The case for IPv6-only data centres

...and how to pull it off in today's IPv4-dominated world

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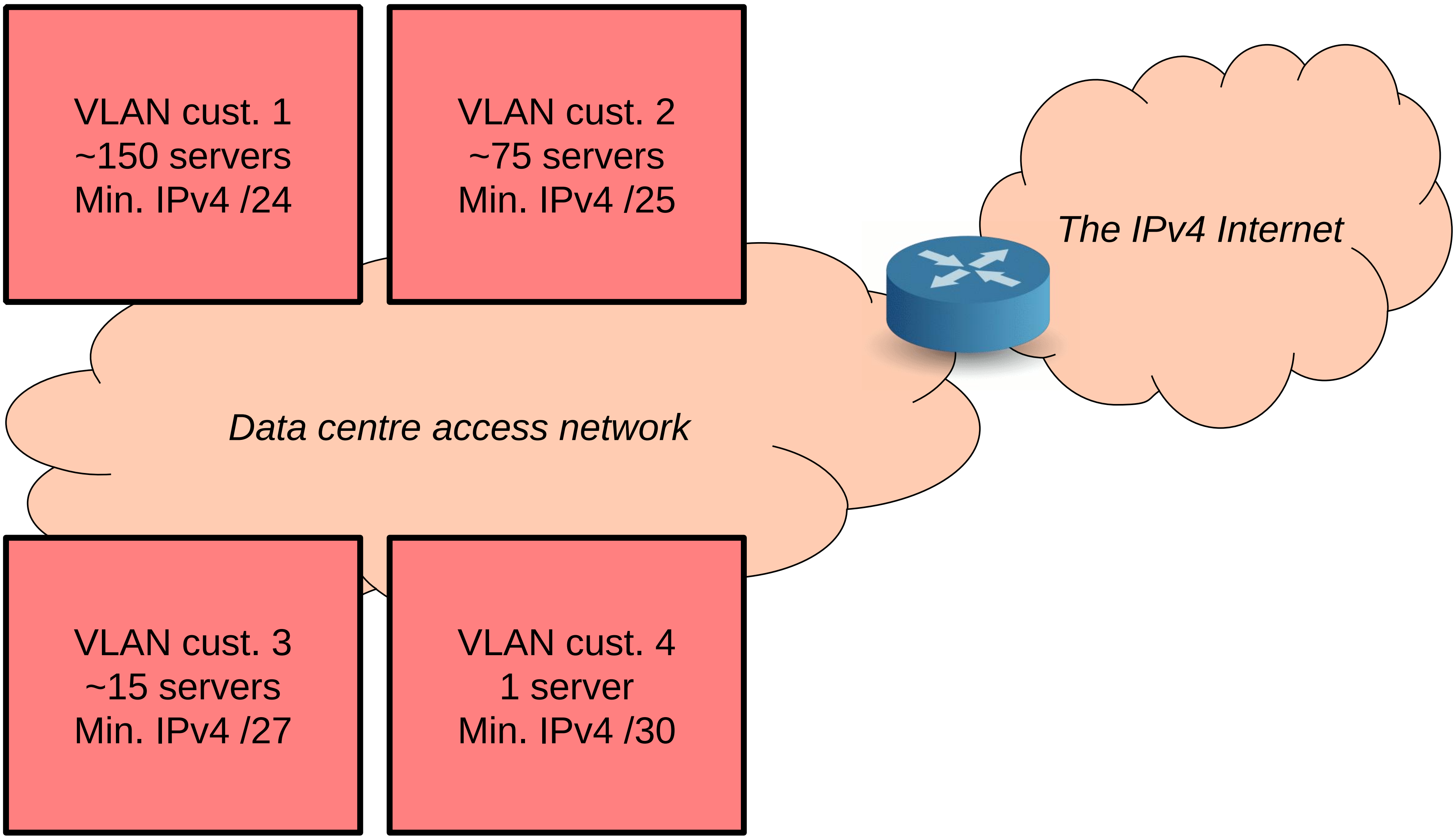
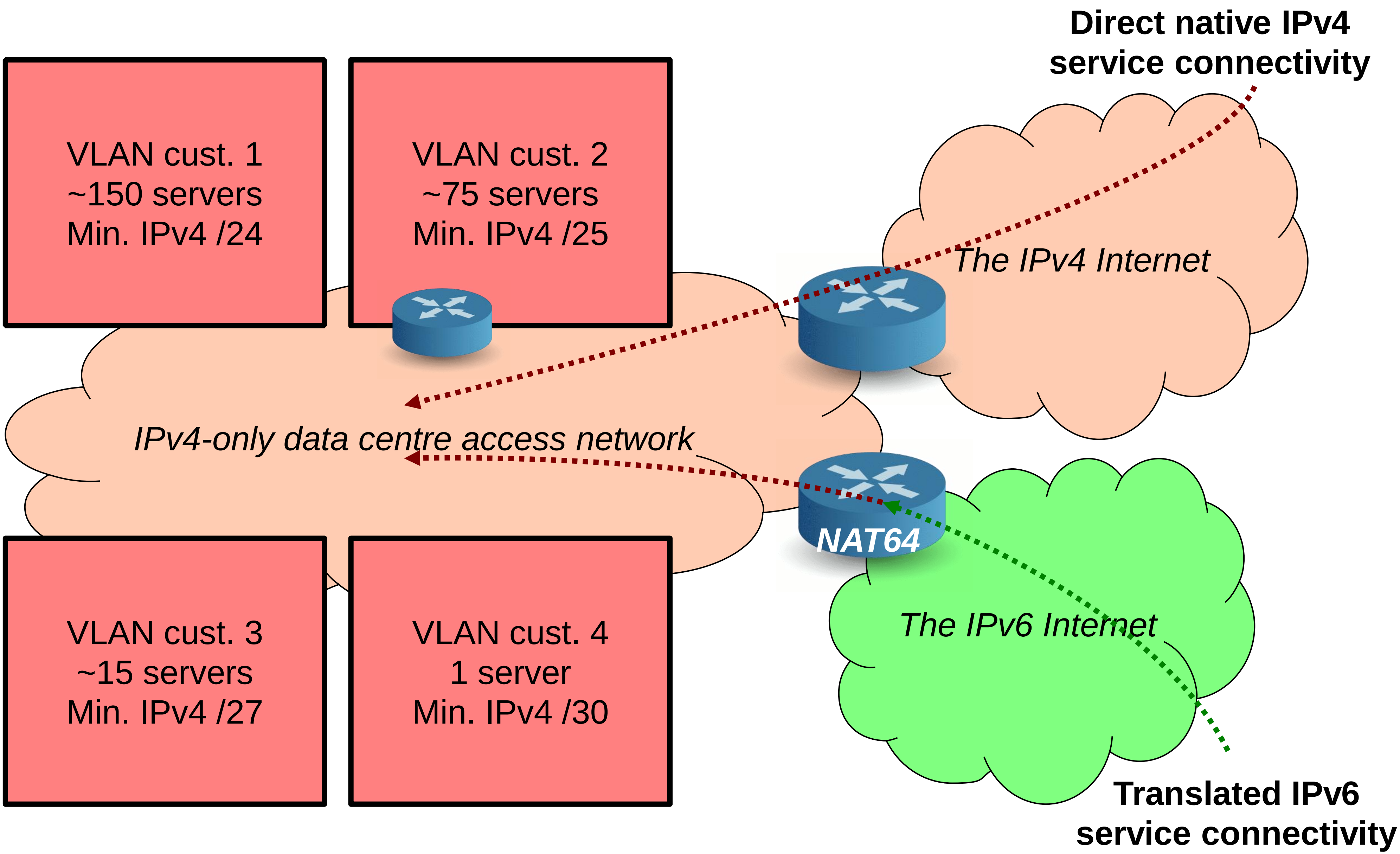
Traditional DC topology



Challenges ahead

- IPv6 deployment
- IPv4 depletion

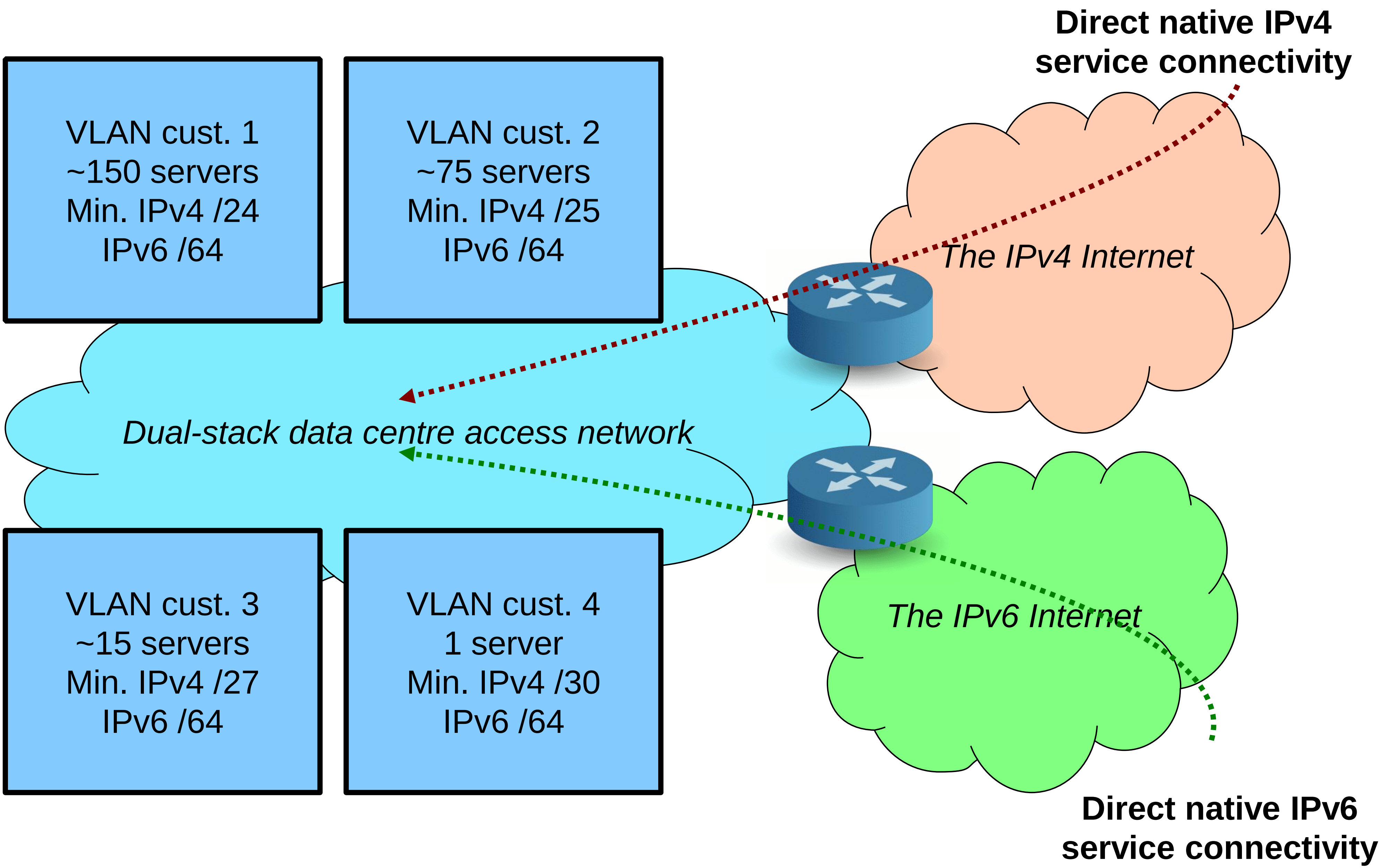
NAT64 (or proxies)



