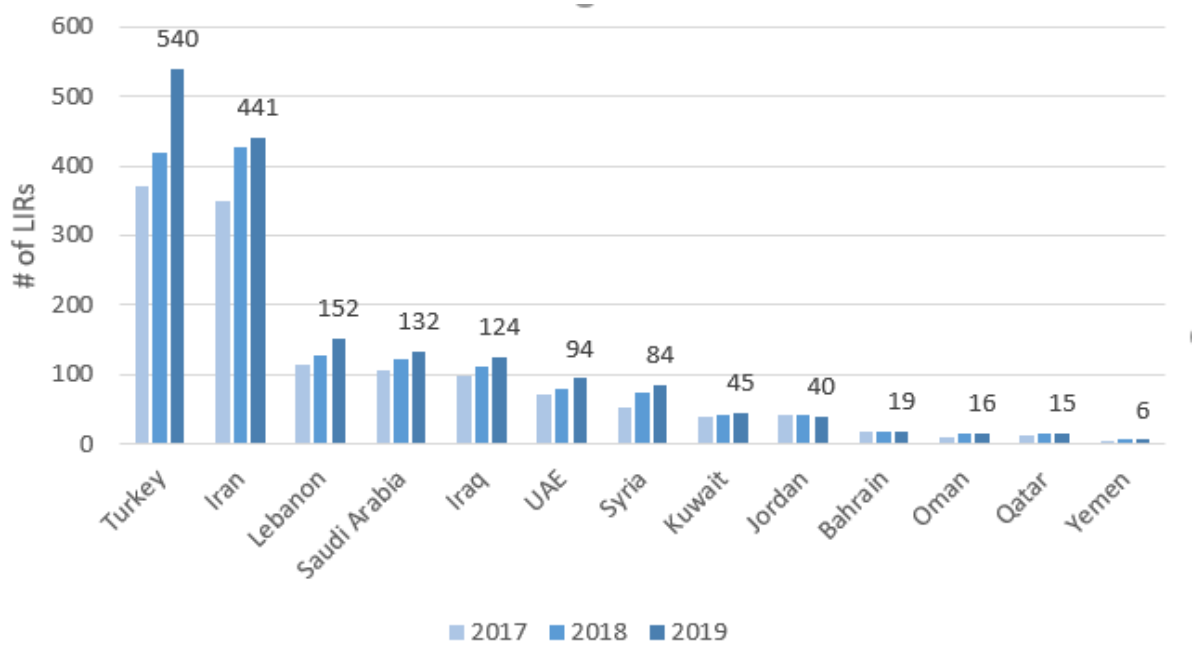
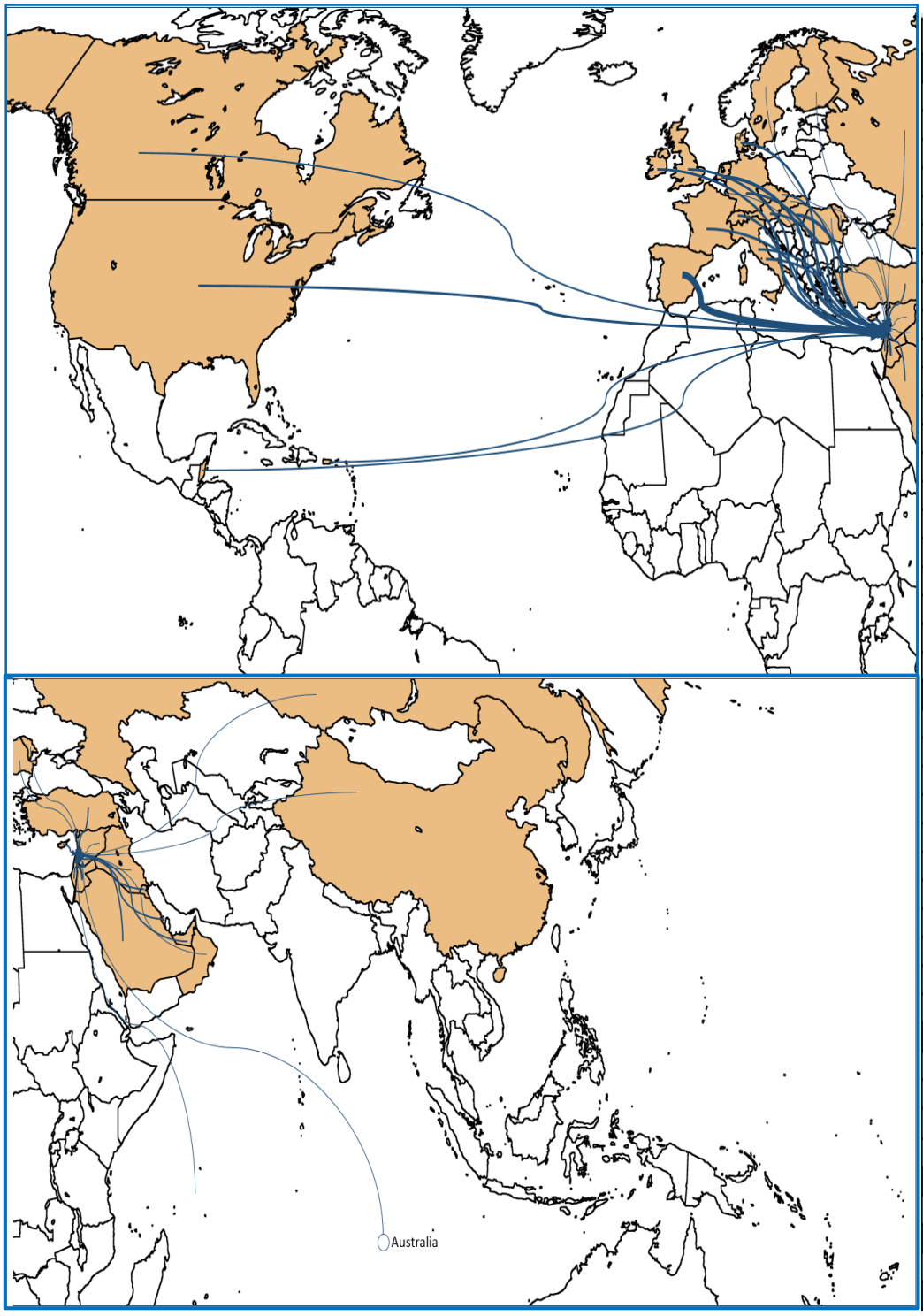


Figure 3: Evolution of the number of LIRs (Local Internet Registries) in the Middle East from 2017 to 2019
Source: RIPE NCC

Figure 4 shows that many LIRs from all around the world are responsible for the transfer of resources to Lebanon. Most of them originate from European countries mainly Spain but also Hungary and the Netherlands. We also note transfers between the country itself and its MEA neighbors.

