The multiple roles that IPv6 can play

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How IP addresses are used today

- In IPv4, one address usually identifies a network interface
  - The limited address space constrains us to go further
- IPv6 brings many more address **and possibilities**
- We propose to go beyond the “one IP” - “one interface” paradigm
- **Multipath transport protocols** are key to enable some of these possibilities

The multiple roles that IPv6 addresses can play in today's Internet – *Maxime Piraux , Tom Barbette , Nicolas Rybowski , Louis Navarre , Thomas Alfroy , Cristel Pelsser , François Michel , Olivier Bonaventure* – ACM SIGCOMM CCR July 2022

What are those roles?

The multiple roles that IPv6 addresses can play in today's Internet
What the hell is this?

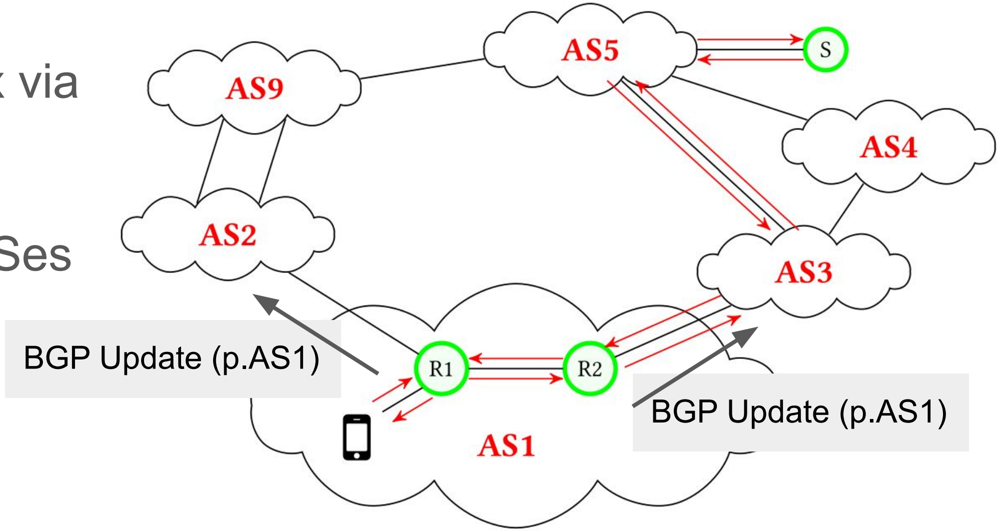
The multiple roles that IPv6 can play

The multiple roles that IPv6 can play

Multihoming
Privacy
Multicast
Load balancing
Segment routing
diff. services

Solving the multihoming problem

- In IPv4, a multihomed stub use BGP to announce its own prefix via their providers
- 63k of the 73k ASes are stub ASes
- **46%** of the BGP messages are coming from stub ASes
- Important burden on BGP



BGP Update (p.AS1)

