CREATING A SUSTAINABLE INTERNET PROTOCOL ECOSYSTEM

Key findings in how IPv4 address leasing and monetization can unlock a recurring revenue stream and help businesses scale operations without high upfront costs while building an open and sustainable internet.

IPXO WHITE PAPER

March 2022

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SUMMARY

Internet Protocol version 4 (IPv4) addresses are instrumental in connecting devices around the world and allowing them to communicate. Although v4 was, in fact, the first version of the Internet Protocol to be introduced to the public in 1981, and IPv6 was introduced in 1995 as a replacement, IPv4 continues to be the foundation of today's internet.

The global reliance on IPv4 has been problematic. Mainly because the number of unique IPv4 addresses was extremely limited from the start. Once the internet exploded in the 1990s, the pool of IPs was quickly depleted. Today, few unused IPv4 addresses exist, and even reused IPs are hard to come by. This has paralyzed many businesses in various industries globally.

IPv4 exhaustion has affected everyone, except for large companies that were allocated IPs back when scarcity was not an issue or companies that can pay millions of dollars to purchase them now. Small-to-medium-sized businesses, on the other hand, are struggling to grow simply because there are not enough unique identifiers to go around.

Fortunately, a sustainable Internet Protocol ecosystem can be built with IP address leasing.
How does IPv4 leasing alleviate the shortage of IPv4 addresses?
How does it support fair resource allocation?
How does it create a more open and stable internet? These are the questions addressed in this white paper.

IP ADDRESSES MAKE THE VIRTUAL WORLD GO ROUND

The internet, as we know it today, does not exist without Internet Protocol (IP) addresses. These unique identifiers help recognize unique devices on the internet and facilitate virtual communication.

Every device connected to the internet requires an IP address. However, the number of IP addresses is not limitless.

The standard version of the Internet Protocol is IP version 4, or IPv4. The internet technology of today heavily relies on IPv4; however, there are 4,294,967,296 IPv4 addresses in total.

According to current trends, we will have over 30 billion Internet of Things (IoT) devices by 2025[1]. While IPv6 (Internet Protocol version 6) was created to support the growing number of internet-connected devices, the adoption of IPv6 is slow. As a result, the internet infrastructure continues to rely on IPv4.

THE ISSUE IS EVIDENT:

There is an insufficient number of IPv4 addresses to support the entire internet and the rapid growth of internet-connected devices.

Network address translation (NAT), classless inter-domain routing (CIDR) and other technologies were introduced to control IPv4 depletion. However, they were not intended as permanent solutions.

The paradox of the situation is that around 20% of IPv4 addresses remain unused. As reported by Geoff Huston, in 2018, the pool of unadvertised IPs was around 49 /8s[2]. This is around 822 million IPv4 addresses, i.e., around 20% of the total IPv4 pool. If these addresses can be brought back into the market, they can significantly impact the sustainability of today's internet.

THE ROLE OF INTERNET PROTOCOL

In the world of networking, protocol refers to a set of rules according to which devices communicate with each other. The Internet Protocol enables communication between networks of computers, making it the basis of the internet overall.

The Advanced Research Projects Agency Network (ARPANET), established in 1969, developed the world's first computer network and, eventually, structured the architecture of the internet.

First, the ARPANET connected four sites:

- The University of California, Los Angeles (UCLA)
- The Stanford Research Institute (SRI)
- The University of California, Santa Barbara (UCSB)
- The University of Utah School of Computing

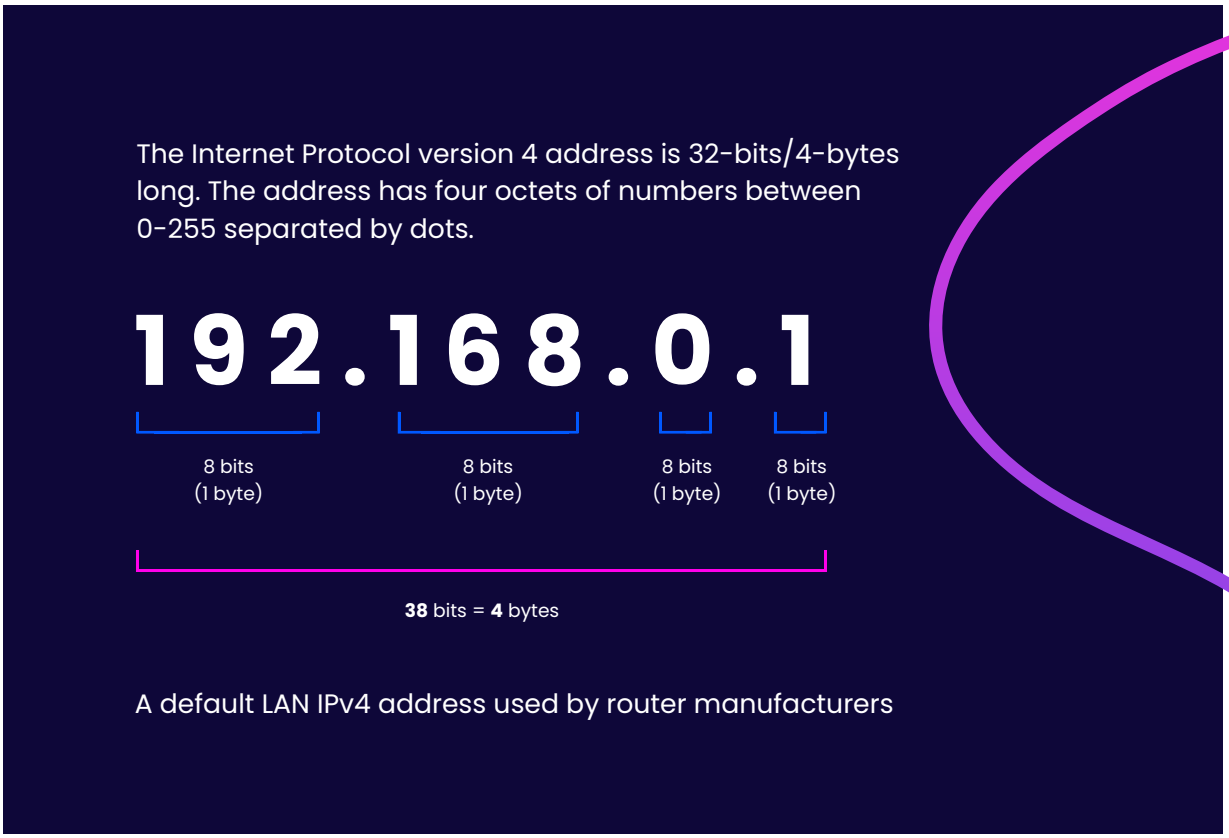
In 1974, Vint Cerf and Bob Kahn, two ARPANET researchers working at UCLA, began the development of the Transmission Control Program. In 1978, with the help of many others, researchers defined the Transmission Control Protocol (TCP) and the Internet Protocol, now known as the TCP/IP suite.