In fact, the IPv4 crisis in the midst of the development of Arab countries pushed them to import more resources. This is the main reason for the upraise of the secondary IPv4 market in which Lebanon is very active. This would possibly allow for a decrease in the ratio of the number of IPs per internet user, which in the moment is too high, explaining the overuse of NAT as mentioned later on in the report.



Number of LIRs offering services in Lebanon	
EUROPE	
Spain	163
Hungary	29
Netherland	15
UK	8
France	7
Czech Republic	4
Denmark	3
Ireland	3
Switzerland	3
Austria	2
Cyprus	2
Germany	2
Italy	2
Holy See	2
Moldova	1
Luxembourg	1
Romania	1
Russia	1
Sweden	1
Slovakia	1
Finland	1
MEA	
Lebanon	8
Jordan	6
Saudi Arabia	4
Bahrain	3
Kuwait	3
United Arab Emirates	3
Occupied Palestine	2
Oman	1
Syria	1
Iraq	1
Turkey	2
NORTH AMERICA	
United States	8
Virgin Islands, British	3
Canada	2
Belize	2
EAST ASIA	
China	1
AFRICA	
Seychelles	1
AUSTRALIA	1

Figure 4: Resources transfers to Lebanon (by number of LIRs)
Source: RIPE NCC

IPv4 Holdings

To come back to the shortage of IPv4 address blocs (/8) in the RIPE NCC community, we wouldn't have been surprised to see a flattening of the curves showing the number of prefixes acquired by the different countries in the Middle East. This is not the case as Figure 4 proves it. On the contrary, the growth continues to shoot up over the years, with a skyrocketing record in Turkey (TR), Saudi Arabia (SA) and Iran (IR) whom IPv4 resources have more than doubled in just a few years.

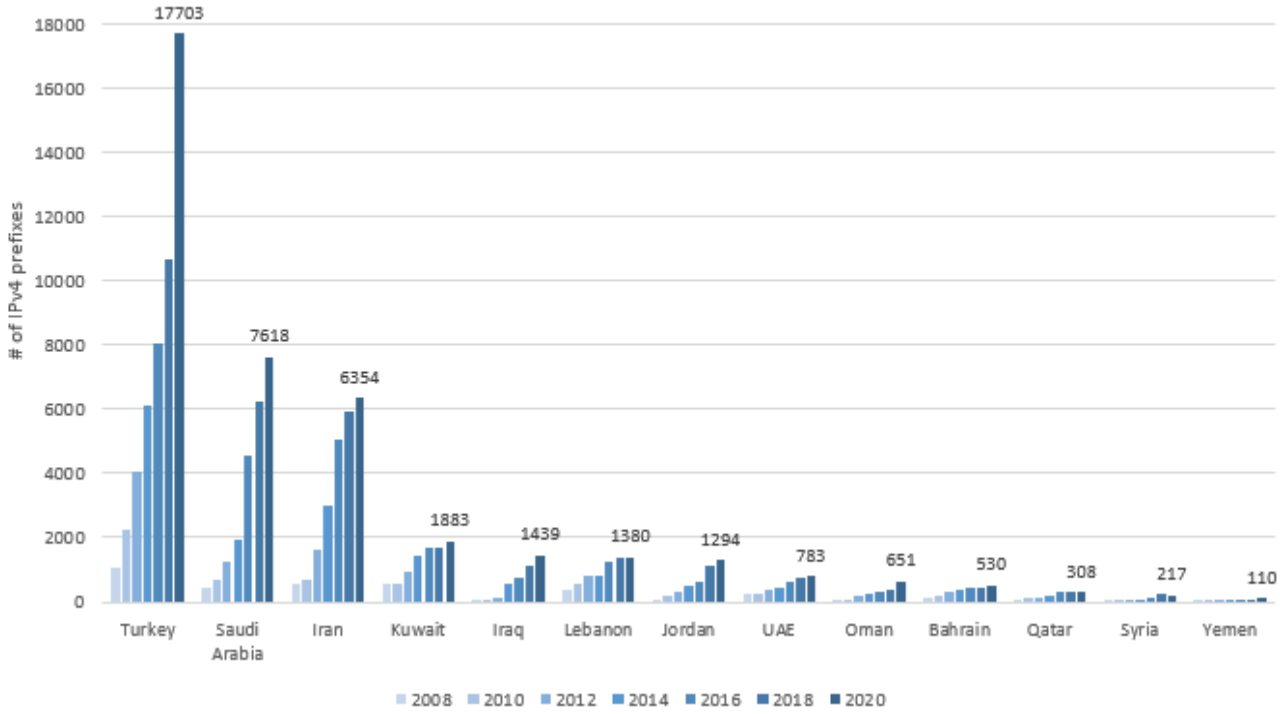


Figure 5: Growth in the number of IPv4 prefixes in the Middle East from 2012 to 2020
Source: RIPE NCC

This can be explained by the existence of a secondary market on IPv4, a phenomenon that can be observed in most countries in the world, even beyond the borders of the region covered by RIPE NCC. Indeed, a vast majority of services stay reluctant to the IPv6 transition.

IPv4 exhaustion, a small background:

Four of the five RIRs (Regional Internet Registry) have already ran out of their original IPv4 blocks. Only AFRINIC still has a single non-allocated /11 block as part of its last /8 block, which means it has entered phase 2 of exhaustion.

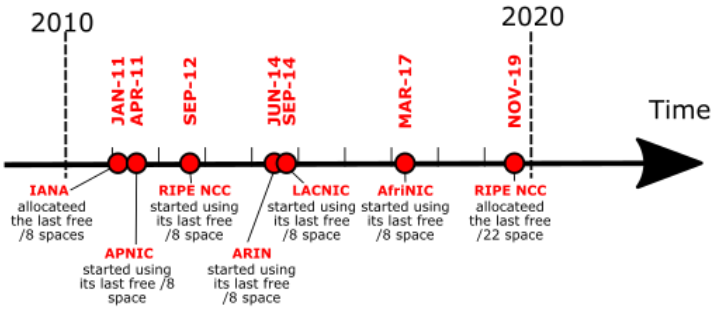


Figure 6: IPv4 exhaustion timeline for the different RIRs
Author: Michel Bakni

IPv6, a Possible Growth?

IPv6 has had quite a slow kick off when in fact the IPv6 Forum was founded by the IETF (Internet Engineering Task Force) Deployment WG (Working Groups) to drive deployment worldwide back in February 1999. It is not until June 6, 2012 that the Internet Society held World IPv6 Launch Day, a global and permanent deployment of IPv6. However, the results were not up to the expectations of the Internet community worldwide including the Middle Eastern countries, Lebanon being one of them.

Nonetheless, we cannot deny the perceptible efforts that Lebanon is putting in the deployment of IPv6 among its networks and services, as it is developed in the next paragraph.