NAT64 (or proxies)

- The good:
  - Services now accessible over IPv6
- The bad:
  - Requires stateful devices – expensive, hard to scale, limits routing flexibility, and vulnerable to DoS attacks
  - Failures/fail-over breaks all sessions
  - Obscures source IPv6 address of user
  - Does <u>not</u> help with IPv4 depletion

Dual stack

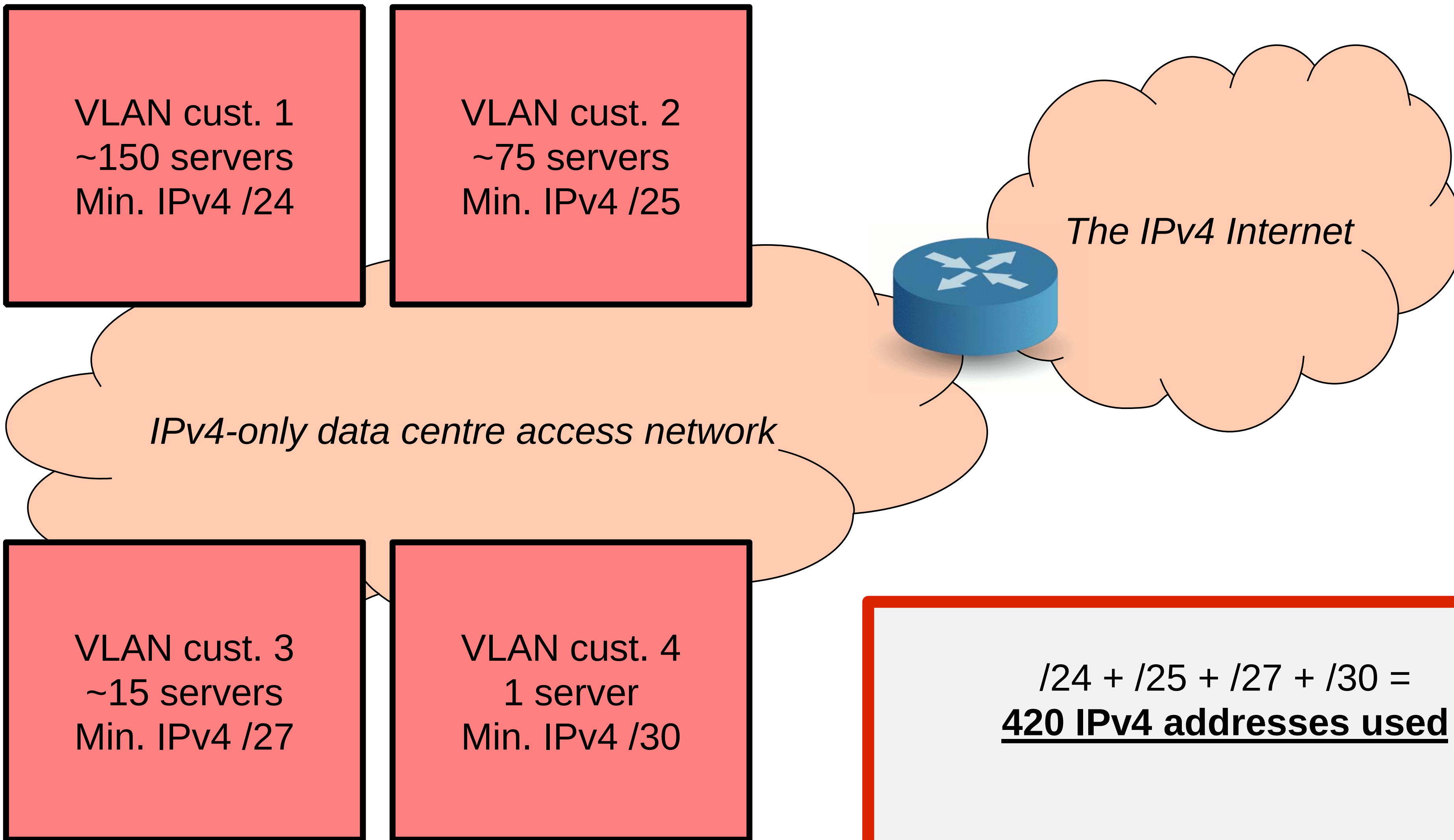


Direct native IPv4
service connectivity
VLAN cust. 1
~150 servers
Min. IPv4 /24
IPv6 /64
VLAN cust. 2
~75 servers
Min. IPv4 /25
IPv6 /64
The IPv4 Internet
Dual-stack data centre access network
VLAN cust. 3
~15 servers
Min. IPv4 /27
IPv6 /64
VLAN cust. 4
1 server
Min. IPv4 /30
IPv6 /64
The IPv6 Internet
Direct native IPv6
service connectivity

Dual stack

- The good:
  - Services now available over IPv6
- The bad:
  - Does <u>not</u> help with IPv4 depletion
  - Greatly increases complexity
    - Doubles the amount of ACLs, monitoring, troubleshooting, possible failure scenarios, staff training, documentation, testing, etc.