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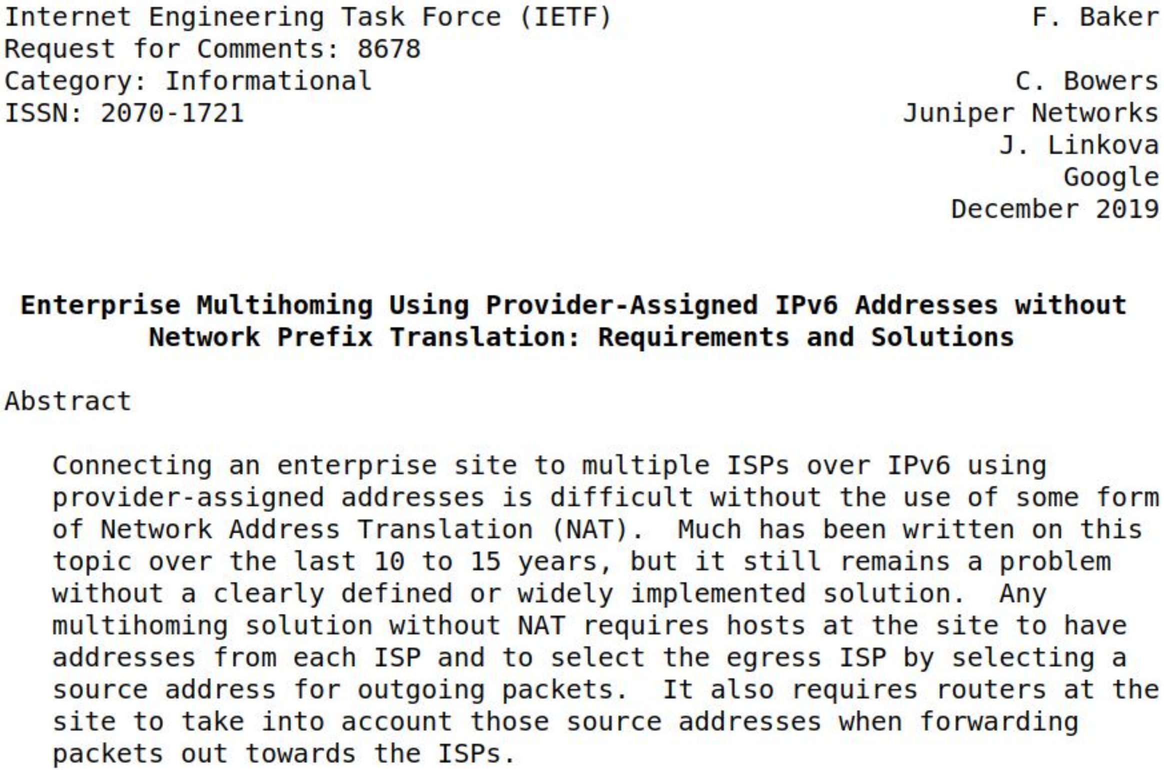
Solving the multihoming problem with IPv6



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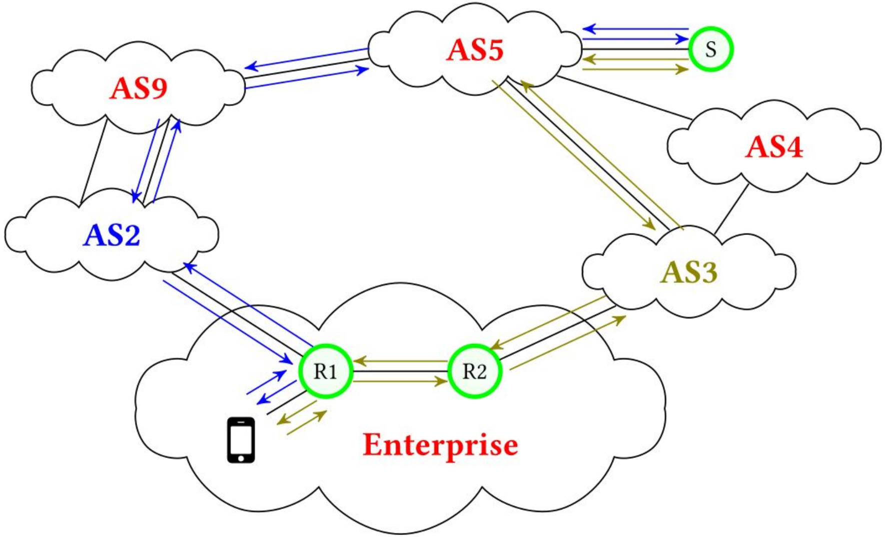
Enterprise Multihoming Using Provider-Assigned IPv6 Addresses without Network Prefix Translation: Requirements and Solutions

Abstract

Connecting an enterprise site to multiple ISPs over IPv6 using provider-assigned addresses is difficult without the use of some form of Network Address Translation (NAT). Much has been written on this topic over the last 10 to 15 years, but it still remains a problem without a clearly defined or widely implemented solution. Any multihoming solution without NAT requires hosts at the site to have addresses from each ISP and to select the egress ISP by selecting a source address for outgoing packets. It also requires routers at the site to take into account those source addresses when forwarding packets out towards the ISPs.