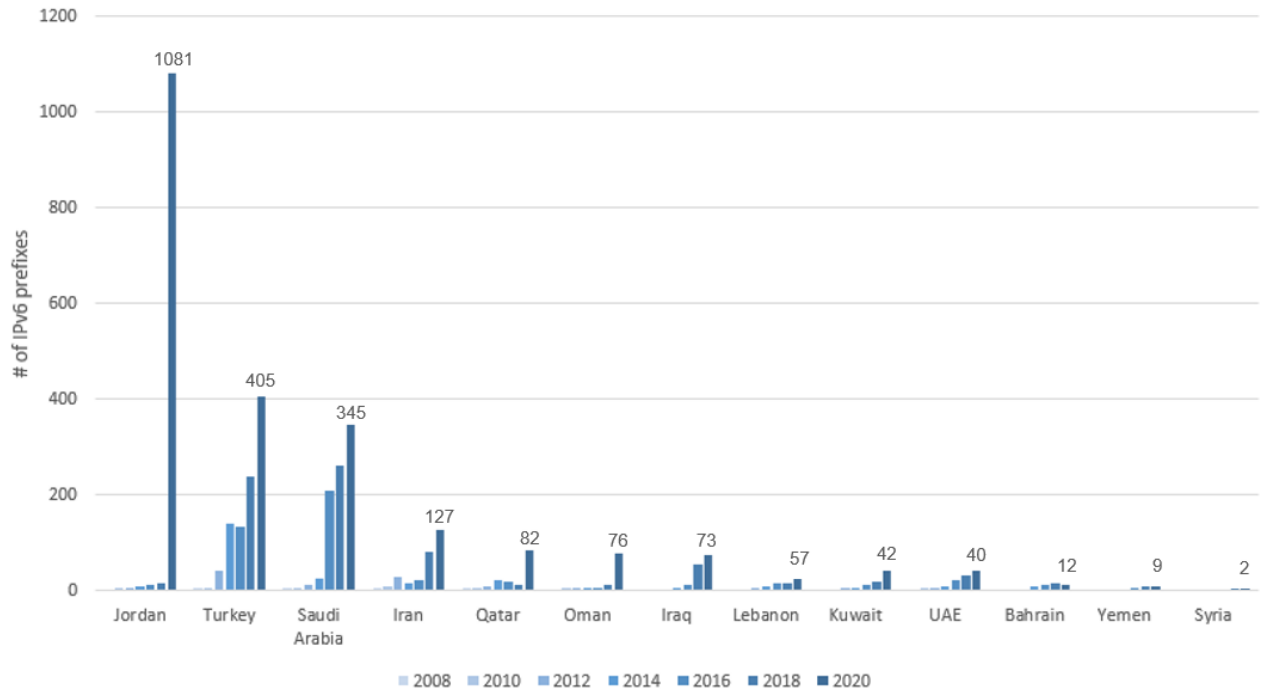


Figure 7: Growth in the number of IPv6 prefixes in the Middle East from 2012 to 2020
Source: RIPE NCC

Distribution of IPv4 and IPv6 addresses by Lebanese autonomous systems

Figure 8 shows the distribution of IP addresses by autonomous systems up to May 2020. As of today, we count approximatively 600 000 IPv4 addresses and only 65 IPv6 prefixes (it has increased a bit since January 2020 which is the value displayed in Figure 7). This may sound contradictory considering that the number of Internet subscribers in the country in 2020 is in millions, a paradox that can only be explained by an overutilization of the NAT protocol.

As expected, when it comes to IPv4, the state-owned enterprise Ogero Telecom holds 22,9% on its own, nearly a quarter of the total address space share of all autonomous systems in the country. It however stays well distributed between the private and the public sectors as it can be noticed through the market share of the main private ISPs: IncoNet Data Management, also known as IDM (13,8%), Sodetel (12,5%) and Terranet (6,73%).

Regarding IPv6, we note at first glance a plethora of actors in the pie diagram which denotes a clear willingness from the whole national Internet community to take the step towards an effective IPv6 deployment. Notably, the main ISPs Ogero, Sodetel, SafawiNet and Terranet have begun to initiate this transition, with 7 to 8 IPv6 prefixes each. We also notice that the mobile network operator Alfa (MobileInterimCompany1) has a share of IPv6 prefixes. In fact, in October 2018, Alfa managed by Orascom TMT launched IPv6. “This launch supports Alfa's strategy to further enhance the capabilities of our network to enable Internet of Things and smart services, in addition to supporting the development plans of the government, ministries, companies, application developers and entrepreneurs, therefore enhancing the capabilities of the telecommunications sector and contributing to economic growth […] it also enhances cyber and digital security and serves Alfa’s approach in the field of sustainable development.” *(via https://www.alfa.com.lb/en/media-center/press-releases/alfa*-launches-*ipv6).*

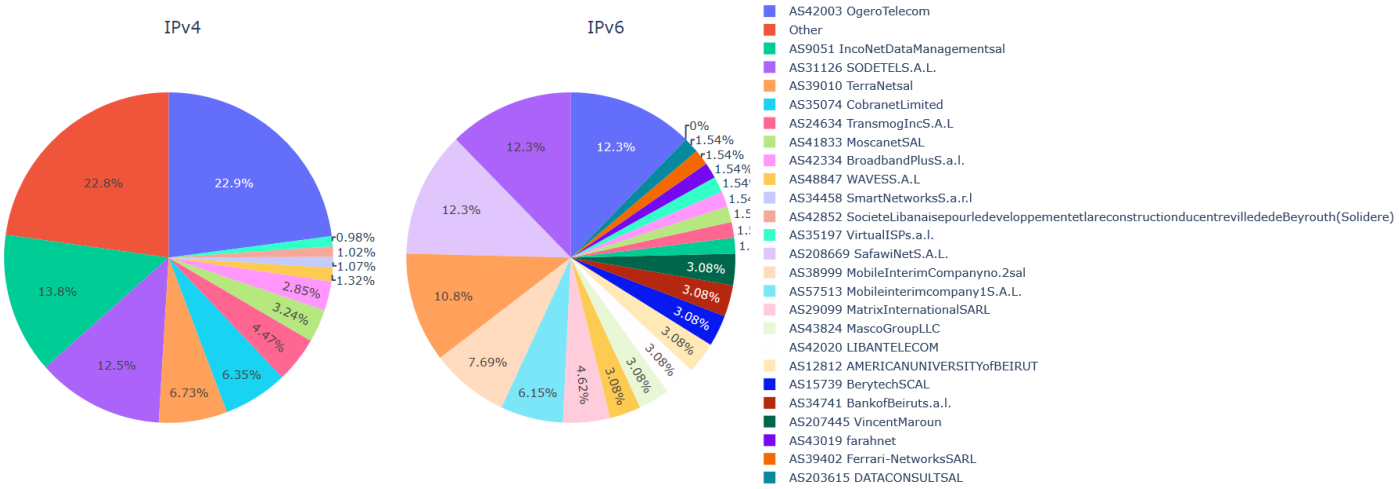


Figure 8: Distribution of IPv4 addresses and IPv6 prefixes by ASes
The category “Other” represents ASes having less than 5000 IPv4 addresses

Interactive graph available for download on the following link:
https://drive.google.com/open?id=1hfLHoNvJTwbKEyKftKvIBR9FKAFN3-lN

3. AUTONOMOUS SYSTEMS

AS evolution in the Middle East countries

Besides Iran and Turkey whose number of autonomous systems is remarkably high, we can see that the number of ASes in most Middle Eastern countries has stagnated or slightly increased for some and has quadrupled for others during the last decade. Saudi Arabia has a curve of its own considering the continuous increase in the number of ASes. Concerning Lebanon, Figure 9 illustrates an important peek in 2016 that is explained by the 2015 regulation in the country. Consequently, Lebanon has seen its AS numbers jump from 15 in 2007 to 140 in 2020.

