

## IPv6-only on Wi-Fi at UCLouvain : test results

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# Sommaire

- Introduction
- Why do we need IPv6-only on Wi-Fi ?
- NAT64+DNS64 tests
- Next steps
- Conclusion



# Introduction

## One university on 6 main sites

- Louvain-la-Neuve
- Bruxelles Woluwe
- Mons
- Bruxelles Saint-Louis
- Bruxelles Saint-Gilles
- Tournai

**600 years old in 2025 !**

UCLouvain is one of the oldest university in Europe/World



# IPv6 state at UCLouvain

- First talk on IPv6 with Belnet (2003)
- IPv4/IPv6 dual stack only on network infrastructure and network services (DNS, RADIUS, ...)
- IPv4/IPv6 dual stack on eduroam (2010)
- Load balancers are not IPv6 compatible, so no IPv6 services.
- From time to time a (new) service is becoming available for IPv6.
- Some infrastructure services (CEPH) are IPv6-only !
- New load balancers are IPv6 compatible (2022),
- But Web Portal is still IPv4 only. Next web portal will be IPv6 ...



**Why do we need IPv6-only ?**

# Why do we need IPv6-only on Wi-Fi ?

- Too much Wi-Fi clients ! (more than 22.000 concurrent Wi-Fi clients at peak time)
- We can not give them IPv4/IPv6 dual stack addresses anymore.
- We had to give to some clients IPv4 NAT44 addresses (ouch ... what a regression).
- We want to get rid of NAT44 (solution of the past) and go to IPv6-only (future).
- So we tested some NAT64+DNS64 solutions.



# NAT64+DNS64 tests



# NAT64 + DNS64 infrastructure

- Easy part : DNS64, it just work out of the box with ISC BIND.

% host www.uclouvain.be dns64

www.uclouvain.be is an alias for uclouvain.be.

UCLouvain.be has address 130.104.6.136

UCLouvain.be has IPv6 address 64:ff9b::8268:688

- NAT64 : Several products have been tested
- JOOL - <https://www.jool.mx/en/run-nat64.html>
- NFWare CGNAT - <https://nfware.com/virtual-cgnat>
- 6Wind vCGNAT - <https://www.6wind.com/vrouter-vsr-solutions/virtual-cg-nat/>
- Fortinet NAT64 - <https://www.fortinet.com/search?q=nat64>

# NAT64+DNS64 results

- 20+ network engineering students in a room working on IPv6-only eduroam SSID
- Question is « what is working on IPv6-only + DNS64/NAT64 network, and what is not working »
- Try to identify why it is not working



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# NAT64+DNS64 results

Home Dashboard My courses Besoin d'aide ? ▾



## General

- Announcements
- Discussion forum
- All course slides
- Second projet
- Second project

## Project

- Questions/Discussions
- NPF (Network Perfor...
- Mini Internet Intro
- Mini Internet AS level...
- Choose your AS
- Part I: Mini-Internet

○ IPv6 Only Activity

LINFO2142 / IPv6 Only Activity / View / View

## IPv6 Only Activity

Mark as done

View ▾

### Banking applications

- Fintro - Iphone11 - OK
- Société Générale - Oneplus 7 Pro - OK
- Boursorama Banque - Oneplus 7 Pro - OK
- Hello Bank/BNP - Iphone/Web/Android - OK
- CBC - Iphone/Web - OK
- Belfius OK
- ING v1.230904.0 - Android 11 (LineageOS 18) - OK
- N26 v3.112 - Android 11 (LineageOS 18) - OK
- CPH IOS 17 - OK
- Payconiq IOS17 - OK
- SantanderConsumerBank web - OK
- Argenta v6.5.1 - Android 11 - OK

### News Applications

- Flowchase : we haven't received our email confirming our connection to our account
- VRT NWS v23.0921.0 - Android 11 - OK
- VRT MAX (live TV) v3.17.0-mobile - Android 11 - OK