Solving the multihoming problem with IPv6

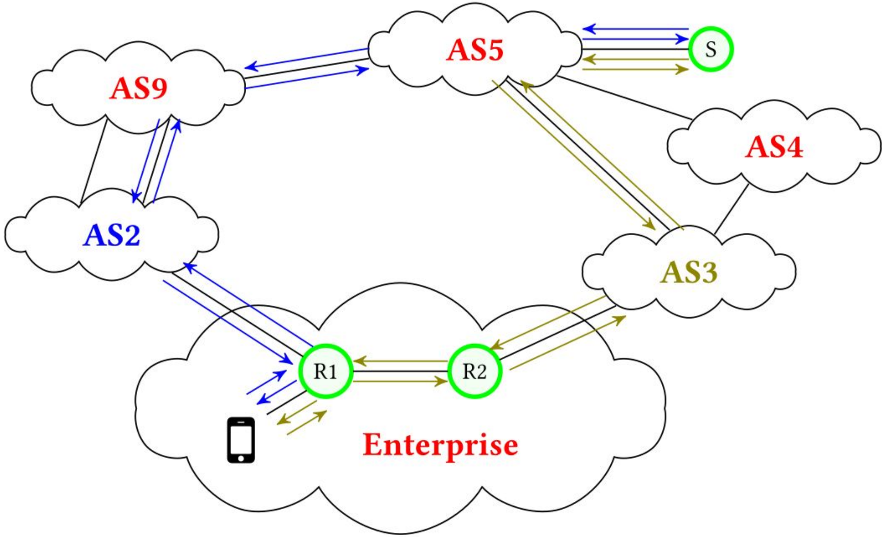
- In IPv6, the stub receives one Provider-Aggregatable prefix from each provider
- Each device receives one IP from each prefix
- **No BGP** is needed
- The device can choose which address to use



Solving the multihoming problem with IPv6

With **Multipath transport protocols**, devices can:

- Quickly react to a provider failure
- Dynamically choose the best provider
- Use both providers at the same time
  - Redundantly
  - Aggregated

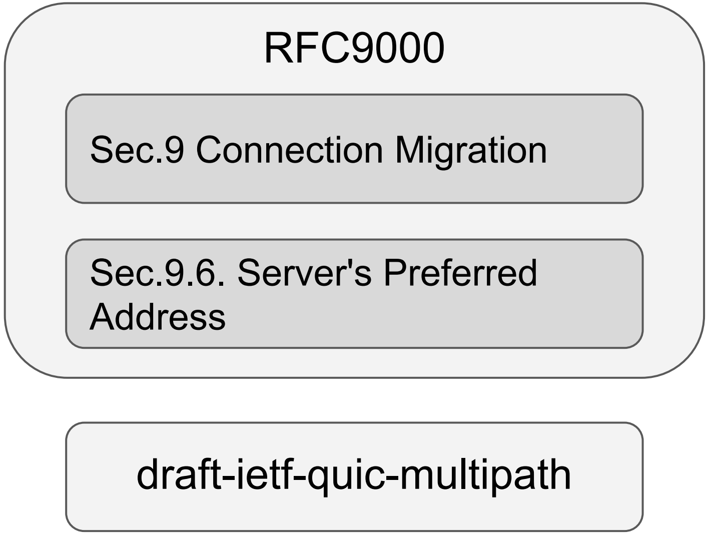


Status of multipath transport protocols

- SCTP – draft-tuexen-tsvwg-sctp-multipath
  - Still ongoing
  - Used in WebRTC
- MPTCP – RFC 8684
  - In mainline Linux 5.6+
  - In Apple devices
- QUIC – RFC 9000
  - Limited to one active path at a time
  - Large-scale deployments
- MPQUIC – draft-ietf-quic-multipath
  - Ongoing effort of the QUIC wg
  - Enables the use of several network paths

Making QUIC support multihomed servers

- QUIC enables clients to change local addresses at any time
- Servers can defer clients to another address right after the handshake
- Multipath QUIC enables the simultaneous use of several network path
- **QUIC v1 lacks a way for server to advertise additional addresses**



