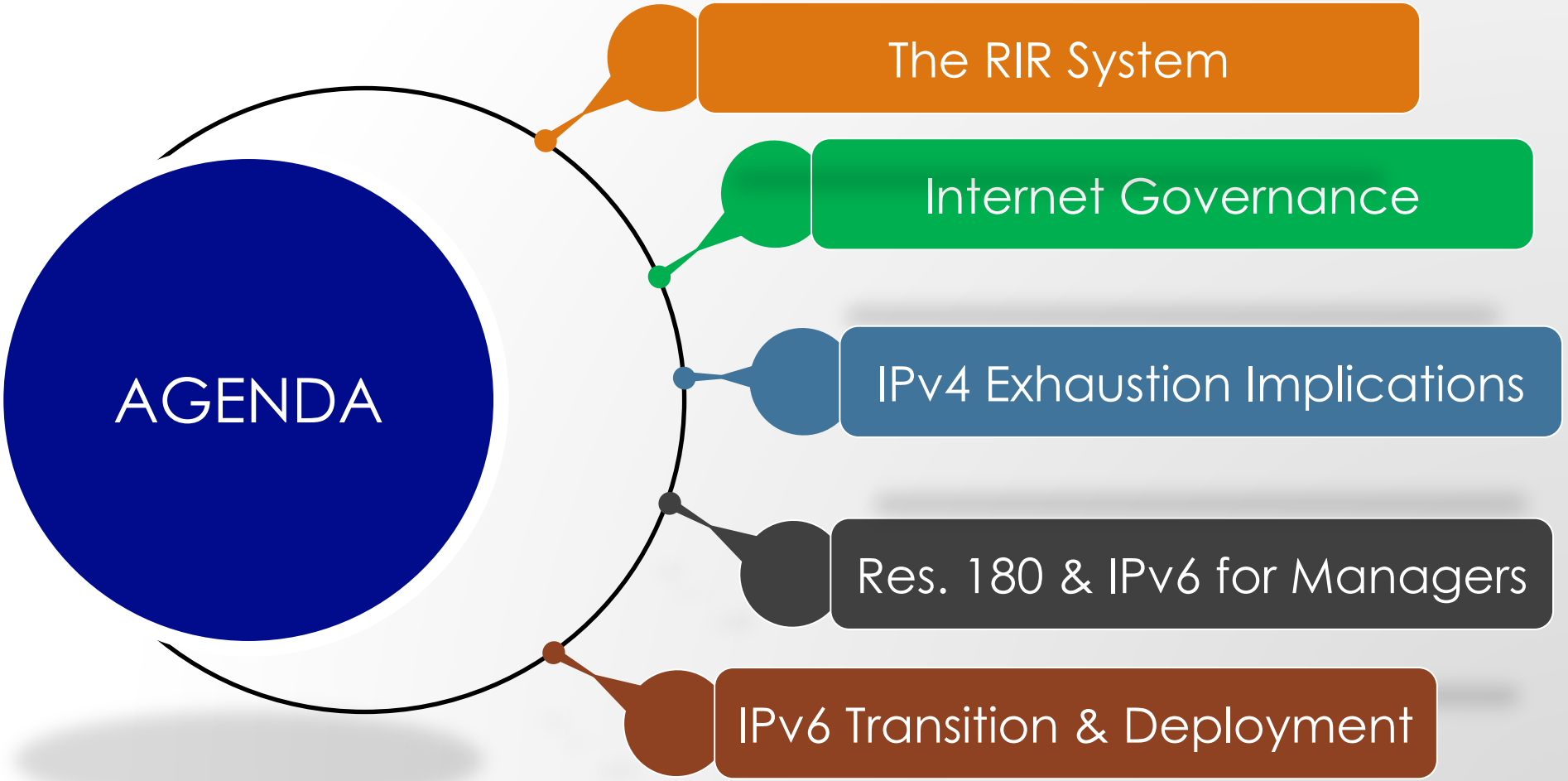
AFRINIC
The Internet Numbers Registry for Africa

IPv6 Deployment for African Government

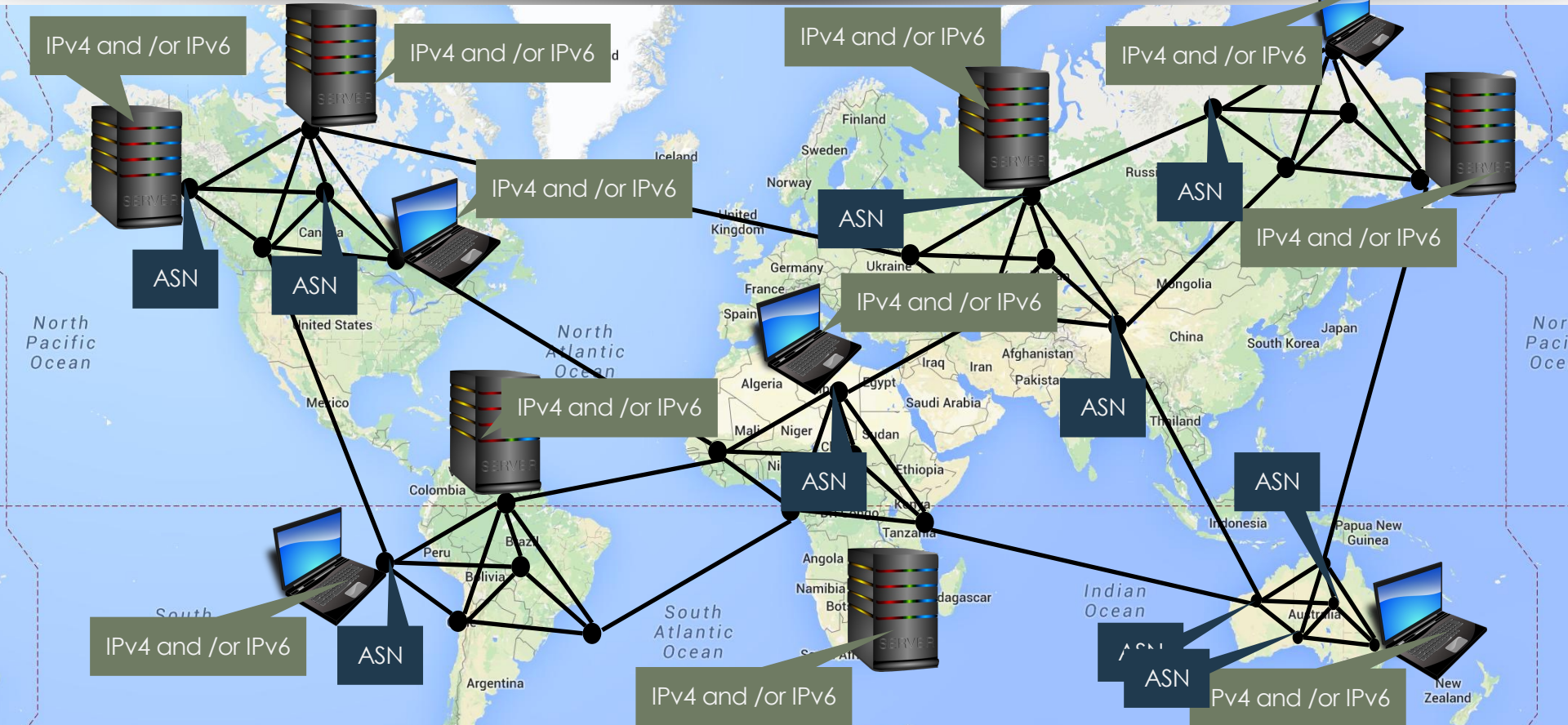
www.afrinic.net blog.afrinic.net /afrinic

Created	Brice ABBA | brice@afrinic.net	AFRINIC Ltd
Contributor	Cedrick Mbeyet | cedrick.mbeyet@afrinic.net	AFRINIC Ltd


AGENDA
The RIR System
Internet Governance
IPv4 Exhaustion Implications
Res. 180 & IPv6 for Managers
IPv6 Transition & Deployment

The RIR System

Devices and Networks are Identified on the Internet

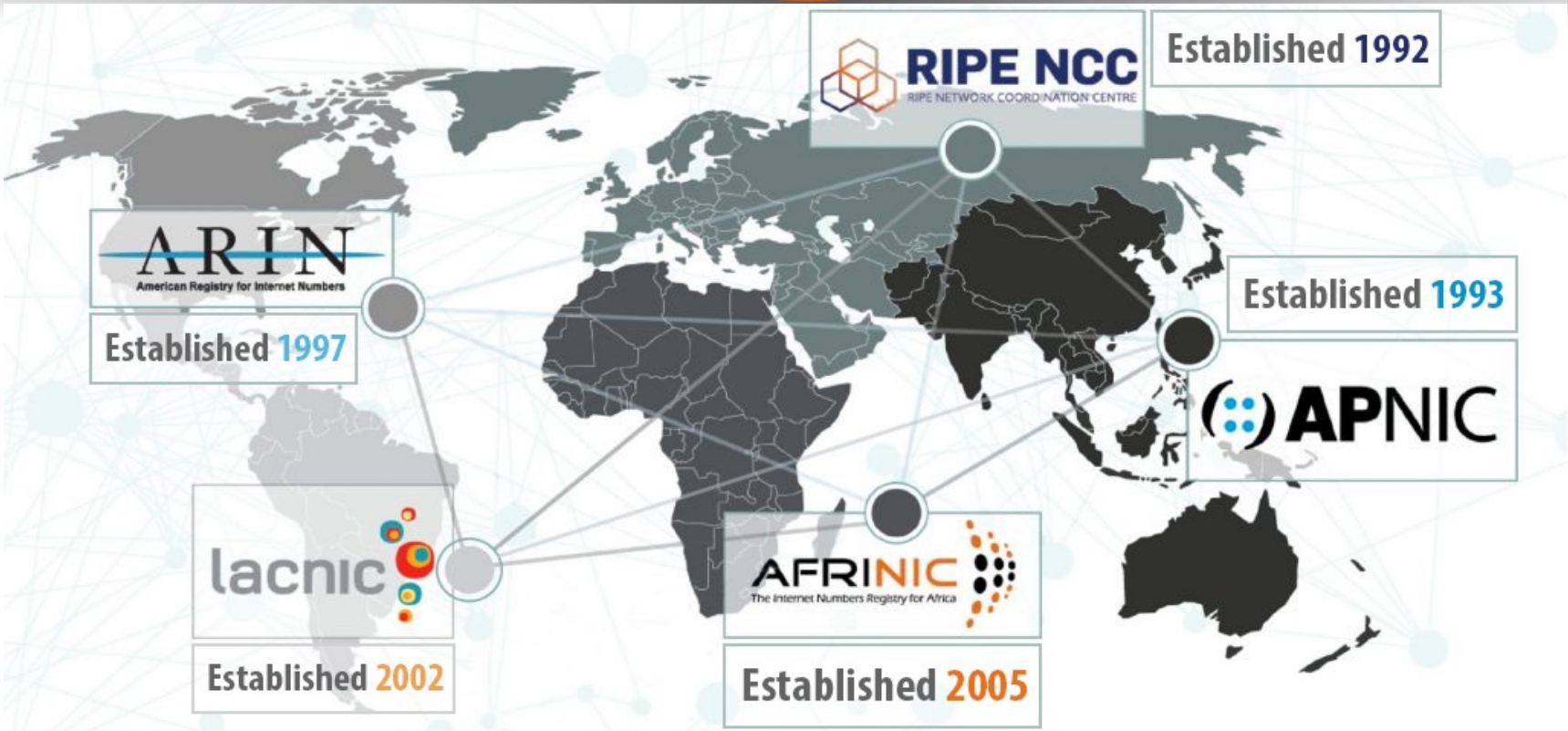


What is an RIR?

