

IPv6

The Internet's Future?



i n e x
i n t e r n e t n e u t r a l e x c h a n g e

Barry O'Donovan

Engineers Ireland - April 25th 2012

<https://www.inex.ie/ei-ipv6-2012.html>



INEX

internet neutral exchange

An IXP – Ireland's IP Peering Hub

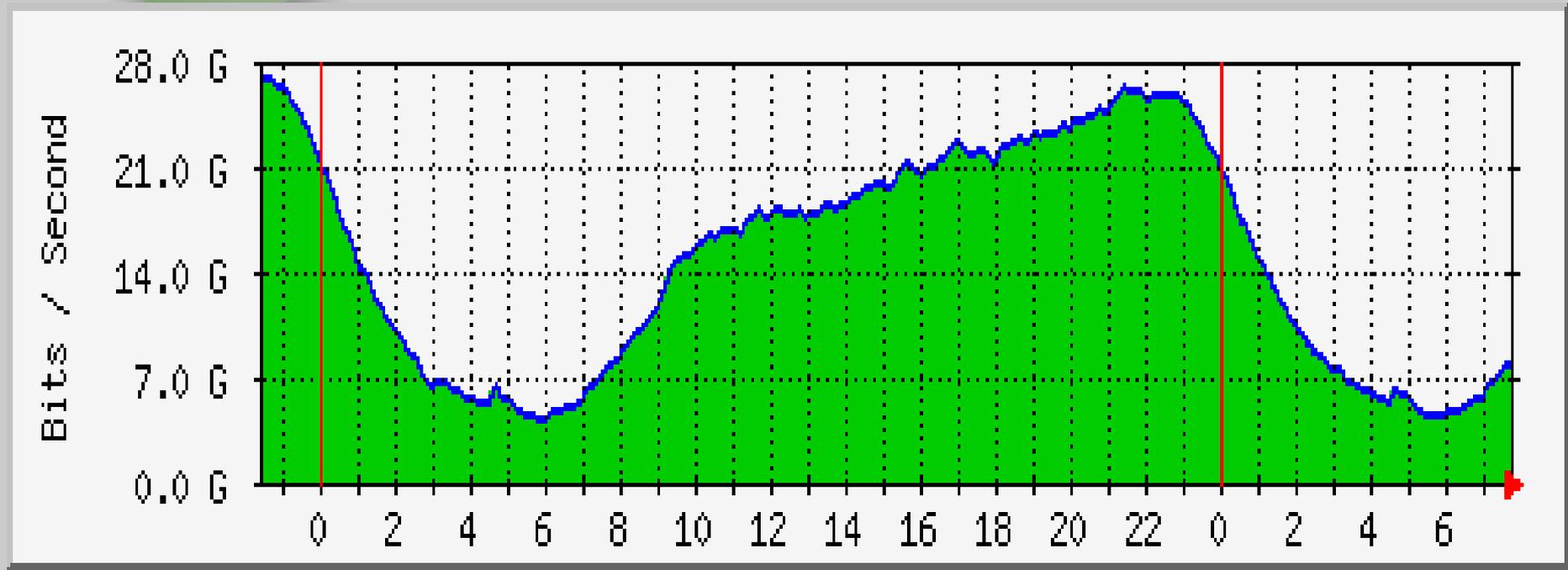
Neutral, industry owned association

Founded 1996; ~66 members; 5 PoPs



INEX

i n e x
i n t e r n e t n e u t r a l e x c h a n g e



<https://www.inex.ie/joining/aboutixps>
<https://www.inex.ie/about/memberlist>



Barry O'Donovan

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

“Internet Infrastructure Specialist”

MD of Open Solutions

“Closet geek; political anorak, husband, father, network enginner, company owner, employer, ...”

<http://www.barryodonovan.com/>

<http://www.opensolutions.ie/>



Overview

i n t e r n e t n e u t r a l e x c h a n g e

A (brief?) history of Internet numbering

IPv4 exhaustion status

Introduction to IPv6

Why IPv6 adoption is sooooooooooooo slow

The IPv6 opportunity



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The Problem

Why IPv6?

Because we've run out of addresses

Again!

Huh? Really!?

Yes, we've been here before!



Internet Time Machine

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

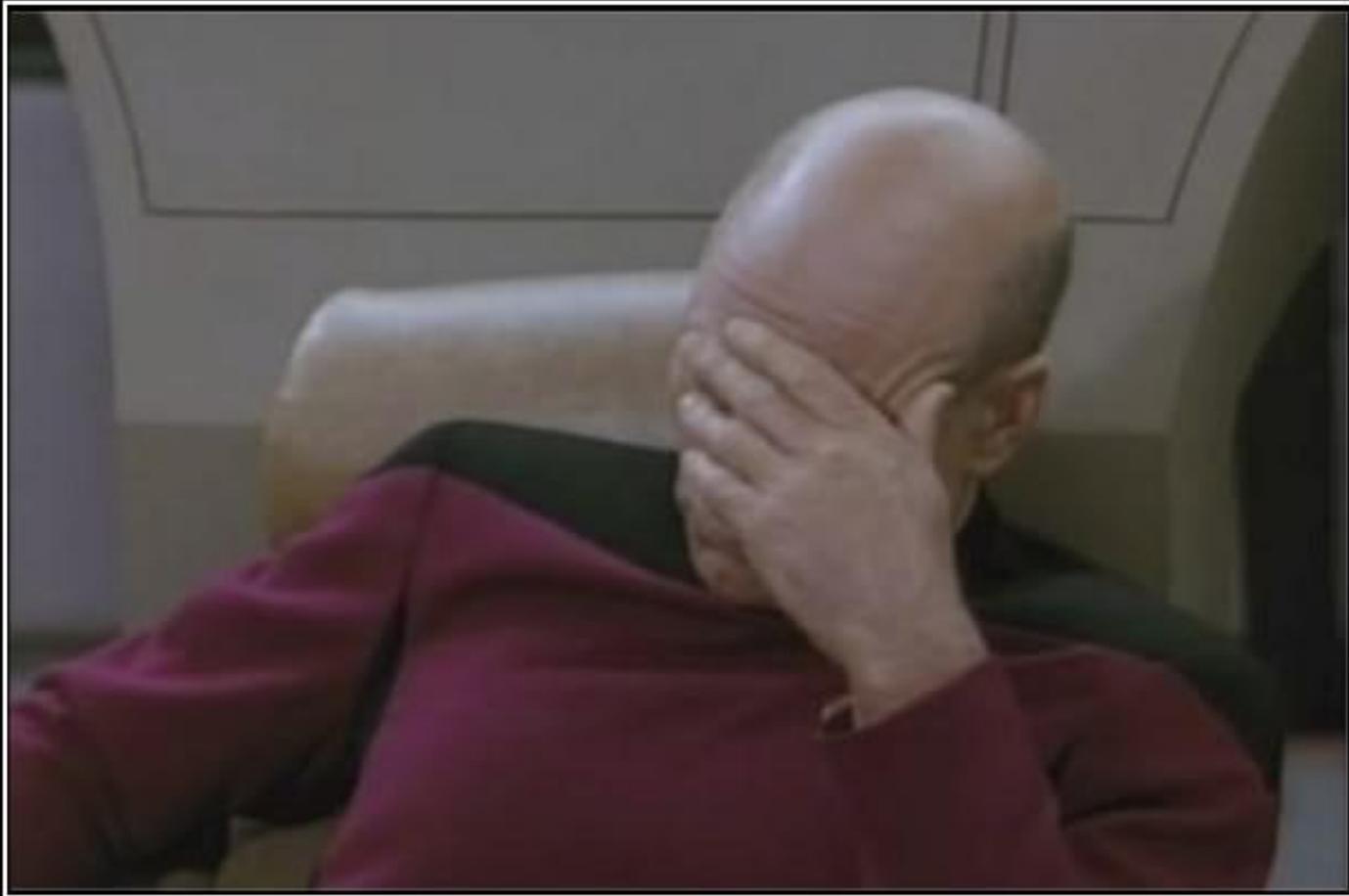
1969: ARPANET commissioned by DoD

1970: ARPANET hosts start using NCP:

Network Control Protocol [RFC33]

8 bit addressing

=> only 256 hosts!



F A C E P A L M

Because expressing how dumb that was in words just doesn't work.



Internet Time Machine

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

1972: Telnet specification [RFC318]

1973: Ethernet outlined in a PhD Thesis

File Transfer specification [RFC454]

1976: Queen Elizabeth sends an email!