RFC9000

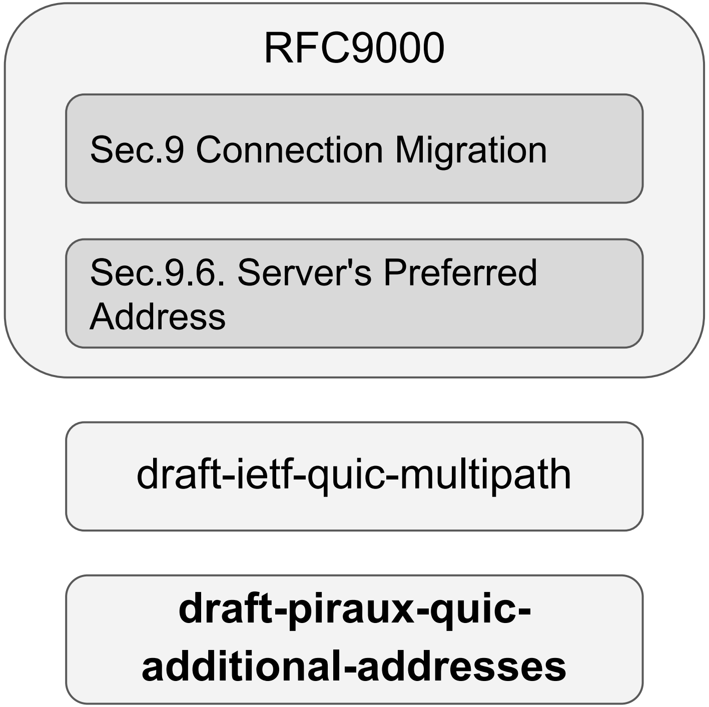
Sec.9 Connection Migration

Sec.9.6. Server's Preferred Address

draft-ietf-quic-multipath

Making QUIC support multihomed servers

- QUIC enables clients to change local addresses at any time
- Servers can defer clients to another address right after the handshake
- Multipath QUIC enables the simultaneous use of several network path
- **We proposed a way to announce additional addresses in QUIC v1**



RFC9000

Sec.9 Connection Migration

Sec.9.6. Server's Preferred Address

draft-ietf-quic-multipath

draft-piraux-quic-additional-addresses

The multiple roles that IPv6 can play

Multihoming
Privacy
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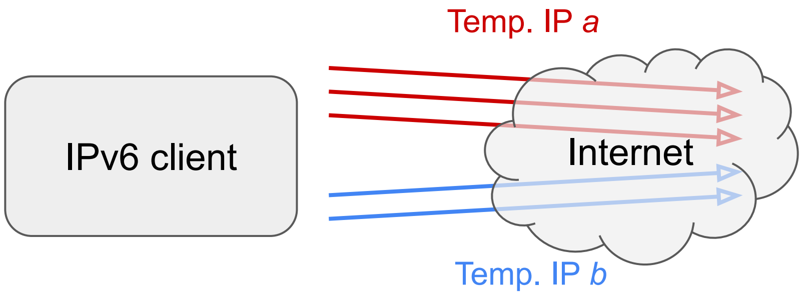
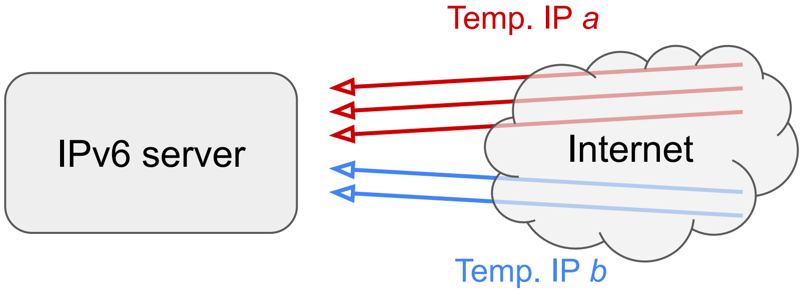
Privacy of IPv6 clients

- RFC8981 define temporary addresses with a limited lifetime
- For example, when IP *a* expires, new flows are established with IP *b*
- IP *a* will remain as long as flows use it
- **Multipath transport protocols** can migrate the flows to the new address



Privacy of IPv6 servers

- IPv6 servers can adopt a “moving target” defense against scanners by hopping from one IP to another within a prefix.
- Chhoyhopper cryptographically derive IP addresses within an assigned prefix.
- Chhoyhopper uses a NAT to maintain flows
- **Multipath transport protocols** can migrate the flows to the new address without a NAT

