Reasons Dynamic Addresses Change

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Can IP addresses be end-host identifiers?

How long can dynamic IP addresses be end-host identifiers?

Dynamic IP

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Home Router

Dynamic IP

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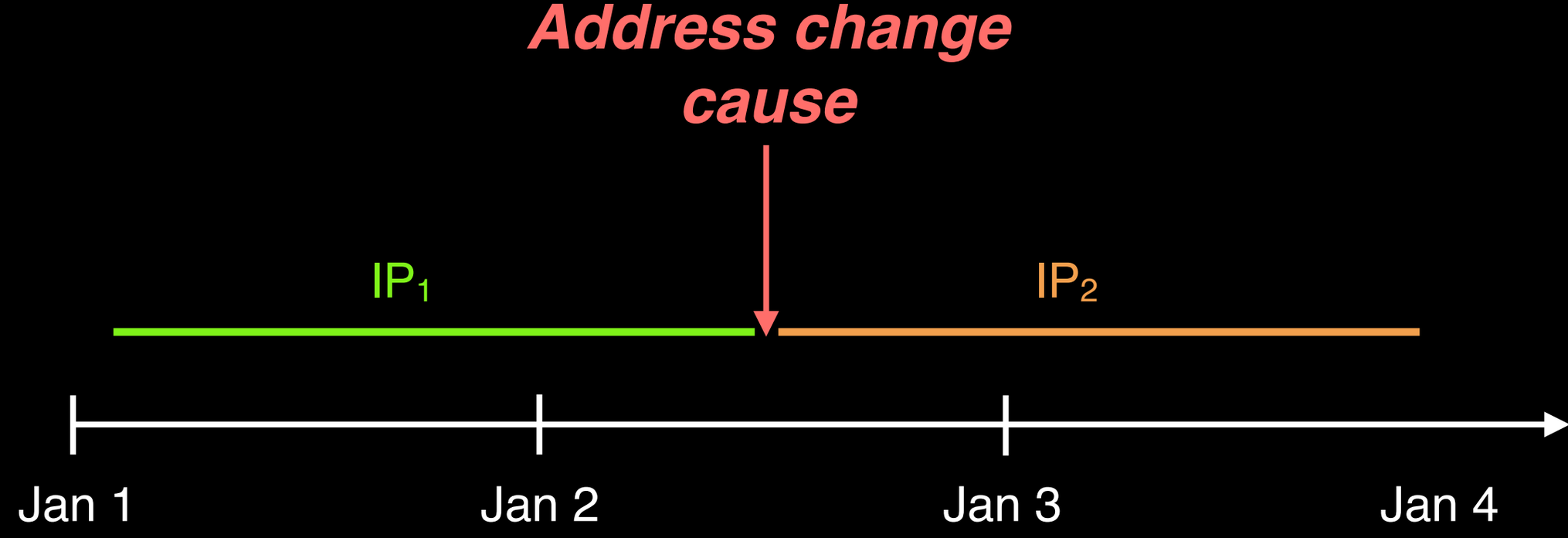
Home Router