### Message Applications (Skype, ...)

Discord (message, photo, fichier) OK

Teams (message, photo, fichier) OK

Messenger OK

Desktop Discord voice calls or video calls NOK (but we see where we are in call, and when we start a screen share)

On discord support : Le message de vérification ICE s'affiche lorsque quelque chose sur le réseau empêche le navigateur d'effectuer des connexions UDP ( C'est le message qui s'affiche )

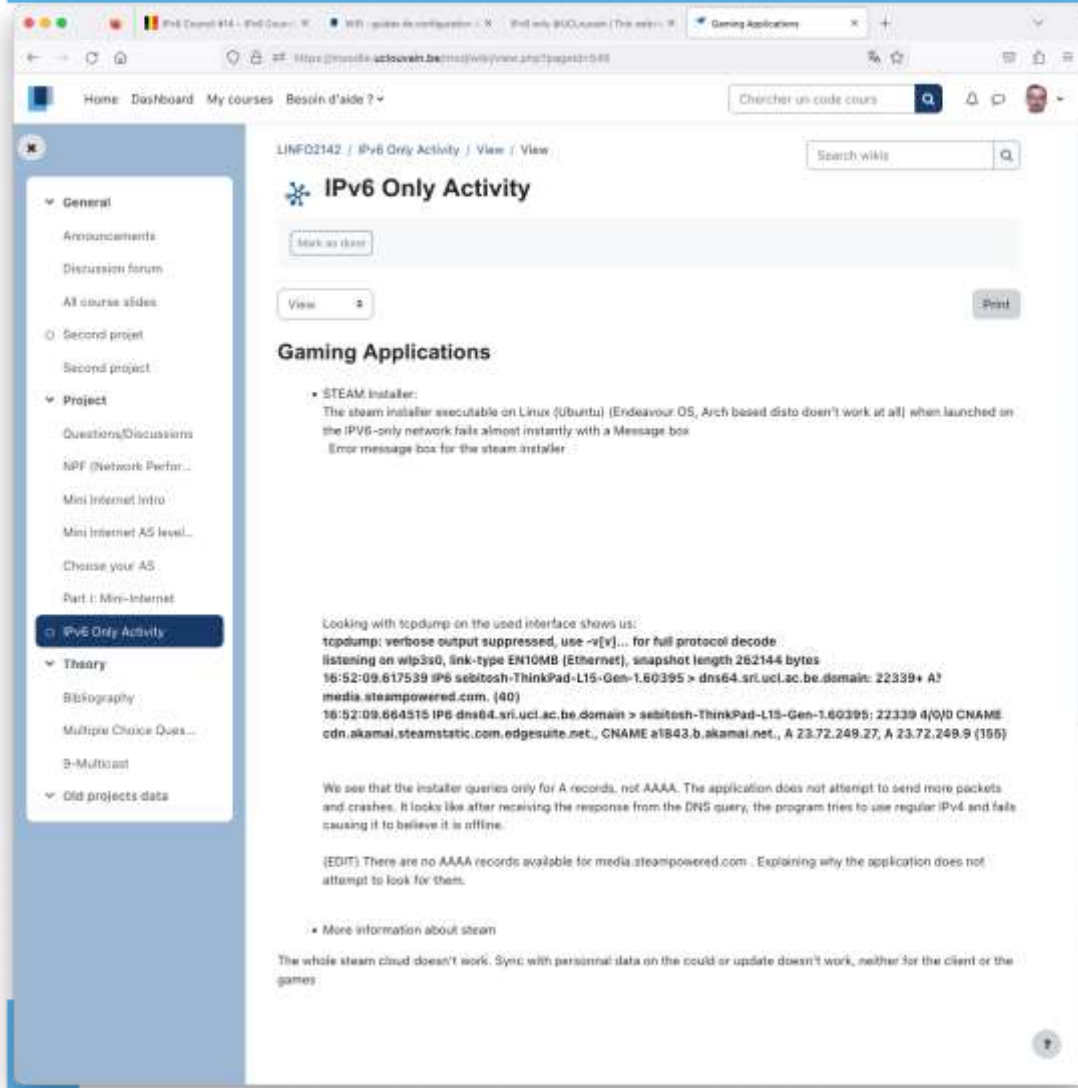
Signal OK

### Booking Applications

- Uber IOS17 - OK
- UberEats IOS17 - OK
- UberEats IOS17 - OK

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# NAT64+DNS64 results



The screenshot shows a web browser window displaying a course page. The page title is "IPv6 Only Activity" and it is part of a course "LINFO2142 | IPv6 Only Activity". The page has a sidebar with navigation options like "General", "Project", and "Theory". The main content area is titled "Gaming Applications" and contains a bullet point about a "STEAM installer" that fails on IPv6-only networks. Below this, there is a code block showing the output of a `tcpdump` command, which shows a DNS query for `media.steampowered.com` and a response with `CNAME` records. The text explains that the application only queries for `A` records and fails when it receives `CNAME` records. There is also a note about the Steam cloud sync issue.

## Programming

- VSCodium + VSCodium Marketplace - EndeavourOS/Archlinux (6.5.4-arch2-1) - OK
- Git v2.42.0 (over https) fetch/push to GitHub - EndeavourOS/Archlinux (6.5.4-arch2-1) - OK
- LiveShare extension on Visual studio code - OK

## VPNs

- Private WireGuard VPN v1.0.20210914-1 - EndeavourOS/Archlinux (6.5.4-arch2-1) - OK  
8) - OK

## Misc

### The Onion Router Browser

Tor Browser is not working on desktop in IPv6, it does with IPv4. Mobile application is working (Android 11).

- EndeavourOS/Archlinux (6.5.4-arch2-1)

When connecting, the application simply loads infinitely.