WHAT IS AN INTERNET PROTOCOL ADDRESS?

The Internet Protocol is responsible for delivering data packets between a host and a destination. This would not be possible without IP addresses.

An IP address is a numeric identifier attached to every data packet. In fact, this data packet includes two IP addresses: one of a host (sender) and one of a destination (recipient). Because IP addresses are unique, data can travel to the right recipient and establish successful communication.

IPv4, the fourth version of the Internet Protocol, was, in fact, the first version to support the global internet. It was introduced in 1981 by the Defense Advanced Research Projects Agency (DARPA) with RFC 791[3].



IPv6 is the sixth version of the IP, and it is the only other version to be used in practice. The Internet Society first introduced the concept of IPv6 in 1995 with RFC 1883[4] and then in 1998 with RFC 2460[5]. The Internet Engineering Task Force (IETF) reintroduced IPv6 with RFC 8200[6] in 2017.

According to the memos:

> IP version 6 (IPv6) is a new version of the Internet Protocol (IP), designed as the successor to IP version 4 (IPv4) [RFC791].
>
> The changes from IPv4 to IPv6 fall primarily into the following categories:
>
> - Expanded addressing capabilities
> - Header format simplification
> - Improved support for extensions and options
> - Flow labeling capability
> - Authentication and privacy capabilities

Internet Protocol version 6 address is 128-bits/16-bytes long. The address comprises eight segments containing hexadecimal values between 0 and FFFF separated by colons. If segments contain only 0s, they are eliminated to introduce a compressed address version.

2001:DB8:0000:0000:0000:0000:1234:5678

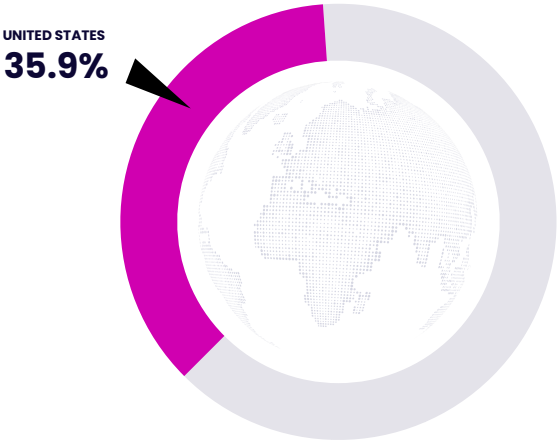
The expanded version of a compressed IPv6 address 2001:db8::1234:5678

THE GLOBAL IPV4 EXHAUSTION

When IPv4 was developed, creators believed that 4.29 billion addresses would suffice for a long time. And big companies had their first dibs on the resource. Regrettably, the allocation of IPv4 addresses in the early days of the internet was unorganized. To put it simply, anyone could request and get IPv4 addresses.

Unsurprisingly, as the internet emerged in the United States, the majority of IPv4 addresses were allocated there. In fact, according to the World Population Review, the U.S. holds 1,541,605,760 IPv4s or 35.9%[7] of the total IPv4 pool.

35.9% OF ALL IPV4 ADDRESSES ARE ALLOCATED IN THE UNITED STATES.



As the internet expanded at incredible speeds, internet architects realized that IPv4 would need a replacement. They started developing IPv6 to address the issue. Simultaneously, the community required a more structured IPv4 allocation.

In 1988, the Internet Assigned Numbers Authority (IANA) was established by Jon Postel. Another UCLA graduate who was also involved with ARPANET. In 1998, a decade later, the Internet Corporation for Assigned Numbers and Names (ICANN) took over the management of IANA.

IANA is responsible for:

- Domain names
- IP addresses
- AS (autonomous system) numbers
- Protocol assignments

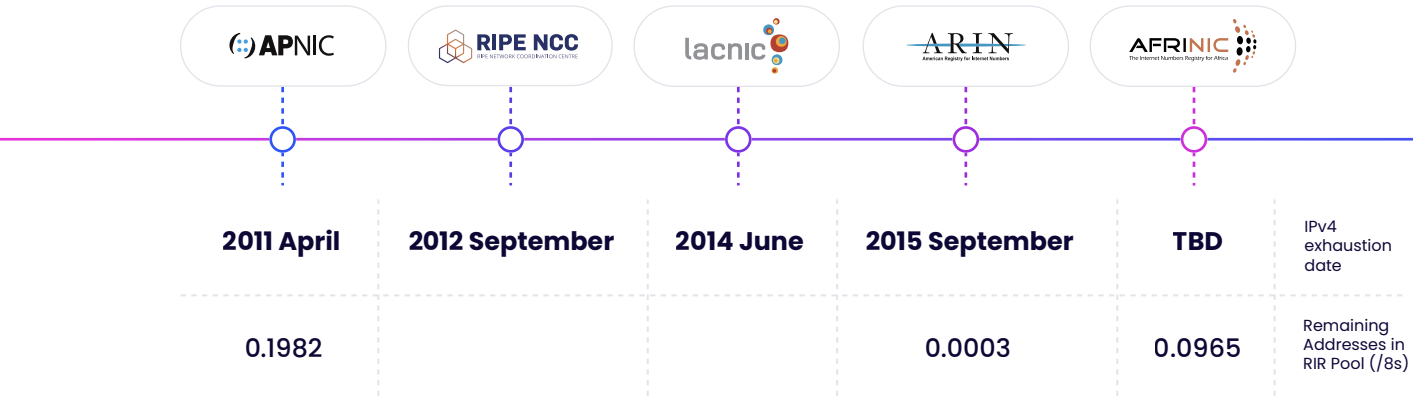
When it comes to IP addresses, the primary task of IANA is to coordinate the global pool of IP addresses and divide them between Regional Internet Registries (RIRs).