Internet Time Machine

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

1982: DCA & ARPA establish TCP and IP

DoD declares TCP/IP as their standard

1983: Cutover from NCP to TCP/IP (IPv4)

“Flag Day” – January 1st 1983

RFC2235 - Hobbes' Internet Timeline



i n e x
i n t e r n e t n e u t r a l e x c h a n g e

“Flag Day”
January 1st 1983

All nodes updated on Flag Day to IPv4
(still “facepalm”?)

8bit addresses → 32 bit addresses
⇒ ~4.29 billion addresses

Enough?

No: 7.008 billion people; 8.01 by 2025
1 billion “smart devices” shipped in 2011



i n e x
i n t e r n e t n e u t r a l e x c h a n g e

Back Up the Truck

Are we all clear on what an IP address is?

“A number assigned to a device on a network”

We've all seen them:

127.0.0.1

192.168.1.254

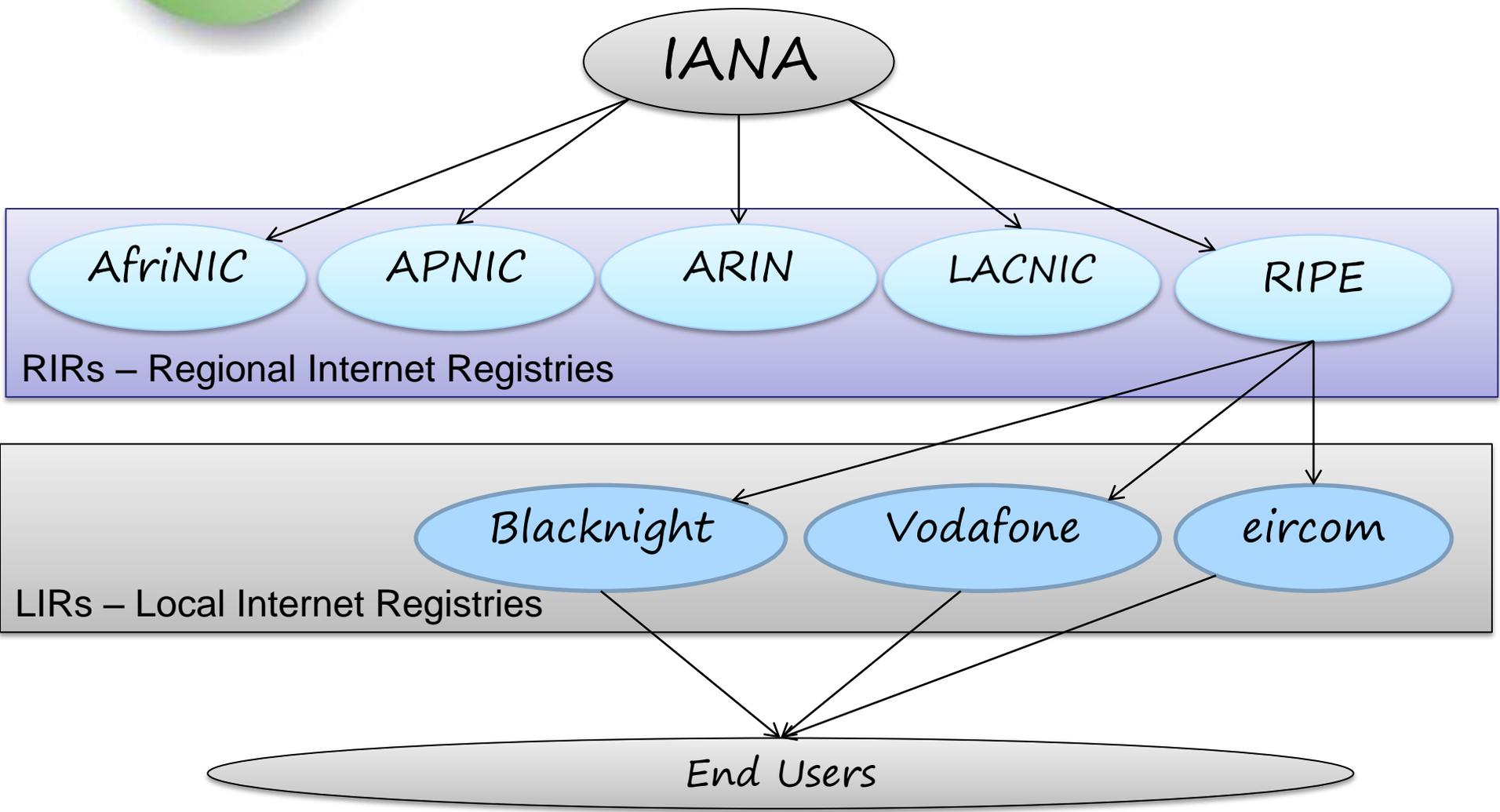
8.8.4.4

DNS: www.engineersireland.ie => 46.22.128.85



i n e x
i n t e r n e t n e u t r a l e x c h a n g e

Who's the Boss?





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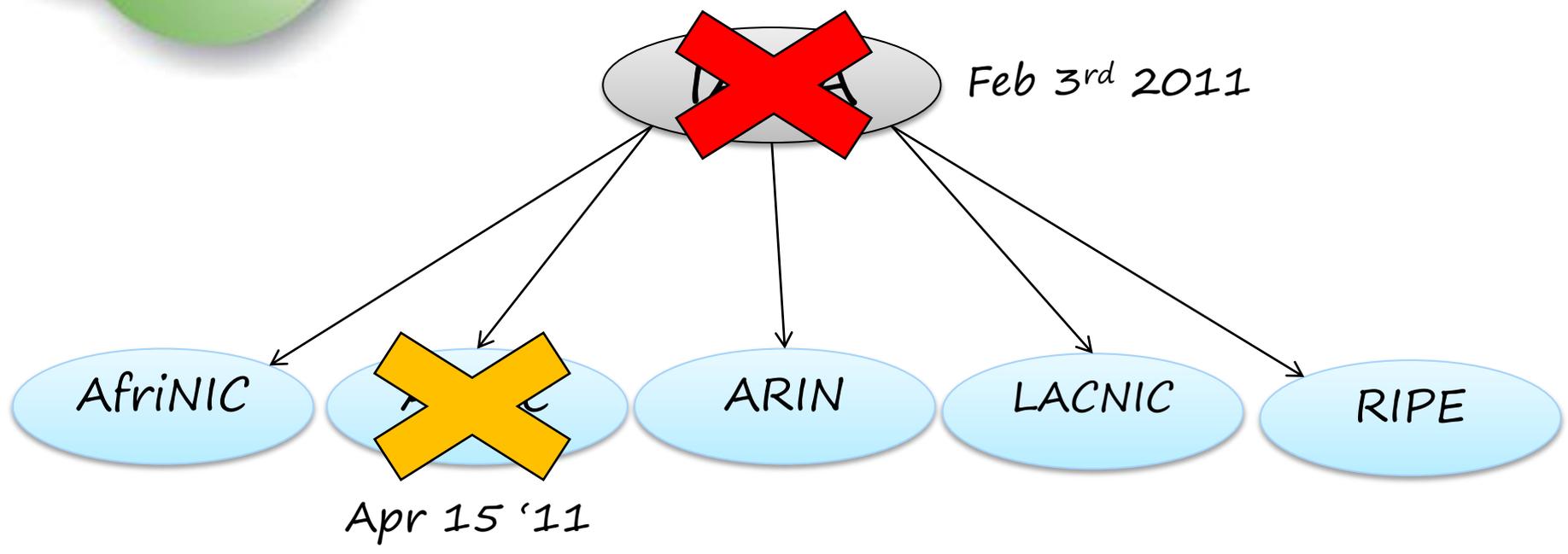
Why IPv6 adoption is sooooooooooooo slow