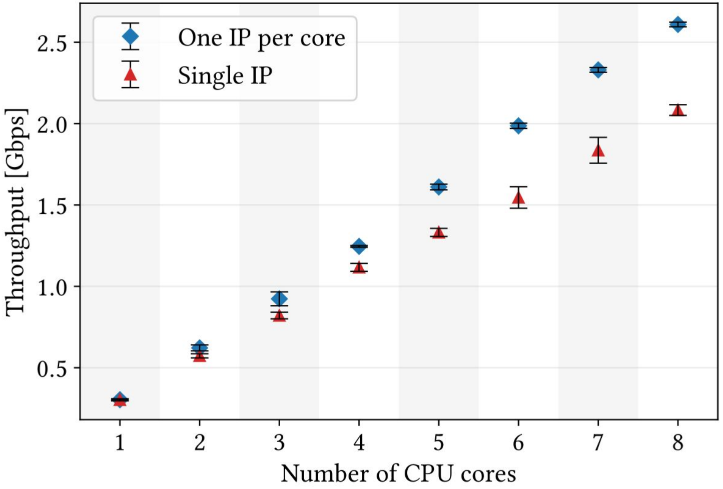


Shared Key + Timestamp *x* + Salt = IP x

Chhoyhopper: A Moving Target Defense with IPv6 – ASM Rizvi and John Heidemann

Improve the load balancing of multi-core servers with IPv6

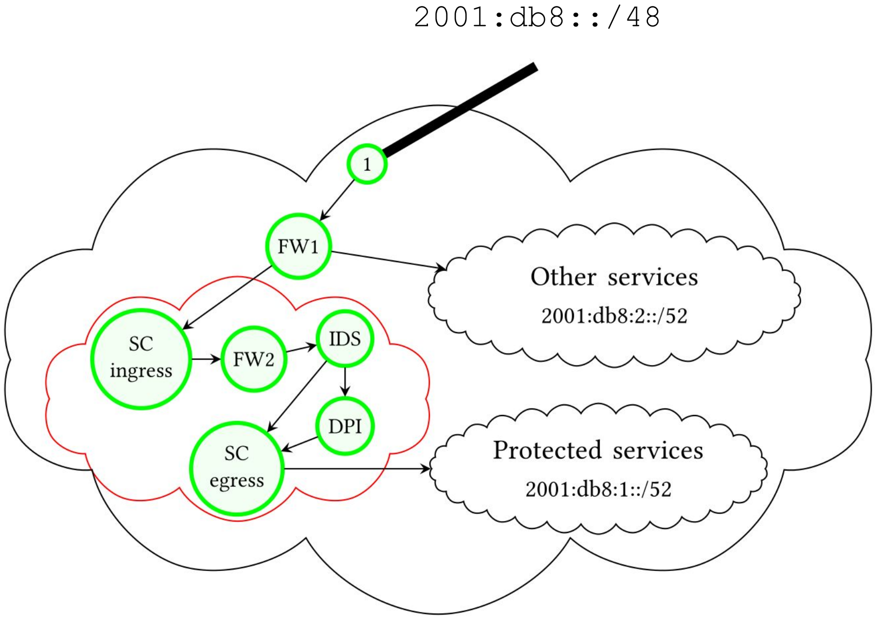
- Assigning one IP per CPU core helps balancing the load in a server
- **Single IP:** The NIC decides the spread of packets between cores based on a hash
- **One IP per core:** The clients uses the DNS to select one of the server IP, each IP is mapped to a core on the NIC
- **Multipath transport protocols** can help sharing the load over CPU cores as well



QUIC throughput with 128 clients making repeated requests

Segment Routing and Service Chains with IPv6

- Services can be partitioned using **IPv6 subprefixes**
- Incoming traffic can be routed through a Service Chain based on the destination prefix
- For instance through a chain with additionals firewall, IDS and DPI protections
- Using IPv6 subprefixes enables control on the incoming traffic



Conclusion

- IPv6 enables us to reconsider the use of IP addresses on hosts and in then network
- There is much more to do than assigning one IP to each network interface
- Multipath transport protocols are a key enabler of this evolution
- Reach to us if your interested on developing use-cases with multipath and several IPv6 addresses
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- Any thoughts in this direction?