FIVE RIRS EXIST IN TOTAL:

- RIPE NCC – Réseaux IP Européens Network Coordination Center established in **1992** manages the IP address space in Europe, Russia, West and Central Asia
- APNIC – Asia-Pacific Network Information Center established in **1993** manages the IP address space in East, South and Southeast Asia as well as Oceania
- ARIN – American Registry for Internet Numbers established in **1997** manages the IP address space in Antarctica, Canada, parts of the Caribbean and the United States
- LACNIC – Latin America and Caribbean Network Information Center established in **2002** manages the IP address space in the Caribbean, Mexico and South America
- AFRINIC – African Network Information Center established in **2004** manages the IP address space in Africa

As reported by Geoff Huston, the chief scientist at APNIC, the Asia-Pacific Network Information Center was the first RIR to run out of IPv4 addresses in 2011. According to February 2022 data, all RIRs – except for AFRINIC – have officially exhausted their pools of IPv4 addresses.[8] Four of the RIRs have a limited number of IPv4 addresses remaining, and the allocation of these resources is stringent.

IPV4 EXHAUSTION BY RIR AND REMAINING RESOURCES



2011 April	2012 September	2014 June	2015 September	TBD	IPv4 exhaustion date
0.1982			0.0003	0.0965	Remaining Addresses in RIR Pool (/8s)

The remaining addresses by RIR (data by Geoff Huston, February 2022)

In a webinar discussing if IPv4 is a commodity[9] held in December 2021, Huston discussed how IPv6 failed to dampen the high demand for IPv4 addresses and prevent the complete exhaustion of the IPv4 pool.

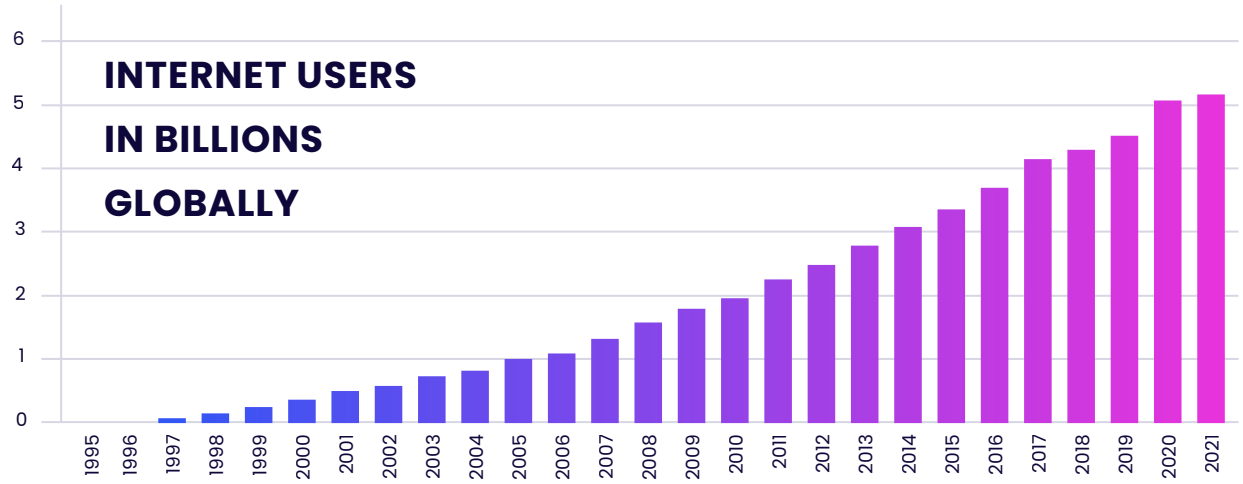
> "The whole idea of damping demand was to buy us time so that we never had to give away the last v4 address. We were meant to have completed the transition [to IPv6] before we got into v4 crunch land. But we didn't because 2011 came, the IANA ran out of its own IPv4 stocks, then APNIC, then the RIRs one by one. A dry IPv4 exhaustion happened, and demand hadn't stopped."
>
> - Geoff Huston, Chief Scientist at APNIC

WHAT INFLUENCED IPV4 DEPLETION?

Poor IPv4 allocation management in the early days of the internet is one of the reasons why we ran out of IPv4 addresses so quickly. However, the global exhaustion of the resource has been affected by other causes as well.

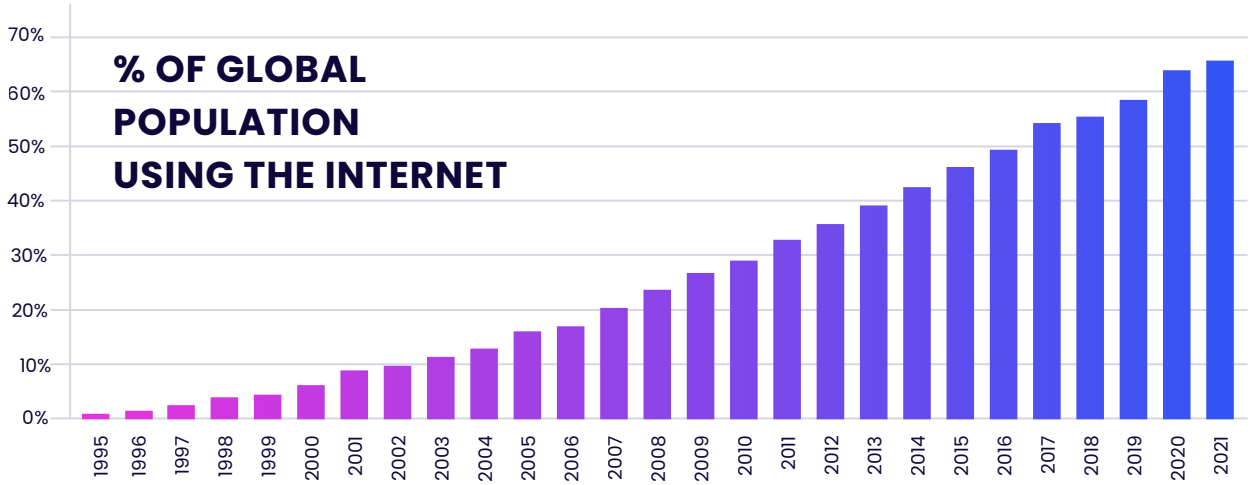
INTERNET EXPLOSION IN THE 90S

According to the historical data provided by Internet World Stats, by the end of 1995, there were 16 million internet users worldwide. In 2021, that number grew to 5.1 billion users.[10]



The number of global internet users in billions (data by Internet World Stats, February 2022)

Between 1995-2021, the percentage of the global population using the internet went up from just 0.4% to 65.6%. A notable change in just 26 years.



The % of global population using the internet (data by Internet World Stats, February 2022)

It must be noted that the global population grew from 5.74 billion in 1995 to 7.79 billion in 2020. This, undoubtedly, influenced the overall number of internet users.