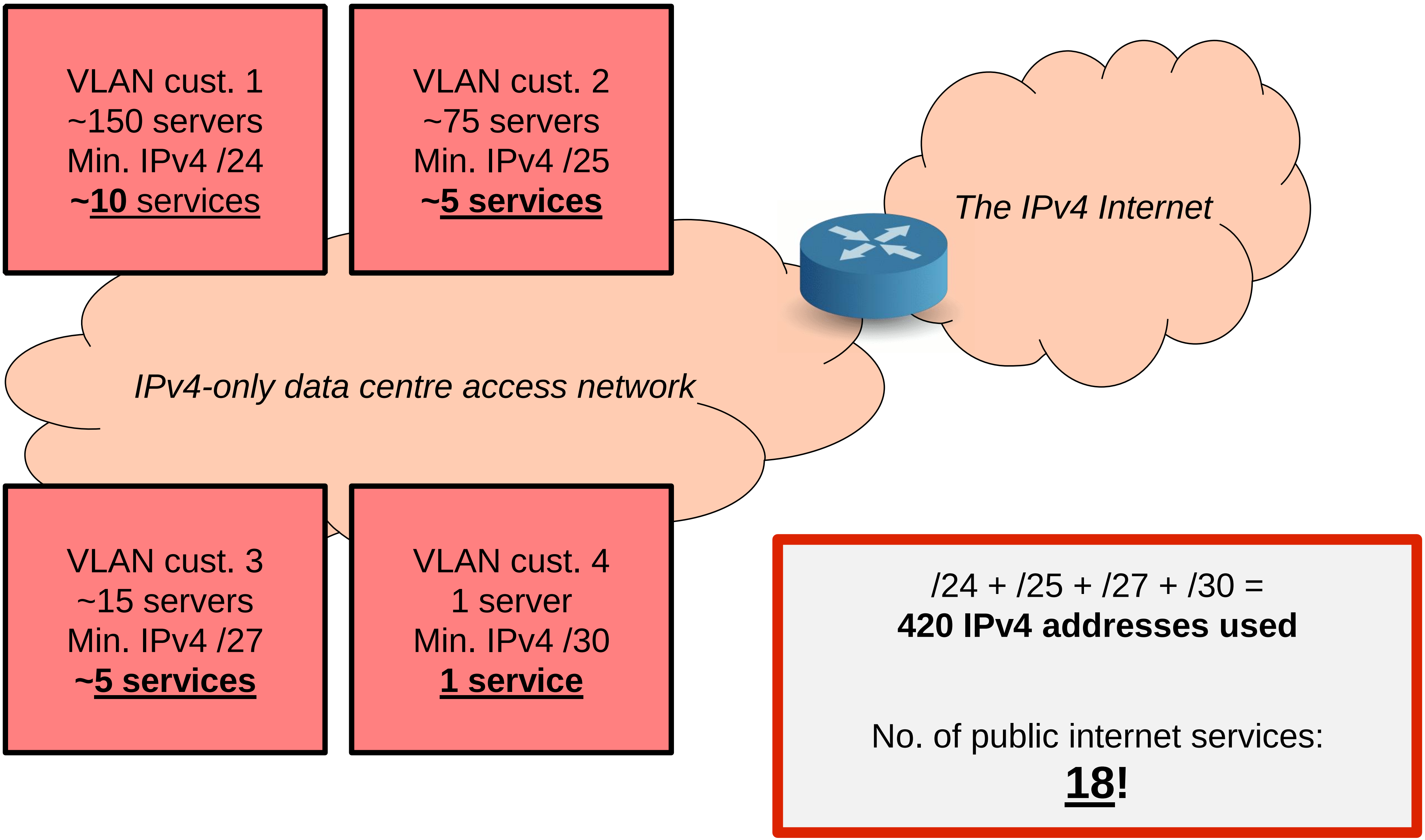
Examining IPv4 usage



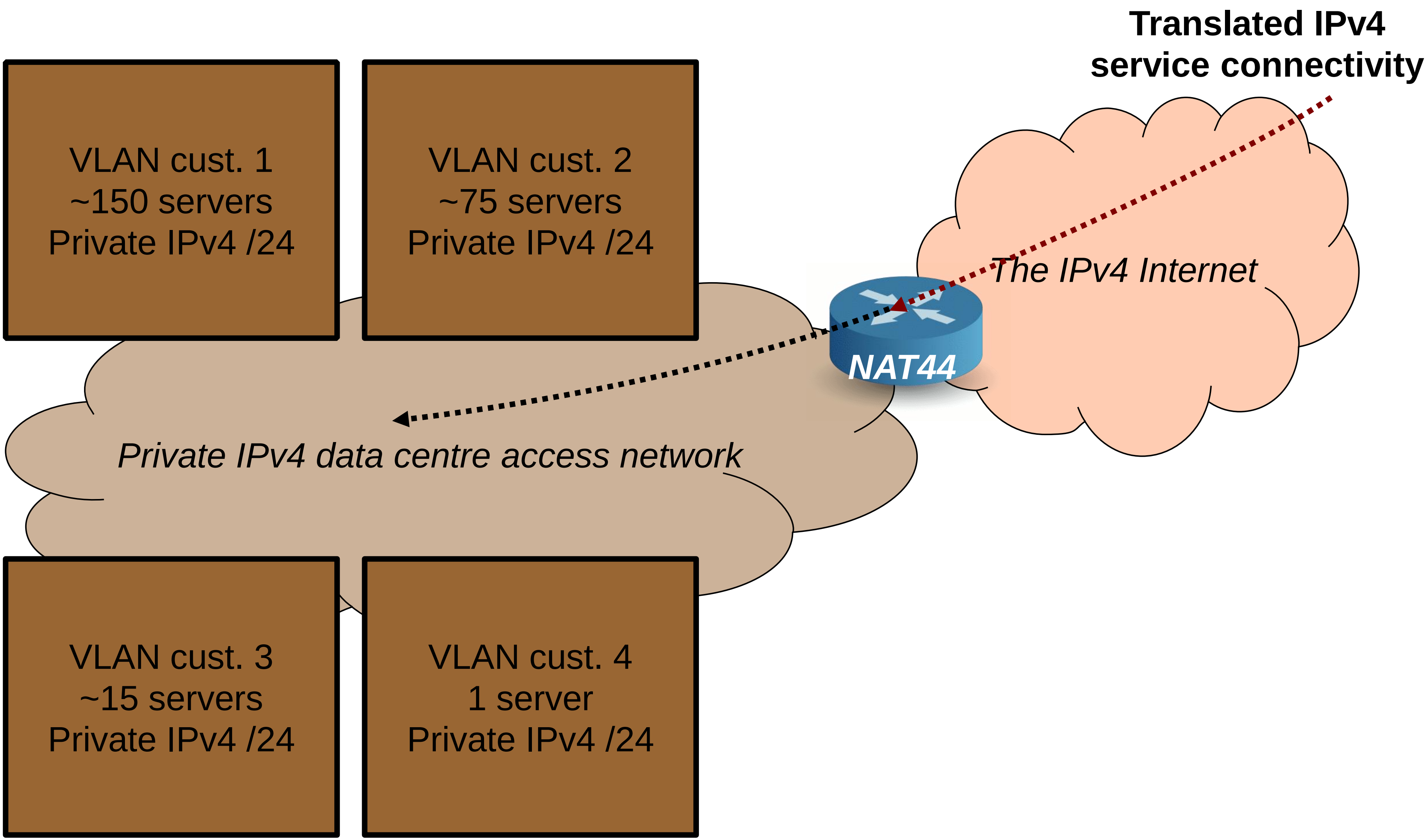
/24 + /25 + /27 + /30 =

420 IPv4 addresses used

Examining IPv4 usage



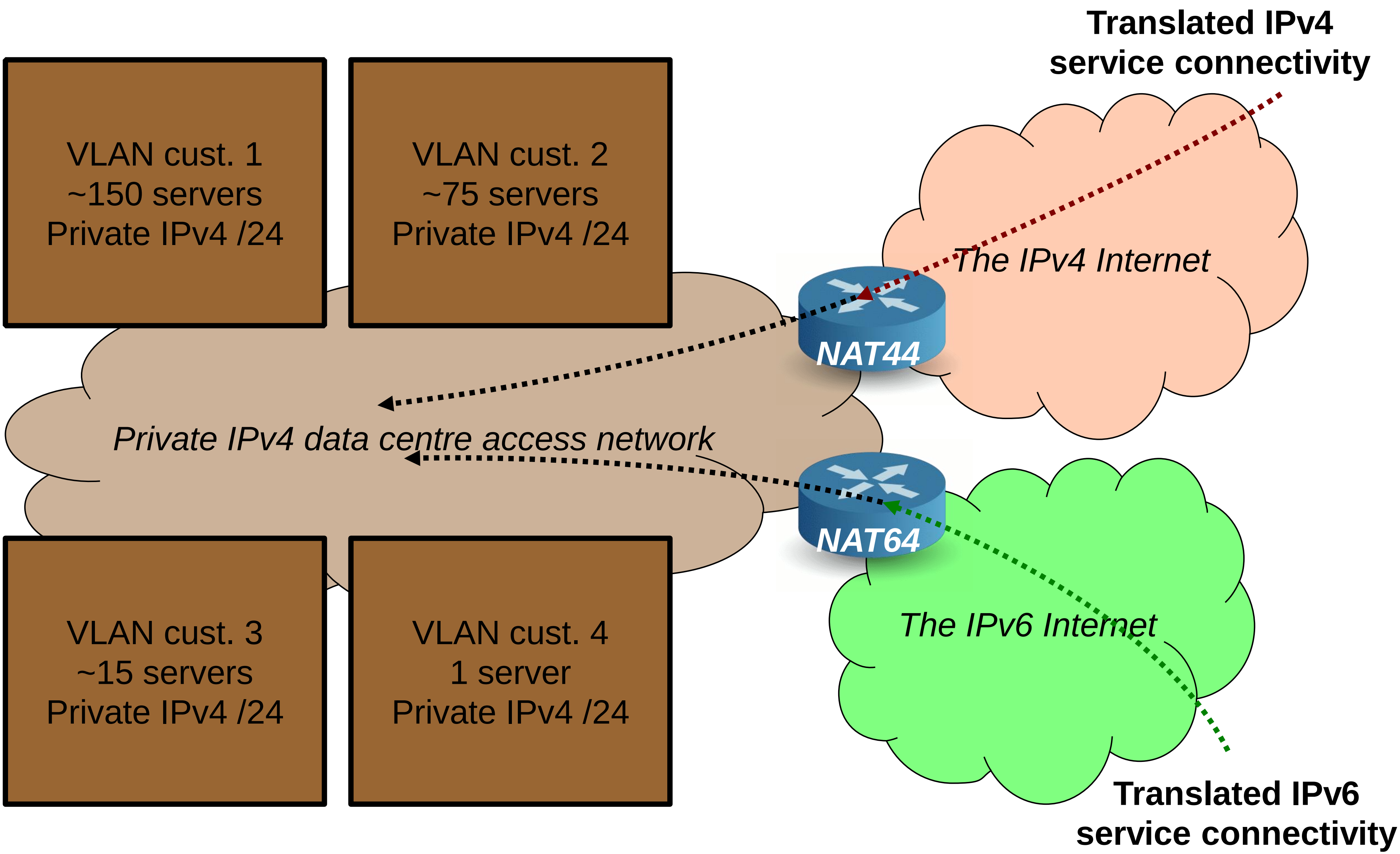
Private IPv4 + NAT44/proxies



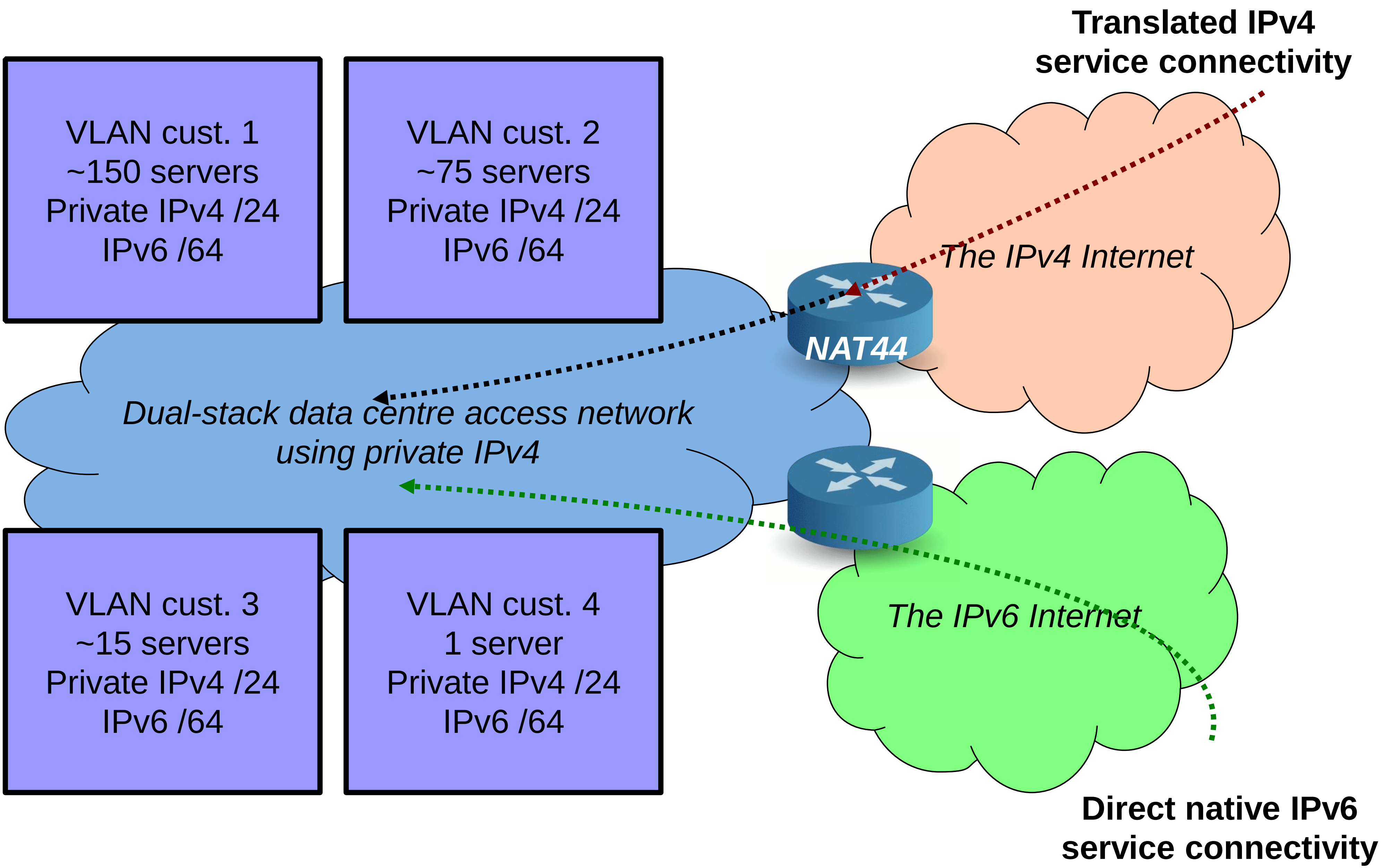
NAT44/proxies

- The good:
  - Solves IPv4 depletion, use only 1 public address per public service
- The bad:
  - Requires stateful devices – expensive, hard to scale, limits routing flexibility, and vulnerable to DoS attacks
  - Failures/fail-over breaks all sessions
  - May obscure source IPv4 address of user
  - Does <u>not</u> help with IPv6 deployment

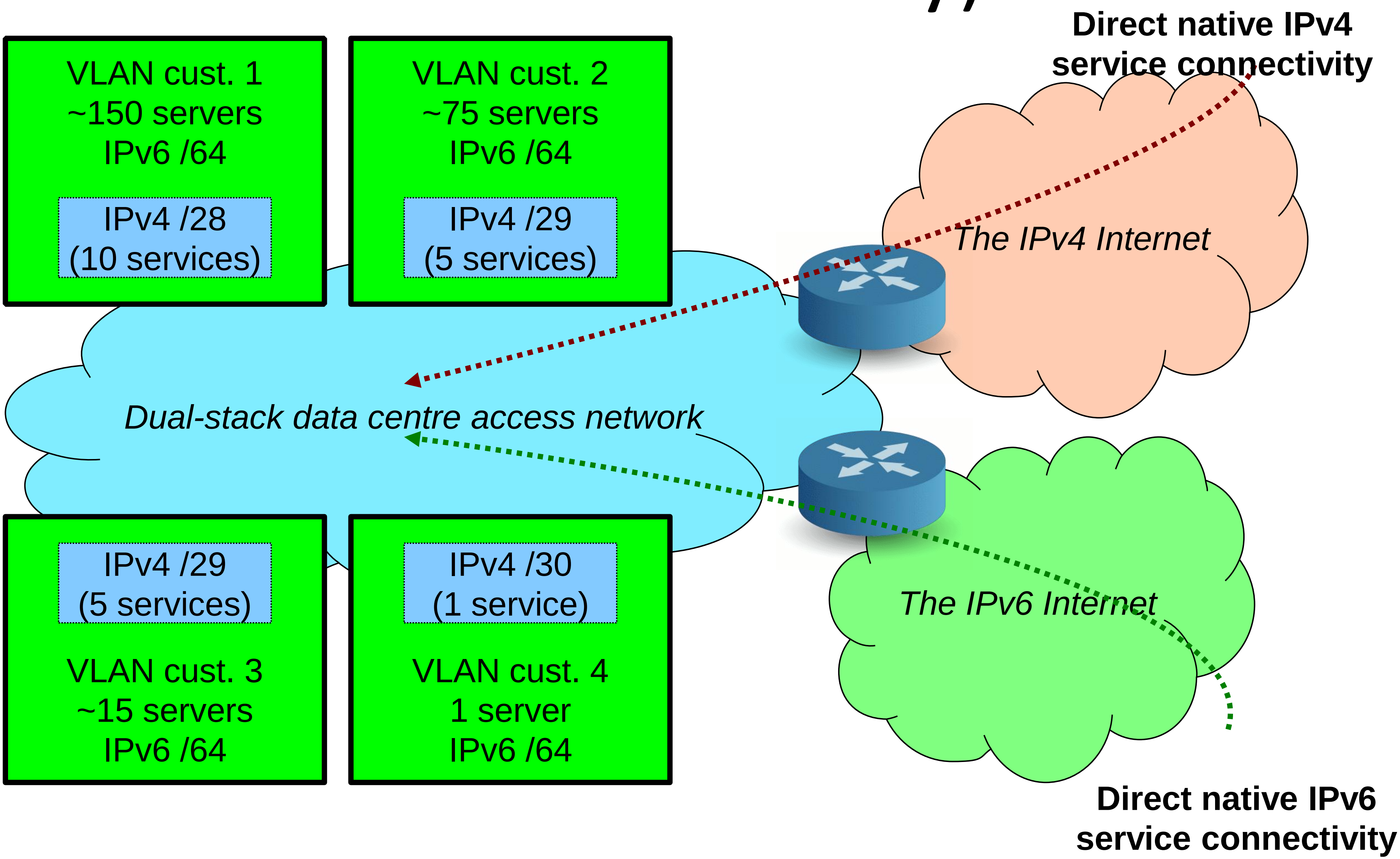
Private v4, NAT44 <u>and</u> NAT64



Native v6, private v4, NAT44



Partial dual stack (IPv4 for service addresses only)



Mix and match solutions?