The IPv6 opportunity



i n e x
i n t e r n e t n e u t r a l e x c h a n g e

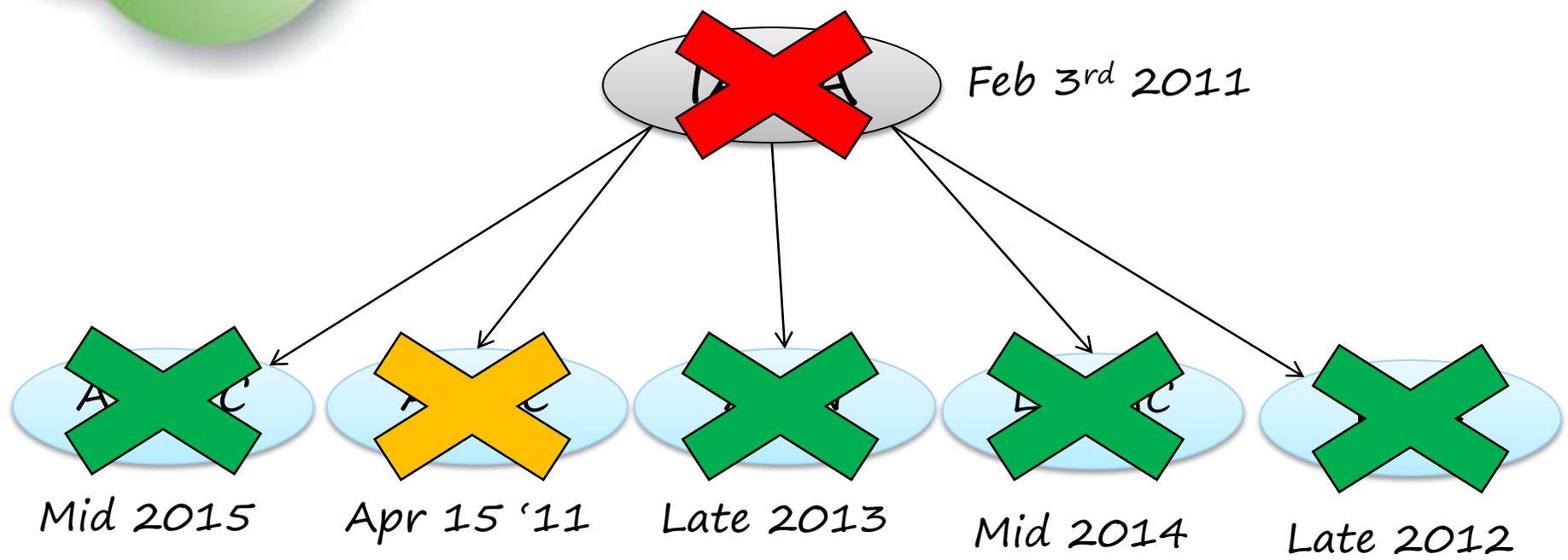
What's Left?





i n e x
i n t e r n e t n e u t r a l e x c h a n g e

What's Left?



Final /8 policies:

once only - /22 (1024) - must have IPv6
~16k allocations (>7k LIRs in RIPE 2010)



i n e x
i n t e r n e t n e u t r a l e x c h a n g e

What's Left?

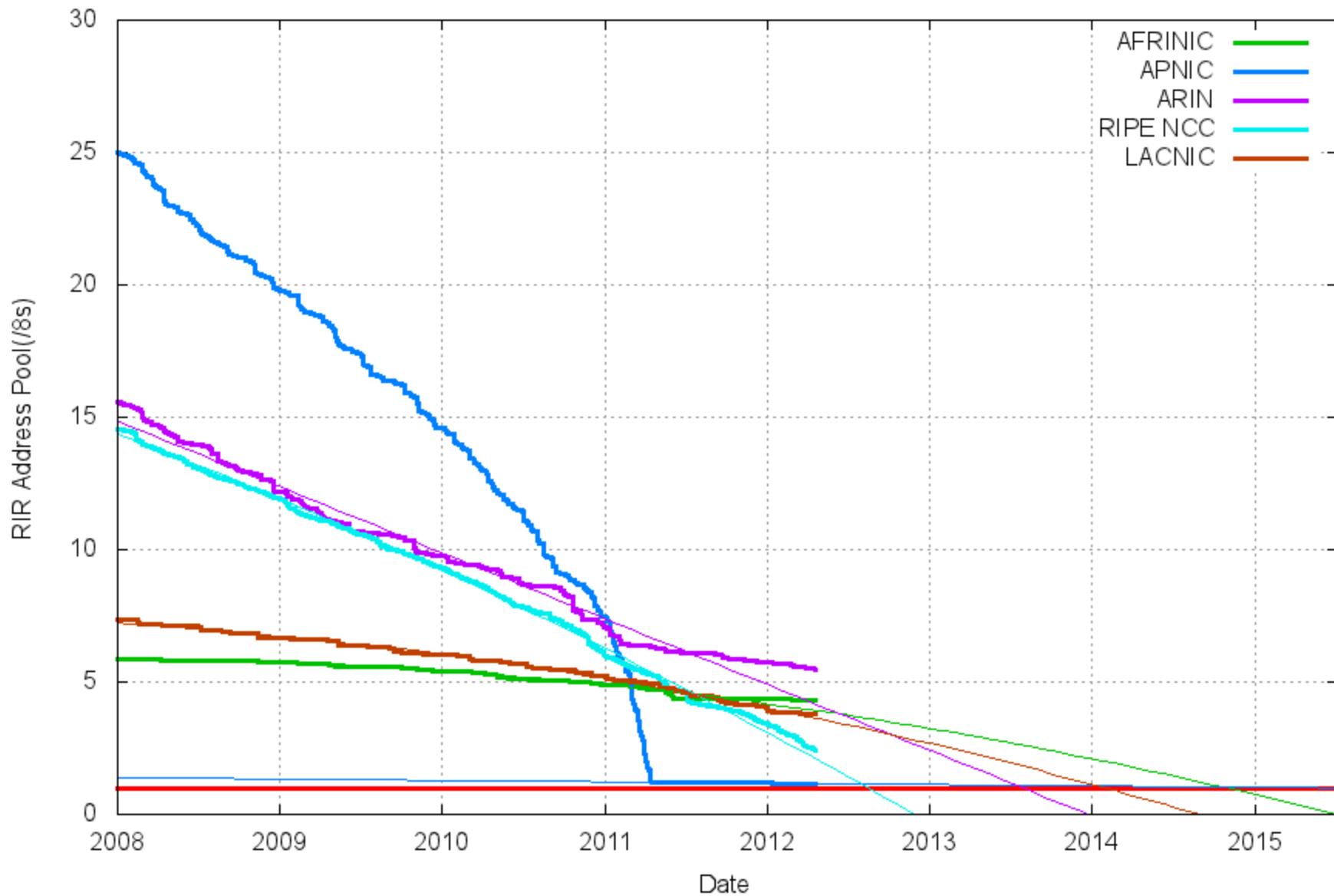
*IPv4 exhaustion projection is a presentation
in its own right*

If you want to know more:

Geoff Huston - <http://www.potaroo.net/>

<http://www.potaroo.net/tools/ipv4/index.html>

RIR IPv4 Address Run-Down Model





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IPv6

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IETF began developing IPng in...

1993!

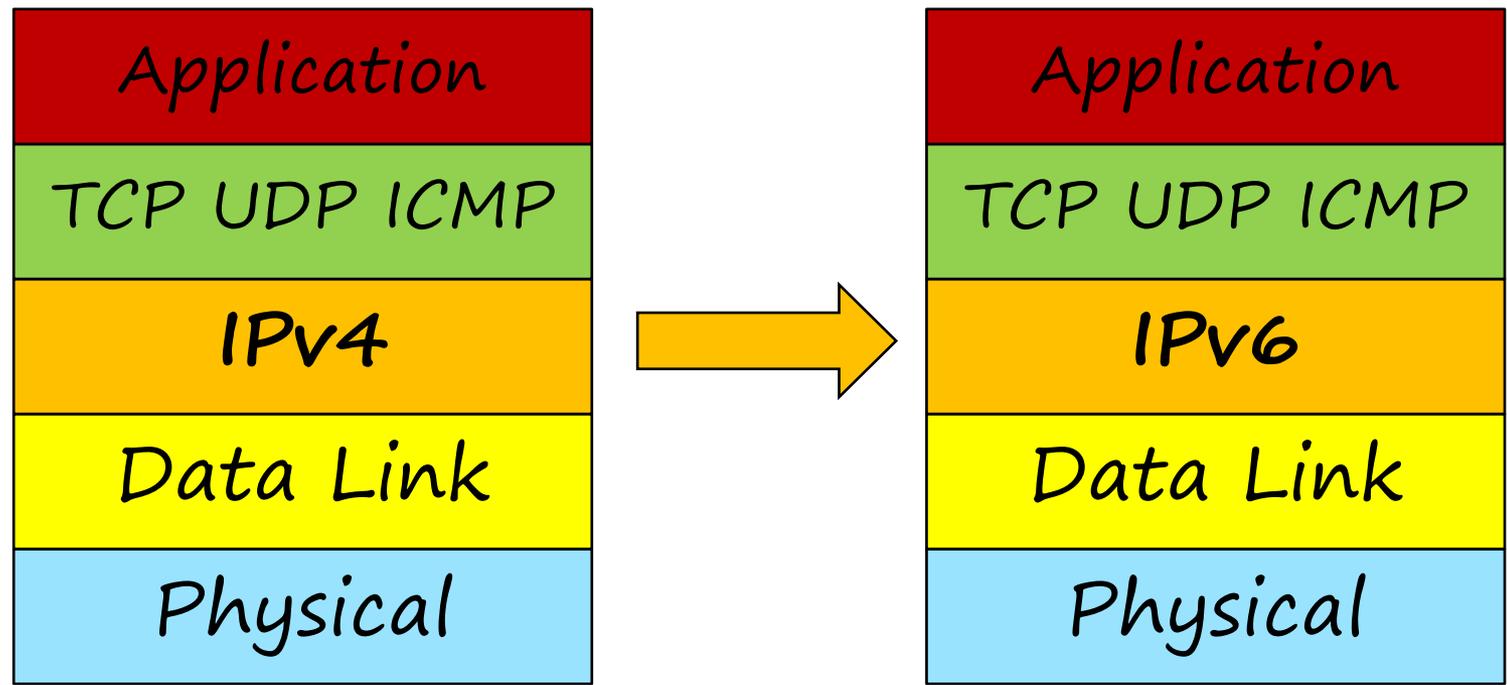
RFC1883 Internet Protocol, V6, Specification
(1995)