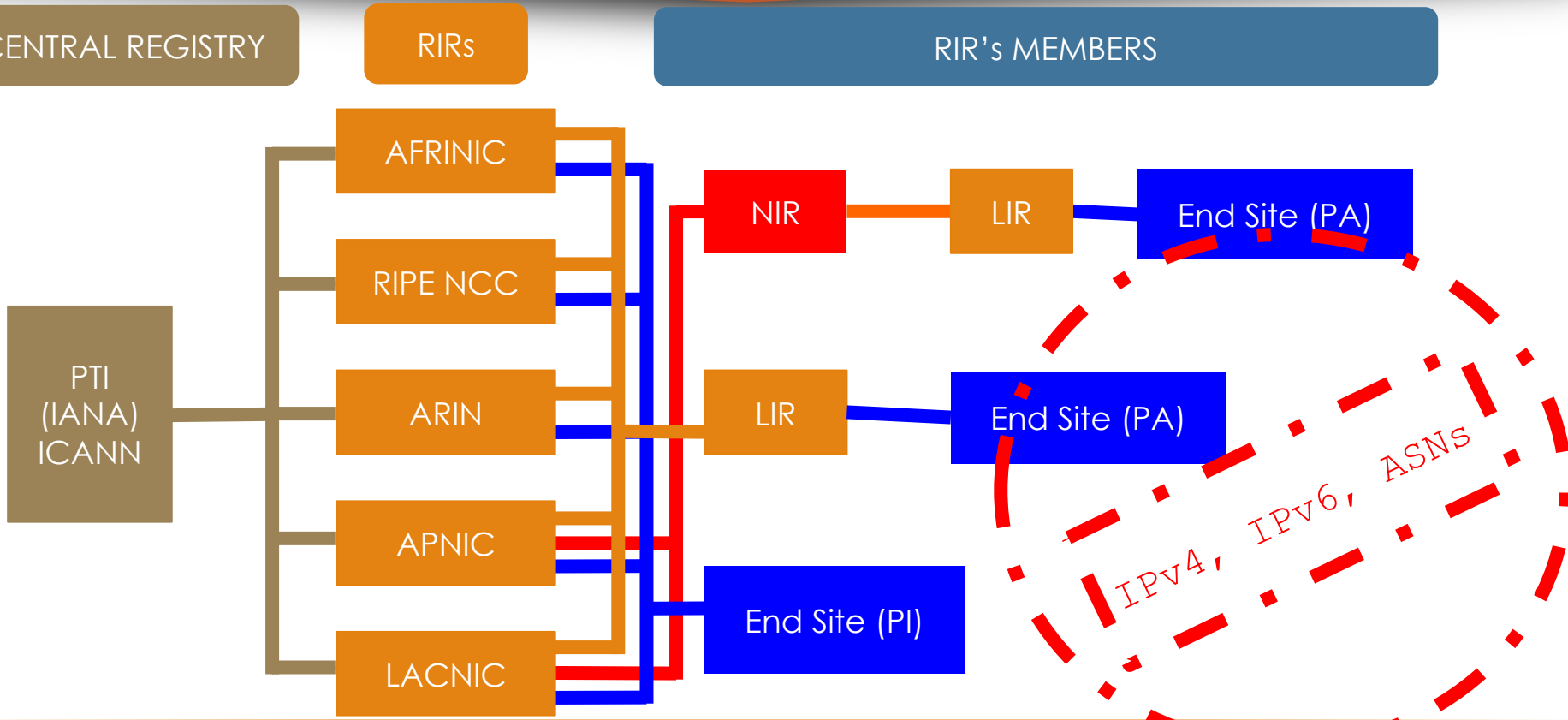
A Regional Internet Registry (RIR) manages the allocation and registration of Internet number resources in a particular region of the world and maintains a unique registry of all IP numbers issued.

*Number resources include IP addresses (IPv4 and IPv6) and autonomous system (AS) numbers

The RIR system today



How Are IP Addresses Issued?




RIPE NCC
RIPE NETWORK COORDINATION CENTRE
ARIN
American Registry for Internet Numbers
APNIC
lacnic
AFRINIC
The Internet Numbers Registry for Africa

AFRINIC Service Region

5th
RIR

55
Economies

49
Staff

NOT for
profit

Operating
since 2005

~2165
Resource
members

AFRINIC

Our Vision

"A secure and accessible Internet for sustainable digital growth in Africa"

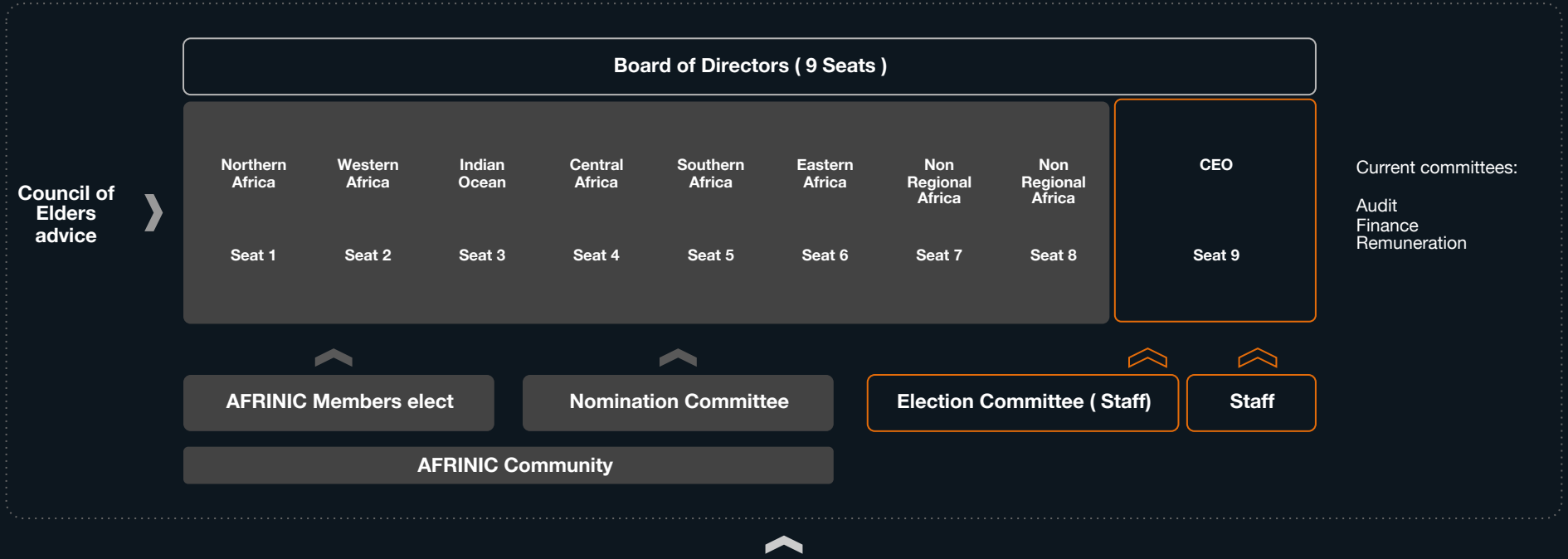
Our Mission

"To serve the African Internet community by delivering efficient services in a global multi-stakeholder environment"

Our Core Values

- Excellence
- Passion
- Integrity
- Community Driven

AFRINIC GOVERNANCE



AFRINIC Current Directors

Seat Num.	Name	Country	Region	From	To
Seat 1	Vacant		Northern Africa		
Seat 2	Vacant		Western Africa		
Seat 3	Subramanian Moonesamy	Mauritius	Indian Ocean	18 Sep. 2020	June 2023
Seat 4	Vacant		Central Africa		
Seat 5	Silvio Almada	Angola	Southern Africa	Dec 2021	June 2023
Seat 6	Abdalla Omari	Kenya	Eastern Africa	18 Sep. 2020	June 2022
Seat 7	Vacant		Non-Regional Africa		
Seat 8	Benjamin Eshun	Ghana	Non-Regional Africa	18 Sep. 2020	June 2023
Seat 9	Vacant - Appointed CEO of AFRINIC				

AFRINIC Membership

	Resource Members	Registered Members	Associate members
Must be a legal entity	✓	✗	✗
Sign contract with AFRINIC Ltd	✓	✓	✓
Use numbered resources from AFRINIC	✓	✗	✗
Pay annual membership fee	✓	✗	✓
Elect board of directors	✓	✓	✗
Observer at AGMM	✓	✓	✓

The AFRINIC Community

- Individuals from member or non member organisation
- Not a legal entity
- No contract with AFRINIC Ltd
- Work via mailing lists
- Deliberate resource policy

AFRINIC Community Meeting

AFRINIC meetings are forums where the tech community, policymakers, governments, and Internet users meet to share know-how and discuss policies for the Internet betterment in our service region.

Held at least 1 per year and include :

- Annual General Members' Meeting (AGMM)
- Not a legal Public Policy Meeting

AFRINIC Has Two Types of Meetings

AIS_Africa

MID YEAR

AFRINIC
The Internet Numbers Registry for Africa

Stand Alone Meeting

END OF THE YEAR

Attended by:

- Governments
- Policymakers
- Techies
- Decision-makers
- Internet users all over the world

Thank You!

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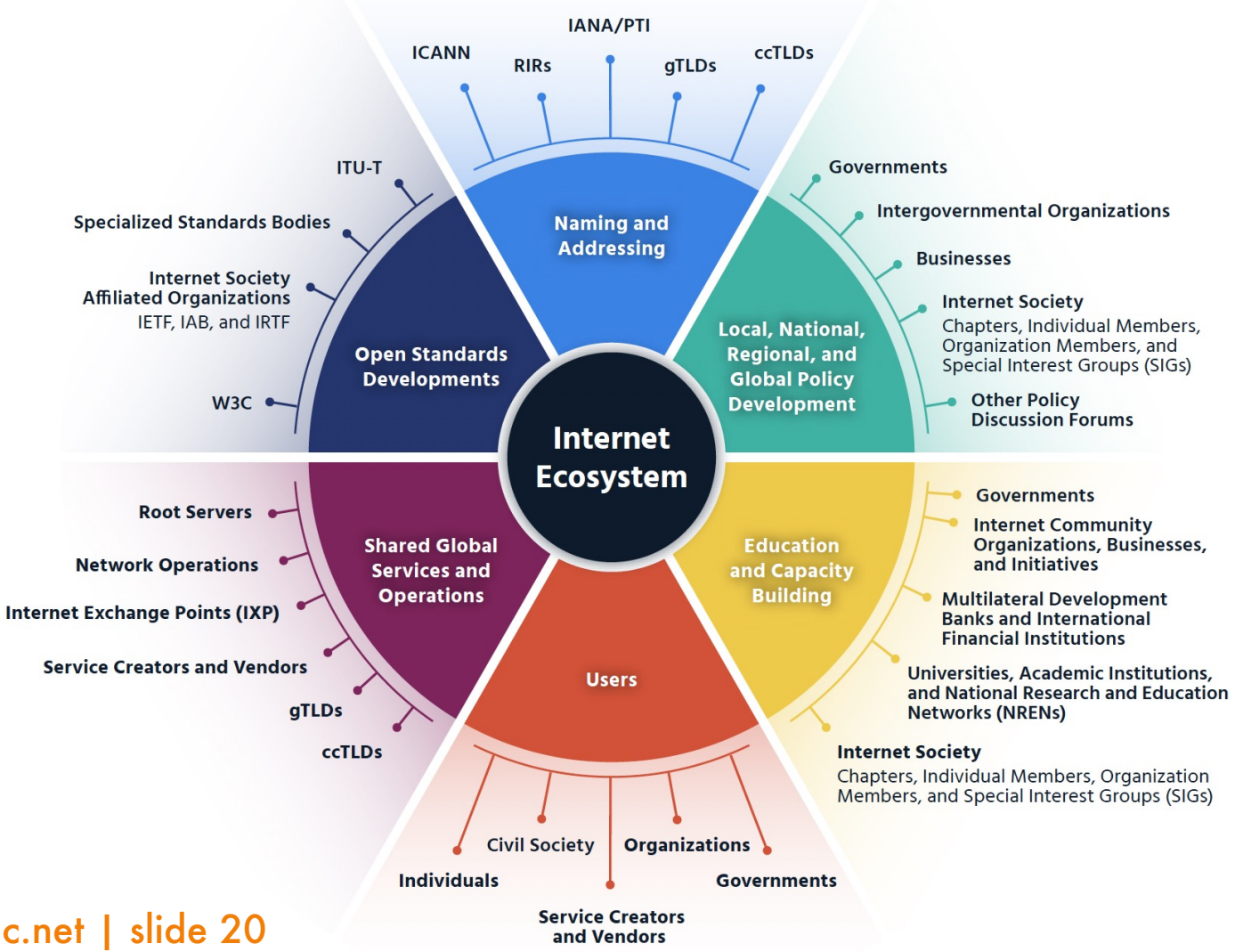
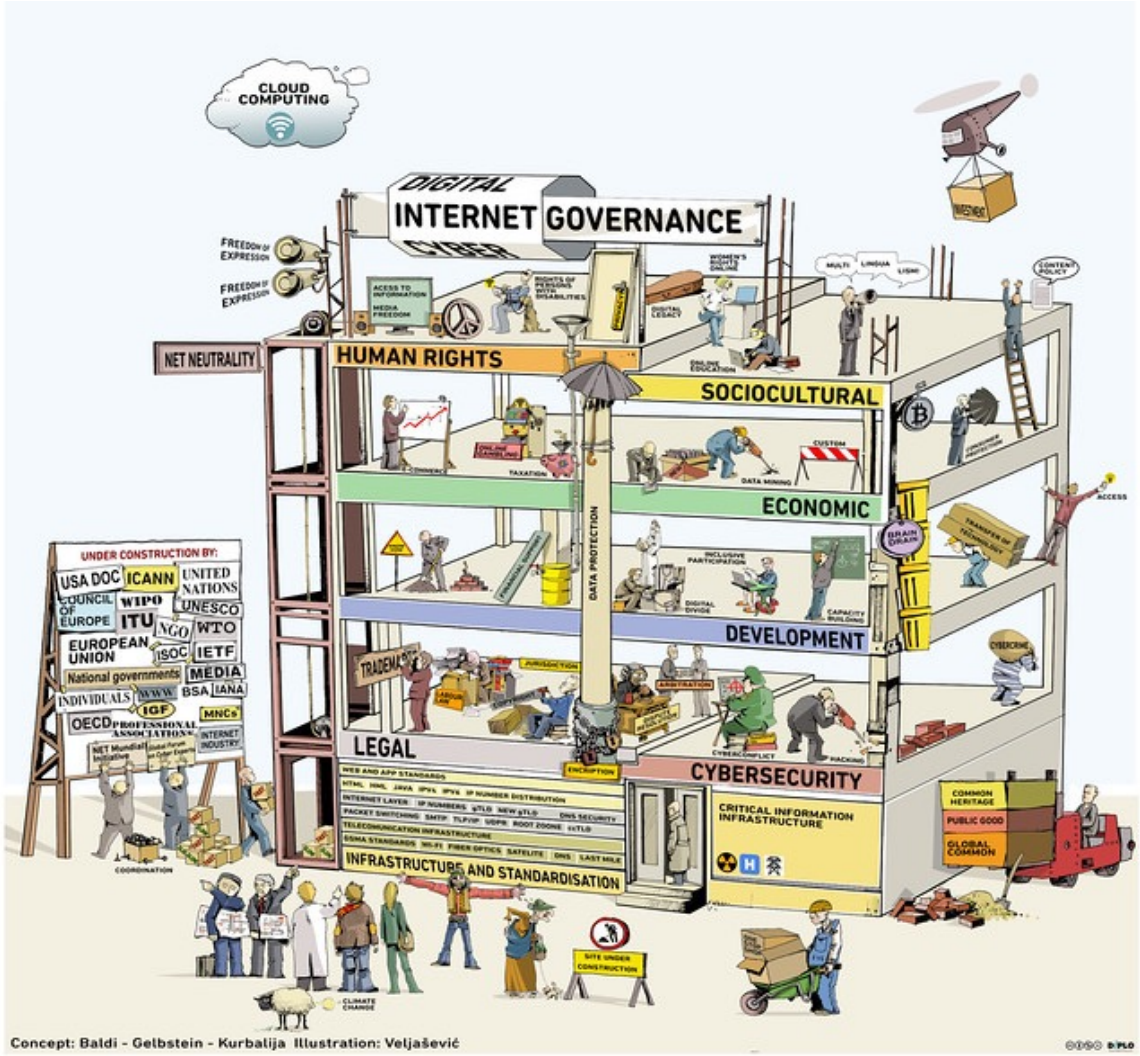
Internet governance & AF*