- The good:
  - Solves IPv4 depletion, use only 1 public address per public service (or close to it)
  - Ensures IPv6 service availability
- The bad:
  - You're still dependent on IPv4 – expect more migration projects down the road
  - You require NAT44, NAT64, or proxies – all stateful devices, ***<u>or</u>***:
  - Accept the operational complexity of running two IP versions in parallel

Deploying IPv6 incrementally

- IPv4-only
- IPv4-only + IPv6 via NAT/proxy
- Dual-stacked public frontend, IPv4 BE
- Full dual-stack
- Dual-stacked public frontend, IPv6 BE
- IPv6-only + IPv4 via NAT/proxy
- IPv6-only

What's possible <u>today</u>?

- IPv4-only
- IPv4-only + IPv6 via NAT/proxy
- Dual-stacked public frontend, IPv4 BE
- Full dual-stack
- Dual-stacked public frontend, IPv6 BE
- IPv6-only + IPv4 via NAT/proxy
- ~~IPv6-only~~

Only a single-digit percentage of end-users world-wide have IPv6!
Switzerland is exceptionally high, but still, IPv6-only content ... no way

Let's take a shortcut...

- IPv4-only

~~IPv4-only + IPv6 via NAT/proxy~~

~~Dual-stacked public frontend, IPv4 BE~~

~~Full dual-stack~~

~~Dual-stacked public frontend, IPv6 BE~~

IPv6-only + IPv4 via NAT/proxy

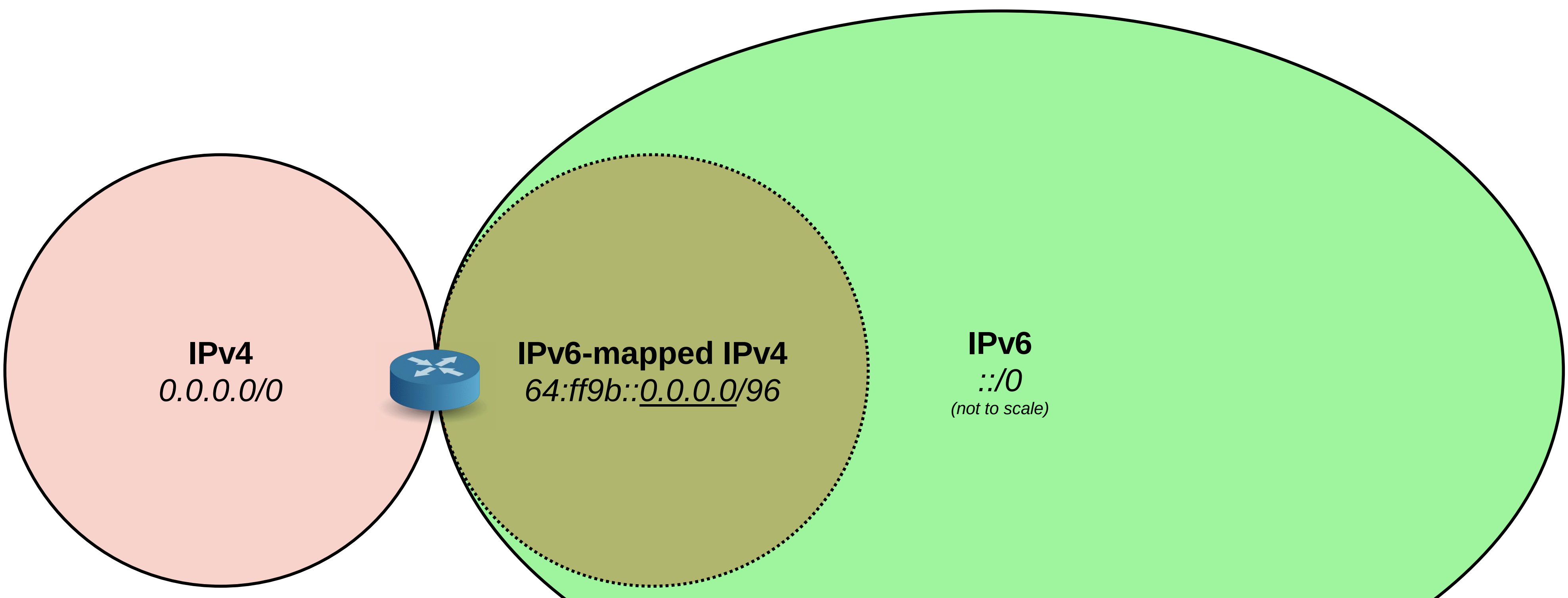
~~IPv6-only~~

Stateless IP/ICMP Translation (SIIT)

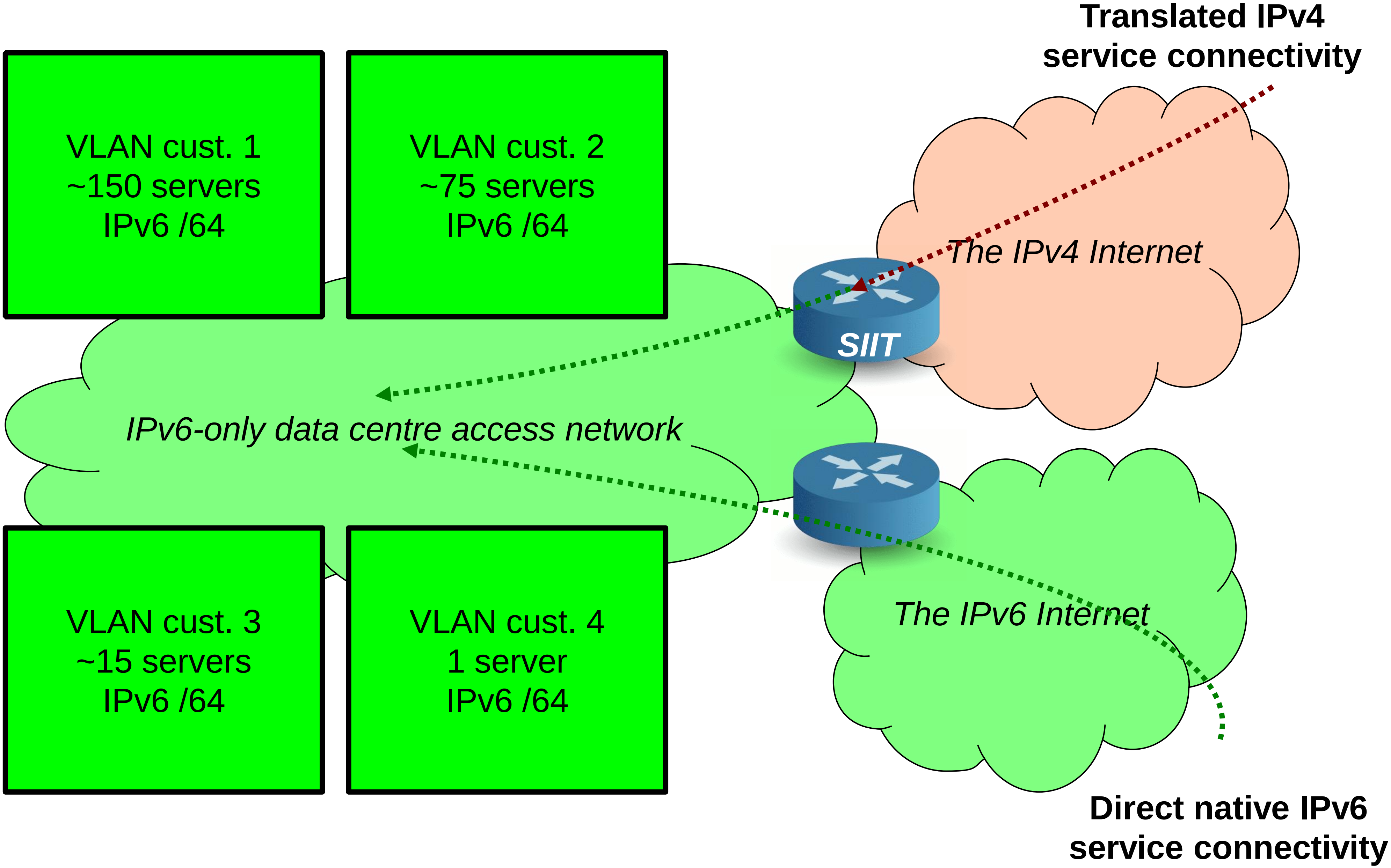
RFCs 6052, 6145,
draft-anderson-siit-dc-00

(Also known as Stateless NAT64 and IVI)

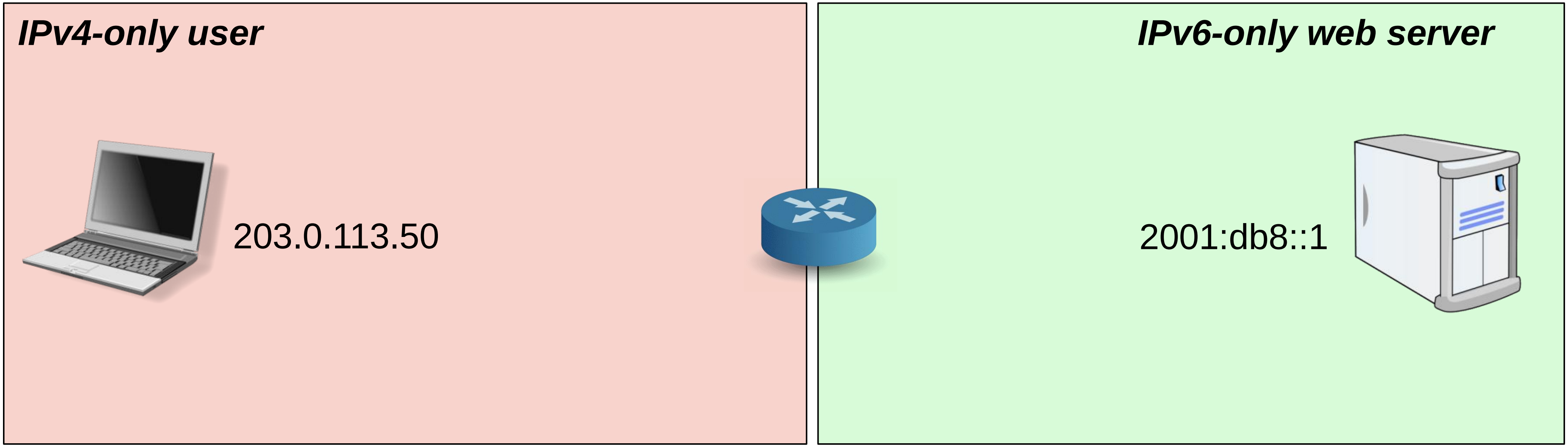
- Maps the entire IPv4 internet into a /96 IPv6 prefix in a 1-to-1 stateless fashion
- Static stateless 1-to-1 IPv4-to-IPv6 mappings defined for each public service
- Server LANs and applications only use IPv6 – IPv4 connectivity is "outsourced" to the network