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

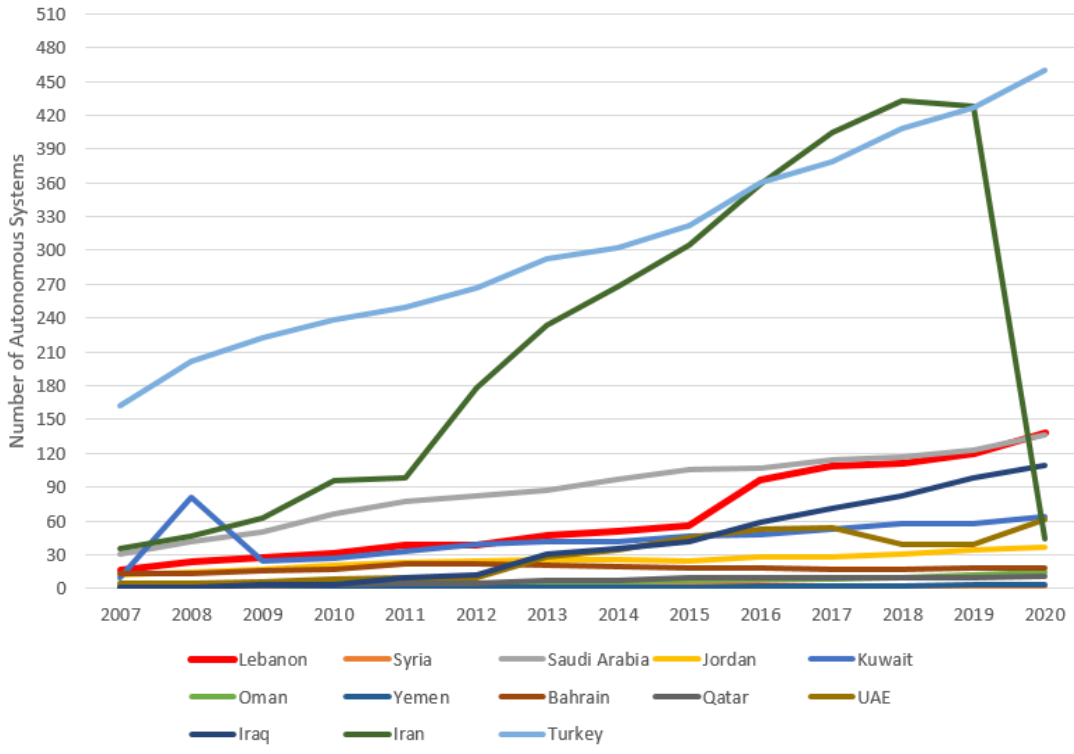


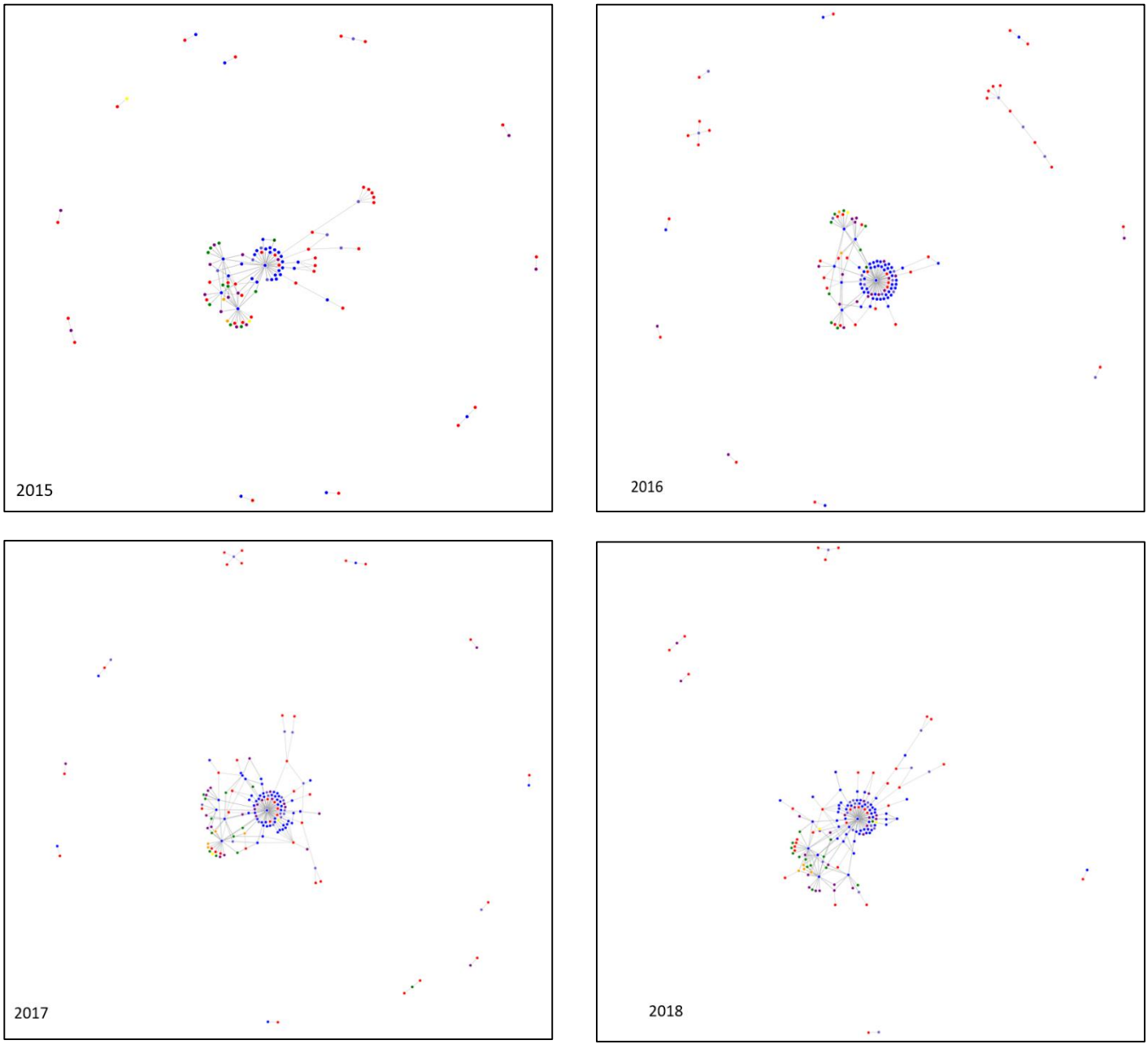
Figure 9: Evolution of the number of autonomous systems in the Middle Eastern countries from 2007 to 2020
Source: RIPE NCC

AS evolution in Lebanon and their distribution amongst different sectors of activity

Overview

Figure 11 is a force-directed graph portraying the different ASes by sector of activity. Each node represents an AS and each edge between two nodes means the correspondent ASes are directly connected.