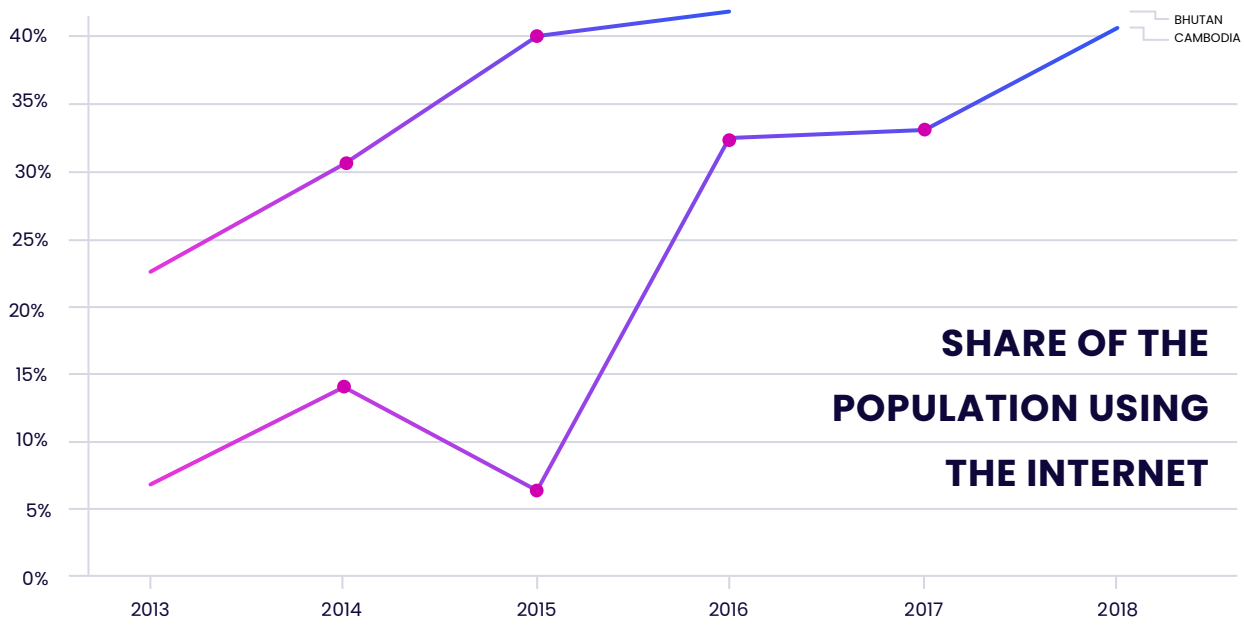
INTERNET EXPANSION ACROSS THE WORLD

In the early days, the internet was a luxury available to few. Naturally, it was first available in more economically advanced countries that invested in technology. The legacy of early and continuous investments is visible even today, as more people in the developed countries have access to the internet.

Statista's Global internet access rate 2005-2021 report illustrates the gaps between the developed, the developing and the least developed countries. According to the report, in 2021, 90% of the population in the developed countries had access to the internet, 57% in the developing countries and only 27% in the least developed countries.[11]

Nonetheless, even in the least developed countries, the internet's expansion is gaining momentum. The United Nations lists Cambodia and Bhutan in the top 10 least developed countries in the world.[12] However, the internet was accessed by 52.6%[13] of Cambodians and 48.1%[14] of Bhutanese in 2021.

How quick is the expansion? According to Our World in Data and the International Telecommunication Union, only 6.8% of Cambodians and 29.9% of Bhutanese had access to the internet in 2013.[15] That means that in Cambodia, for example, the number of internet users grew eightfold in under a decade.



All individuals who have used the Internet in the last 3 months are counted as Internet users. The internet can be used via a computer, mobile phone, personal digital assistant, gaming device, digital TV etc.

Share of the population using the internet (data by Our World In Data, February 2022)

COVID-19 PANDEMIC

According to the International Telecommunication Union research, 2.9 billion people are not connected to the internet, and 96% of these people live in the developing countries.[16] That said, the Union found that between 2019-2021, the so-called COVID connectivity boost increased the total number of internet users by 17% (782 million users).

As the pandemic swept across the globe, unemployment rates climbed rapidly. According to the International Labor Organization, global unemployment might affect 205 million people in 2022[17], which is a sharp increase compared to the 187 million unemployed in 2019.

During the pandemic, people who were not already part of the internet community were forced to join it for several reasons:

To apply for unemployment benefits

To find new employment opportunities

To communicate during extended lockdowns

According to Caesar Sengupta, the former VP at Google's Next Billion Users initiative, most new internet users come from Africa, Asia and Latin America.[18]

Undoubtedly, in the coming years, the internet will permeate across an even larger portion of the global population. As the number of internet users grows,

THE NEED FOR A MORE SUSTAINABLE INTERNET GROWS TOO.

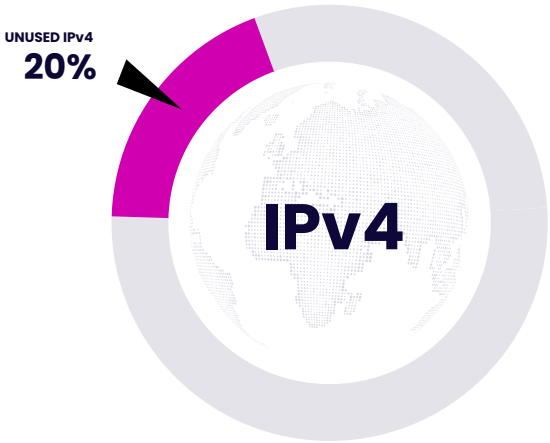
WHAT IS A SUSTAINABLE INTERNET AND CAN IPV4 SCARCITY ENCOURAGE IT?

The Cambridge Dictionary defines sustainability[19] as the idea that goods and services should be produced in ways that do not use resources that cannot be replaced.

A SUSTAINABLE INTERNET

is an internet that maintains a sustainable Internet Protocol ecosystem, in which IP addresses are managed in a way to avoid unfair IP address allocation and encourage accountability.