Internet Ecosystem



The Internet governance in a nutshell



Internet Governance: Definition

Complementary development and application by governments, the private sector, civil society and the technical community, in their respective roles, of **shared principles, norms, rules, decision-making procedures, and activities that shape the evolution and use of the Internet**

Internet Governance Forum (IGF)

serves to bring people together from various stakeholder groups as equals, in discussions on public policy issues relating to the Internet

NOT a governing body

IGF Internet Governance Forum

Internet Governance: Challenges

1. The pace and changing nature of the internet
2. The internet as part of digitalisation
3. The concentration of digital power
4. Digital geopolitics (and the environment)
5. Shaping the digital future
6. The future of regulation
7. Multilateralism and multistakeholderism
8. Participation in decision-making

Internet Ecosystem: I*

I* are International organisations (usually non-for-profit) working for a **better Internet in the world**. These organisations names usually start by "**I**" but not always the case

Some example of I* include: ICANN, ISOC, IETF, W3C, APC, PIR

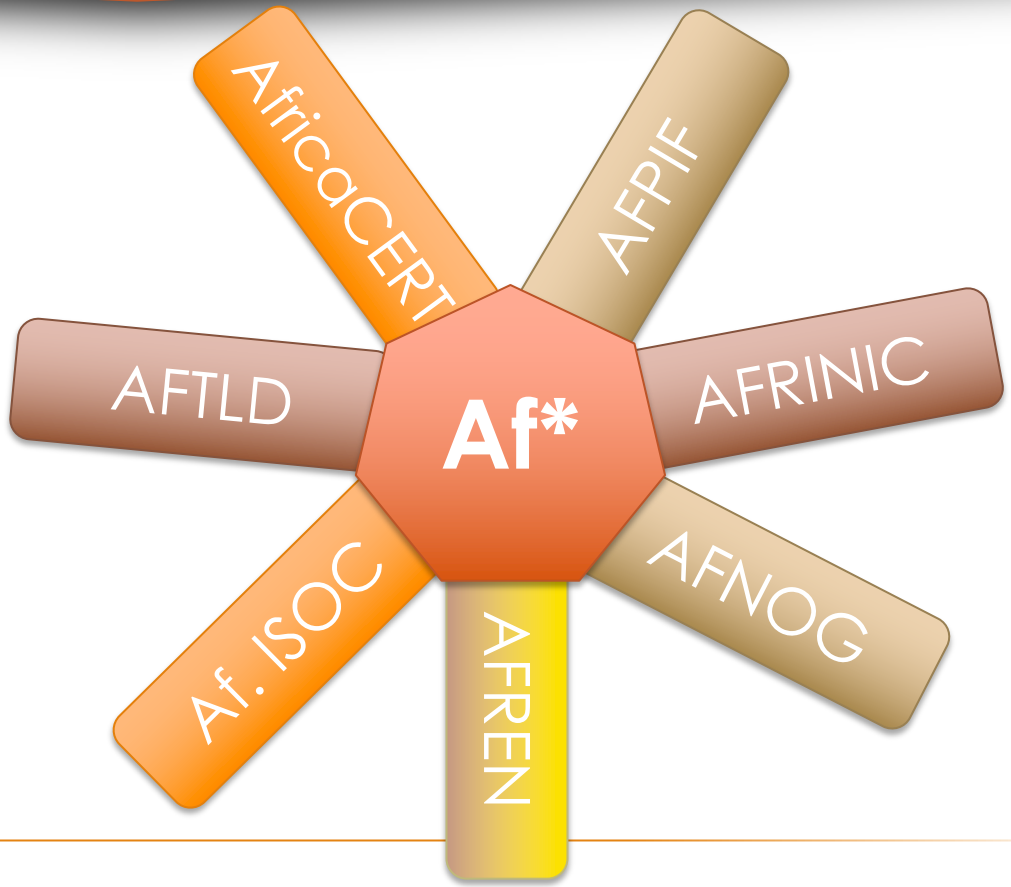
ICANN

Internet Corporation for Assigned Names and Numbers

ICANN coordinates with other partners to help make the Internet work: Protocol parameters, Names and Numbers,

Africa Internet Ecosystem: Af*

Af* are organisations collaboratively working for a **better Internet in Africa**. These organisations include the various sectors of the Internet such as: Internet Numbers, Policy, Content and Names, Research, Infrastructure, Capacity building, and Security.

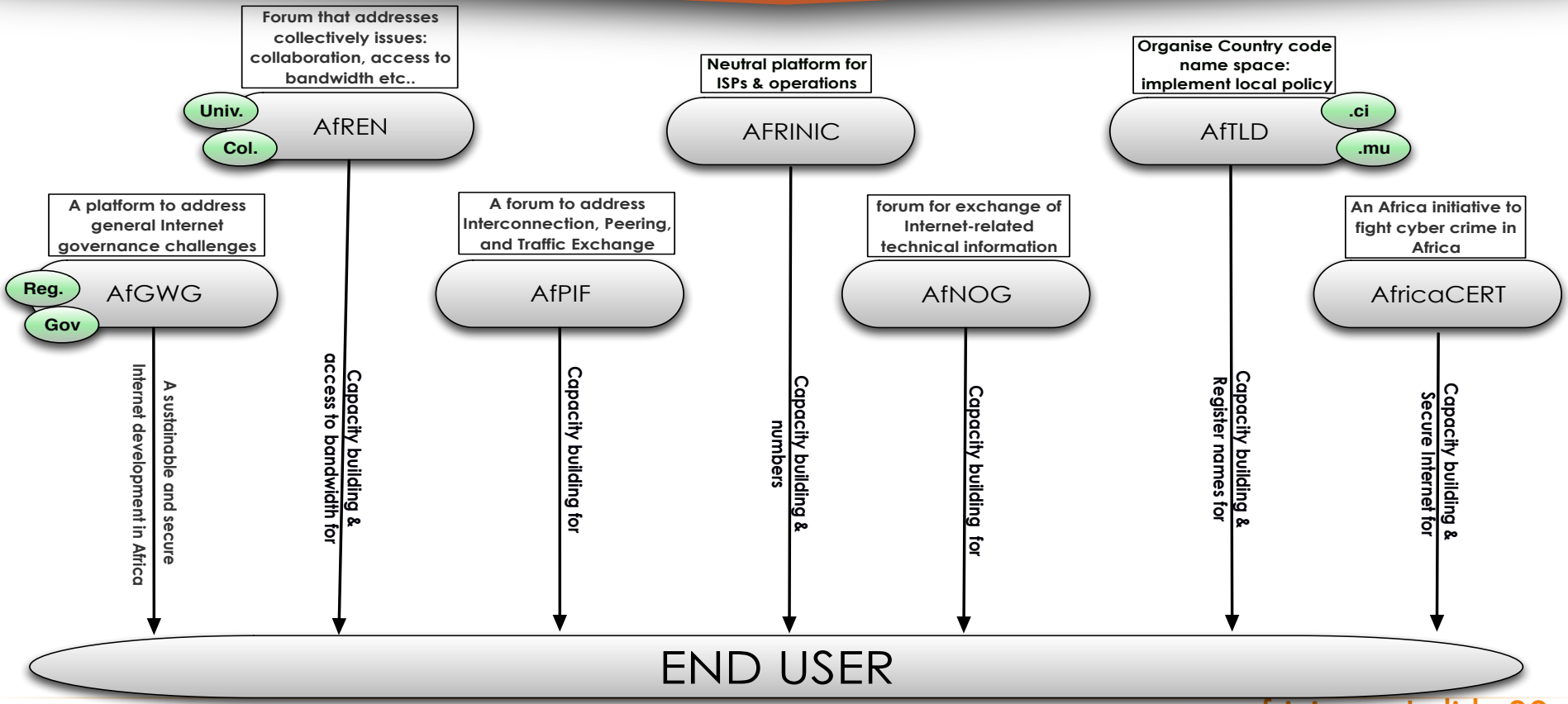


Africa Internet Ecosystem: Af*

- AFRINIC for **numbers**
- AfricaCERT for **security**
- AfREN for **research and education**
- AF-IX for **Internet Exchange Point**
- AfTLD for **domain names**
- AFNOG and the others for **Capacity Building**
- AfCHIX for **Women in Technology**
- ISOC African Chapters for **Internet Development**
- African IGFs for **Internet Governance in Africa**
- AFGWG for **Government implication in Number resources**

Many more still evolving within the ecosystem.