IETF Standard 1998 (RFC2460)



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i n t e r n e t n e u t r a l e x c h a n g e

IPv6 in the OSI Model?





i n e x
i n t e r n e t n e u t r a l e x c h a n g e

What's New in IPv6

It's (only?) an evolution of IPv4

Extended address space

32bit addresses => 128bit addresses
~4.29 billion => ~340 undecillion

Huh?

340,282,366,920,938,000,000,000,000,000,000,000,000



i n e x
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What's New in IPv6

Stateless autoconfiguration (and RD)

Simplified header

Removed on-the-fly fragmentation

No more ARP – Now ICMPv6 ND

Native Security, Flow labels & IPsec



IPv6 Addressing

128 bits / 16 bytes: 8 x 16bit hex blocks

2001:0db8:0000:0000:0702:b33f:001b:0055

2001:0db8::0702:b33f:001b:0055

2001:db8::702:b33f:1b:55

2a01:268:3002::35



IPv6 Subnetting

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340 undecillion addresses is a bit misleading...

2001:0db8

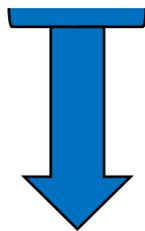
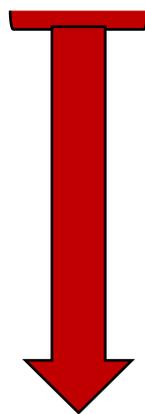
Typical initial LIR allocation is /32.



IPv6 Subnetting

340 undecillion addresses is a bit misleading...

2001:0db8:0000:0000:0702:b33f:001b:0055



64 bit interface ID

18,446,744,073,709,551,616
addresses – 18.4 “quintillion”.

ISP end user assignment /48 (/56)
65,536 /64 subnets at end user.

Typical initial LIR allocation is /32.
65,536 /48 end users / sites



IPv6 in the “Real World”

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

It's been around and live for a long time!

“If the end user ever needs to know about IPv6 then we've made a complete f&%k up of the transition.”

All current operating systems support it.
Natively and by default.

Even Windows!



IPv6 in the “Real World”

internet neutral exchange

It's been around and live for a long time!

```
Ethernet adapter Local Area Connection 2:
```

```
Connection-specific DNS Suffix . :  
Link-local IPv6 Address . . . . . : fe80::dc87:8870:16a5:4869%11  
IPv4 Address. . . . . : 192.168.140.17  
Subnet Mask . . . . . : 255.255.255.0  
Default Gateway . . . . . : 192.168.140.1
```

*All current operating systems support it.
Natively and by default.*

Even Windows!



IPv6 in the “Real World”

Most services have long supported IPv6

SMTP, POP3, IMAP, DNS, HTTP(s), SSH,
Telnet, FTP, Bit Torrent, IRC, IM, ...

Modern systems default to IPv6
(e.g. DNS AAAA lookups before A)



IPv6 in the “Real World”

```
barryo@destiny:~ $ host www.opensolutions.ie
www.opensolutions.ie has address 87.232.16.35
www.opensolutions.ie has IPv6 address 2a01:268:3002::35
```

```
barryo@destiny:~ $ host -t MX opensolutions.ie
opensolutions.ie mail is handled by 10 mail.opensolutions.ie.
```

```
barryo@destiny:~ $ host mail.opensolutions.ie
mail.opensolutions.ie has address 87.232.16.61
mail.opensolutions.ie has IPv6 address 2a01:268:3002::61
```

So what's the problem...?



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Transition to IPv6

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IPv6 is not backwards compatible with IPv4

A second “Flag Day” is impossible

That leaves two real choices:

(a) Dual stack networking (medium term)

(b) CGNs, CDNs, ALGs (medium -> long term)



Dual Stack Transition

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i n t e r n e t n e u t r a l e x c h a n g e

Running IPv4 and IPv6 in parallel

Already in place for modern OS'

Already in place for modern (ISP) routers

Firewalls & L7 Devices Caught/Catching Up

Main issues are: access network and CPEs
And demand.

And we still have IPv4.

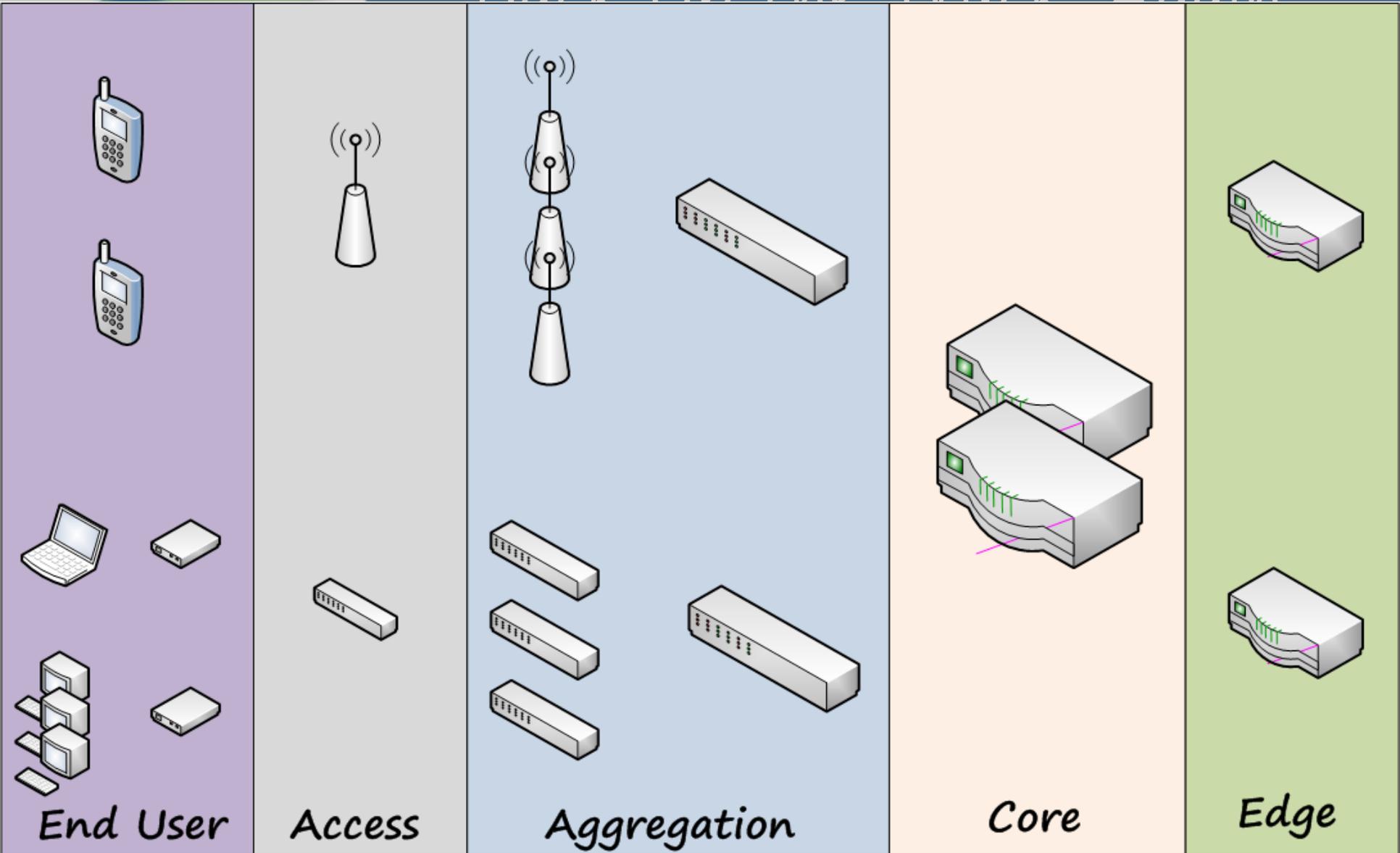


Back Up the Truck. Again.