At a first glance, we can clearly see an evolution in the number of autonomous systems in the country as well as the different local and international connections (red nodes being international ASes).



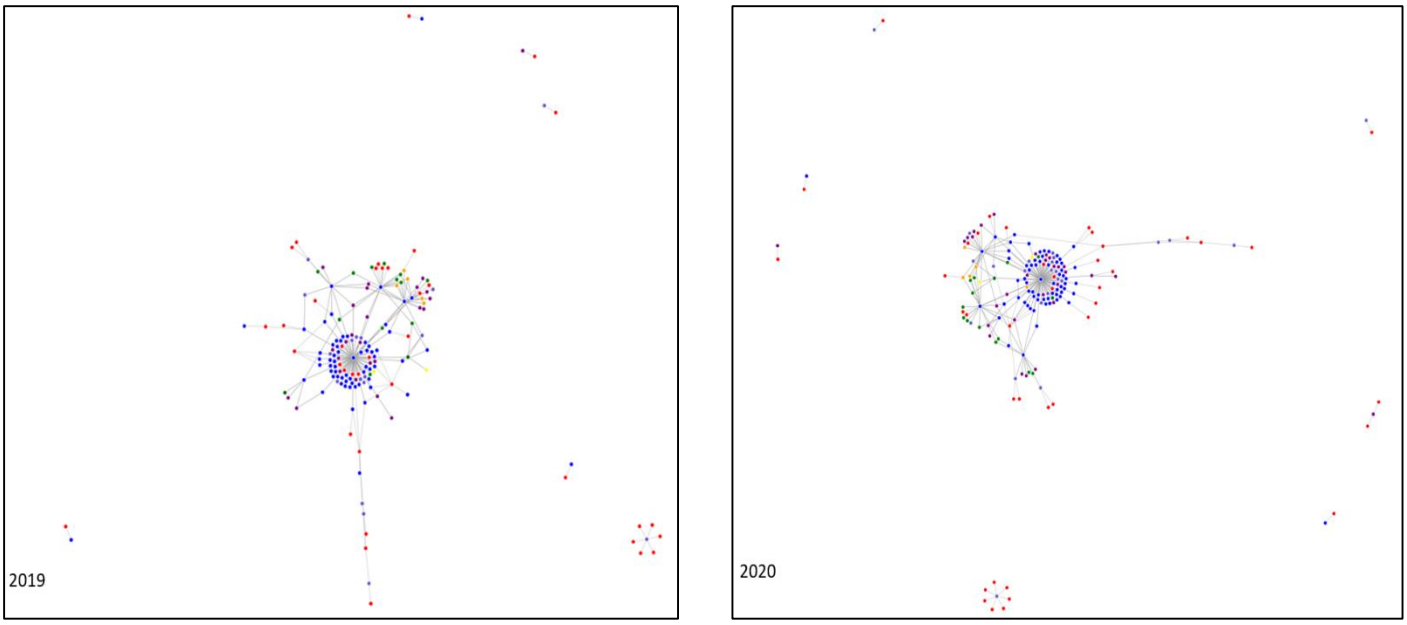
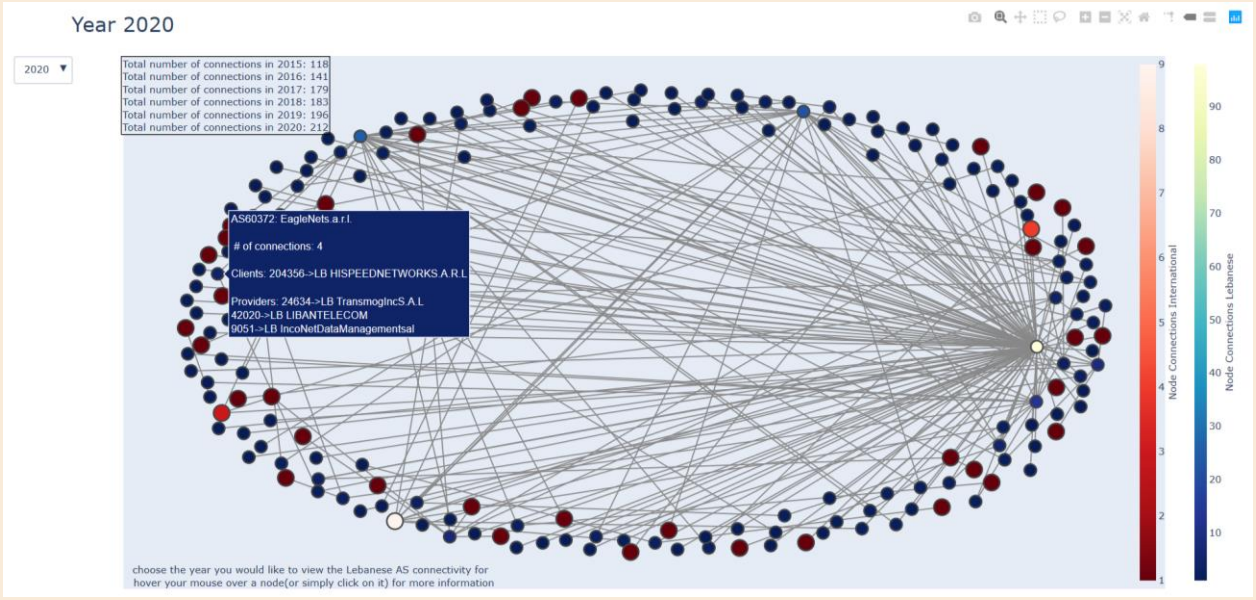


Figure 10: Overview on the AS interconnections from 2015 to 2020

Graph edges go from a count of 118 in 2015 to 212 in 2020 which shows an important increase of AS paths. At the center lies LibanTelecom, the country's main ISP having 94 local clients in 2020. Providers of LibanTelecom include Level3 (US) ,BTN (US),OpenTransit Orange(FR) and SeaBone Net (IT).

Full interactive graphs available for download on the following link:

https://drive.google.com/open?id=1hfLHoNvJTwbKEyKftKvIBR9FKAFN3-lN



Detailed view and analysis

Figures 12 to 17 show in more depth the Lebanese ecosystem evolution over the last five years and its ramification amongst numerous and varied activity sectors. They notably highlight a diversification of actors which underlines a desire for more autonomy. Governments, banks, academic institutions are seeking more privacy and more control over their network. This also denotes a well spread awareness about basic cybersecurity issues.