Some AF* stakeholder's role



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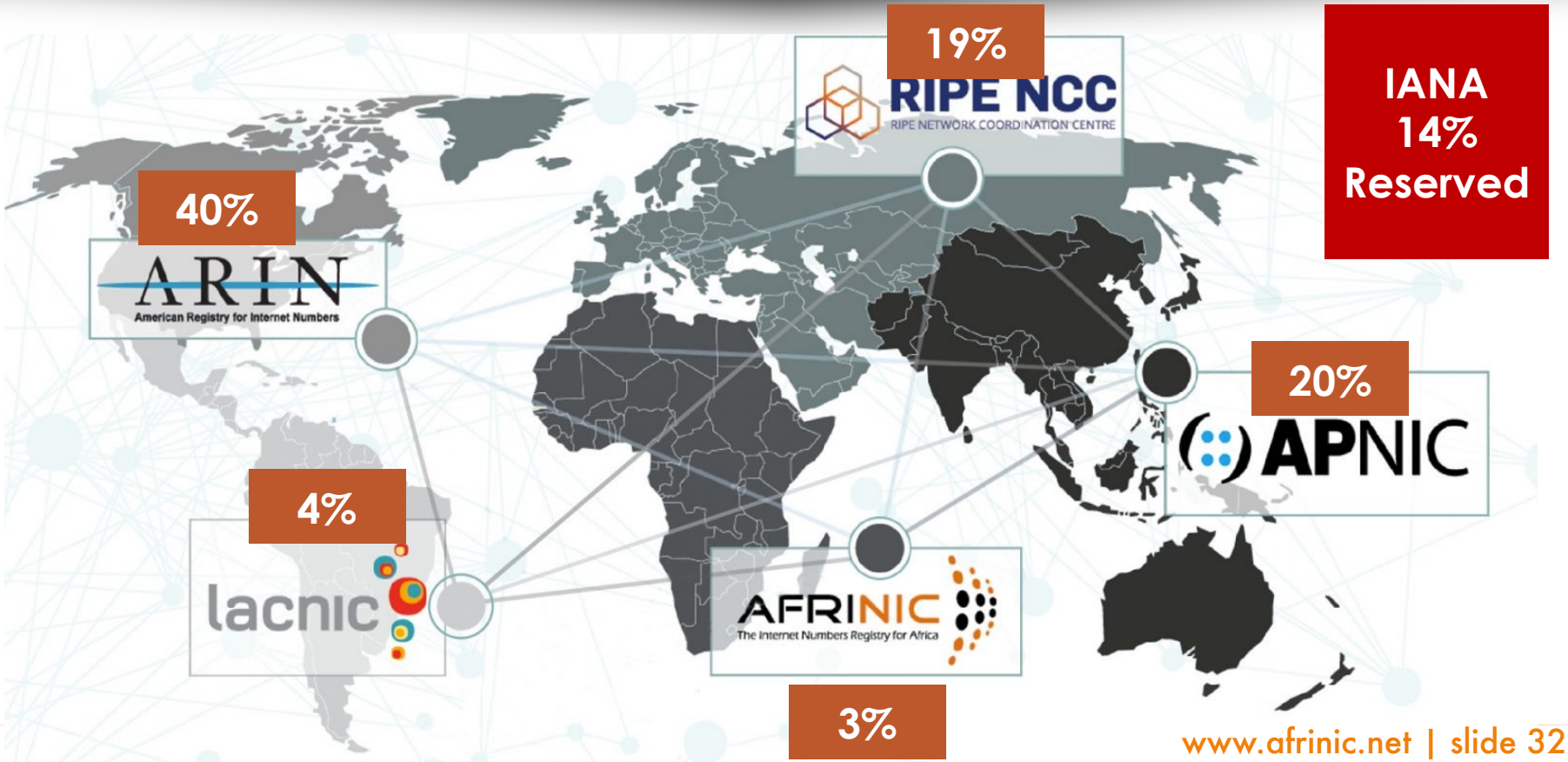
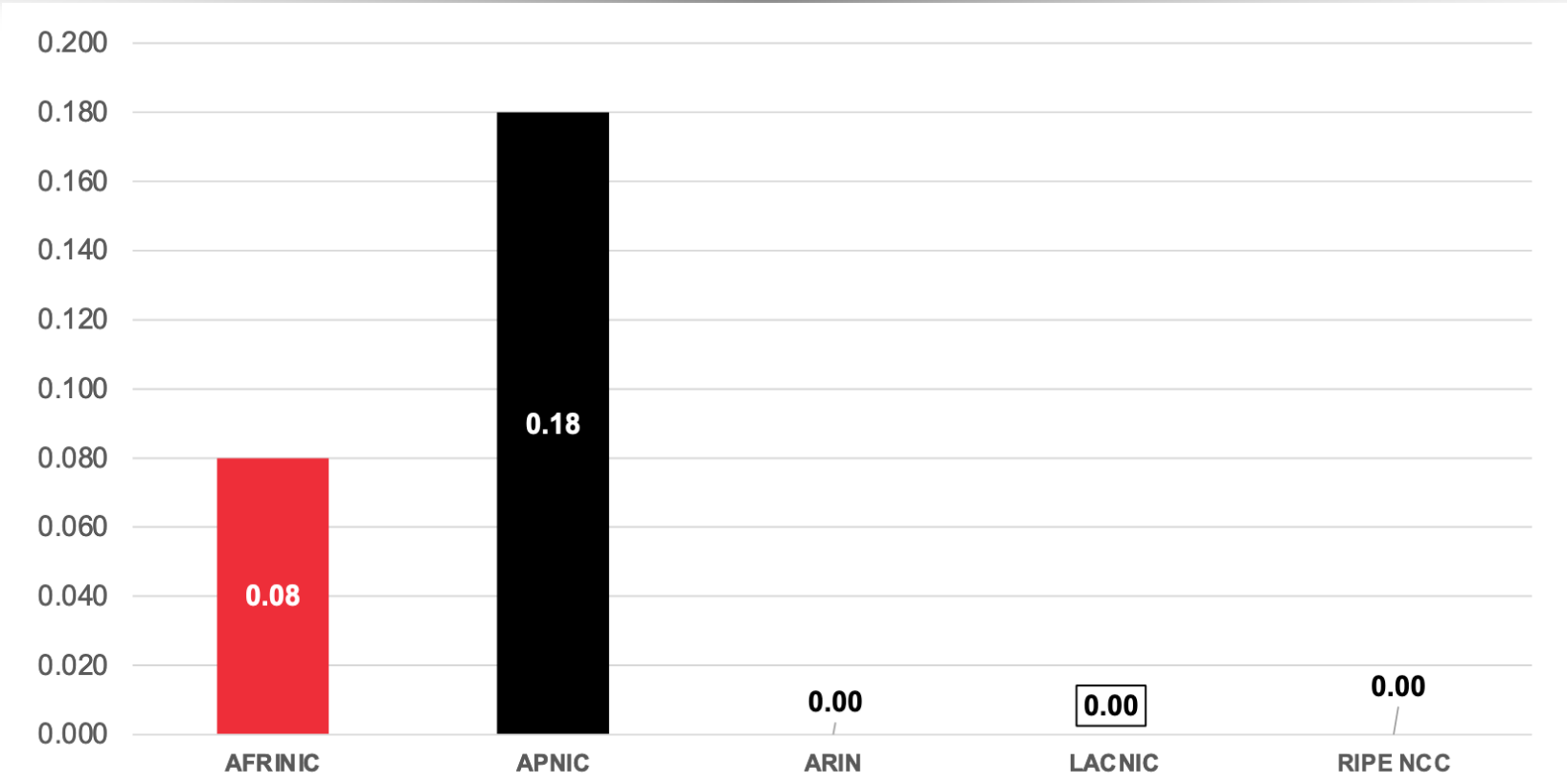
IPv4 Exhaustion Implications

IPv4 distribution per region (RIR)



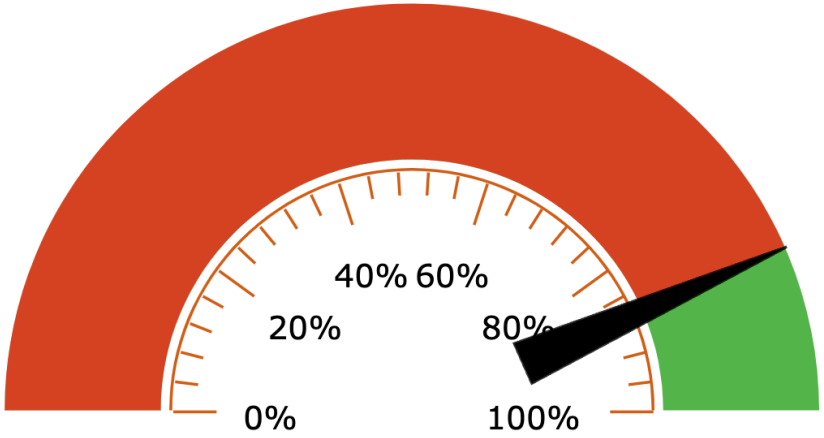
IPv4 today at the RIR level



We now have

1,325,568

available /32 left to hit total exhaustion.



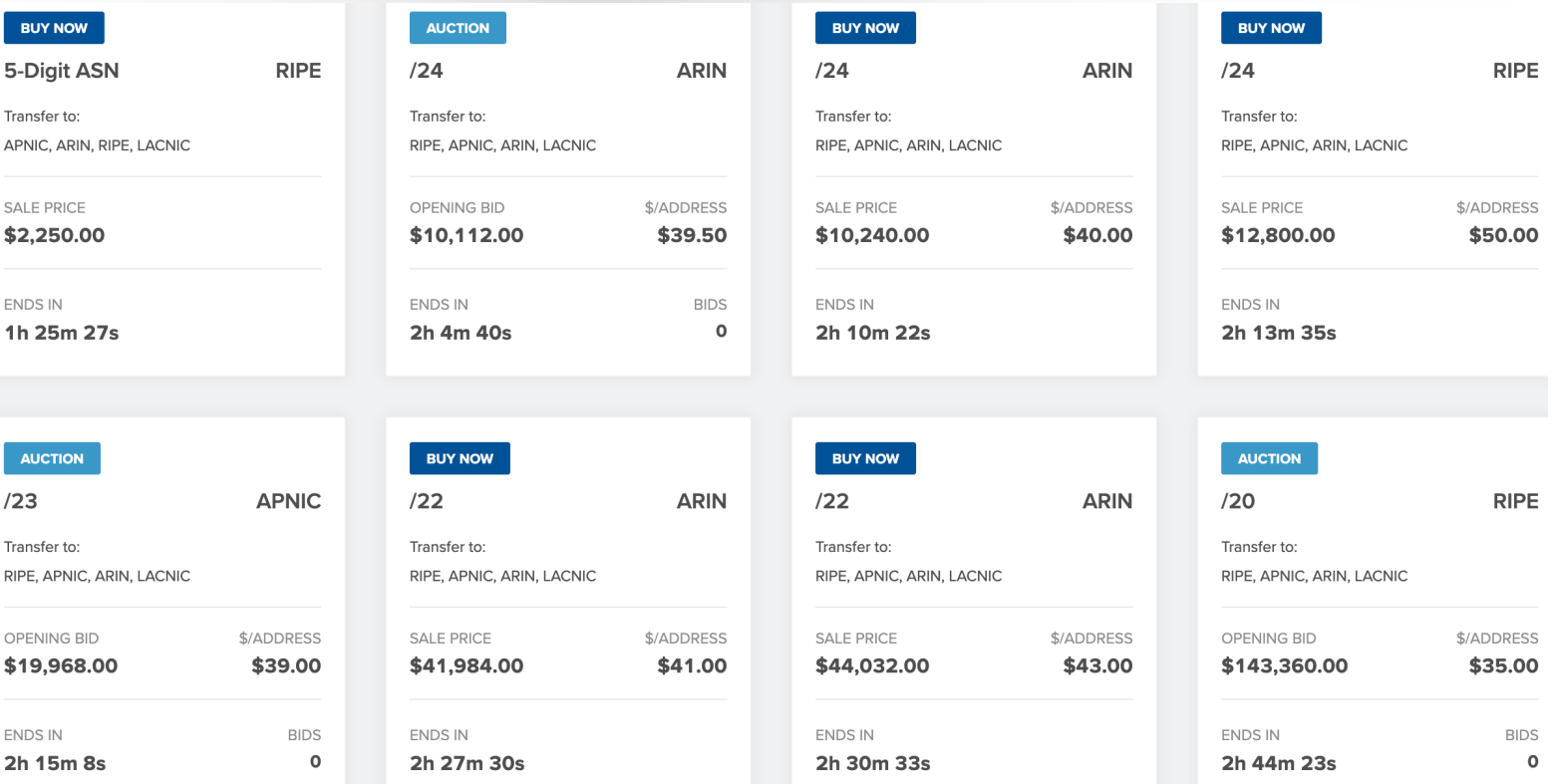
86.74432 %

https://stats.afrinic.net/

How many connected devices do you have at home?