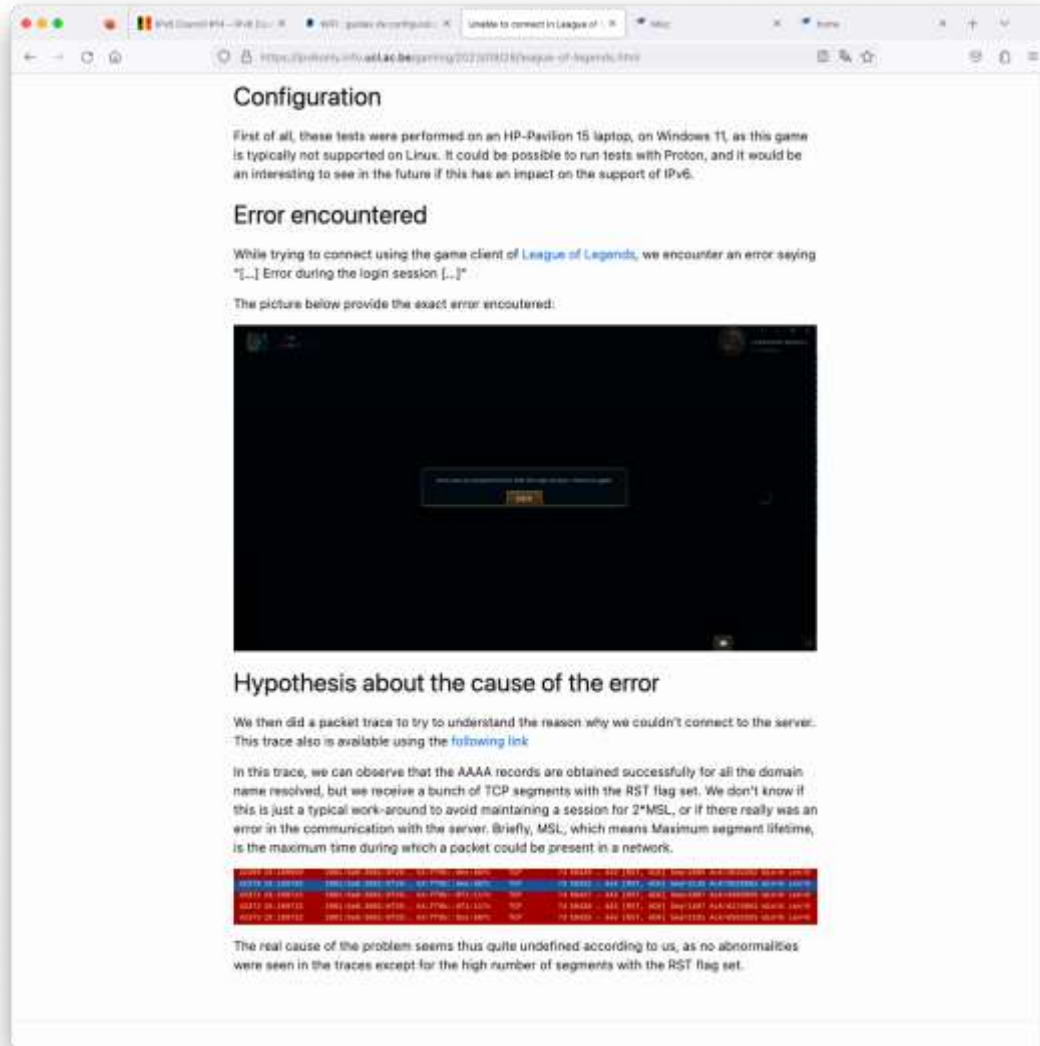
```
2023-09-22 15:36:58.074 [NOTICE] New control connection opened from 127.0.0.1.
2023-09-22 15:36:58.075 [NOTICE] New control connection opened from 127.0.0.1.
2023-09-22 15:36:58.075 [NOTICE] DisableNetwork is set. Tor will not make or accept non-control network connections. Shutting
down all existing connections.
2023-09-22 15:36:58.075 [NOTICE] DisableNetwork is set. Tor will not make or accept non-control network connections. Shutting
down all existing connections.
2023-09-22 15:37:02.621 [NOTICE] Opening Socks listener on 127.0.0.1:9150
2023-09-22 15:37:02.621 [NOTICE] Opened Socks listener connection (ready) on 127.0.0.1:9150
2023-09-22 15:37:04.909 [NOTICE] Application request when we haven't used client functionality lately. Optimistically trying
directory fetches again.
2023-09-22 15:37:05.175 [NOTICE] New control connection opened from 127.0.0.1.
```

- Application Tor dernière version 12.5.4: Reste bloqué sur "Démarrage du client Tor ... terminé"

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# NAT64+DNS64 results




**Configuration**

First of all, these tests were performed on an HP-Pavilion 15 laptop, on Windows 11, as this game is typically not supported on Linux. It could be possible to run tests with Proton, and it would be interesting to see in the future if this has an impact on the support of IPv6.

**Error encountered**

While trying to connect using the game client of *League of Legends*, we encounter an error saying "[...] Error during the login session [...]"

The picture below provide the exact error encountered:



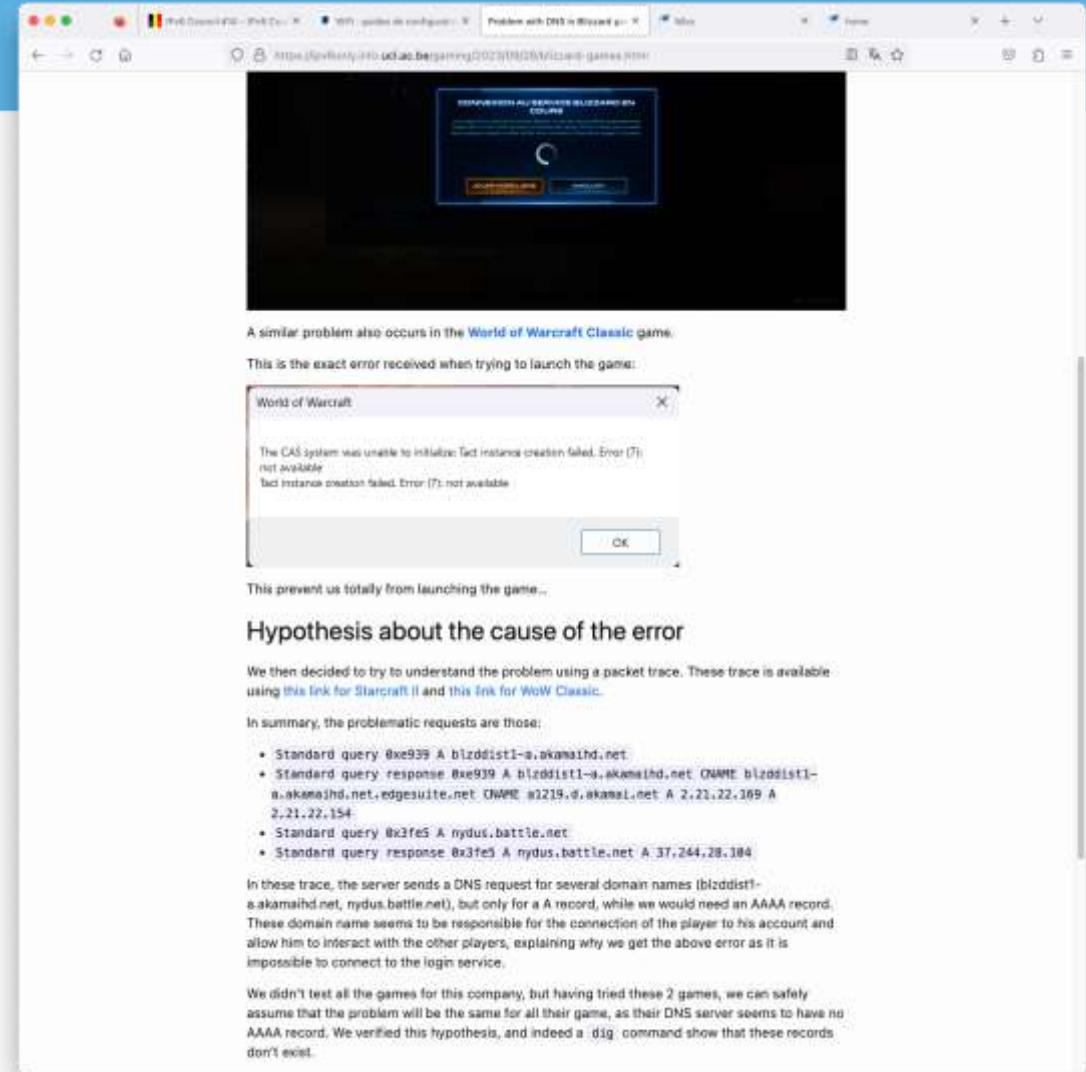
**Hypothesis about the cause of the error**

We then did a packet trace to try to understand the reason why we couldn't connect to the server. This trace also is available using the [following link](#)

In this trace, we can observe that the AAAA records are obtained successfully for all the domain name resolved, but we receive a bunch of TCP segments with the RST flag set. We don't know if this is just a typical work-around to avoid maintaining a session for 2\*MSL, or if there really was an error in the communication with the server. Briefly, MSL, which means Maximum segment lifetime, is the maximum time during which a packet could be present in a network.

```
0.000 0.000000 192.168.1.100:54321 → 192.168.1.1:80 [RST] Seq=1234567890 Win=0 Len=0
0.000 0.000000 192.168.1.100:54321 → 192.168.1.1:80 [RST] Seq=1234567890 Win=0 Len=0
0.000 0.000000 192.168.1.100:54321 → 192.168.1.1:80 [RST] Seq=1234567890 Win=0 Len=0
0.000 0.000000 192.168.1.100:54321 → 192.168.1.1:80 [RST] Seq=1234567890 Win=0 Len=0
0.000 0.000000 192.168.1.100:54321 → 192.168.1.1:80 [RST] Seq=1234567890 Win=0 Len=0
```

The real cause of the problem seems thus quite undefined according to us, as no abnormalities were seen in the traces except for the high number of segments with the RST flag set.