We should probably talk about

ISP networking

Back Up the Truck Again





Back Up the Truck. Again.

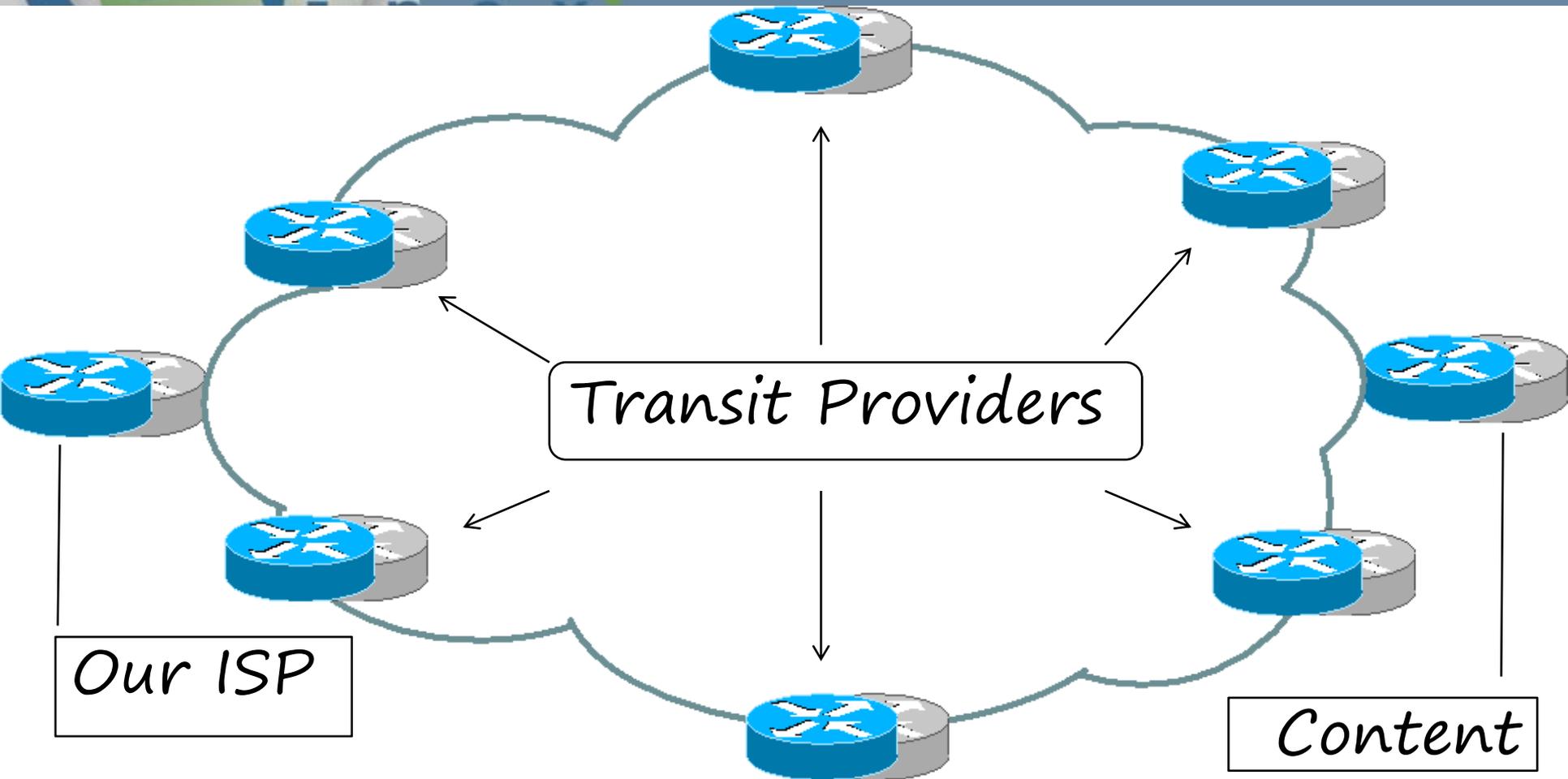
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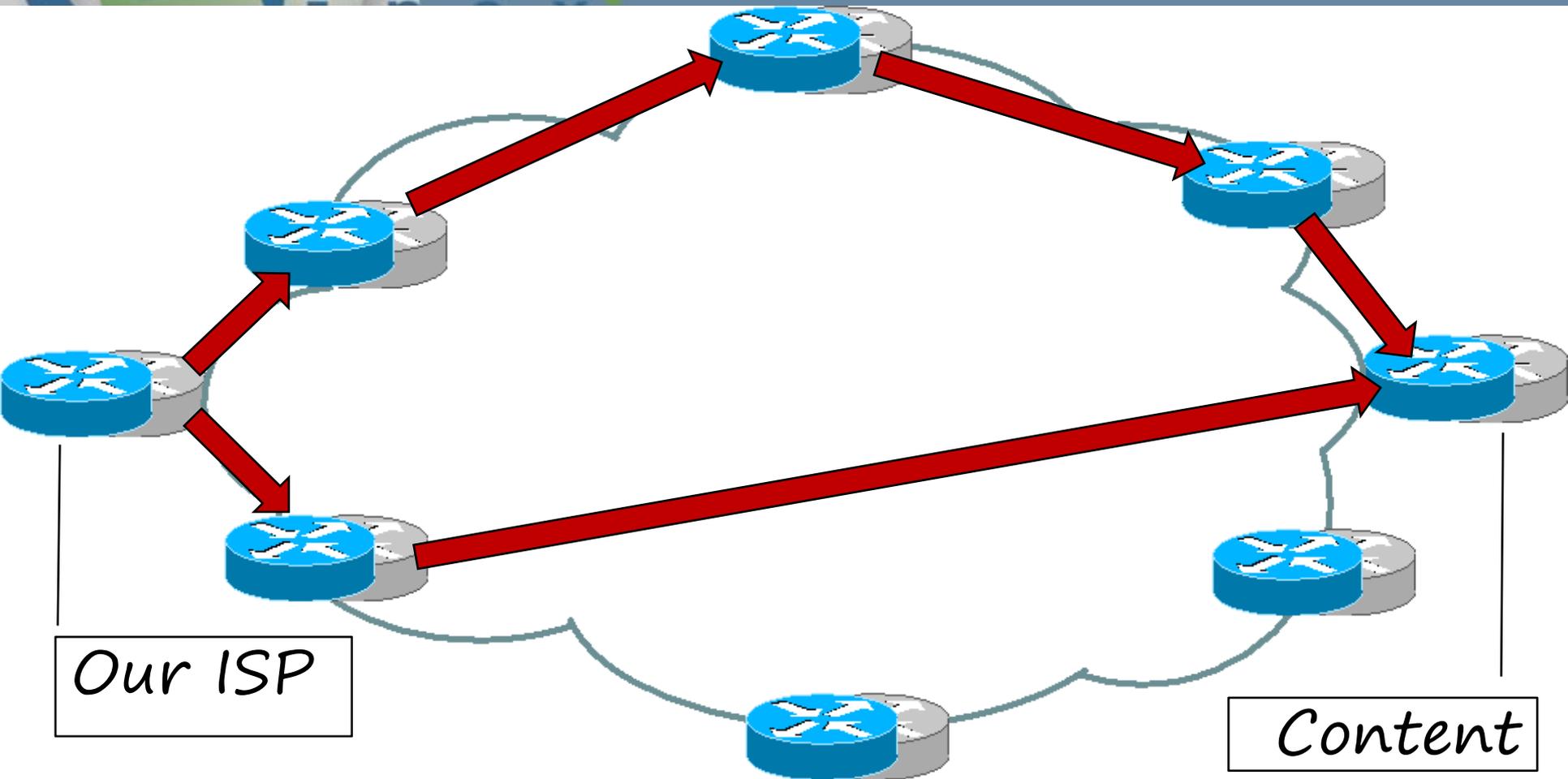
And