Dynamic IP



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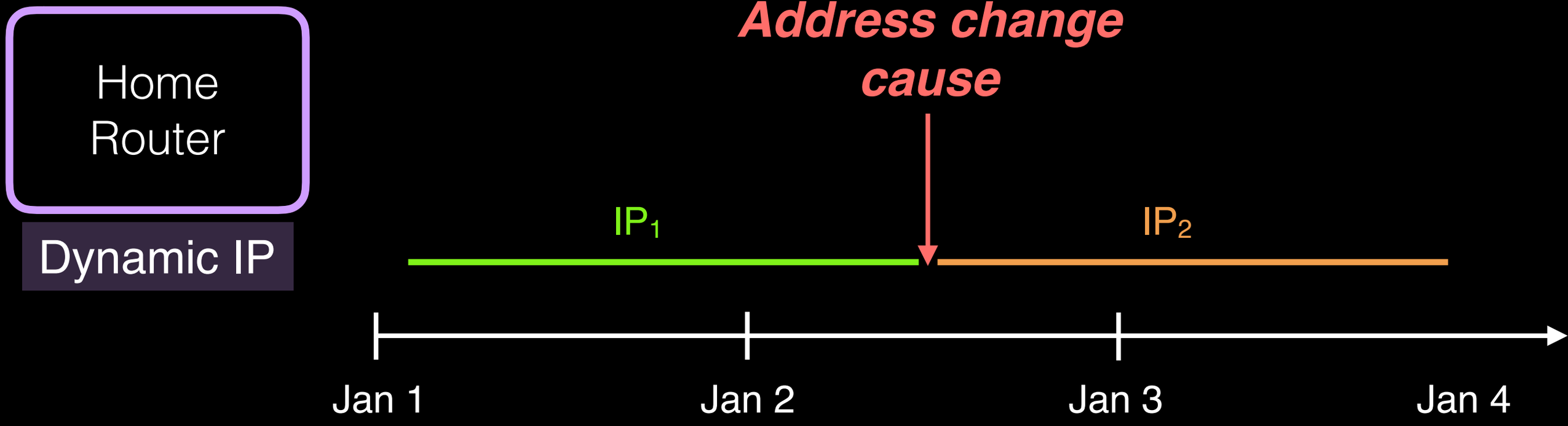