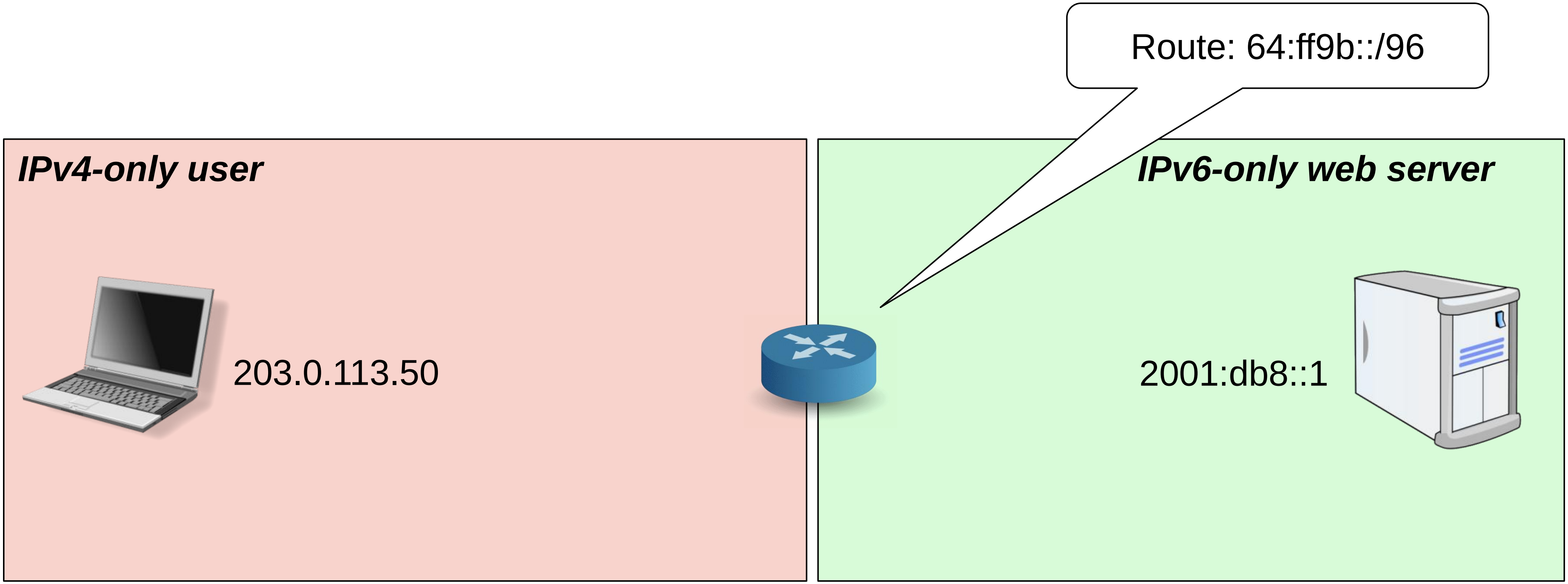


Native IPv6 + IPv4 via SIIT

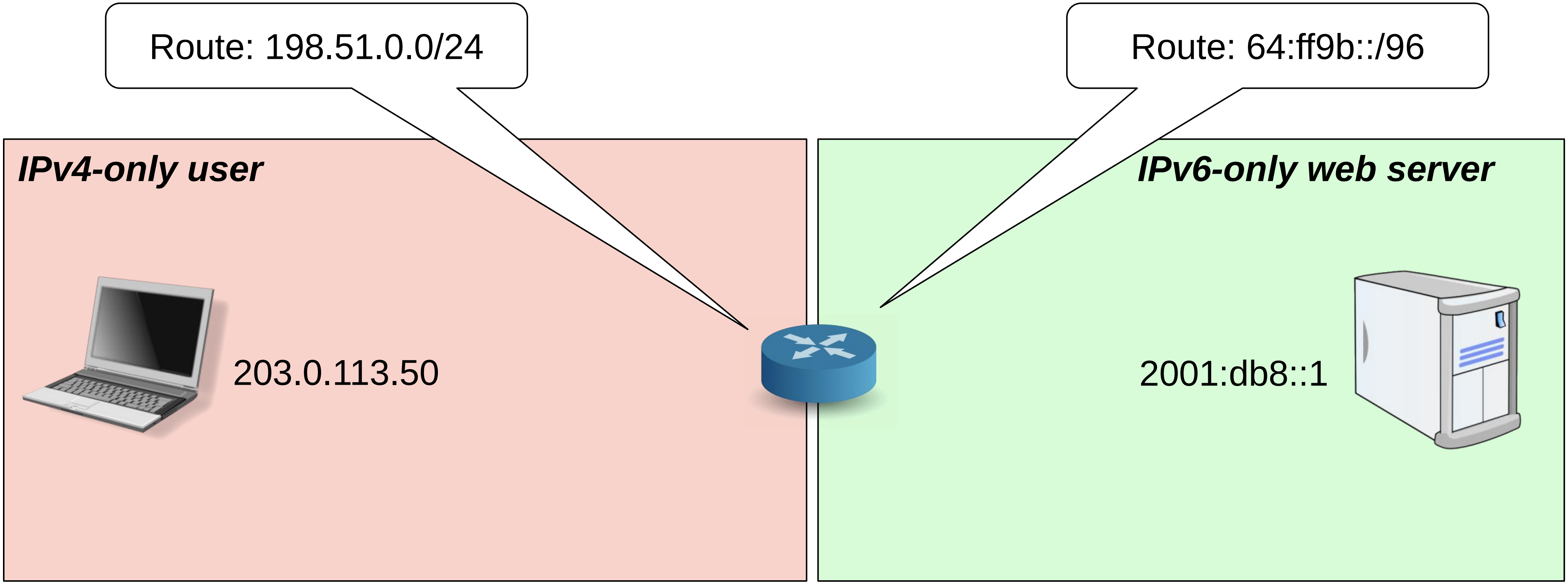


Technical walkthrough

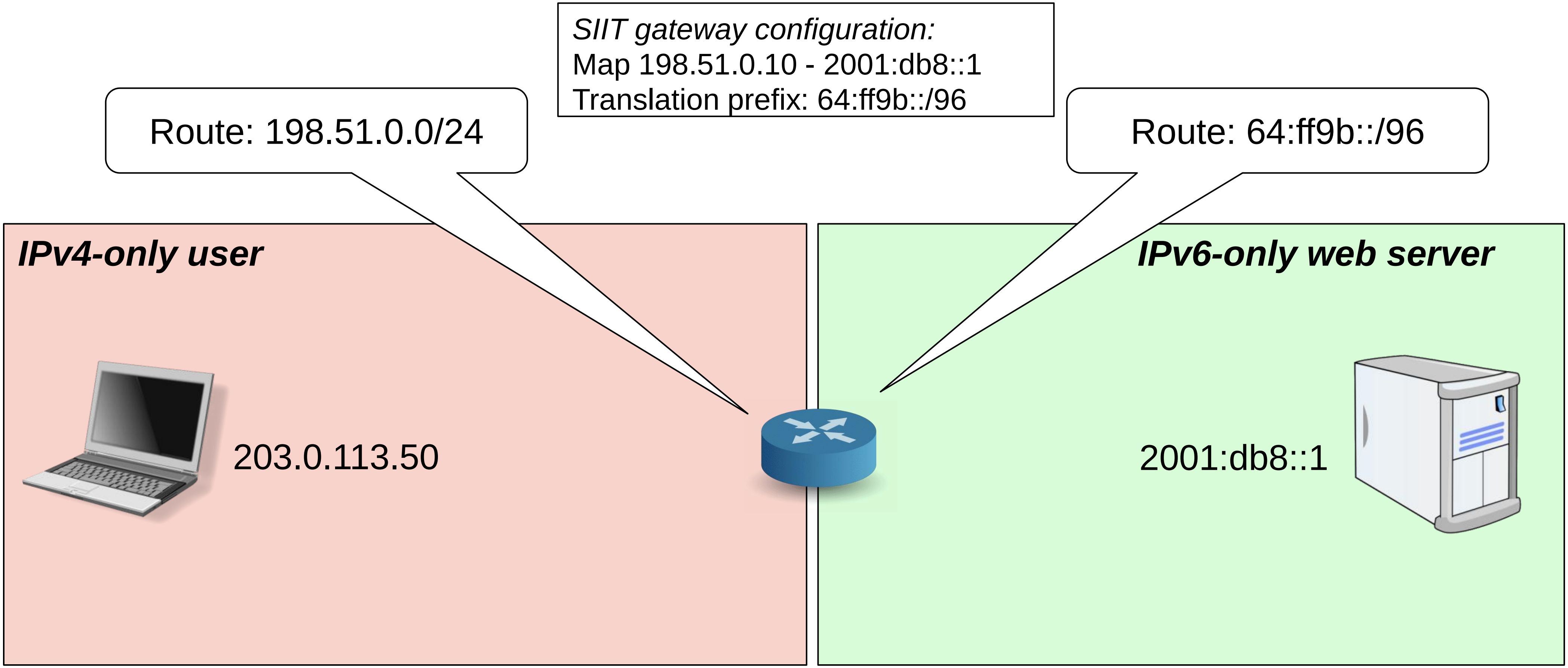




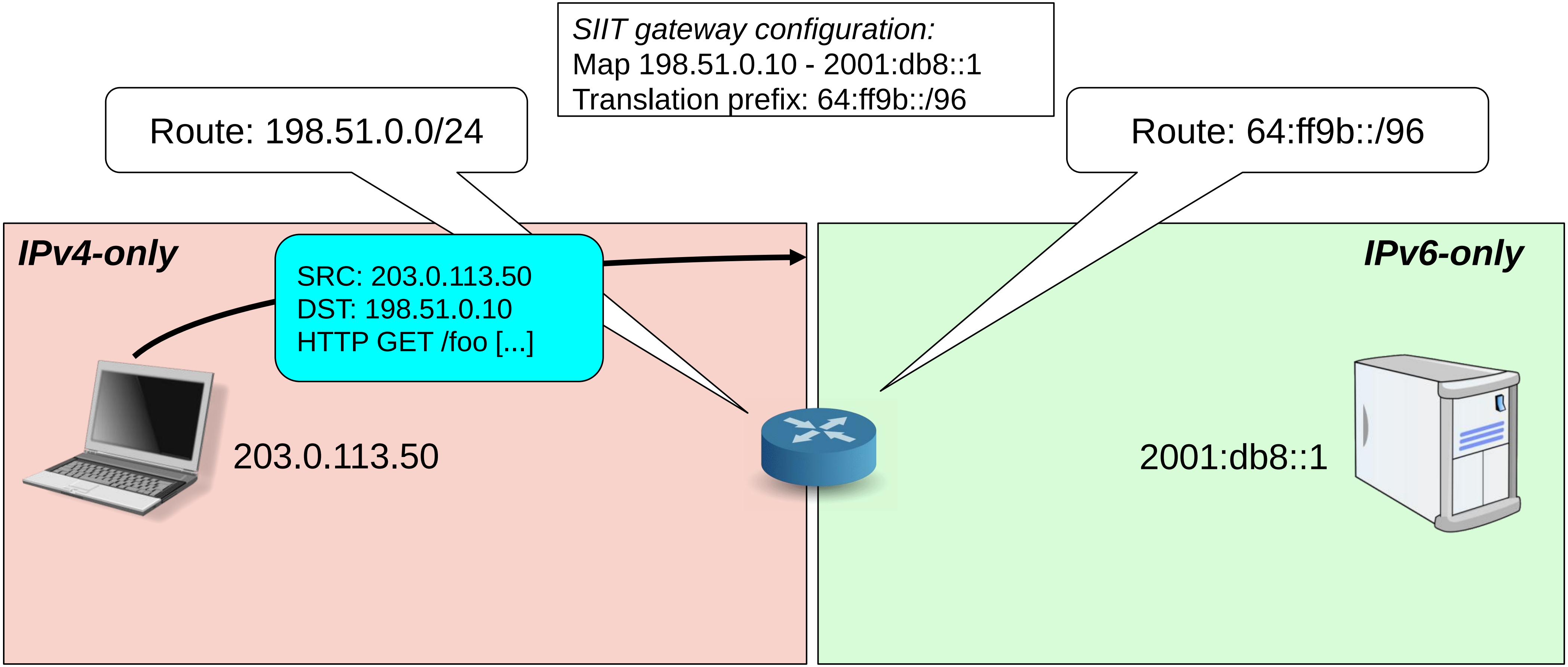
- An IPv6 /96 prefix is assigned as the translation prefix representing the IPv4 internet and routed to the SIIT gateway



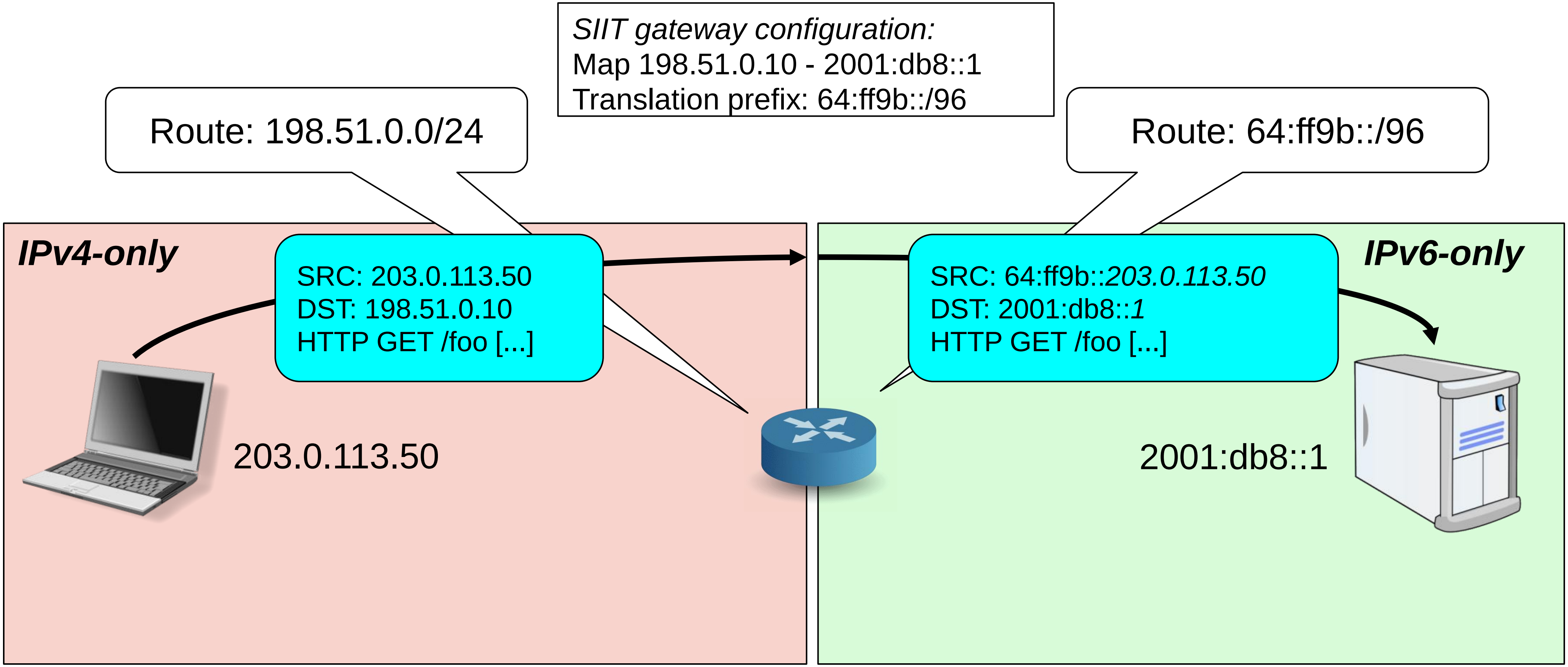
- An IPv6 /96 prefix is assigned as the translation prefix representing the IPv4 internet and routed to the SIIT gateway