IPv4 exhaustion impact #1

IPv4 addresses are very rare today then expensive



IPv4 exhaustion impact #2

IPv4

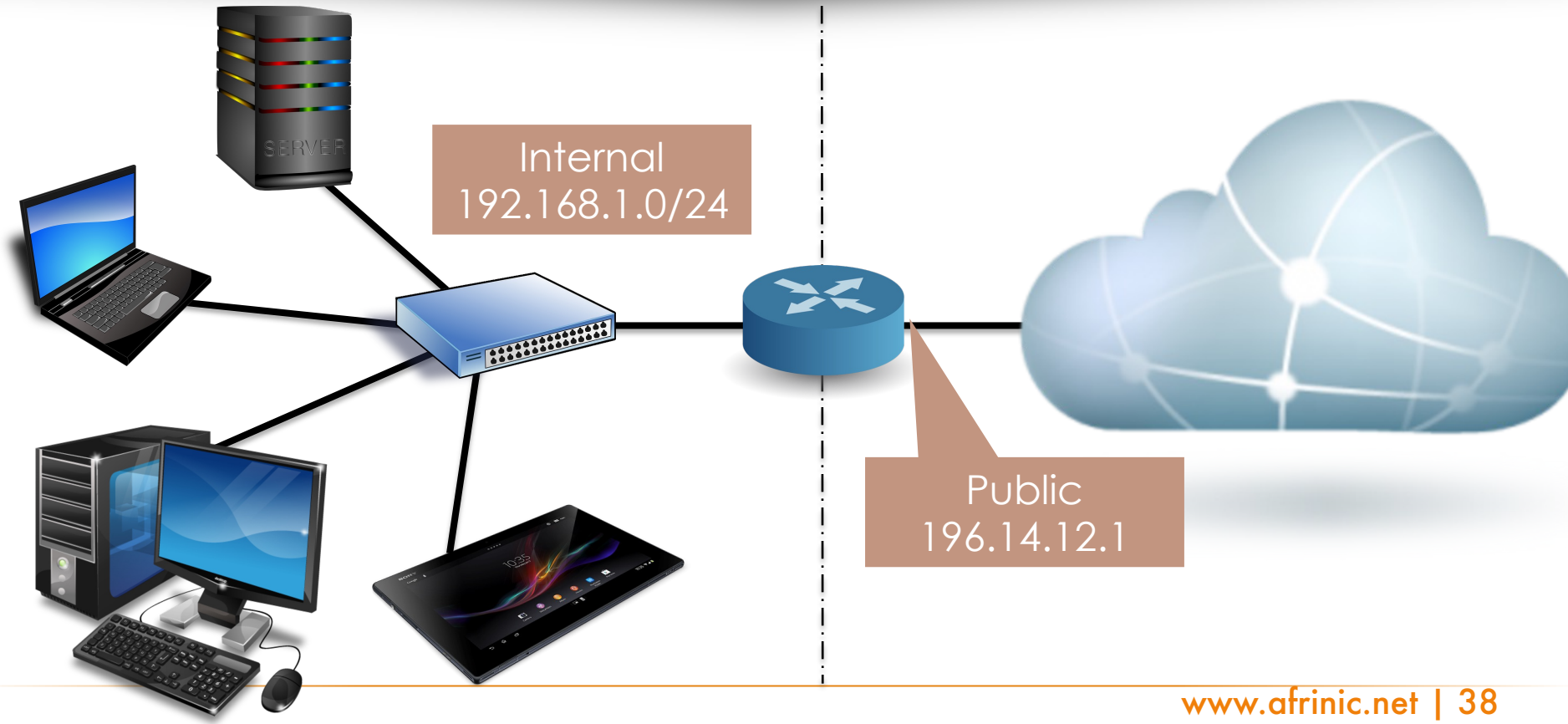
Expensive

Increase the use of

NAT

- Limited Address pool
- Complex Configuration
- Application limitations
- Breaks end to end
- Complicates remote access
- Complicated peer-to-peer application
- Cripples innovation
- Increases OPEX

NAT is a public IP sharing technology



NAT is Breaking the End to End Model

- ✓ Peer-to-Peer applications break and need complex workarounds.
  - Social media servers (Facebook, Linkedin, etc)
  - Chat servers
  - NAT traversal
  - Voice and video gateways

- ✓ IPsec, SIP, FTP depend on end-to-end model to work.

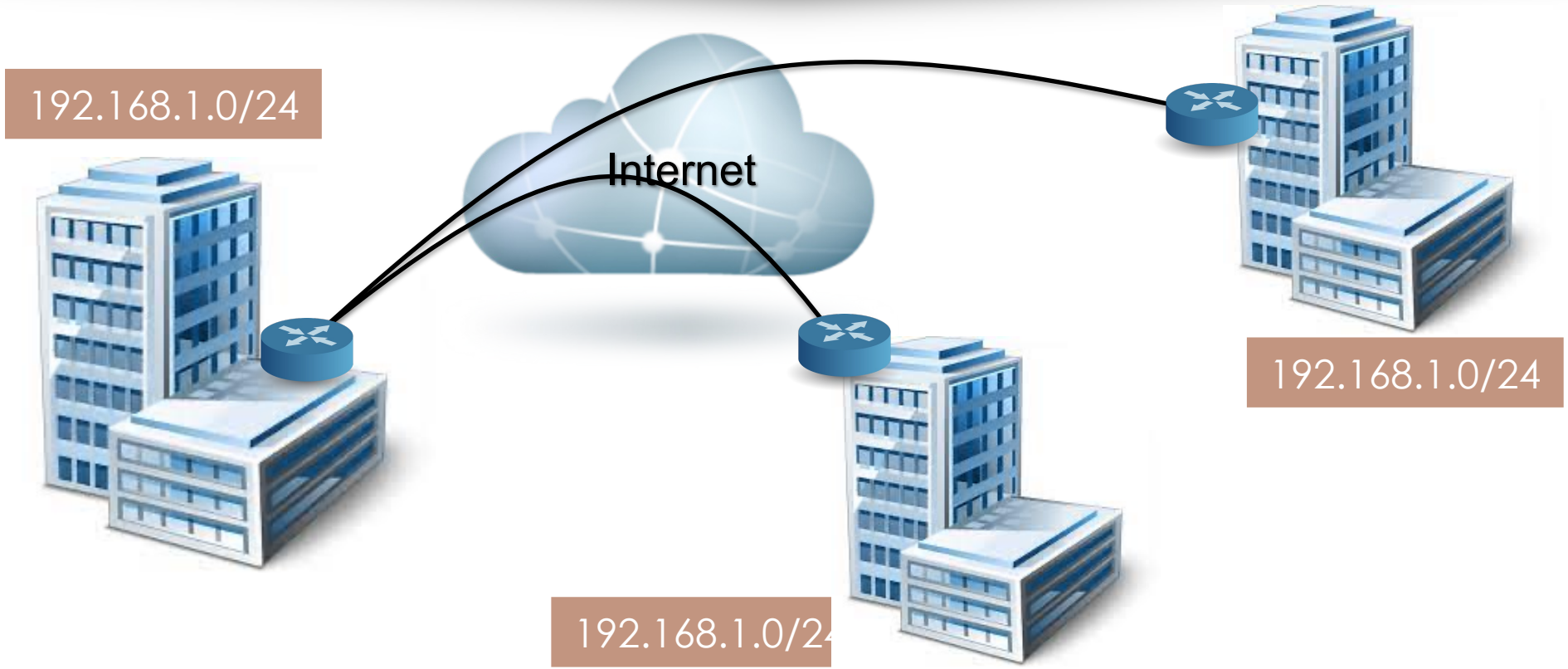
- ✓ End users cannot easily run their services
  - Personal servers (web,email, calendar, music etc)
  - Home automation
  - Video streams

NAT complicates devices identification & monitoring

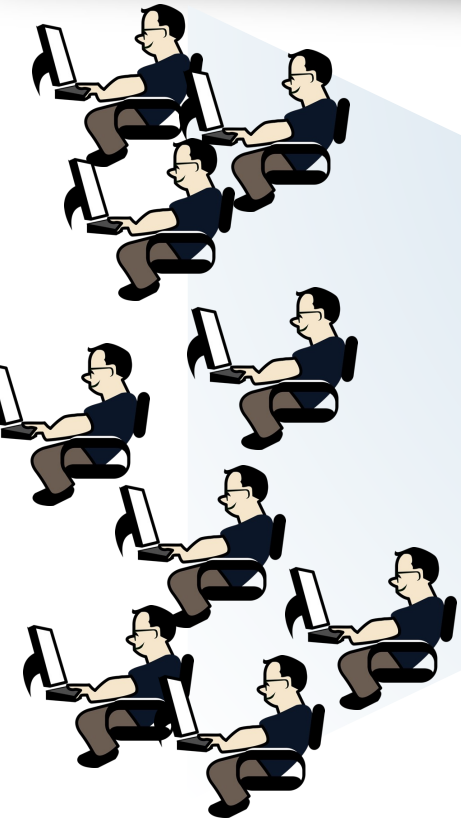
- ✓ Devices behind a NAT are invisible to monitoring systems outside
  - Make it hard to correlate network events
  - Makes it hard to track ‘evil’ people and ‘victims’ on the network.

- ✓ Consequences
  - Punish entire organisation for the sins of one person
  - (blacklisted IP)
  - Extra work/cost to track port - > private v4 addresses

Duplicated Private IP addresses

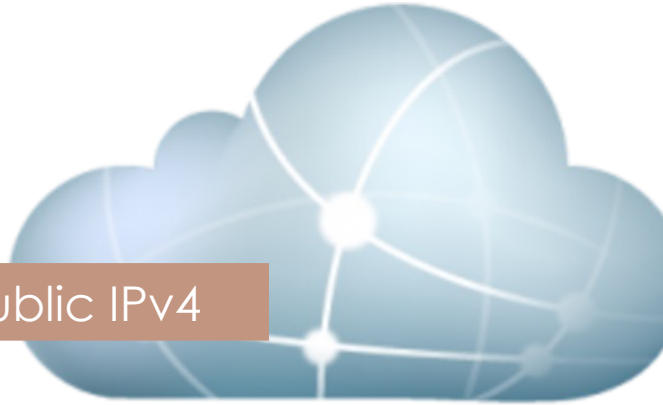


From an ISP perpective (NAT increases OPEX)



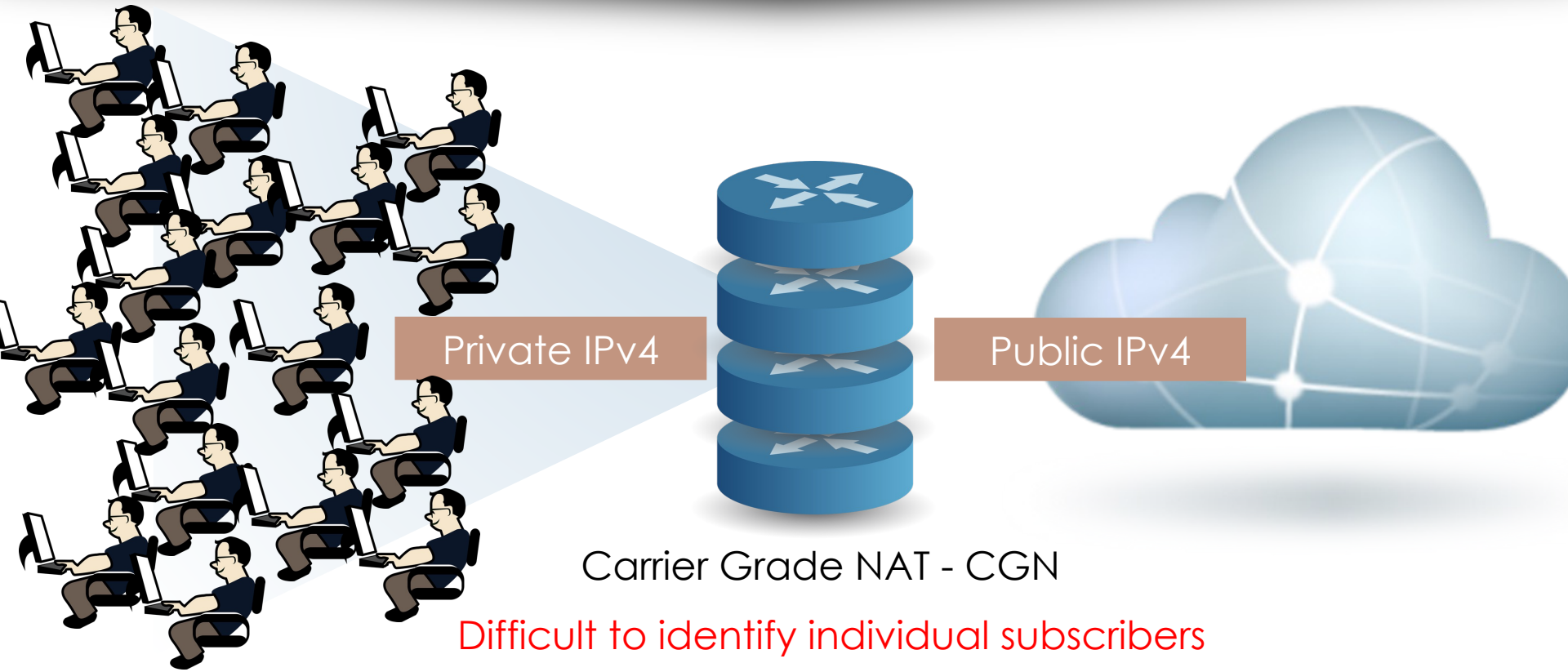
Private IPv4

Public IPv4



Carrier Grade NAT - CGN

From an ISP perpective (NAT increases OPEX)