**World of Warcraft**

The CAS system was unable to initialize: Tact instance creation failed. Error (7): not available  
Tact instance creation failed. Error (7): not available

**Hypothesis about the cause of the error**

We then decided to try to understand the problem using a packet trace. These trace is available using [this link](#) for *Starcraft II* and [this link](#) for *WoW Classic*.

In summary, the problematic requests are those:

- Standard query 0xe939 A blzddist1-a.akamaihd.net
- Standard query response 0xe939 A blzddist1-a.akamaihd.net ONAME blzddist1-a.akamaihd.net, edg-suite.net ONAME #1219.d.akamai.net A 2.21.22.169 A 2.21.22.154
- Standard query 0x3fe5 A nydus.battle.net
- Standard query response 0x3fe5 A nydus.battle.net A 37.244.28.184

In these trace, the server sends a DNS request for several domain names (blzddist1-a.akamaihd.net, nydus.battle.net), but only for a A record, while we would need an AAAA record. These domain name seems to be responsible for the connection of the player to his account and allow him to interact with the other players, explaining why we get the above error as it is impossible to connect to the login service.

We didn't test all the games for this company, but having tried these 2 games, we can safely assume that the problem will be the same for all their game, as their DNS server seems to have no AAAA record. We verified this hypothesis, and indeed a `dig` command show that these records don't exist.

# NAT64+DNS64 tests conclusion

- Same results as anywhere else :
  - some applications are fully working,
  - others are partially working and
  - others do not work at all on IPv6 + DNS64/NAT64.
- 
- Conclusion : We can not put IPv6-only + DNS64/NAT64 in production to bypass IPv4 shortage. We need something else.



**Next steps**



## Deploying IPv6-mostly access networks

IPv6-only and dual stack in one  
network

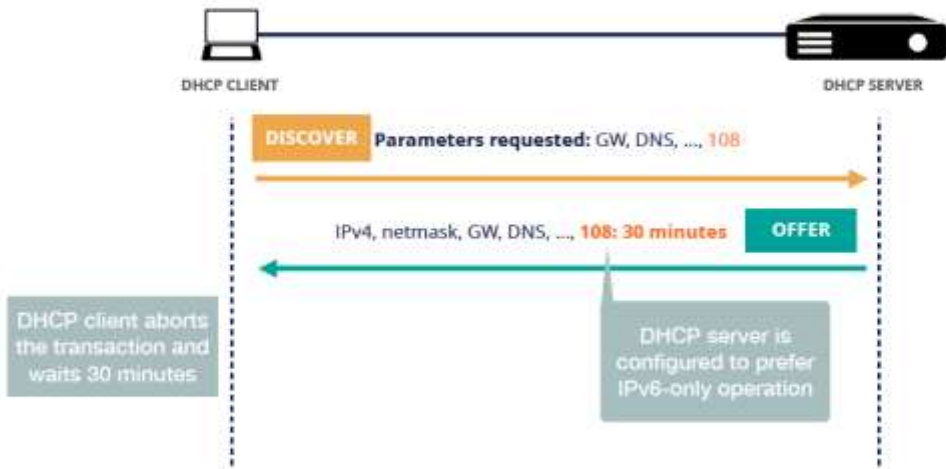
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# IPv6-mostly – step 1