- A pool of IPv4 service addresses are assigned and routed to the SIIT gateway



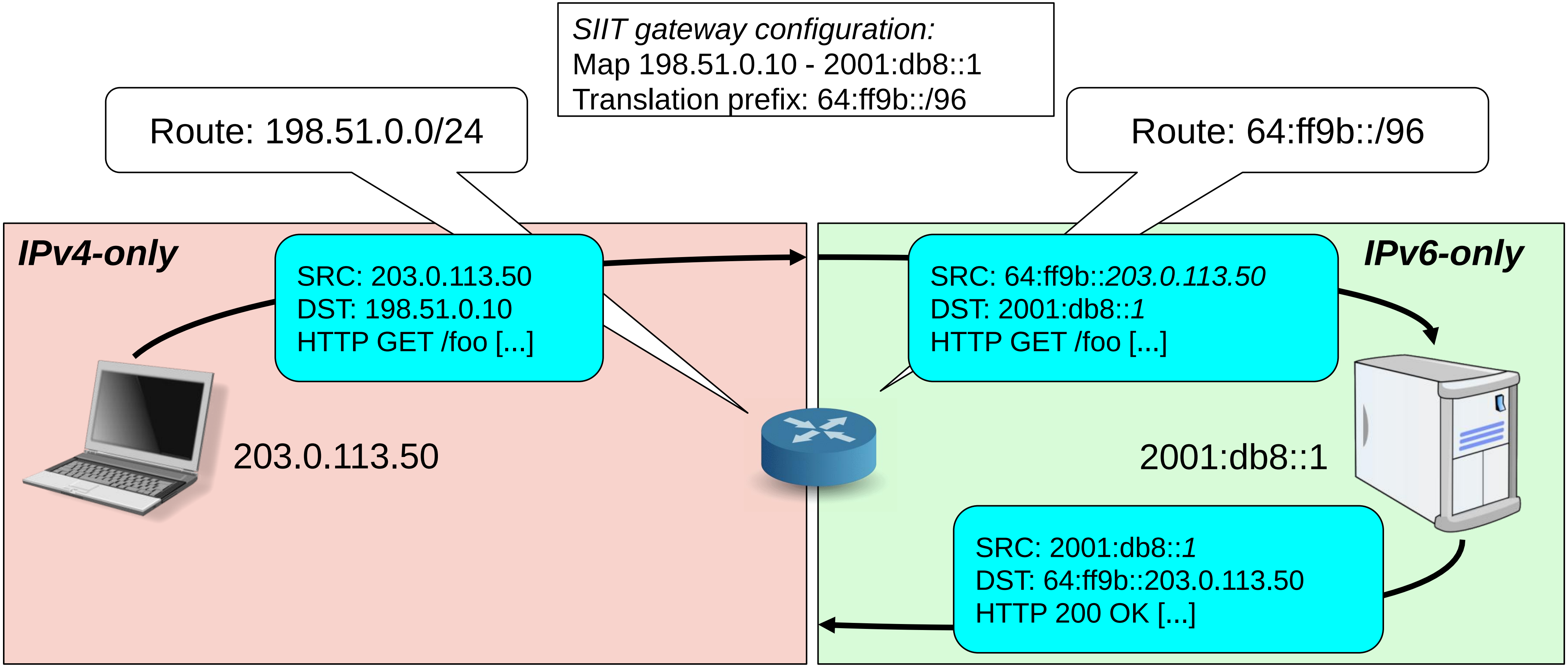
- The SIIT gateway is configured with static IPv4 mappings for each IPv6 service
- The IPv6 /96 prefix is configured as a default rule (used if no static map match)
- IPv4 (IN A) records are added to DNS



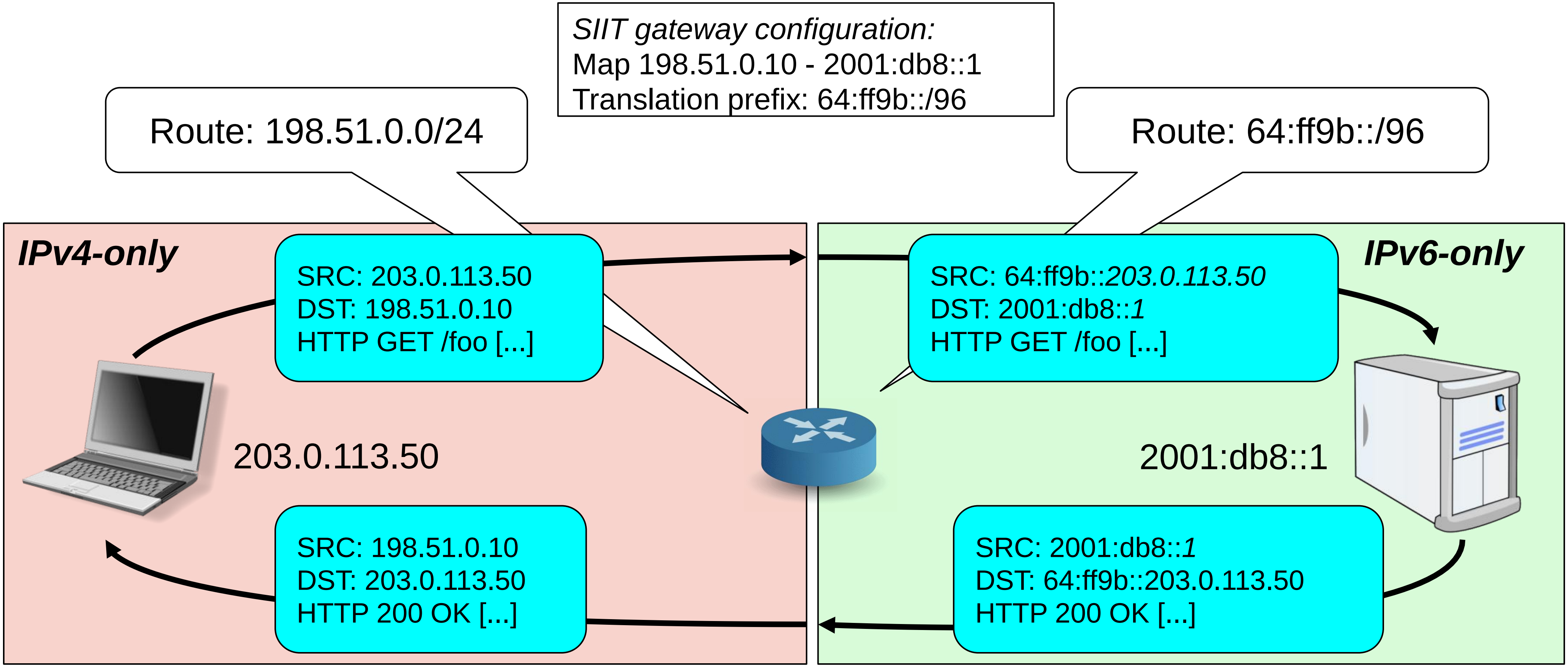
- The client looks up the service's IPv4 address in DNS, and connects to it like it would with any other IPv4 address
- The IPv4 packet is routed to the SIIT gateway's IPv4 interface