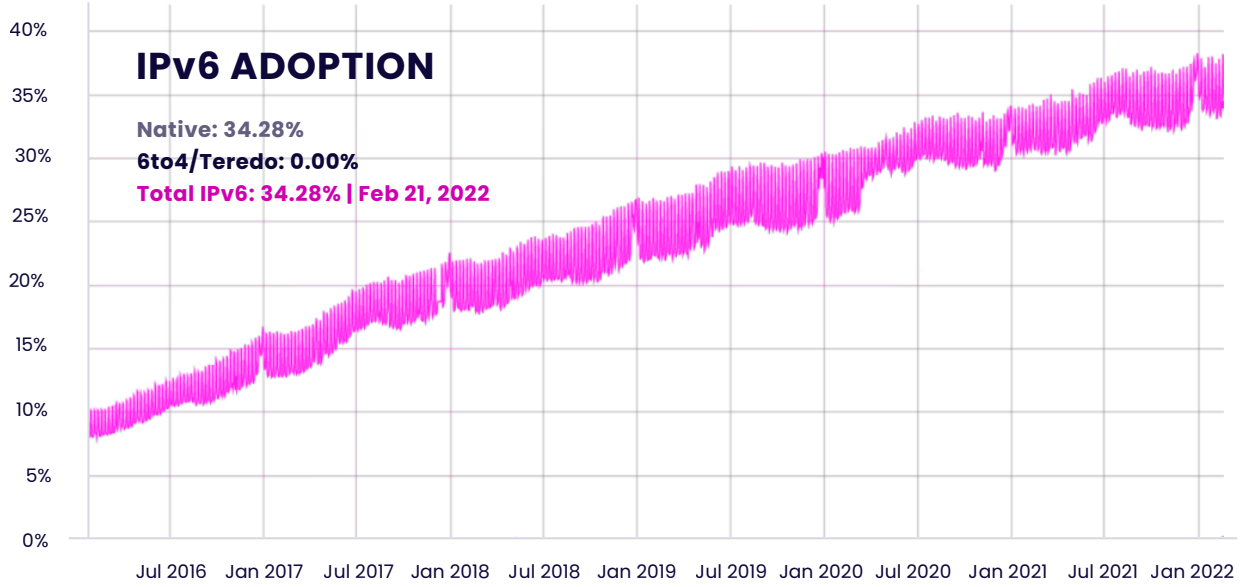
Today, around **20% of IPv4 addresses are unused**, which is unfair for the companies that cannot scale due to IPv4 shortage and financially untenable as unused IPs can be easily monetized.



Why do large companies and organizations hold onto IPv4 addresses if they do not use them? Some may be holding onto a scarce resource just in case they require it in the future. Others do not know how many IP addresses they have or are unaware of the opportunity to profit.

WHY IPV6 CANNOT SOLVE THE IPV4 SCARCITY ISSUE TODAY

IPv6 was introduced and developed to replace IPv4. It was not meant to work alongside IPv4 or as the lesser alternative. Nonetheless, in 2022, IPv6 adoption continues to be sluggish. According to the IPv6 connectivity among Google users data, in early 2022, IPv6 was used by 38% of users in peak times.[20]



IPv6 adoption statistics among Google users (data by Google, February 2022)

We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.

While IPv6 adoption rates are climbing steadily, they are not climbing quickly enough. If IPv6 was adopted as intended, IP address scarcity would not be an issue: There are 340 undecillion IPv6 addresses in total. In theory, this number should suffice internet-connected devices indefinitely.

THE PRIMARY REASONS WHY IPV6 ADOPTION IS SLOW:

- Many view IPv6 as an alternative to IPv4, which is the version they are already familiar with Full IPv6 integration requires time and extensive training for the personnel
- Replacing IPv4-compatible equipment with IPv6-compatible equipment is expensive
- Network Address Translation (NAT) allows network operators to use fewer IP addresses than necessary

Although IPv6 offers more efficient routing, a massive IP address pool, direct addressing, better security and enhanced mobility, companies and organizations around the world are not ready to invest money and switch from IPv4.

According to Gartner researchers, Andrew Lerner and Neil Rickard, big enterprises have complex networking environments based on IPv4 built up over decades, which makes migration to IPv6 a daunting prospect. Furthermore, enterprises have little pressure to transition to IPv6.

"

Many large enterprises either possess adequate quantities of publicly registered IPv4 address space or use private IPv4 addressing internally, using only a handful of public IP addresses for their internet-facing services. As a result, there has been little pressure for enterprises to adopt IPv6.

- Andrew Lerner and Neil Rickard, Gartner

"

Due to lack of initiative, it is believed that IPv6 will not replace IPv4 soon. At the moment, there is no timeframe for IPv6 adoption. While most wish for a speedy transition, some industry experts believe that the transition from IPv4 to IPv6 will not be complete for decades to come.[21]

Although IPv6 is often referred to as the future of the internet, its adoption is still slow. Therefore, it is impossible to rely on this version of the Internet Protocol to solve the IPv4 depletion crisis.

WHY DO WE NEED A SUSTAINABLE INTERNET PROTOCOL ECOSYSTEM?

Unfair IP address allocation and lack of accountability have plagued the internet since the early days. This is perfectly illustrated by the fact that around 822 million or 20% of IPv4 addresses remain unused.

822 million IPv4 addresses are not utilized by major companies and organizations that stockpiled them back in the 80s and 90s.

For businesses that cannot scale because they cannot attain the required IPv4 addresses, this could mean an inability to support growth.

While RIRs continue to allocate the remaining IPv4 addresses, their allocation policies are usually incredibly strict. Moreover, companies no longer can request as many IPs as they need. Instead, they must accept the resources that RIRs are willing to allocate.

HOW DO RIRS DIVIDE THE IPV4 ADDRESS POOL?

This table lists the main policies that AFRINIC[22], APNIC[23], ARIN[24], LACNIC[25] and RIPE NCC[26] use to allocate IPv4 resources in 2022.

RIR	IPv4 allocation policies
AFRINIC	The minimum allocation size is /24 and the maximum is /22.
APNIC	Members can receive a total maximum of one /23 allocation.
ARIN	Micro allocations no smaller than /24 are reserved for critical infrastructure providers and ISPs.
lacnic	The minimum allocation size is /24 and the maximum is /22, based on utilization rates.
RIPE NCC	The maximum allocation size is /24 (allocated once).

IPv4 allocation policies by RIR (data by AFRINIC, APNIC, ARIN, LACNIC, RIPE NCC, February 2022)

It is not easy to receive IPv4 allocations from RIRs. First, it is a complicated process that often involves an LIR (Local Internet Registry). Second, RIRs simply can no longer allocate as many IPv4s as companies and organizations may need.

How big is the demand for IPv4 resources? RIPE NCC, ARIN and LACNIC created waiting lists for applicants who are eligible for IPv4 addresses.