“The Internet”

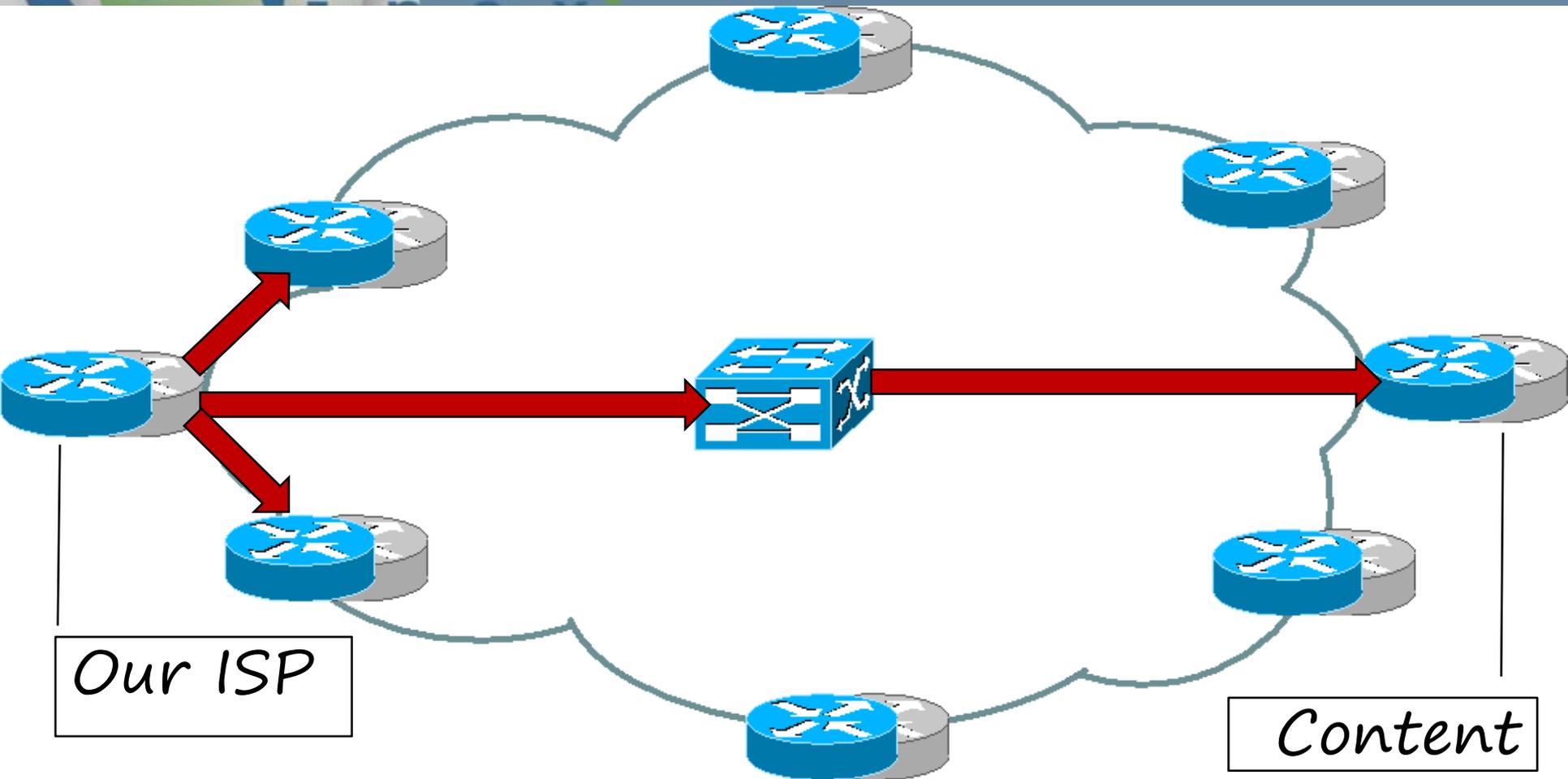
Back Up the Truck. Again.



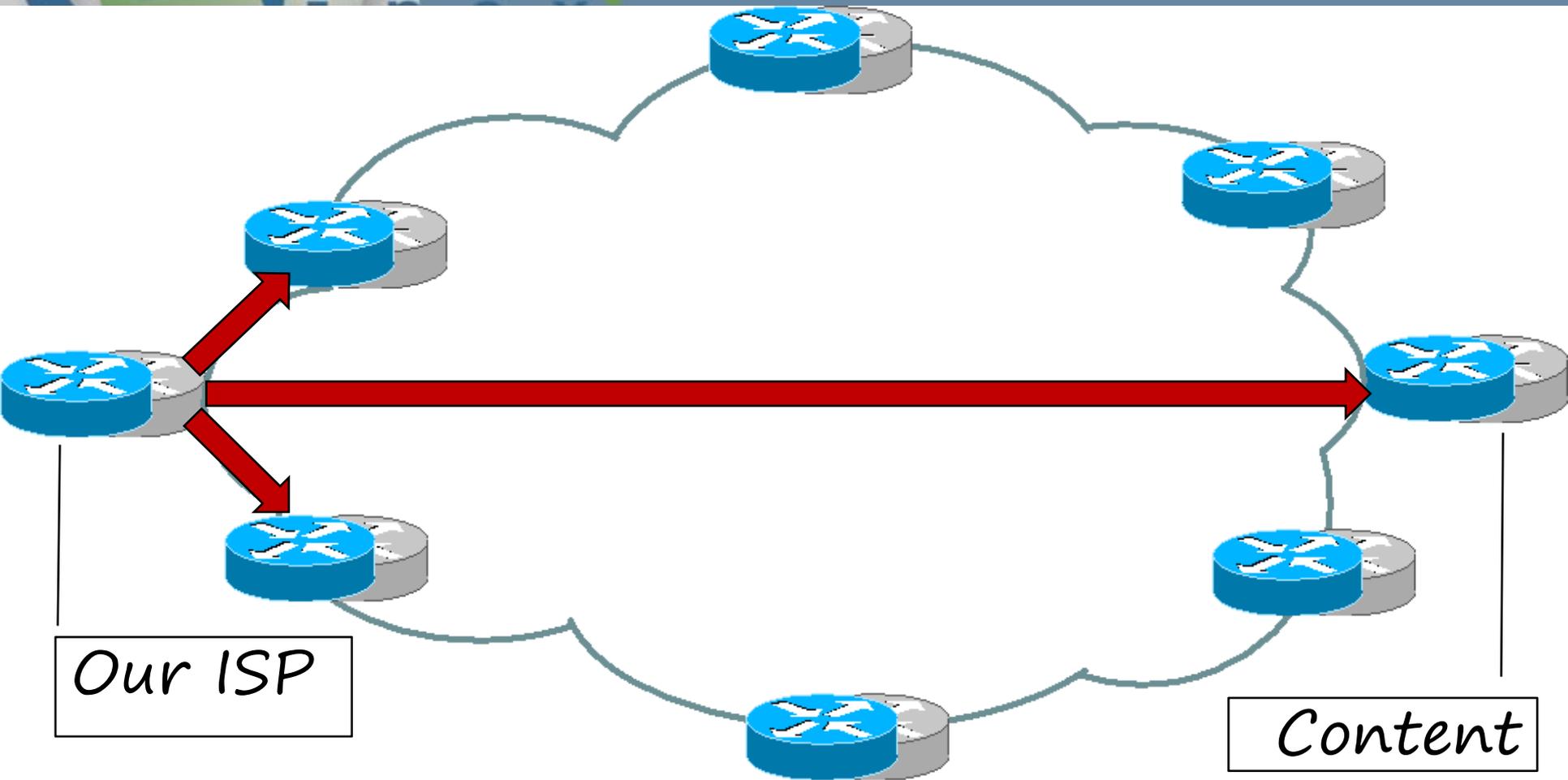
Back Up the Truck. Again.



Back Up the Truck. Again.



Back Up the Truck. Again.