Some flaws also appear and persist throughout the half-decade evolution such as the centralized structure that the majority of ISPs seem to constitute by being agglomerated around LibanTelecom (AS42020). This topology results in a lack of resilience in case of any problem in the connections related to LibanTelecom (technical, political or strategic).

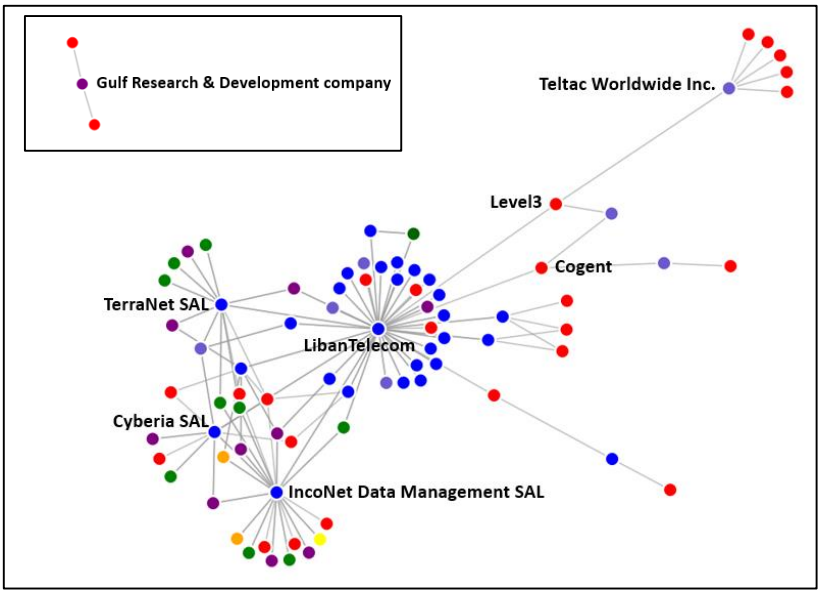


Figure 11: Detailed view of the AS interconnections in 2015

Finally these graphs also provide important incentives on the AS paths available, thus giving an interesting idea on different parameters such as the number of hops a packet has to pass through to reach the global Internet, the delays (linked to the length of the taken path) and the redundancy on the networks.

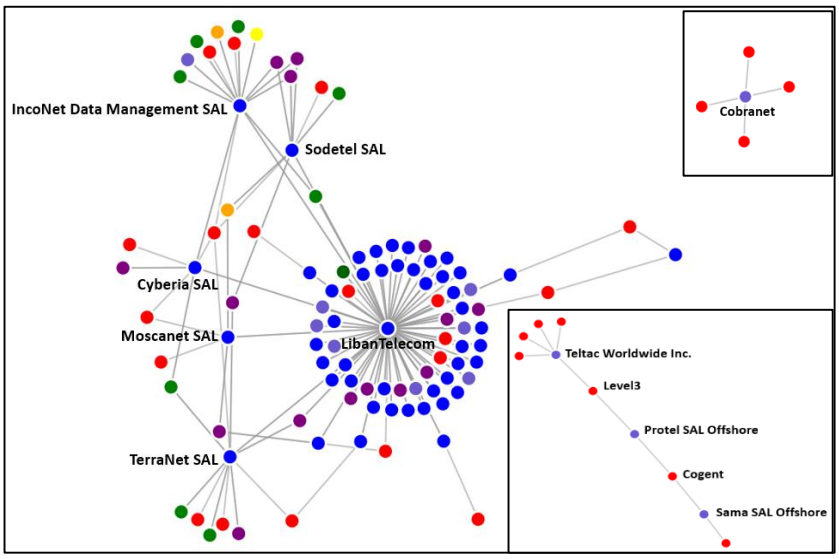


Figure 12: Detailed view of the AS interconnections in 2016

In 2015, the majority of Lebanese ASes were ISPs (colored in blue) along with only a handful of networks owned by banks. Approximatively all of the ISPs were linked to LibanTelecom, an enterprise owned and managed directly by the Lebanese Government. It was in its turn their one and only gateway to international tiers 1 such as Cogent and Level3, a monopoly that could be seen as threatening for the development and the stability of the national Internet landscape, although there were already some alternative paths passing by IDM or Cyberia.

In 2016, the most significant change was the blooming of a number of new ISPs (also in the LibanTelecom-centered cluster). This arised as a consequence of the changing legislations in 2015, that gave small operators the opportunity to get licensed and registered as ISPs.

In the following years, this cluster continued to grow in size on a steady pace without fundamentally changing the nature of its topology. Some recurrent observations could be highlighted:

- The meshing between the main ISPs (IDM, Cyberia and Terranet) got strengthened: we can see a clear increase in the number of edges between the corresponding nodes
- The international connectivity becomes direct with more and more ISPs, which provides a greater autonomy. More details on the international connectivity that Lebanon has already achieved are available in the next section
- Terranet appears to be particularly attractive for the banking sector and benefits from a rising international connectivity. This coincidence probably derives from the important Lebanese diaspora whose existence requires a proper and secure infrastructure of the banking sector for the exchange of funds between the diaspora and their families
- The government first possessed a single AS, and then only two since 2017. This underlines a public sector that still needs a lot of improvement in regards to the digitalization and the structuring of its virtual infrastructure
- A growing number of universities and academic institutions are acquiring the status of independent AS. Their presence in this sector comes from their willingness to not only gain better control over their networks but also and most importantly take part as actors in the Lebanese transition toward a better and more stable Internet ecosystem