Find causes of address changes

Find causes of address changes: DHCP

Home Router

Dynamic IP

DHCP tries to reassign same address

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DHCP Server

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Dynamic IP

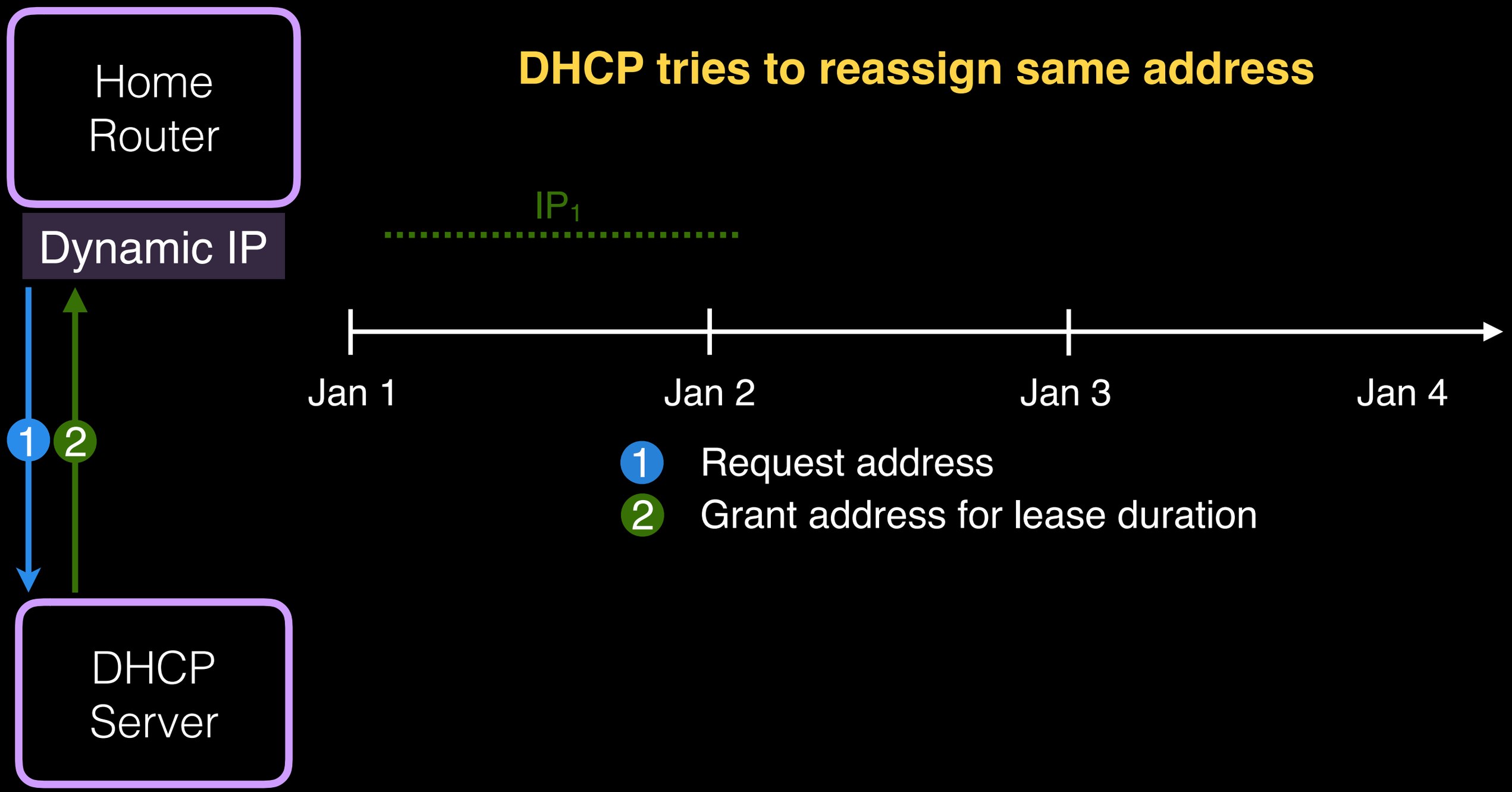
1

DHCP Server

DHCP tries to reassign same address

1 Request address

Find causes of address changes: DHCP



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DHCP Server

DHCP tries to reassign same address

1. Request address
2. Grant address for lease duration

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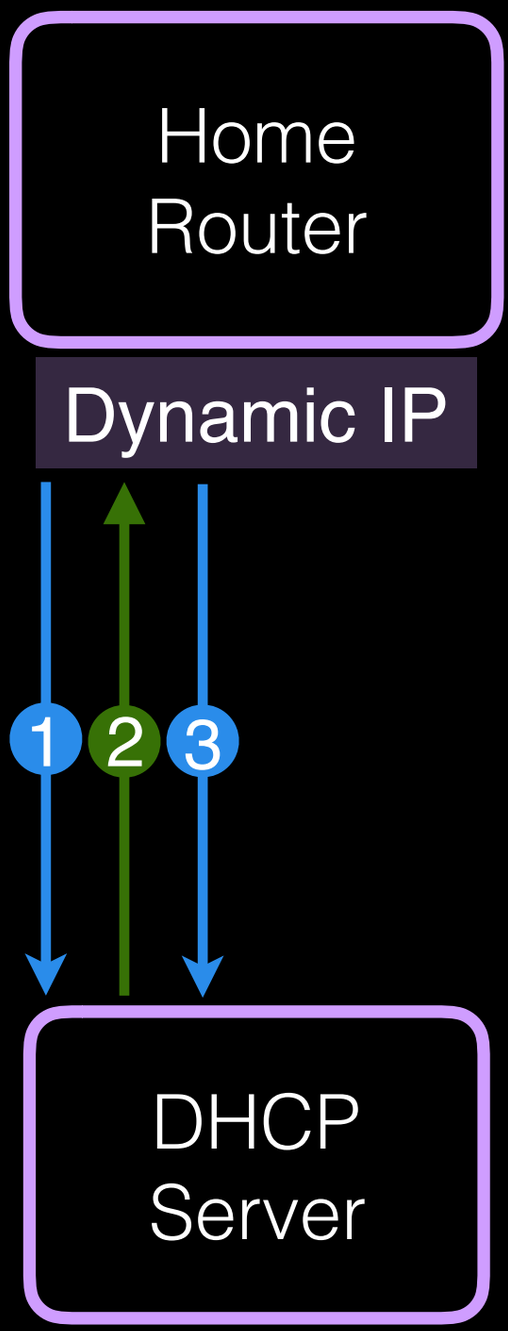