Dual Stack Transition

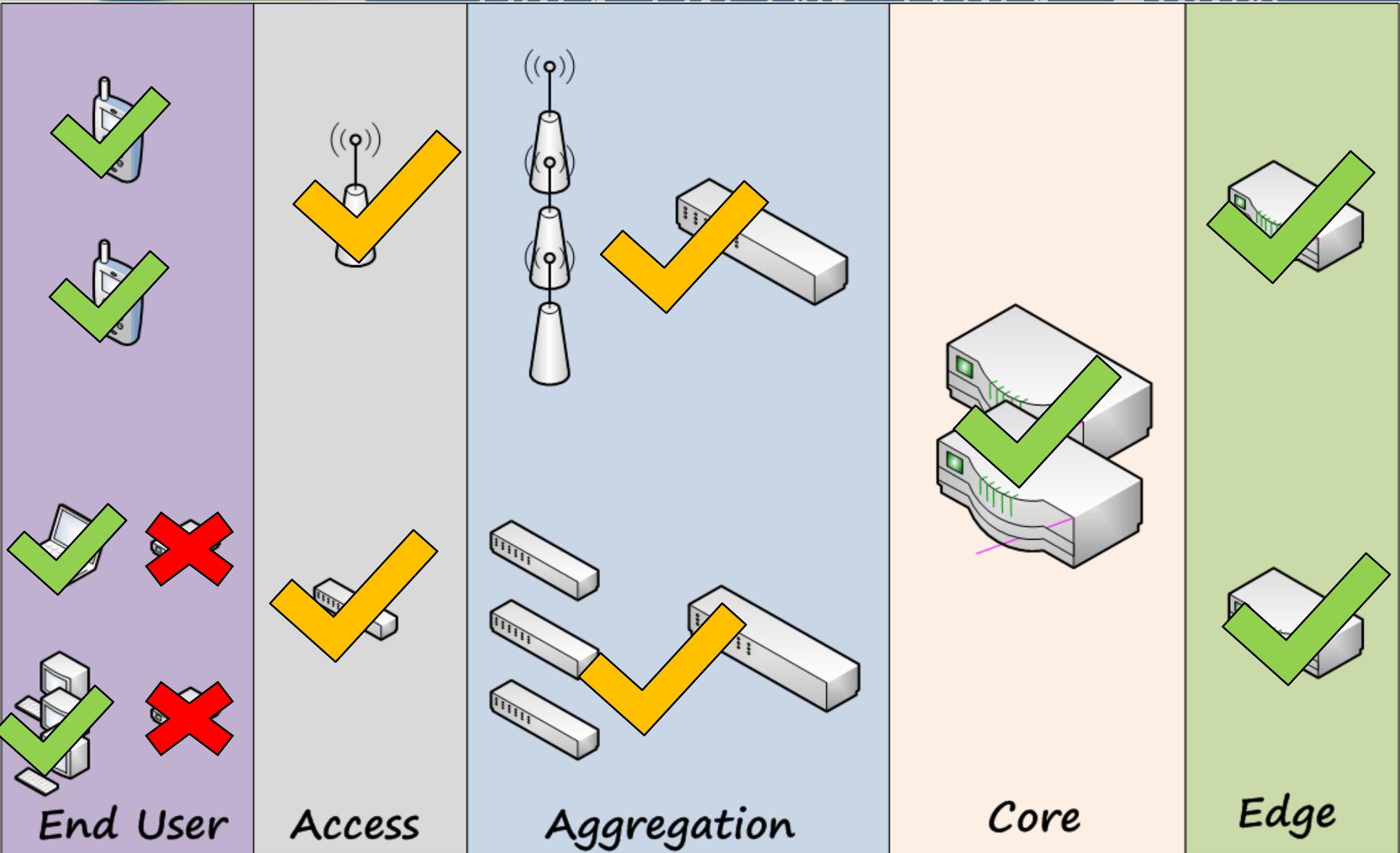
i n e x
i n t e r n e t n e u t r a l e x c h a n g e

We said:

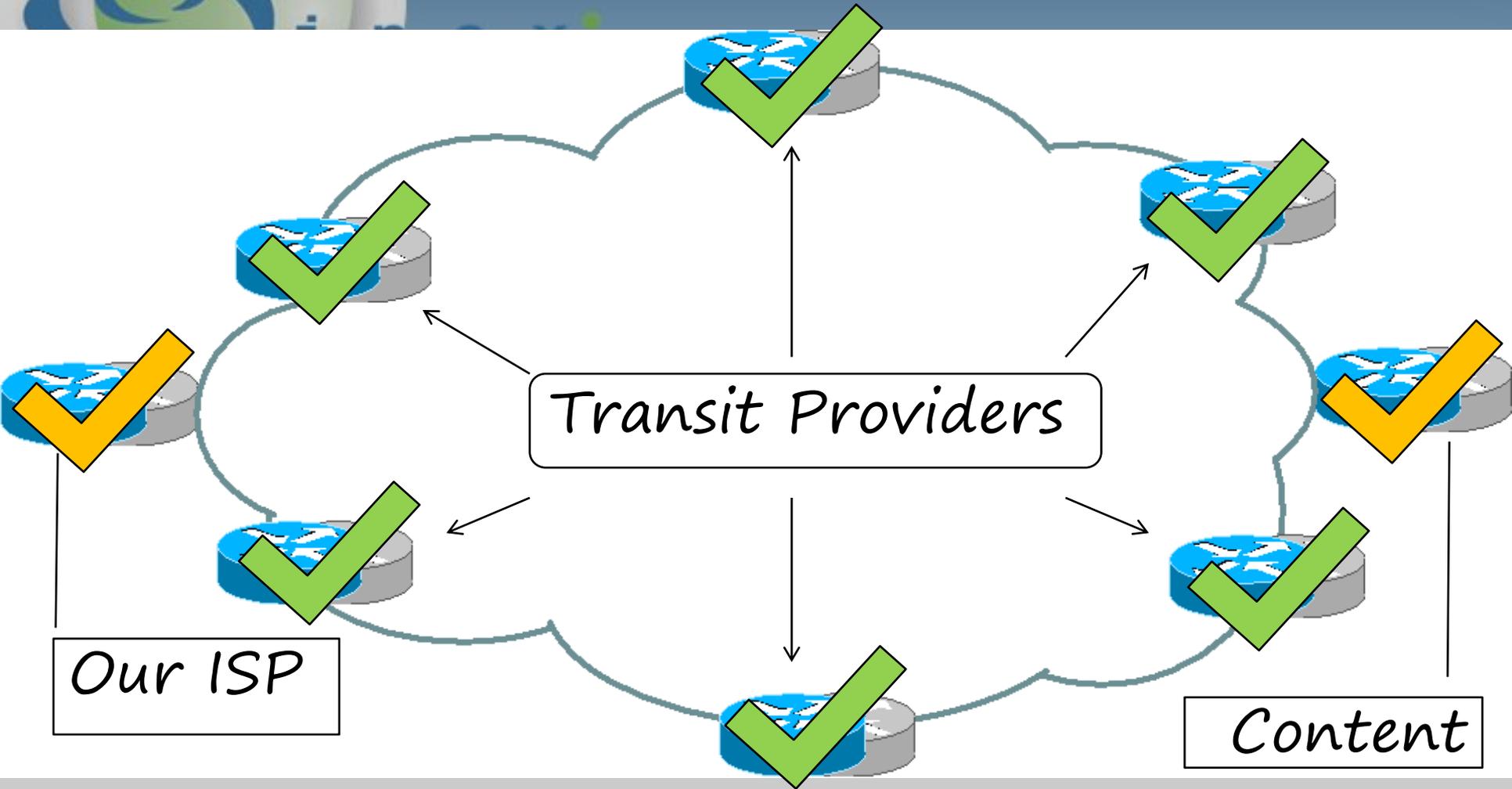
“Main issues are: access network and CPEs”

From what we just learned,
where are we with IPv6 transition?

Back Up the Truck Again



Dual Stack Transition





i n e x
i n t e r n e t n e u t r a l e x c h a n g e

Transition to IPv6

Next issue: Demand.

*End user demand – have you asked your ISP?
Your IT vendors? RFTs?*

Access Provider ↔ Content Provider

Need IPv6 content that users demand

Need IPv6 users that content providers need

Transition to IPv6



Need IPv6 users that content providers need to reach



Transition to IPv6

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

How do we solve “chicken and egg” problem?

It's actually quite easy...

But painful... and slow...

We wait.

IPv4 is running out. Fast.