Carrier Grade NAT - CGN

Difficult to identify individual subscribers

NAT Limits the Number of Concurrent Applications

- ✓ 16 bit TCP/UDP port field 65536(2^{16}) ports per address
- ✓ Each session uses a port on each communicating node
- ✓ Number of sessions used by some apps on my own computer
  - Google chrome: 2495
  - Safari: 2169
  - Apple TV: 1204
  - Deezer: 479
- ✓ By NATing say 100 users to a single you severely limit what each user can do!

Google Maps @ 30 Connections

Google Maps @ 20 Connections

Google Maps @ 15 Connections

Google Maps @ 10 Connections

Implications for RIRs including AFRINIC #1

More fraudulent requests to transfer IPv4 addresses:

- IPv4 addresses have increasing market value as supply depletes

Hijacking of IPv4 addresses & ASNs:

- *Fraudulent Whois changes; Target dormant/out of date records*
- *Submit falsified documents (e.g. passports)*
- *Set up shell companies*

Route Hijacking:

- *Unauthorized use of abandoned/un-routed IPv4 addresses*

Implications for RIRs including AFRINIC #2

Leasing/buying/selling of IPv4 address space (outside of registry system)

People not validating their contact information in Whois

Carrier Grade NAT
Difficult to identify individual subscribers

Implications for Governments #1

- ✓ With Limited IPv4 addresses governments may face challenges in obtaining sufficient IP addresses to support their growing infrastructure and expanding services (E-Gov, FinTech, E-Agriculture E-Health etc).
- ✓ Governments promote Internet access for all and strive to bridge the digital divide. Limited IP addresses is a blocker as IP is needed to connect the unconnected.
- ✓ Governments may face Compatibility and Interoperability Challenges, IPv6 compatibility of legacy devices and applications.

Implications for Governments #1

- ✓ Governments need to start deploying IPv6 as they are seen as the body that must lead any national change/update and more.
- ✓ For national Security and Governance, Governments want to identify Internet users that commit cybercrimes. Unfortunately, IPv4 exhaustion increases NAT and IP sharing technologies usage, that compilates users and network identification
- ✓ Governments as key actor in shaping Internet related policies and regulations must consider the evolution of Internet with IPv6 and apply updated texts where need-be

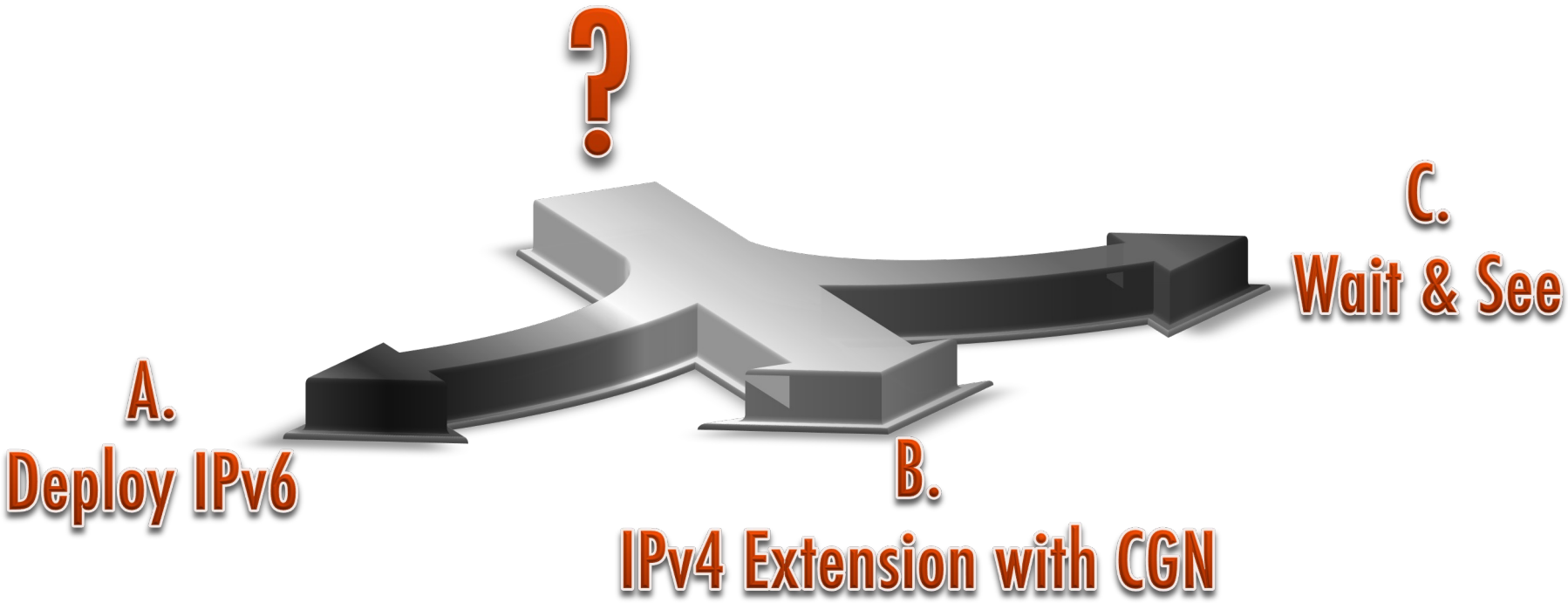
Implications for Internet Service Providers

- ✓ Challenge to connect news users over IPv4, ISPs may face difficulties in obtaining sufficient IP addresses to meet the growing demand for internet connectivity.
- ✓ As IPv4 become rare and expensive, purchasing IPs will increase OPEX
- ✓ Frequent CGN replacement will increase OPEX
- ✓ ISPs need to educate their customers on the implication of the IPv4 exhaustion (clients don't care about IPv4 or Ipv6 they want to get connected to the Internet)
- ✓ Network and devices update/replacement in order to support both IPv4 and IPv6

Implications for Users

- ✓ Challenge in getting one IP per each user devices
- ✓ With IPv4 depletion, NAT is the new normal this may introduce limitations and complications for certain applications, such as peer-to-peer file sharing, online gaming.
- ✓ User won't be able to host some personal content at home.
- ✓ Students can't continue their work remotely as the university/college can't get enough public IPv4 to connect classrooms and laboratories to the Internet

What are we doing ?



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Exercise #1 (Print and share)

	Extension with NAT	Deploying IPv6	Wait and see	Deploying IPv6 & some NAT
Addresses IPv4 exhaustion				
Enables business continuity				
Supports explosive growth of the Internet				
Enables return to end-to-end Internet				
Contributes to keeping outdated devices				
Short term costs				
Long term costs				
Helps fight cybersecurity				
Need for internet governance capability				
Helps host personal content				

Explain your choices to the class

Exercise #1 (A solution)

	Extension with NAT	Deploying IPv6	Wait and see	Deploying IPv6 & some NAT
Addresses IPv4 exhaustion	Yes	Yes	No	No
Enables business continuity	No	Yes	No	Yes
Supports explosive growth of the Internet	No	Yes	No	No
Enables return to end-to-end Internet	No	Yes	No	No
Contributes to keeping outdated devices	Yes	No	Yes	Yes
Short term costs	No	No	Yes	Yes
Long term costs	Yes	No	Yes	Yes
Helps fight cybersecurity	No	Yes	No	No
Need for internet governance capability	Yes	Yes	Yes	Yes
Helps host personal content	No	Yes	No	Yes

Explain your choices to the class

Interactive session

Relevant stakeholders, policies and programs to engage to drive IPv6 deployment:

-- USE EXERCICE BOOK --

Exercise #2: State 4 policies that may help drive IPv6 deployment

Exercise #3: List 4 governments programs and explain how they can be used to drive IPv6 deployment.

Exercise #4: How IPv6 supports digital transformation in Africa

Government initiatives for IPv6 adoption #1

- ✓ Awareness and Education Campaigns to inform locals about IPv4 exhaustion implication and the need to adopt IPv6
- ✓ IPv6 Readiness Assessments, to ensure government networks and devices are IPv6 ready can also open make it a public service offered by government to all stakeholders
- ✓ Collaboration with Network Operators Group – NOGs (ISPs have many clients so they can boost the IPv6 adoption) By putting in place measures to like fund to upgrade their infrastructure, rewrded competition etc…

Government initiatives for IPv6 adoption #2

- ✓ National IPv6 Task Forces government can assist establish a working group with all relevant stakeholders that will work together in a master project that will lead to a National IPv6 adoption plan.
- ✓ Governments can start its own IPv6 deployment journey and showcase each achievement. Government will then be considered the national champion to the IPv6 adoption. This will urge all hesitant stakeholders to start as well
- ✓ Global collaboration as per the ITU resolution 180, Governments can collaborate with international organization like AFRINIC to promote IPv6 adoption.

Government's policies for IPv6 adoption

- ✓ Mandating IPv6 Support in procurement policies and contracts. Also, ensuring that government-funded projects and services are IPv6 compliant.
- ✓ Establishing IPv6 Transition Deadlines, These deadlines can be enforced through regulatory measures and can apply to both government agencies and private sector entities (explain why its urgent to migrate)
- ✓ Incentives and Funding Programs to reward organization that are deploying IPv6. This can be tax reduction or direct funding.

IPv6 Adoption Policies Abroad #1

- ✓ ITU and the resolution 180
- ✓ China: The Chinese government has included IPv6 adoption as part of its national strategic plan. The "Next Generation Internet Protocol (IPv6) Promotion Plan" sets targets for IPv6 deployment in various sectors and mandates that government agencies, telecommunication operators, and large-scale websites support IPv6.
- ✓ Japan: In Japan, the "IPv6 Promotion Policy" was established by the Ministry of Internal Affairs and Communications. This policy encourages IPv6 deployment in government agencies, educational institutions, and private businesses. It also sets specific goals for IPv6 adoption and provides support for IPv6-related projects.

IPv6 Adoption Policies Abroad #2

- ✓ South Korea: South Korea has implemented the "IPv6 Roadmap" to promote the adoption of IPv6. The roadmap includes measures such as requiring all government agencies to support IPv6, encouraging IPv6 deployment in the private sector, and providing financial incentives to ISPs for offering IPv6 services.
- ✓ European Union: The European Union has recommended IPv6 adoption through various policy initiatives. The "Digital Single Market" strategy emphasizes the need for IPv6 deployment to support the growth of the digital economy and ensure the availability of sufficient IP addresses. Additionally, the EU has provided funding programs to support IPv6 research, pilot projects, and capacity building.

IPv6 Adoption Policies Abroad #3

- ✓ United States: While there are no specific federal laws mandating IPv6 adoption in the United States, the Office of Management and Budget (OMB) issued a memorandum in 2005 that required all federal agencies to support IPv6 in their network infrastructures. This directive aimed to ensure interoperability and future-proofing of government systems.