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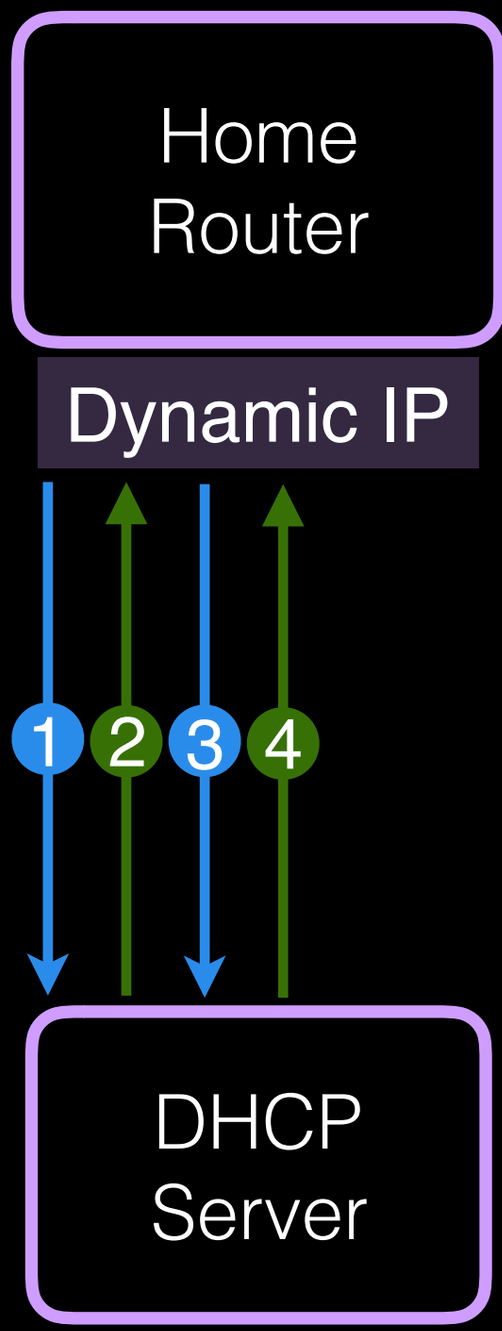

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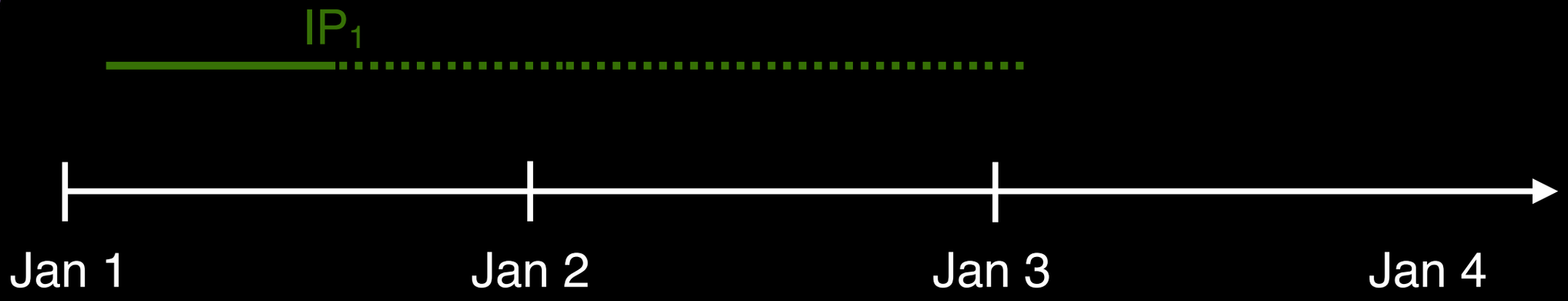