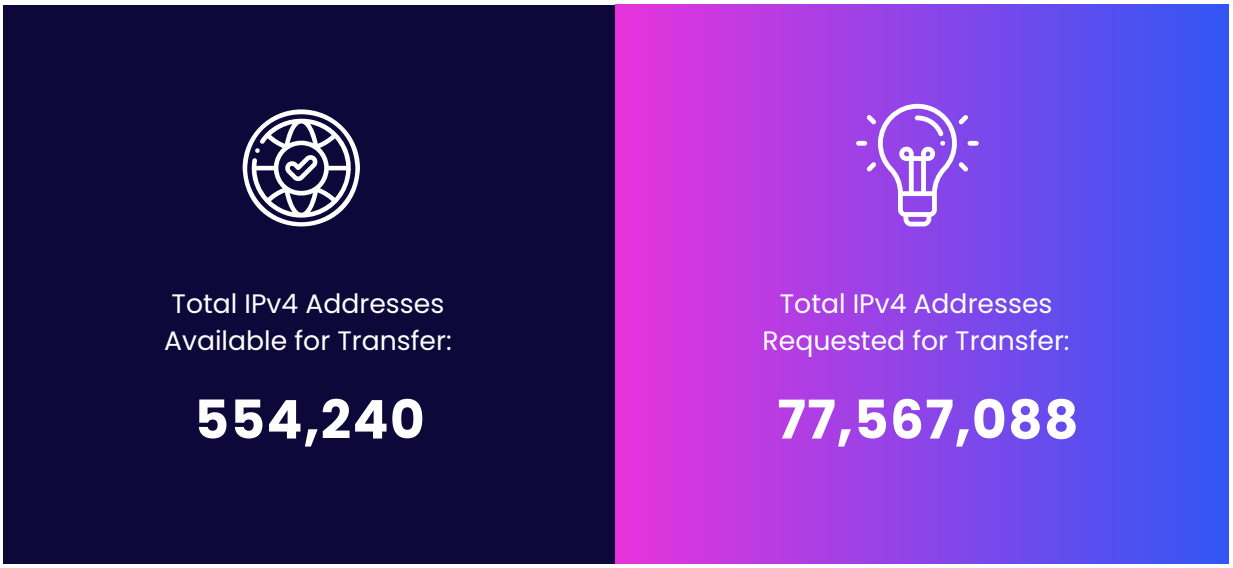
RIRS' WAITING LISTS (FEBRUARY 2022)

- At the time of research, RIPE NCC's IPv4 Waiting List had 587 LIRs waiting for IPv4 allocations. The first LIR in line had been waiting for 77 days.[27]
- ARIN's IPv4 Waiting List had 187 applicants in waiting, with the earliest IPv4 address distribution date set on April 1, 2022.[28]
- According to LACNIC's report on IPv4 exhaustion, the latest applicant for IPv4 addresses was expected to receive their allocation in September 2025.[29]

Due to high demand and low supply, RIRs often encourage IPv4 transfers. In intra-RIR transfers, IPv4 addresses are transferred between members within the same RIR. In inter-RIR transfers, IPv4 addresses are transferred between RIRs. In early 2022, AFRINIC was not involved in inter-RIR transfers.

However, even with the opportunity to transfer IPv4 addresses, the options are not limitless. For example, in February 2022, RIPE NCC had a total of 554,240 IPv4s available for transfer. However, the total number of requested transfers was 77,567,088.[30]

IPv4 Transfer Listing Service



IPv4 addresses available and requested for transfer (data by RIPE NCC, February 2022)

HOW DO COMPANIES COPE WITH IPV4 SCARCITY?

Companies and organizations that are not eligible for IPv4 allocations from RIRs or cannot wait for IPv4 transfers have other options. Most commonly, companies choose to buy or lease IPv4 addresses.

IPv4 addresses have been sold and bought for over a decade now, and numerous IP address brokerages exist to assist both IP holders and companies that require the resource. Here are a few memorable IPv4 sale deals in the past decade.

- In 2011, Microsoft bought 666,624 IPv4 addresses from Nortel for $7.5 million ($11.25/IP)[31]
- In 2017, Google bought 1,048,576 IPv4 addresses from Merit Net for an undisclosed sum[32]
- Between 2017 and 2019, Amazon bought 8 million IPv4 addresses from MIT, 16 million from General Electric and 4 million from AMPRNet[33]

While large companies can allocate funds to buy IPv4 addresses, smaller companies are locked in because they cannot handle the high upfront costs involved in buying.

Depending on the broker of choice, one /24 block (the most popular block size) can go anywhere from 40-65 USD. $10,240-$16,640 for 256 addresses in total. This block may support some small to medium-sized businesses, but not all small to medium-sized businesses have the capital to justify the demand.

Unfortunately, some companies choose to rely on unregulated markets, where IP addresses are sold or leased in a way that is detrimental to the health of the internet's ecosystem. IPv4 addresses that end up on the underground market are often abused, which causes immense problems when owners try to bring them back into the legitimate sale and lease markets.

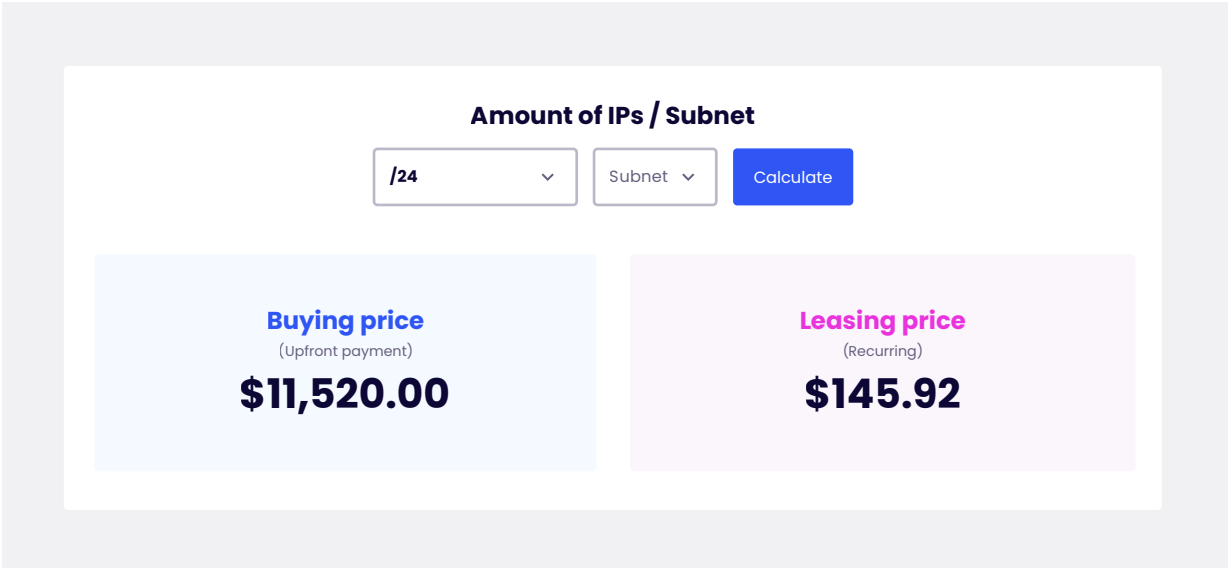
IPV4 LEASING HELPS BUILD A SUSTAINABLE INTERNET PROTOCOL ECOSYSTEM

The days of price gouging and poor abuse regulation are over, and IPv4 leasing is no longer an option enveloped in mystery. On the contrary, IP leasing is safe and highly beneficial for all parties involved.