*** Leading by example ***

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1. Highlights of Resolution 180 (Rev Bucharest 2022)

- On promoting Internet Protocol version 6 (IPv6) deployment
- Subsequent to Resolution 63 (Rev Kigali 2022)
- ITU-WTDC Resolution 180 (Rev Bucharest 2022) adopted during the ITUPP22 held in Bucharest (Romania),
- support other Member States who request capacity building assistance, including support from relevant organizations
- …

1. Highlights of Resolution 180 (Rev Bucharest 2022) Ctd

- …
- encourage IP-based telecommunication/ICT services and infrastructure support IPv6;
- share best practices in IPv6 deployment;
- to encourage industry and academia to participate in IPv6 deployment and capacity building;
- encourage government agencies and private-sector organizations to ensure their websites and services support IPv6..

2.Tangible Values of an effective IPv6 deployment in Africa

Deploy more networks in your country.

By 2024, it won't be possible to get continuous IPv4 addresses blocks from AFRINIC to keep on deploying networks in IPv4 only.

More efficient packet processing – Compared with the IPv4, IPv6 contains no IP-level checksum, so the checksum does not need to be recalculated at every router hop.

Reduce address sharing from more than 40 people per 1 IPv4 to 1000+ IPv6 per person, enabling end to end applications and better traceability of malicious actors by address.

Directed Data Flows – IPv6 supports multicast rather than broadcast. Multicast allows bandwidth-intensive packet flows to be sent to multiple destinations simultaneously, saving network bandwidth.

2.Tangible Values of an effective IPv6 deployment in Africa (2)

Simplified network configuration – IPv6 devices can independently auto-configure themselves when connected to other IPv6 devices. Configuration tasks that can be carried out automatically include IP address assignment and device numbering.

More Efficient Routing –

IPv6 reduces the size of routing tables and makes routing more efficient and hierarchical.

Security –

IPSec security, which provides confidentiality, authentication, and data integrity, is engraved into IPv6.

Route filtering:

Traffic may be filtered based on registered routes, preventing network problems caused by accidental or malicious routing announcements.

3. State of Resolution 180 (Rev Bucharest 2022)

The Plenipotentiary Conference of the International Telecommunication Union (Bucharest, 2022)

… Resolves …

1/ to explore ways and means, in accordance with the Tunis Agenda for the Information Society, for greater reciprocal collaboration and coordination between ITU and relevant organizations involved in the development of IP-based networks and the future Internet in the context of emerging telecommunications/ICTs, through cooperation agreements, as appropriate, in order to increase the role of ITU in Internet governance, and to foster greater participation by Member States in Internet governance, so as to ensure maximum benefits to the global community through affordable international connectivity;

3. State of Resolution 180 (Rev Bucharest 2022) ctd

2/ to step up the exchange of IPv6 experiences and information with all stakeholders, with the aim of creating opportunities for collaborative efforts and ensuring that feedback enriches ongoing efforts on this matter;

3/ to collaborate closely with the relevant international recognized partners, including the Internet community (e.g. RIRs, the Internet Engineering Task Force and others), in order to encourage the deployment of IPv6 through capacity building;

3. State of Resolution 180 (Rev Bucharest 2022) ctd

4/ to support those Member States which, in accordance with the existing allocation policies, require and request assistance in management, allocation and capacity building in the deployment of IPv6 resources, including support from relevant organizations, pursuant to relevant resolutions;

5/ to continue the studies of IP address allocation and use, both for IPv4 addresses and for IPv6 addresses, in cooperation with other relevant stakeholders, based on their respective roles,

4. Risk of not deploying IPv6 for African government

- High cost of catching up with technology (sovereignty)
- Law enforcement and fight against cybercrime
- Hostage of those with IPs (ISP, Network ops, IP brokers,)
- What happen when Tier 1, GAFAM, etc switch off IPv4
- Challenge in achieving AU Digital Transformation Strategy For Africa (2020-2030)
- …

Thank You!

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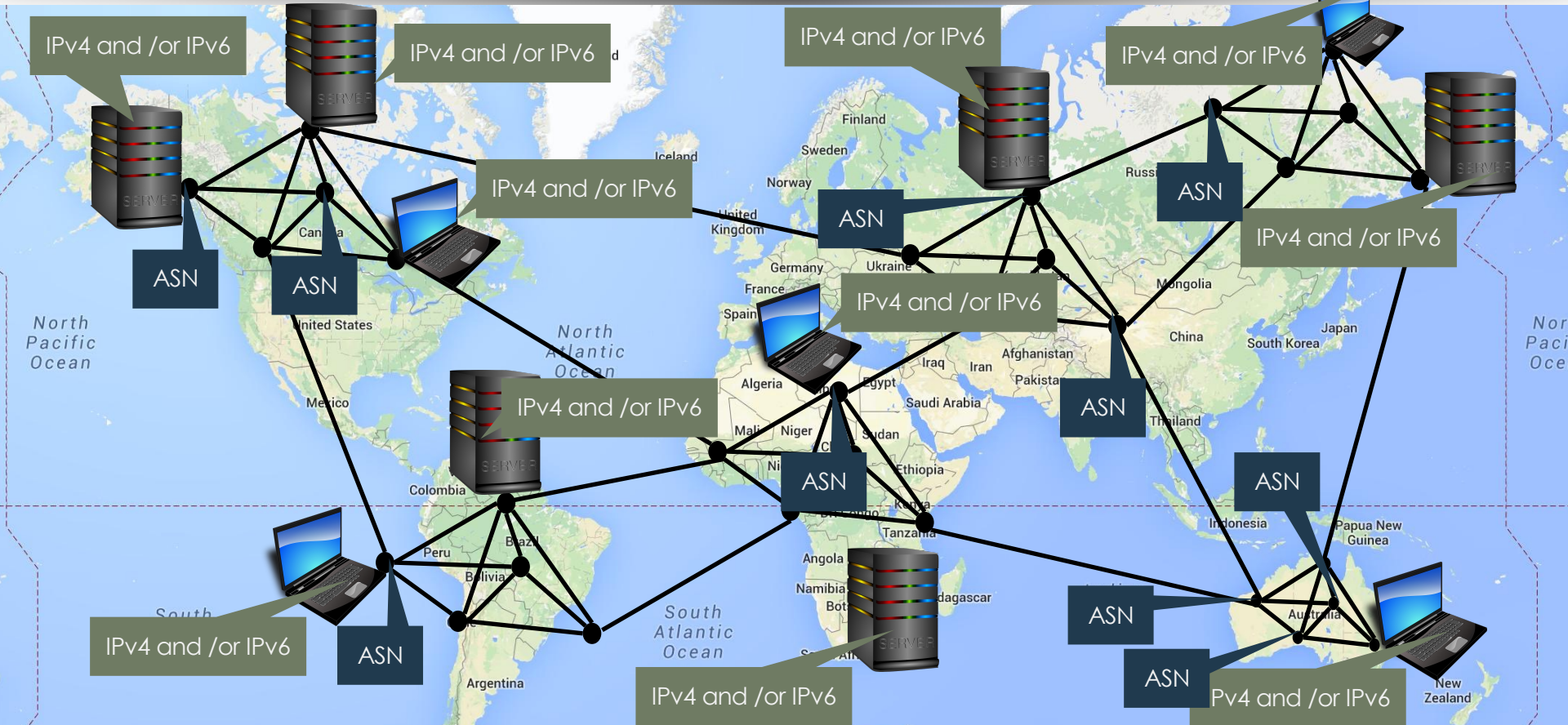
IPv6 for Goverments

The Internet is as a public utility

Internet is the concrete of all business sectors.

- E-Gov
- E-Health
- E-Agriculture
- Fintech
- Education
- Entertainment
- Politics
- War
- ...

Recall the Internet



The Internet is constantly evolving

- Source statistica.com and Cisco annual internet report:
  - In 2021 = 26 billions of devices connected
  - In 2030 = 50 billions of devices connected

IPv4

32 bits:

4,29

Billions

IPv6

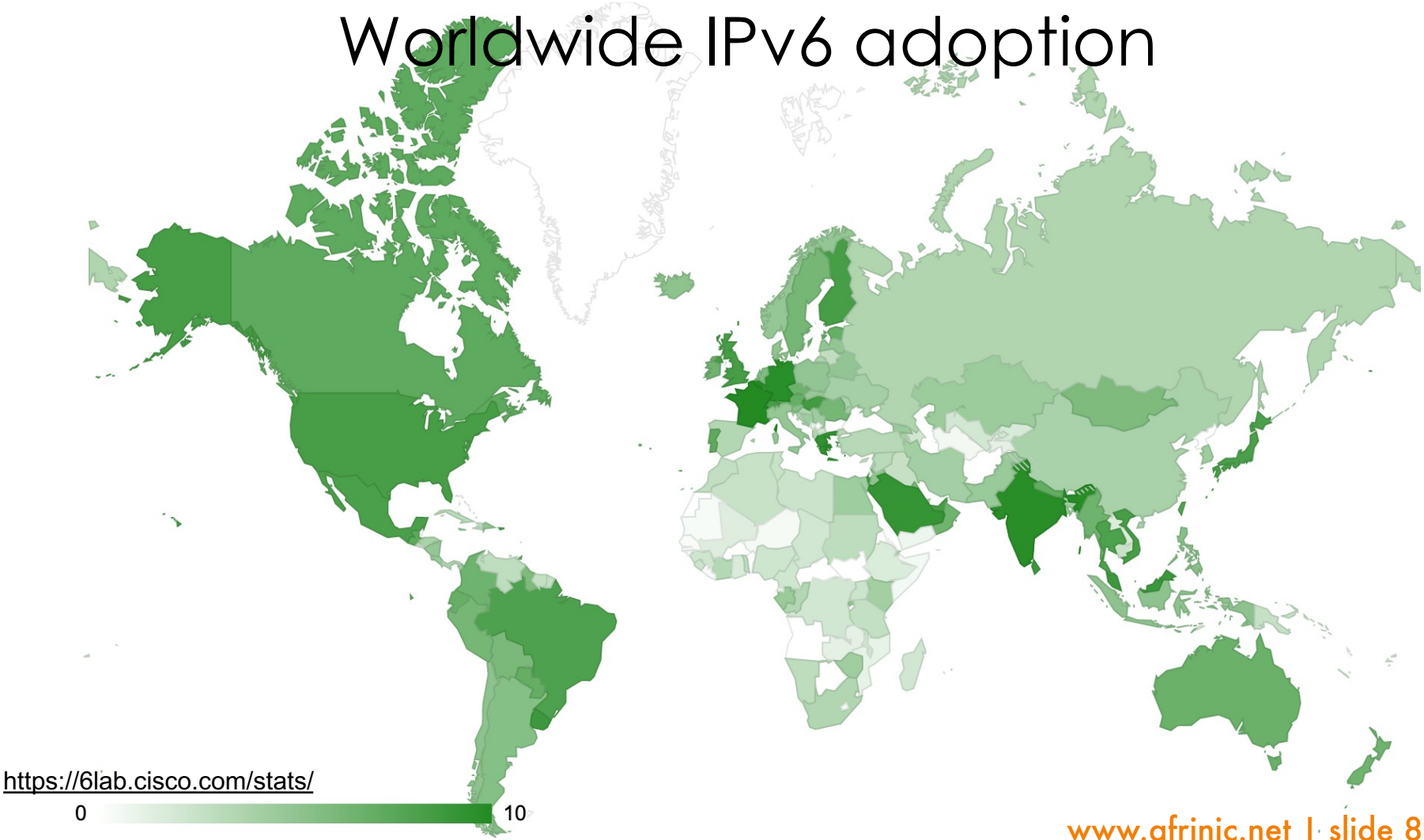
128 bits:

3,4

Trillions of trillions

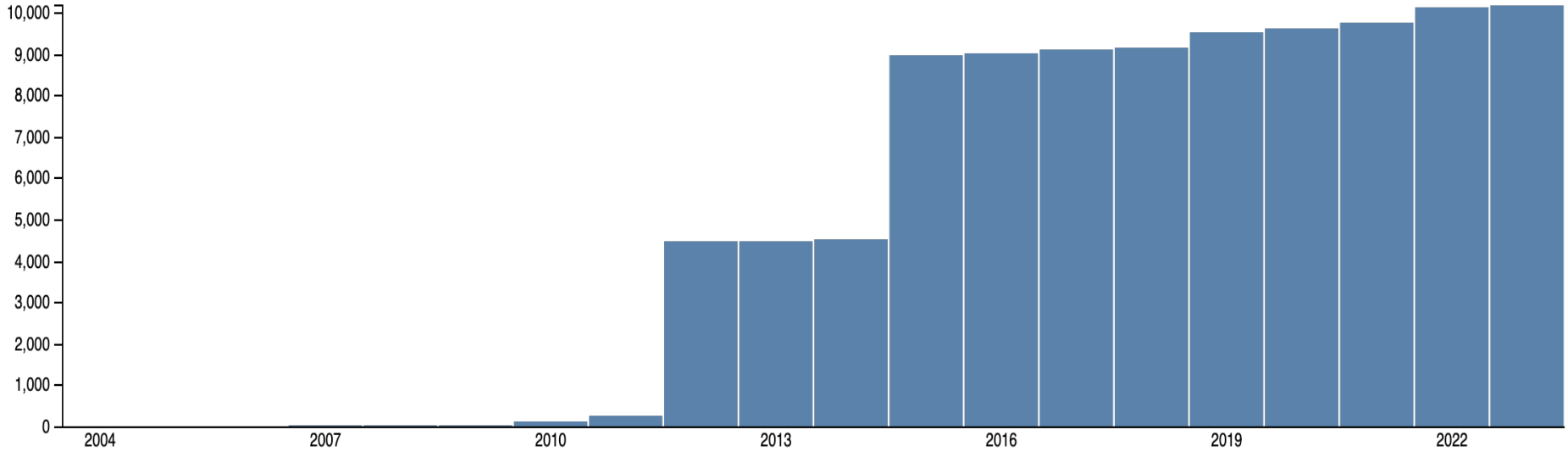

IPv4
100
It is therefore time to deploy IPv6
IPv6

Worldwide IPv6 adoption



IPv6 issued Cumulative per year (/32s) since 2004

May 2023: 10 186 /32 - IPv6



https://stats.afrinic.net/ipv6

Options to consider for business continuity

- ✓ Addresses IPv4 exhaustion
- ✓ Enables business continuity
- ✓ Supports explosive growth of the Internet
- ✓ Enables return to end-to-end Internet
- ✓ Contributes to keeping outdated devices
- ✓ Long term costs
- ✓ Deployment cost
- ✓ Helps fight cybersecurity
- ✓ Helps host personal content

What is happening here ?

IPv6 Transition Techniques & Deployment

Why we need IPv6 Transition Techniques

Why we need Transition Techniques

- IPv4 and IPv6 are not compatible
- Both protocols have to co-exist
- Gradual transition to IPv6
- At the mercy of the big players

Overview: Transition Techniques

There're 3 categories of transition techniques

Dual stack

Tunneling

Translation

Dual Stack

- Nodes runs both IPv6 and IPv4 protocol stacks
- DNS reply determines which protocol stack to use
- Happy Eyeballs – "**Better Connectivity Using Concurrency**" (RFC8305) improves it and could make fallback from IPv6 to IPv4

Pros

- At first sight, easy to roll out
- It is easy to discontinue IPv4 when all services are on IPv6

Cons

- You still need IPv4 addresses
- Additional monitoring, troubleshooting, security policies e.t.c.

Tunneling

- point-to-point tunnels made by encapsulating IPv6 within IPv4 to carry them over IPv4 routing infrastructures.
- Dual-stack devices run both IPv4 and IPv6 protocols simultaneously and thus can inter-operate directly with both IPv4 and IPv6 end systems and devices
- useful to offer an end-to-end IPv6 service without major upgrades to the infrastructure..

Pros

- interconnect isolated IPv6 domains over existing IPv4 infrastructures
- A variety of transition mechanisms are available

Cons

- You still need more IPv4 addresses
- Subscribers share addresses
- the more tunnel endpoints you have, the more tunnels you need

Translation

- Example of 464XLAT
- Combines stateful (NAT64) + stateless translation
- Minimal IPv4 resource requirements
- Components
  - Provider-side translator
  - Customer-side translator

Pros

- The only Translation Techniques that works in cellular networks!
- Works with literal addresses and socket APIs

Cons

You still need more IPv4 addresses for NAT64

Which Transition Technique should we use?

Exercise #5 : Transition technique

Check all applicable transition mechanisms for the below network operator

Transition Technique	Enterprise	ISP	Bandwidth provider	Mobile operator	Government
Dual Stack					
Tunneling					
Translation					

Deployment Stages

- An existing network typically runs IPv4-only
- Dual stack usually easy entry point
- End goal is IPv6-only, but need to keep IPv4 service
  - IPv6-only with IPv4aaS makes more sense
  - In a single step you reach your end goal
    - IPv4 traffic vanish without impacting your network

IPv6 Deployment milestones

- Training
- Communication
- Technical Audit
- Connectivity plan
- Approach technique
- Implementation

Some Initiatives that work

- ISP
- **University**
- **College**
- **Research labs**
- Corporate
- International Org.

IPv6 Use Case / Example

- Nigeria – NCC
  - Main upstream have IPv6 resources and announce it
  - Certification training for May 2023
- Rwanda
  - Ongoing with the help of AOS (national datacenter)
  - Nation wide deployment planned for this year
- Malawi – MACRA
  - Ongoing planification and project to boot soon!!

MACRA Migration plan Gantt chart (1)

IPv6 National Migration Plan

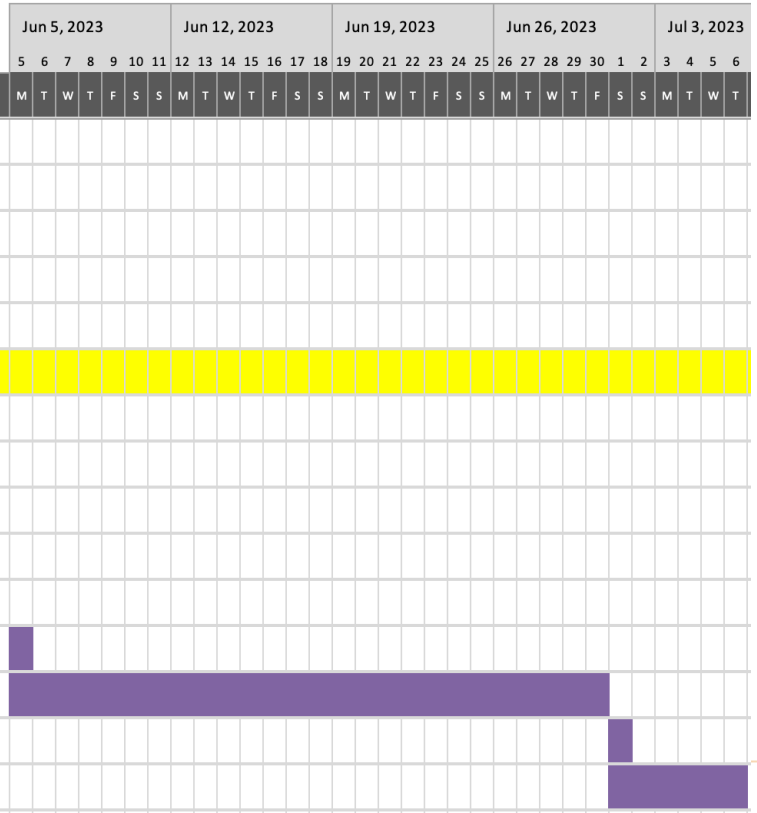
Malawi Communication and Regulation Authority

Steven PRETE

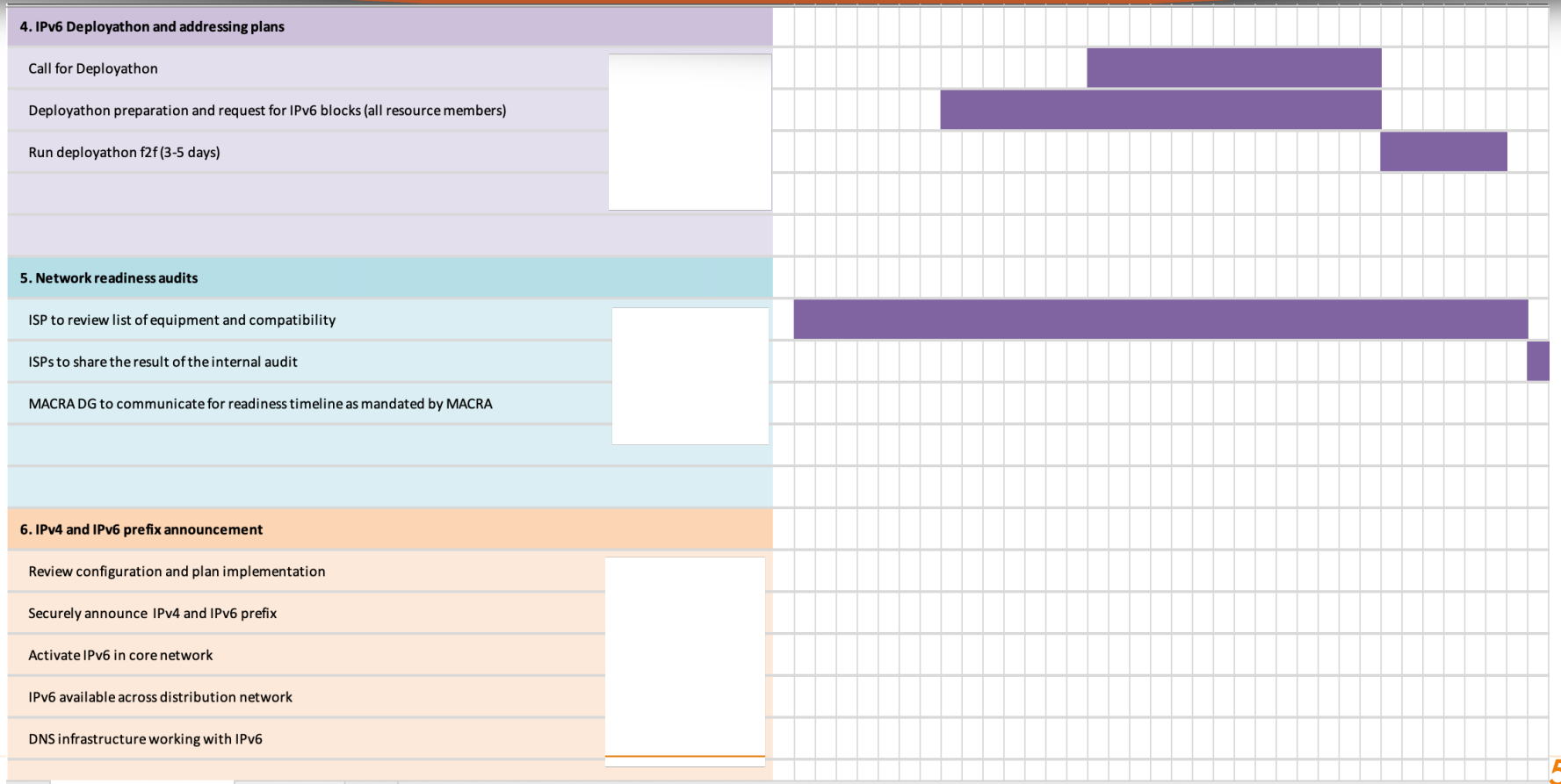
Project Start: Mon, 12/5/2022

Display Week: 27

TASK	ASSIGNED TO	PROGRESS	START	END
1. Project manager				
Designate project manager		100%		
Confirm and get validation from DG		100%		
2. Set up the project implementation Team				
PM and Legal to define and agree on the size and composition of committee		100%		
Designate project team and get confirmation from DG		100%		
Distribute roles and responsibilities		75%		
Oragnise Informative session with ISP and stakeholders		0%		
Restitution and next step preparation - freeze overall plan		0%		
3. Train & certify network engineers in charge of IPv6				
Call for participation and selection (At least 2 per stakeholders)				
Send confirmation to participant				
Run training and monitor progress				
End of training ceremony				
Certification week				



MACRA Migration plan Gantt chart (2)



MACRA Migration plan Gantt chart (3)

7. Deploy IPv6-enabled websites and services
Review system compatibility and plan implementation
Activate IPv6 in access network
Website and services available via IPv6
8. Deploy IPv6 to users
Enable IPv6 to Broadband Customers
Enable IPv6 to Enterprise Customers
IPv6 only celebration day

Interactive session day 2

-- USE EXERCICE BOOK --

Exercise #6: List 4 potential blockages to an IPv6 national deployment plan

Next steps

1. Migration team / task force
2. What migration technique for your context?
3. Migration plan (national + individual)
4. Implementation

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Thank You!

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