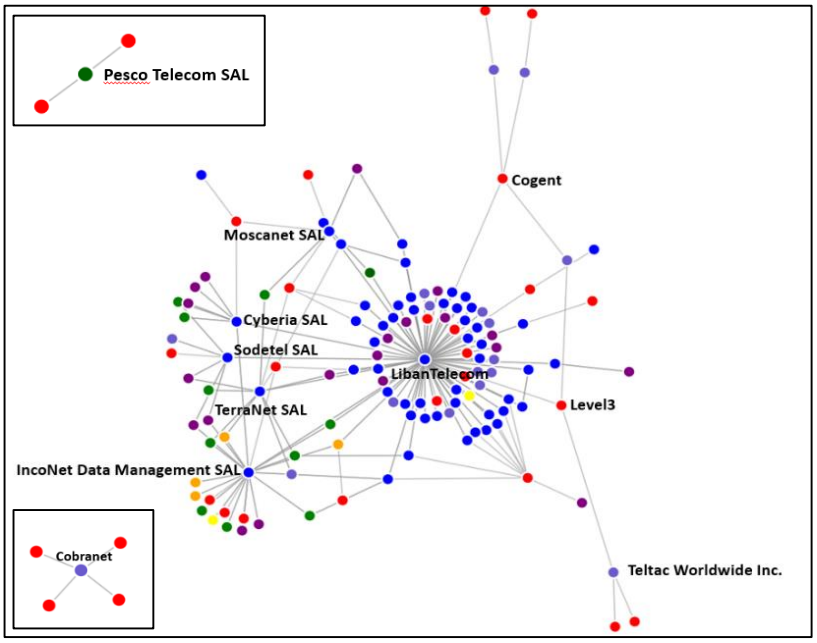


Figure 14: Detailed view of the AS interconnections in 2017

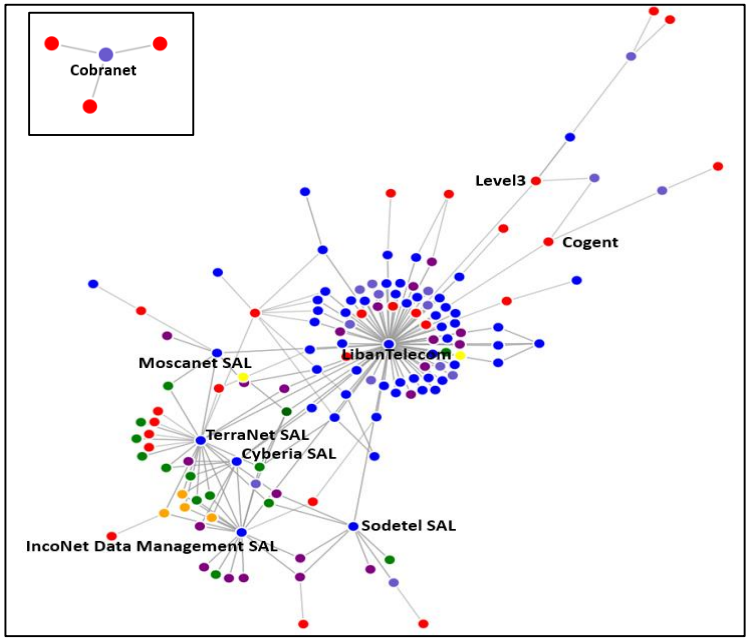


Figure 15: Detailed view of the AS interconnections in 2018

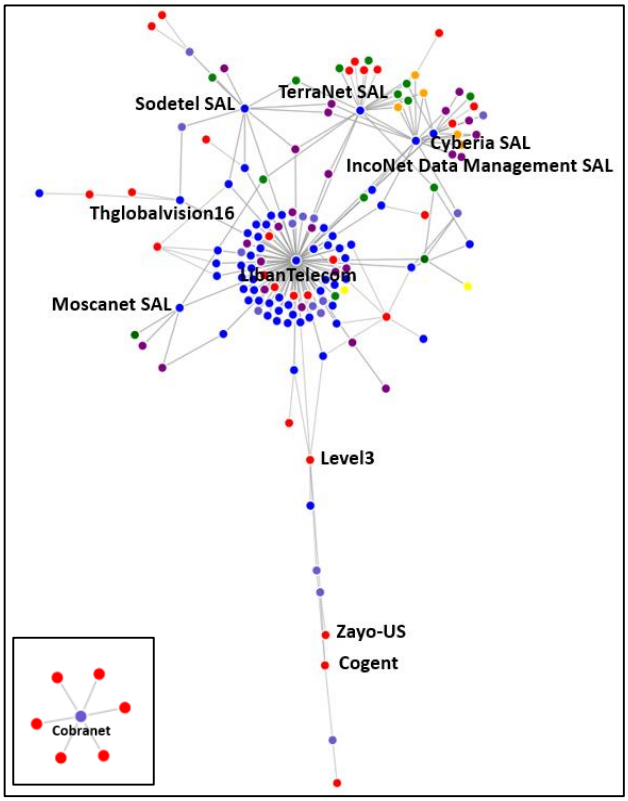


Figure 16: Detailed view of the AS interconnections in 2019

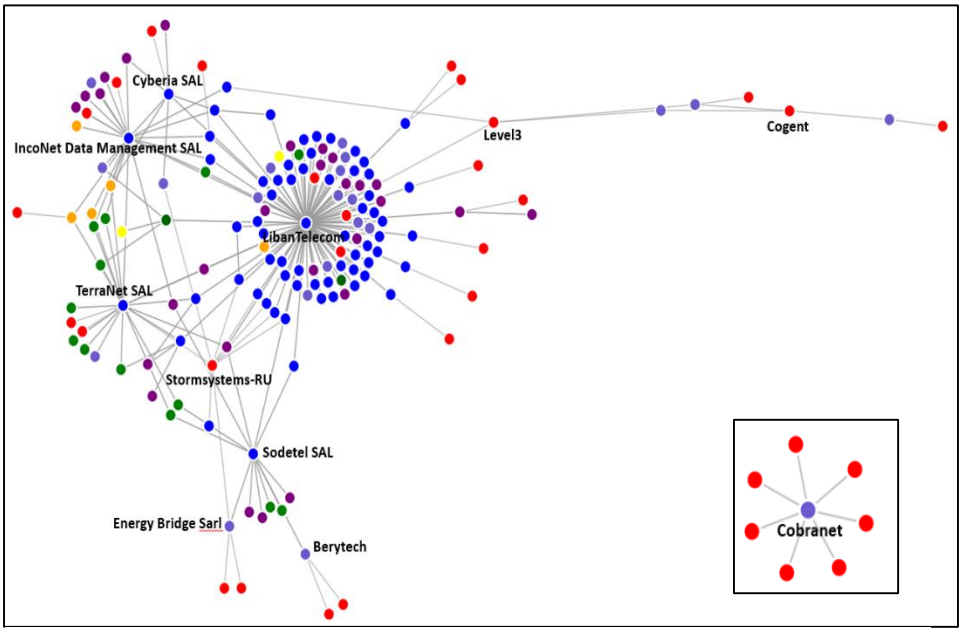
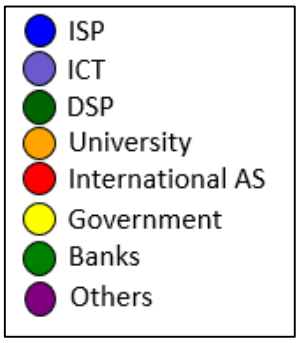