We need to aggressively push / demand IPv6

We need to avoid CGNs / CDNs / ALGs



Irish ISPs and IPv6 Ripeness

i n e x
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RIPE have an IPv6 RIPLEness project

Up to 4 stars assigned for:

- Having an IPv6 allocation
- Visibility in routing tables
- Having a “route6” object
- Having a reverse DNS delegation

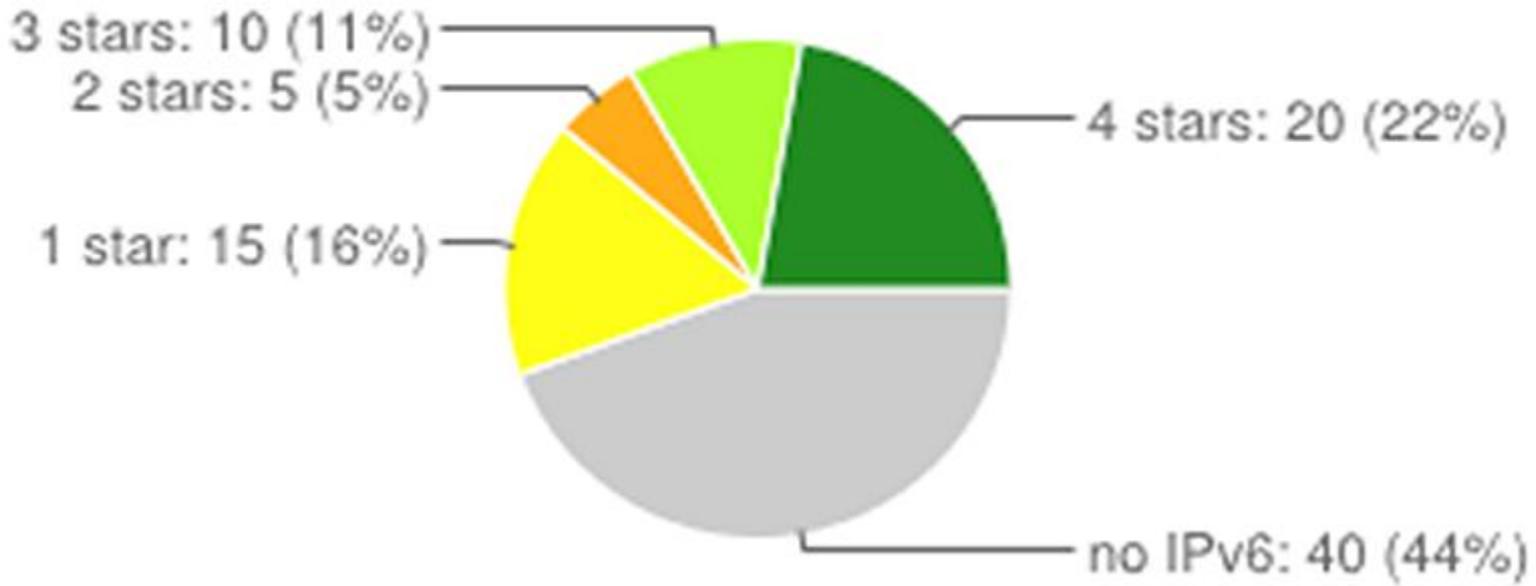
<http://ripeness.ripe.net/>



Irish ISPs and IPv6 Ripeness

i n e x
i n t e r n e t n e u t r a l e x c h a n g e

Ireland (90 LIRs/DAUs)

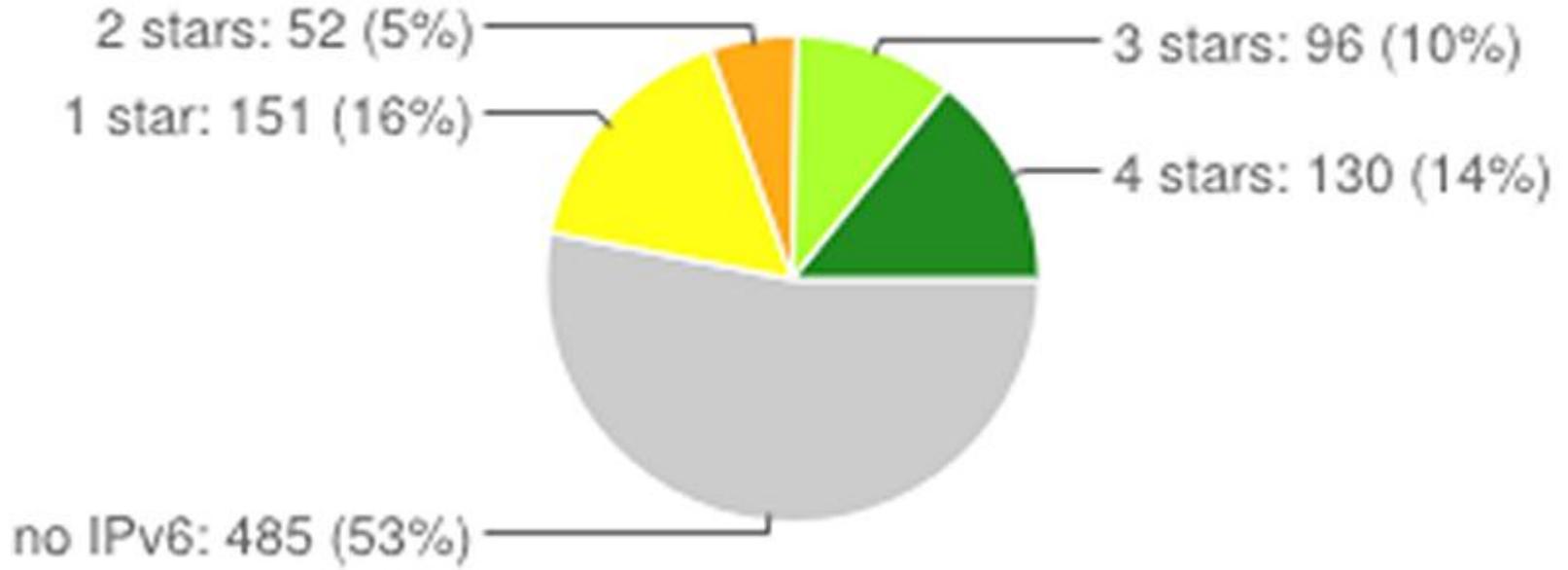




Irish ISPs and IPv6 Ripeness

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United Kingdom (914 LIRs/DAUs)





Irish ISPs – Top Performers

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i n t e r n e t n e u t r a l e x c h a n g e





World IPv6 Day – June 8 '11

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Top websites & ISPs turned on IPv6

Google, Facebook, Yahoo!, Akamai, Limelight

“To see what would happen...”

Microsoft (and xbox, bing); 100+ million users

“Almost no connectivity issues”

“Brokenness was within the margin of error”



World IPv6 Launch – June 6 '12

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Permanently enabling IPv6

Google, Facebook, Yahoo!, Akamai, Limelight
Microsoft, AT&T, D-Link, Cisco

6 '12

Google

elight



THIS TIME IT IS FOR REAL
6 JUNE 2012



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The IPv6 opportunity



The IPv6 Opportunity

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IPv6

“The Powerhouse of the Internet’s Future”

Hmmm...

Well certainly enabling the Internet’s future

We’re all aware of the benefits of the Internet

But what advantages does IPv6 offer?



The IPv6 Opportunity

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i n t e r n e t n e u t r a l e x c h a n g e

More address space.

Auto-configuration (local and routable).

Return to end-to-end networks. Woot!

i.e. no more NAT!

“An Internet of Devices”

IPv6 is built to scale – no manual intervention



The IPv6 Opportunity

i n e x
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Network merges – renumbering (and VPNs)

More efficient routing

More efficient packet processing

Directed Data Flows & Multicast



The IPv6 Opportunity

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i n t e r n e t n e u t r a l e x c h a n g e

To sum it up:

IPv6 is about the future;

And future possibilities.



Overview

A (brief?) history of Internet

IPv4 exhaustion starts

Introduction:

Getting starting with IPv6

IPv6 adoption is 500000000000 slow

The IPv6 opportunity



Getting Started with IPv6

Ask your ISP for IPv6

They'll probably say no. Do it anyway!

Then goto a "tunnel broker"

SixXS: <http://www.sixxs.net/>

Hurricane Electric: <http://www.tunnelbroker.net/>

6to4 - 6rd - Teredo



That's All Folks!

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Copy of the Presentation:

<https://www.inex.ie/ei-ipv6-2012.html>

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