IP leasing enables IP holders to monetize unused IP resources and secure a recurring revenue stream.

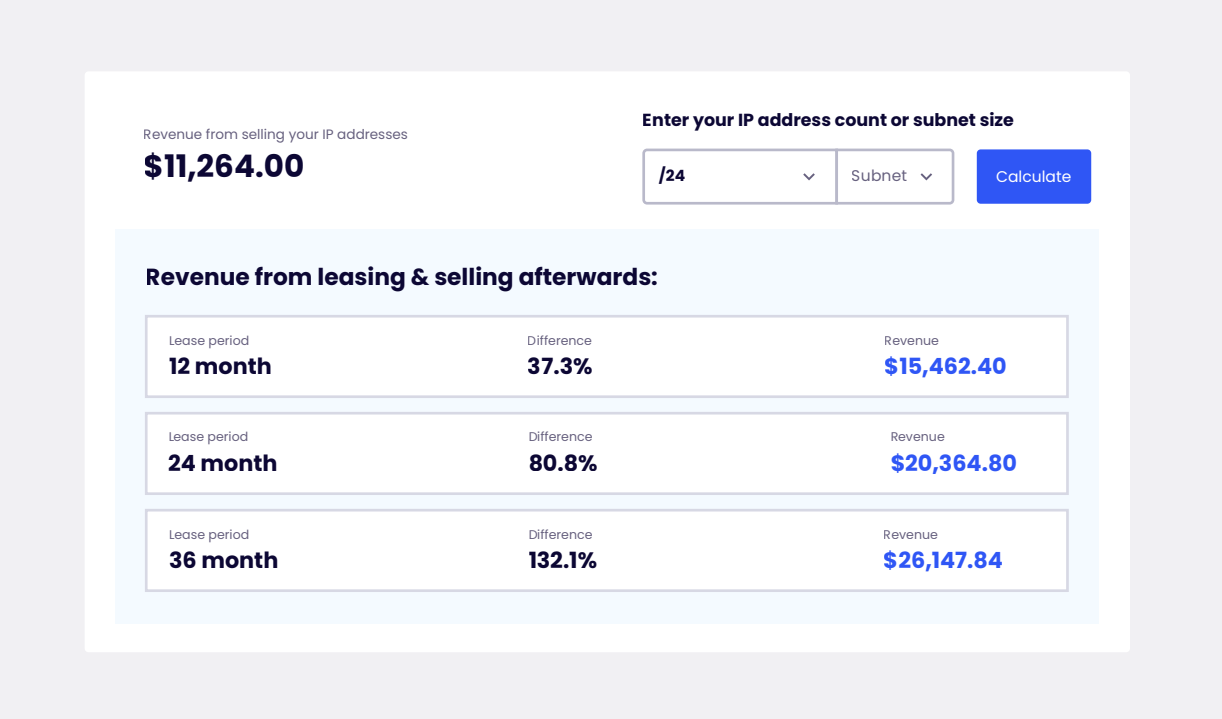
IP leasing enables IP lessees to grow their businesses without buying expensive IP addresses.

LEASING VS BUYING CALCULATOR



Leasing vs. Buying calculator

PXO's Leasing vs. Selling Calculator[35] compares the revenue from selling your IP addresses with the revenue from leasing and selling afterward. For example, if an IP holder decides to sell a /24 subnet once, the earnings are set at around $11,200. However, according to the calculations, the IP holder can earn significantly more by leasing the same number of IPs for just a year and selling afterward.



Leasing vs. Selling calculator

IPv4 leasing creates a sustainable Internet Protocol ecosystem, in which the high demand for IP addresses is supported by providing companies in need of IP addresses with access to unused resources.

THE IMPORTANCE OF PROFESSIONAL IP MANAGEMENT

The high demand and low supply have created fertile ground for an underground market, in which IP addresses are sold, leased and traded without proper regulation and care.

Undeniably, big IP holders continue to hold onto resources, and companies that require IP addresses cannot wait because they need to scale now. Nonetheless, participating in unregulated underground markets is too risky.

According to Leslie Nobile, Senior Director for Trust and Public Safety at ARIN, cybercriminals are constantly searching for dormant records (i.e., unused IPs) that could be hijacked. If criminals locate IP addresses that do not have up-to-date contact information or active administrators, they attempt to hijack these resources by re-registering the names of defunct companies and establishing themselves as administrators.[36]

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THE IPXO IP ADDRESS LEASE & MONETIZATION PLATFORM IS SUPPORTED BY:

- Dedicated abuse prevention team
- Automated abuse reporting system
- Real-time IP address monitoring

Innovative abuse management practices help monitor and maintain IP reputation to ensure the IP addresses on the IPXO Marketplace are safe.

The IPXO Marketplace offers professional abuse and IP reputation management along with delegated RPKI, IP geolocation, DNS management and IPAM services.

- Delegated RPKI
- IP Reputation
- DNS Management
- IP Geolocation
- Abuse Management
- IP Address Management

Over 75 industries are served to ensure that companies within different sectors can scale their operations and grow despite the global IPv4 exhaustion.

Telcos/ISPs

All IPv4 resources are already allocated and you need IPs to meet the scale of your customers. Offering millions of IPs, we can help you scale your business.

Hosting and Infrastructure

The most valued strategic asset for any hosting company is an IPv4 address. More IPs mean more customers, and we can help with the latter. Scale with IPXO.

SaaS

Whether big or small, developing SaaS requires IP addresses to support and scale networks and infrastructure. Expand your reach with more IPv4 resources.

Cybersecurity

While more hardware and infrastructure can be made and sold, IP resources are finite because of the shortage. To grow your business further, lease unused IPs.