Figure 17: Detailed view of the AS interconnections in 2020

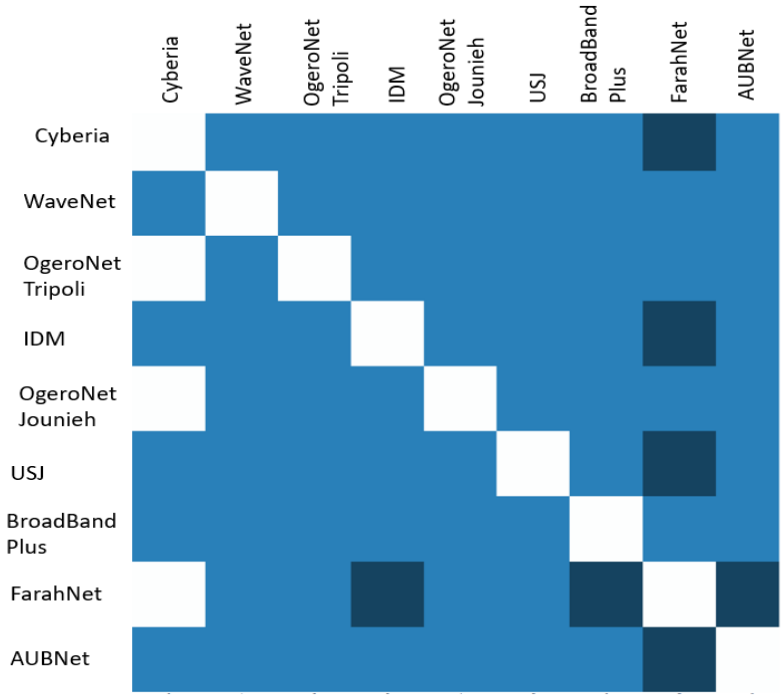


4. INTERNAL ROUTING

The following matrix chart was obtained by analyzing the results of a meshed traceroute involving all of the 9 RIPE Atlas connected probes present in Lebanon. We surprisingly end up with an Internet traffic that stays nearly entirely within the Lebanese borders, when it comes to routing the traffic both from and to the country. This denotes the incredible independence that Lebanon seeks to obtain from its external peering and transit and the autonomy it wants to acquire regarding its geographical neighbors.

Another very important thing to highlight is the existence of IXPs on the Lebanese soil, as they are key quality boosters for the Internet landscape. In very simple terms, they are layer 2 switches that are used to route traffic that can therefore be kept local instead of sending it to the nearest major Internet node (usually located in Europe) and back to Lebanon. Not only they help keep the traffic local, but by doing so they also – and most importantly – strengthen security amongst the national network, reduce traffic from and to foreign countries, and thus lessen the congestion on the correspondent links, and finally cut down delays. All of which result in an overall enhanced end-to-end user experience.

On a higher level, this characteristic of local traffic is especially attractive to some organizations such as banks or other institutions susceptible to route sensitive content who would consequently feel more secured if the traffic stays local.



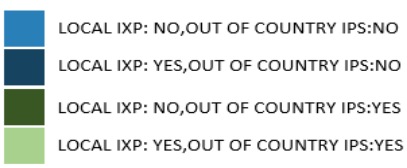
Overview of IXPs in the Middle East:

"Lower latency, better cost efficiency, and control-of-traffic-sovereignty" *Internet Society*

Today there are five main operational IXPs in the region: two in Lebanon, two in the United Arab Emirates, and the newest one DE-CIX Istanbul in Turkey.

Lebanon registers in its territory the oldest regional IXP, Beirut IXP, inaugurated in 2007, as well as Advanced-IX (A-IX).

Figure 13: Internal routing representation
Source: Data extracted from traceroutes between active Lebanese RIPE Atlas probes



5. INTERNATIONAL CONNECTIVITY

The Sankey diagram below was plotted using RIPE NCC's *announced-prefixes* database. It shows the number of prefixes announced by Lebanese ASes (right side) to worldwide ASes (left side), therefore giving an idea on which networks provide international connectivity, or in other words, how an abroad user can reach a site hosted by a Lebanese bounded AS. The total number of announced prefixes reaches over 1210 with the majority being /20, /22 or /24.

We can notice a wide diversity in the Lebanese autonomous systems announcing BGP routing information. Two major ISPs, IDM and Terranet as well as the ICT CobranetLimited play predominant roles in this context. Lebanese prefixes are announced to almost all continents in a well-balanced distribution that allows different parts of the world to access Lebanese networks without congesting particular paths while also avoiding excessive delays. Connection with the African continent is established by Cobranet that holds exclusive links with Nigeria and Angola.

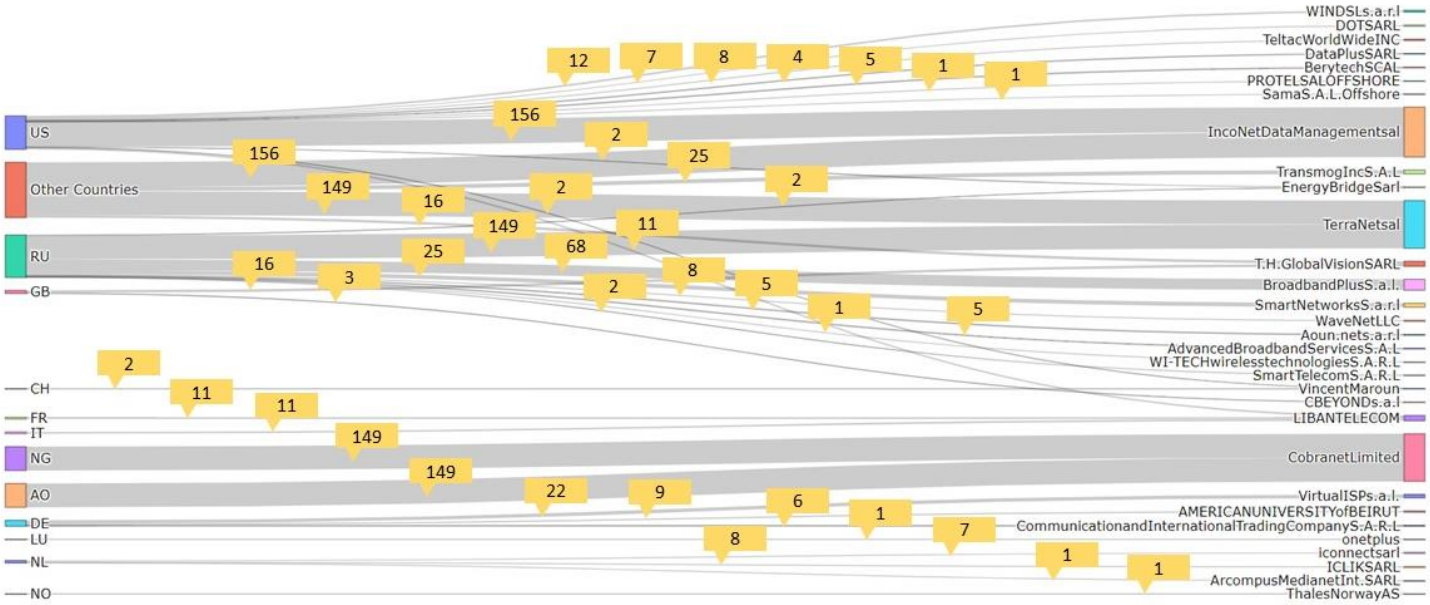


Figure 14: Sankey Diagram showing the number of announced prefixes to Lebanese ASes from various countries
Source: Raw data from RIPE NCC database

Interactive graph available for download on the following link:
https://drive.google.com/open?id=1hfLHoNvJTwbKEyKftKvIBR9FKAFN3-lN