- The SIIT GW translates the packet to IPv6
  - DST address rewritten according to static map
  - SRC address gets the /96 prefix prepended (as it does not match any static maps)
- Layer 4 payload is copied verbatim

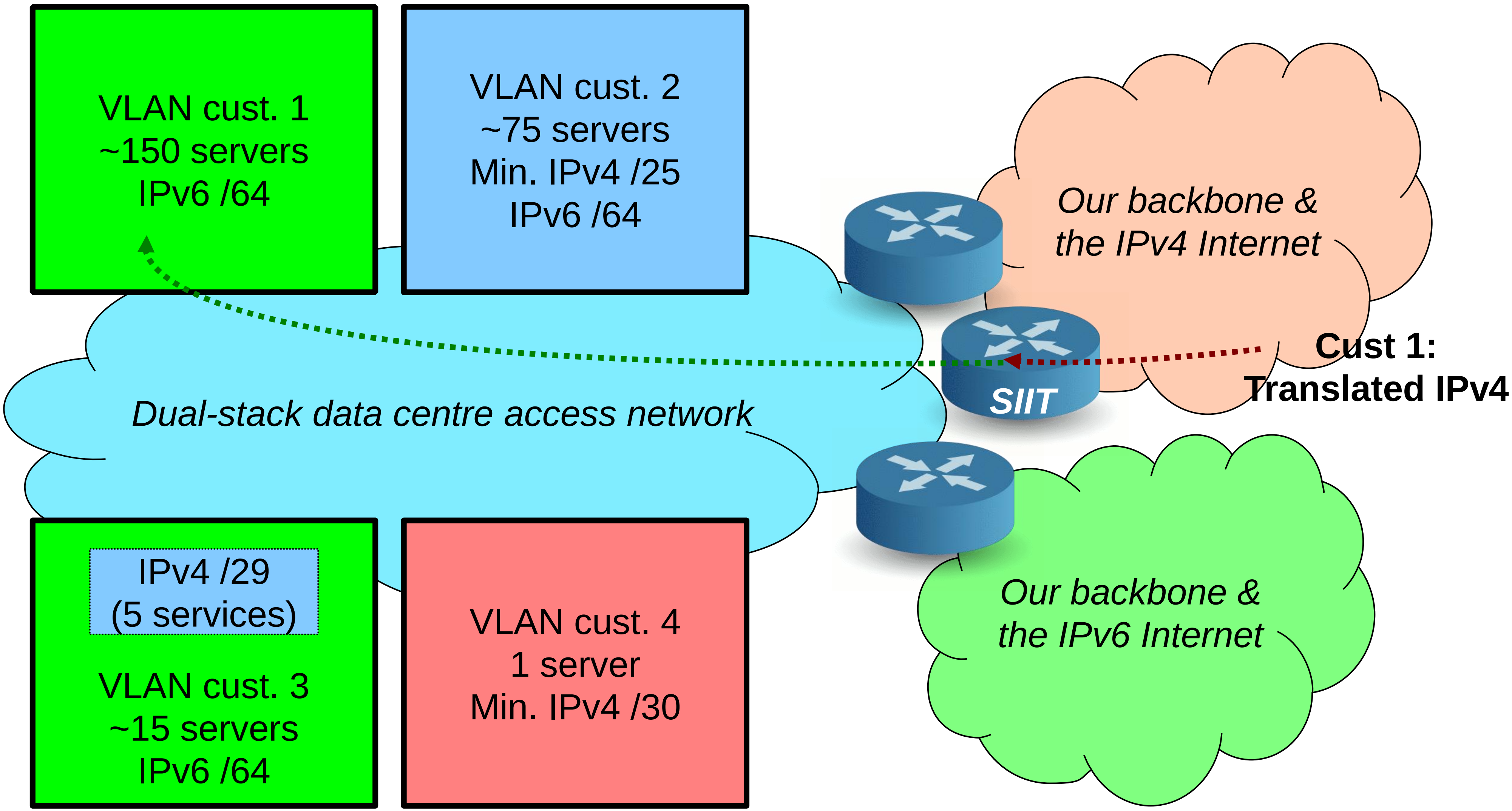


- The server responds to the packet just as it would with any other IPv6 packet
  - Server needs no specific support for SIIT
- The original IPv4 source address isn't lost
- Response is routed back to the SIIT GW

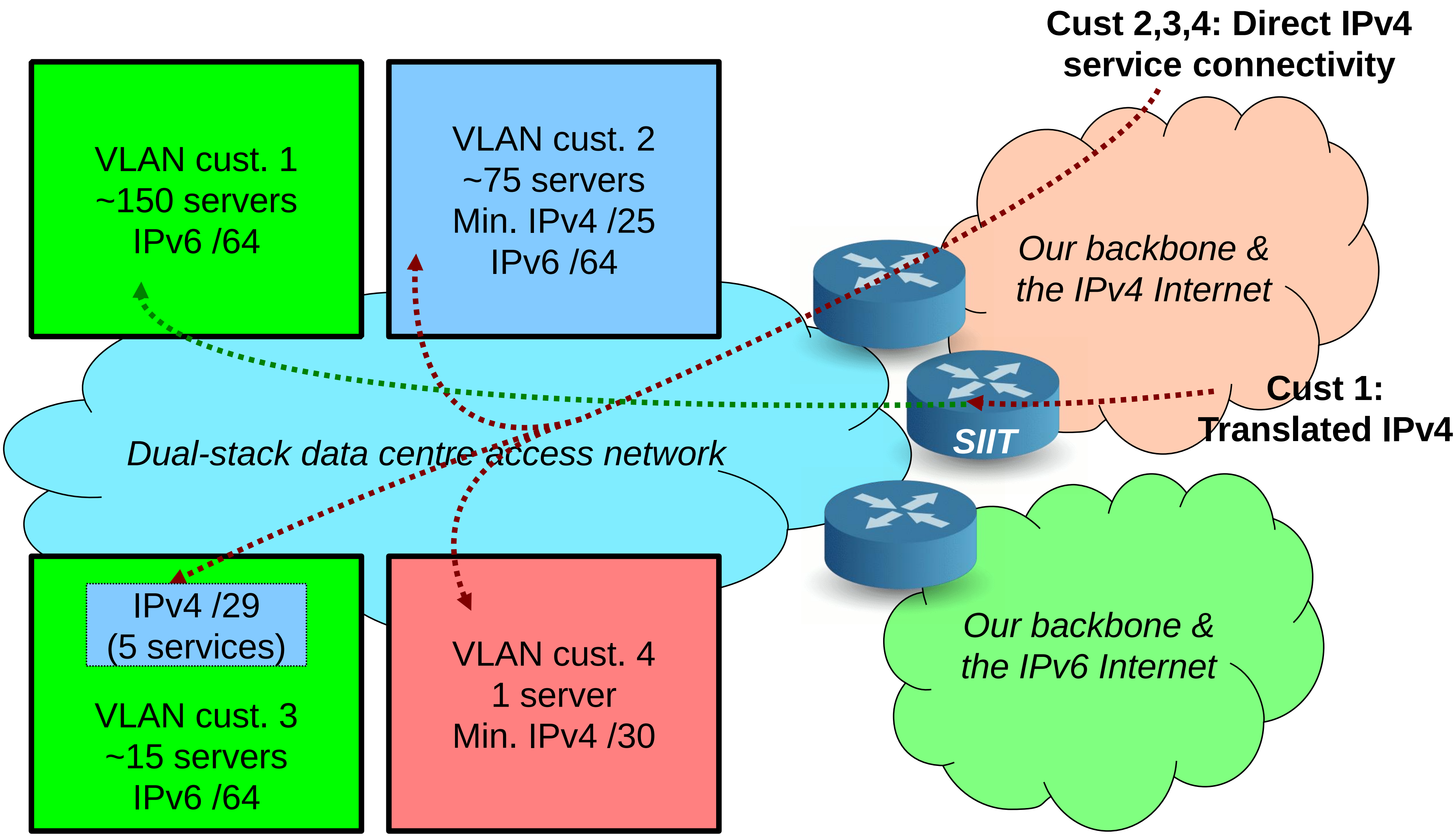


- The SIIT GW translates back to IPv4:
  - SRC address according to static mapping rule
  - DST address doesn't match any static map, so it only gets the /96 prefix stripped
- Response packet is routed back to client