- RFC 8925 - IPv6-Only Preferred Option for DHCPv4

## Using DHCP to turn IPv4 off



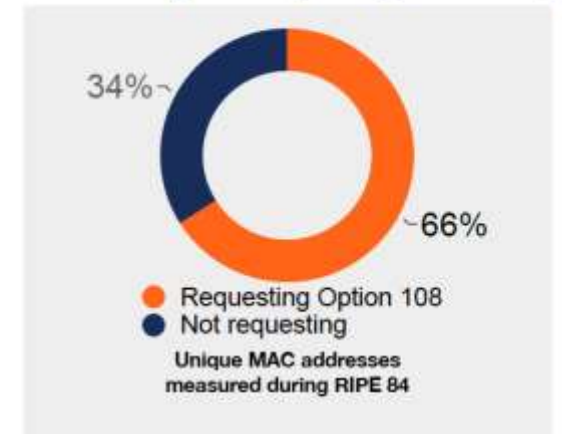
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(RFC 8925)

## Is DHCP option 108 already deployed?

You bet! Option 108 is requested by recent:



Devices are **ready**, networks are lagging behind.

8

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9



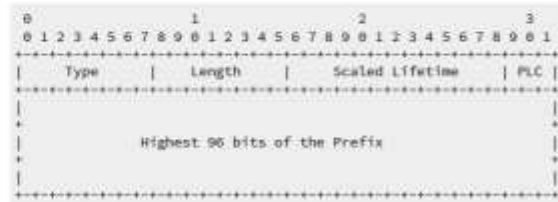
# IPv6-mostly – step 2

- RFC 8781 - Discovering PREF64 in Router Advertisements

## PREF64 RA Option



- A Router Advertisement option **carrying NAT64 prefix**
- Needed for **CLAT configuration**, local DNS64 or Happy Eyeballs 2.0 (*dealing with IPv4 literals*)
- **Shares fate** with other configuration parameters
  - can be trusted a **bit more** than DNS64
- Supported by recent Android, iOS and macOS



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11

## PREF64 RA option is harder



- No **custom RA option** support in routers
  - We already **had this issue** with Recursive DNS Server option, now we **have it again**
  - Router vendors should really implement **custom options** similar to DHCP
- Adoption is *slowly* increasing:
  - radvd (merged but unreleased)
  - FRR (pull request pending)
  - odhcpd (pull request pending)
  - rad (part of OpenBSD)
  - MikroTik RouterOS v7.8 beta2

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14



# IPv6-mostly

- Can we deploy IPv6-mostly at UCLouvain ?
- At least two problems:
- RFC8781 (Discovering PREF64 in Router Advertisements) is not implemented on our routers.
- Support for RFC 8106 - IPv6 Router Advertisement Options for DNS Configuration is incomplete.  
Implementation is only global(whatever VRF or VLANs), but we need RA DNS conf pointing to DNS64 on IPv6-only, and casual DNS for IPv4/IPv6 dual stack networks.
- We have to wait our two Product Enhancement Request (PER) achieve production.



**Conclusion**

# Conclusion

- Tests show that IPv6-only with NAT64/DNS64 cannot go in production at UCLouvain. Some apps refuse to work.
- IPv6-only with NAT64/DNS64 is almost a complete solution.
- Clients need CLAT implementation to be IPv6-only ready.
- IPv6-mostly is a promising path.

- But ...