Business Intelligence

Strategic decisions need to be made quickly, and you should not let the underlying technology slow you down. IPXO ensures IPv4 availability for your business.

VoIP

The VOIP industry is growing fast, and we are prepared to provide our VOIP partners with the IPs that support their infrastructures and help them grow further.

MSPs

Whether you're managing IT infrastructures or outsourcing managed hardware to clients, we can provide you with the IP assets you need to support your services.

CDN

Content delivery networks utilize a vast amount of IP addresses in order to deliver content from multiple geolocations, all of which you can find within IPXO.

IoT

IoT affects nearly every other industry out there and as such is one of the core industries we support and work with. One thing IoT always needs is more IP addresses.

CONCLUSION

IPv4 addresses were limited from the start, but the architects of the early internet could not have predicted that we would run out of 4.29 billion IPs this quickly. Although the internet boom in the 90s encouraged the development of IPv6 – the advanced version of the Internet Protocol with a vast IP address pool – and other technologies, IPv4 continues to be the backbone of the internet today.

IPv6 adoption is slow because it requires significant investments, time and network operators' determination to finally make the switch from IPv4. Unfortunately, because IPv4 continues to offer everything for the smooth running of the internet, they are in no rush for the transition. The problem here is that new companies and companies ready to scale are locked in because they do not have enough resources.

Because the demand for IPv4 addresses is much greater than the available supply, IPv4 sale prices have been climbing significantly ever since IANA allocated the last IPs in 2011. Buying IP addresses is especially expensive for small to medium-sized companies that may not have the capital required for even the smaller blocks of IPs. On top of that, companies often choose to hold onto IPv4 addresses instead of selling them.

Either due to a desire to hold onto a valuable commodity or lack of knowledge regarding the revenue potential behind unused IP resources, big IP holders keep around 20% of the global IPv4 pool unused. The IP lease market bridges the gap between IP holders with unused resources and companies that need IPs. In a sustainable Internet Protocol ecosystem, IP holders retain ownership, and companies that do not own IPs can grow without covering high upfront costs.

Moreover, IP leasing can offer sustainability not only on a business level but also on an environmental level. The IP lease market enables eco-conscious businesses to repurpose unused IPv4 resources, enhance the internet's efficiency and positively impact the global energy bill.

IPv4 lease market bridges the gap between IP holders with unused resources and companies that need IPs. In a sustainable Internet Protocol ecosystem, IP holders retain ownership, and companies that do not own IPs can grow without covering high upfront costs.

REFERENCES

[1] Vailshery, L. S. March 8, 2021. Internet of Things (IoT) and non-IoT active device connections worldwide from 2010 to 2025. Statista

[2] Huston, G. January 2019. Addressing 2018. Potaroo

[3] Information Sciences Institute, University of Southern California. September 1981. INTERNET PROTOCOL. IETF Datatracker

[4] Network Working Group. December 1995. Internet Protocol, Version 6 (IPv6) Specification. IETF Datatracker

[5] Network Working Group. December 1998. Internet Protocol, Version 6 (IPv6) Specification. IETF Datatracker

[6] Internet Engineering Task Force. July 2017. Internet Protocol, Version 6 (IPv6) Specification. IETF Datatracker

[7] World Population Review. 2022. Ip Address by Country 2022. World Population Review

[8] Huston, G. February 2022. IPv4 Address Report. Potaroo

[9] IPXO. December 15, 2022. Is IPv4 a Commodity? YouTube

[10] Miniwatts Marketing Group. July 3, 2021. INTERNET GROWTH STATISTICS. Internet World Stats

[11] Johnson, J. January 24, 2022. Percentage of global population accessing the internet from 2005 to 2021, by market maturity. Statista

[12] United Nations. UN list of least developed countries. UNCTAD

[13] Kemp, S. February 2021. DIGITAL 2021. CAMBODIA. DataReportal

[14] Kemp, S. February 2021. DIGITAL 2021. BHUTAN. DataReportal

[15] ITU. July 14, 2015. Percentage of individuals using the internet by country, 2000 to 2014. Our World in Data

[16] ITU. November 30, 2021. 2.9 billion people still offline. ITU

[17] ILO. June 2, 2021. Slow jobs recovery and increased inequality risk long-term COVID-19 scarring. International Labor Organization

[18] Sengupta, C. October 28, 2020. Building a more inclusive internet, beyond COVID-19. The Keyword

[19] Cambridge Advanced Learner's Dictionary & Thesaurus. Sustainability. Cambridge Dictionary

[20] Google. IPv6 Adoption. Google IPv6

[21] IPXO. May 28, 2021. When will IPv6 replace IPv4? YouTube.

[22] AFRINIC. AFRINIC IPv4 Exhaustion. AFRINIC

[23] APNIC. APNIC IPv4 post-exhaustion. APNIC

[24] ARIN. Request IPv4 Addresses. ARIN

[25] LACNIC. Phases of IPv4 Exhaustion. LACNIC

[26] RIPE NCC. IPv4 Address Allocation and Assignment Policies for the RIPE NCC Service Region. RIPE NCC

[27] RIPE NCC. IPv4 Waiting List. RIPE NCC

[28] ARIN. IPv4 Waiting List. ARIN

[29] LACNIC. Phases of IPv4 Exhaustion. LACNIC

[30] RIPE NCC. IPv4 Transfer Listing Service. RIPE NCC

[31] Vijayan, J. March 24, 2011. Microsoft offers $7.5M for 666,624 IPv4 addresses. ComputerWorld

[32] ISOC. May 24, 2017. Google buys a /12 IPv4 Address Block. Internet Society

[33] Toonk, A. October 20, 2020. AWS and their Billions in IPv4 addresses. Toonk

[34] IPXO. Leasing vs Buying Calculator. IPXO

[35] IPXO. Leasing vs Selling Calculator. IPXO

[36] Sharwood, S. June 16, 2016. Crims set up fake companies to hoard and sell IPv4 addresses. The Register

[37] U.S. Attorney's Office, District of South Carolina. May 15, 2019. Charleston Man and Business Indicted in Federal Court in Over $9M Fraud. United States Department of Justice

ABOUT IPXO

IPXO is a fully automated IP address lease and management platform built to help lease and monetize unused IP resources while alleviating the global IPv4 shortage problem.

IPXO provides clients with a full automation stack that ensures accessibility and innovative solutions for companies in 75+ industries. We combine 10+ years of experience in the industry and innovative thinking to build a sustainable internet that supports the growth of any business. US Patent No. 11,005,811.

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