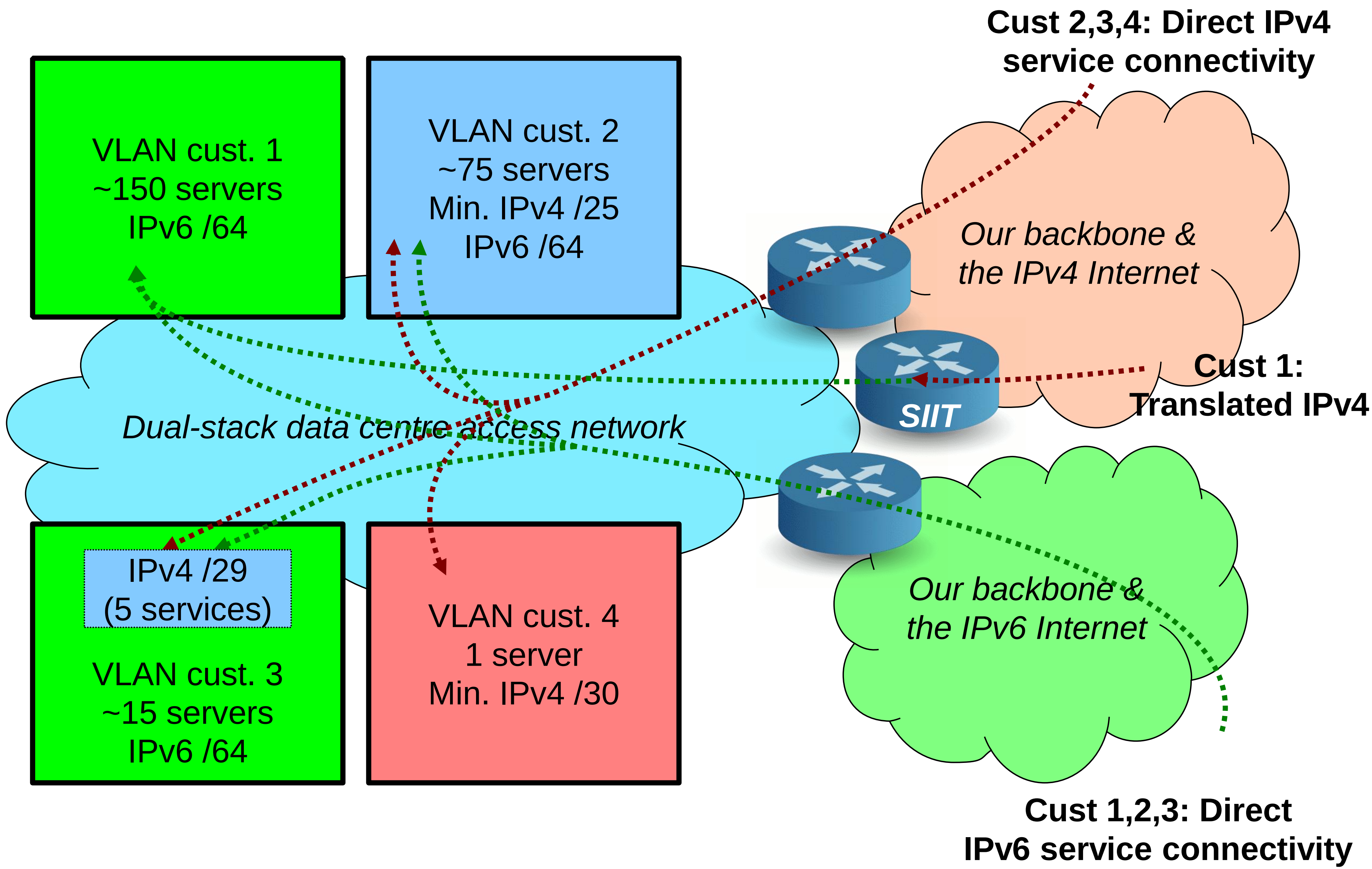
SIIT isn't all or nothing



SIIT isn't all or nothing

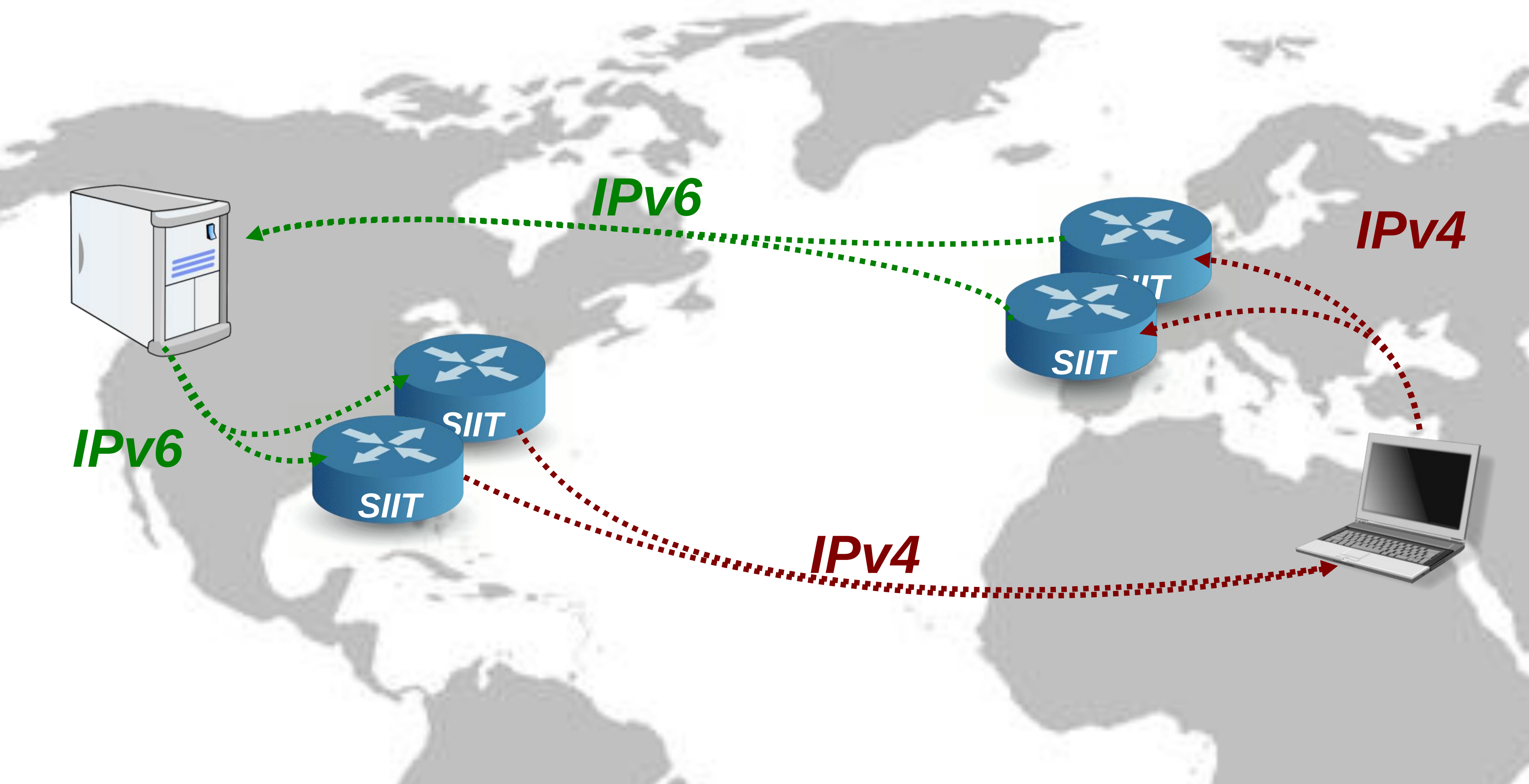


SIIT isn't all or nothing



Anycast, high availability, and ECMP (load balancing)

No problem thanks to the stateless nature of SIIT



SIIT highlights

- Stateless per-packet operation
  - You can use anycast, ECMP load balancing, ...
  - Does not require flows to bidirectionally traverse a single translator box
  - Doesn't need to be the servers' default route, may be placed anywhere in your network
  - Concurrent flow count and fps are irrelevant for performance (unlike NAT44 and proxies)
- The original IPv4 address remains known
  - Applications may geolocate IPv4 users

SIIT highlights, cont.

- Maximum conservation of IPv4 addresses
  - 1 address used per public service, none lost to infrastructure or subnet ^2 overhead, etc.
- Single-stack applications and server LANs
  - No additional complexity, unlike dual stack
- Application stack is independent of IPv4
  - Forget about further IPv6 migration projects
  - When IPv4 has become irrelevant, remove IN A records and shut down SIIT gateways - done

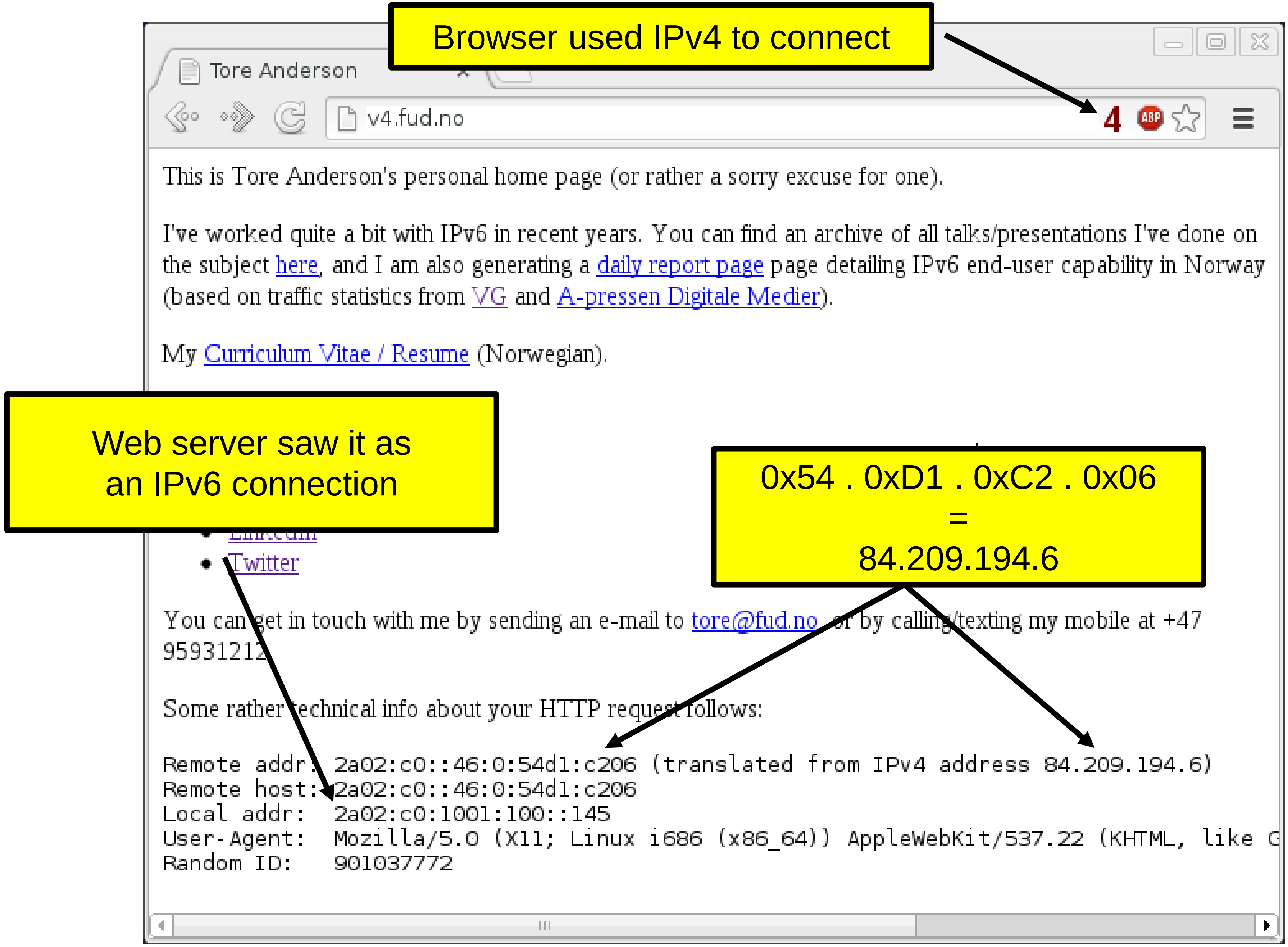
Application requirements

- If the application doesn't work through NAT44, it will likely not work with SIIT
  - e.g., FTP (uses IP literals in Layer 7 payload)
- If the application does work with NAT44, it will likely work with SIIT as well
  - e.g., HTTP and HTTPS
- The servers' OS and application stacks must fully support IPv6

Existing implementations

- TAYGA for Linux (open source)
  - http://www.litech.org/tayga/
- Cisco ASR1K
  - Static mapping feature implemented in IOS XE version 3.10 (due to be released in July)
- Others? Let me know!

It works in practice too :-)



Questions?
Thank you for listening!

Further reading:

RFC 6052 - IPv6 Addressing of IPv4/IPv6 Translators

RFC 6145 - IP/ICMP Translation Algorithm

RFC 6219 - The China Education and Research Network (CERNET) IVI Translation Design

draft-anderson-siit-dc-00 - Stateless IP/ICMP Translation in IPv6 Data Centre Environments

http://toreanderson.no - My personal home page (contact info, social media links, slides from this and earlier talks)

http://redpill-linpro.com - My employer and sponsor of this project

Note: IPv4 traffic to both of the above URLs is routed through a SIIT gateway (eating my own dog food)