# One more thing ...

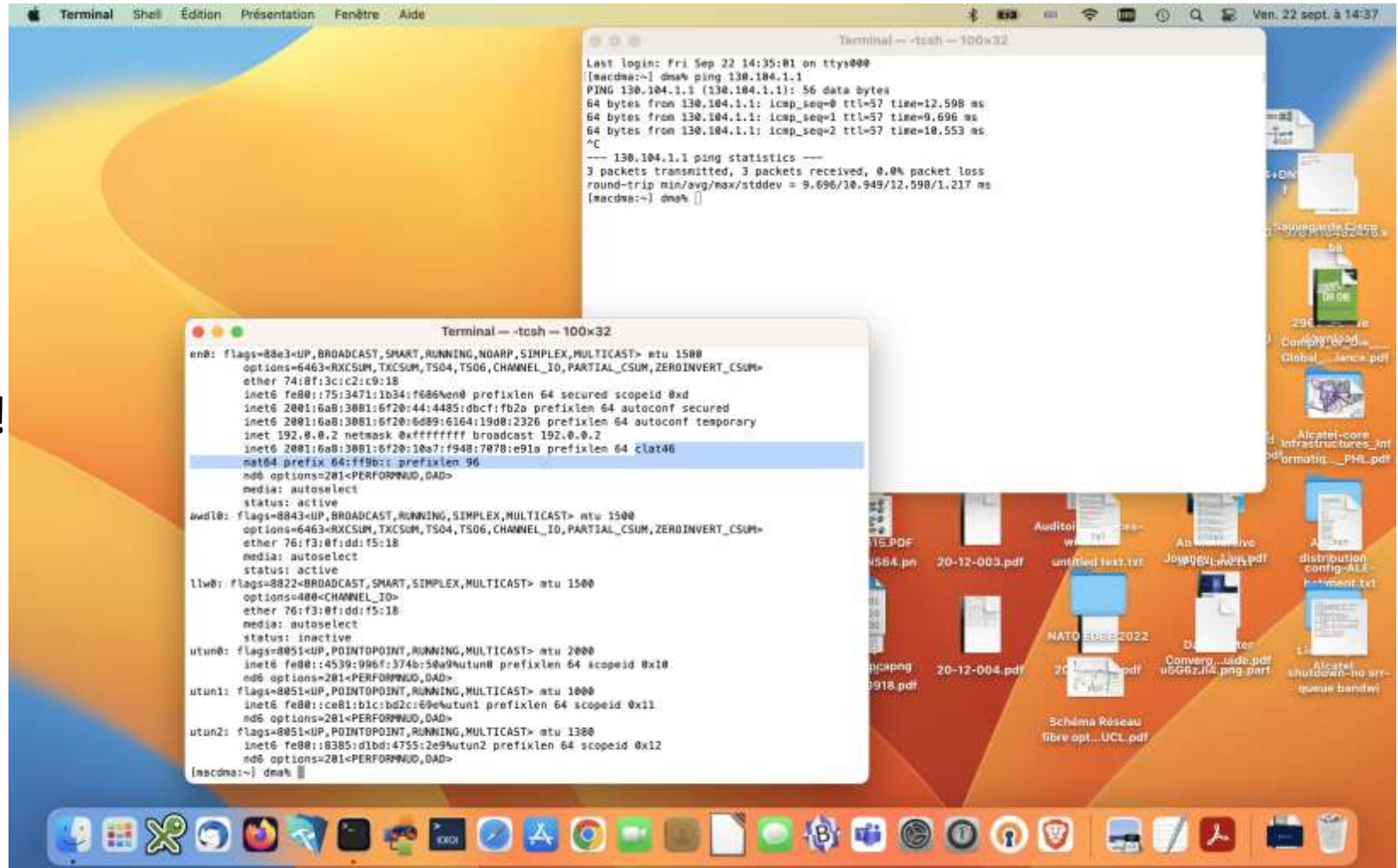
Hey ! Look at my Mac !

It find itself it is on a IPv6-only network with DNS64+NAT64.

So it launches itself CLAT46 !

And now I can ping IPv4 literals and use my IPv4 applications.

Hope will come from our clients ... 😊



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Illustrations provenant de

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[https://www.ripe.net/about-us/press-centre/publications/presentations/2023/deploying-ipv6-mostly-access-networks-apnic-55/at\\_download/download](https://www.ripe.net/about-us/press-centre/publications/presentations/2023/deploying-ipv6-mostly-access-networks-apnic-55/at_download/download)