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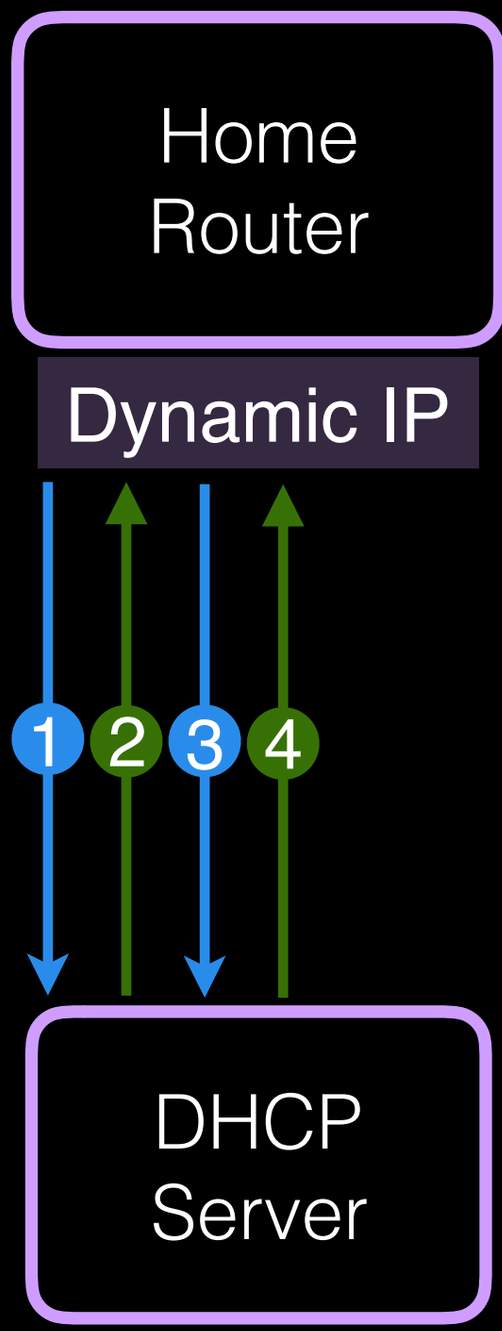

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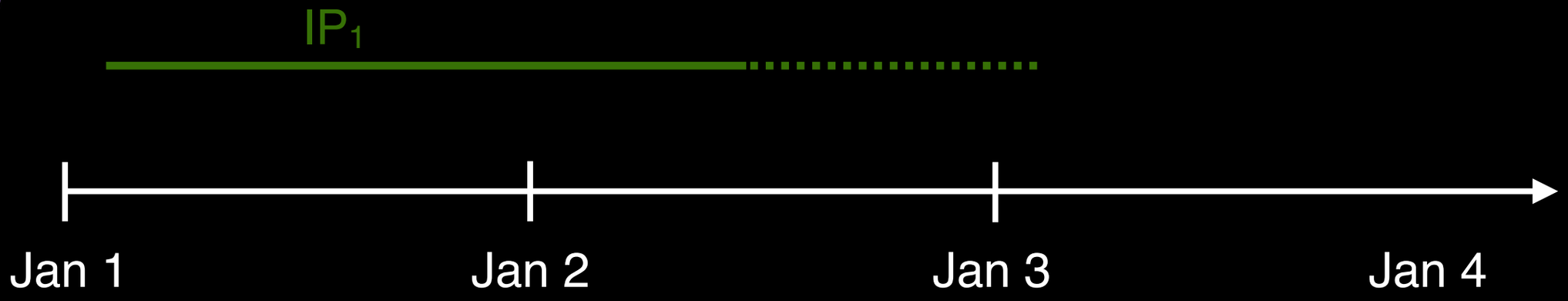

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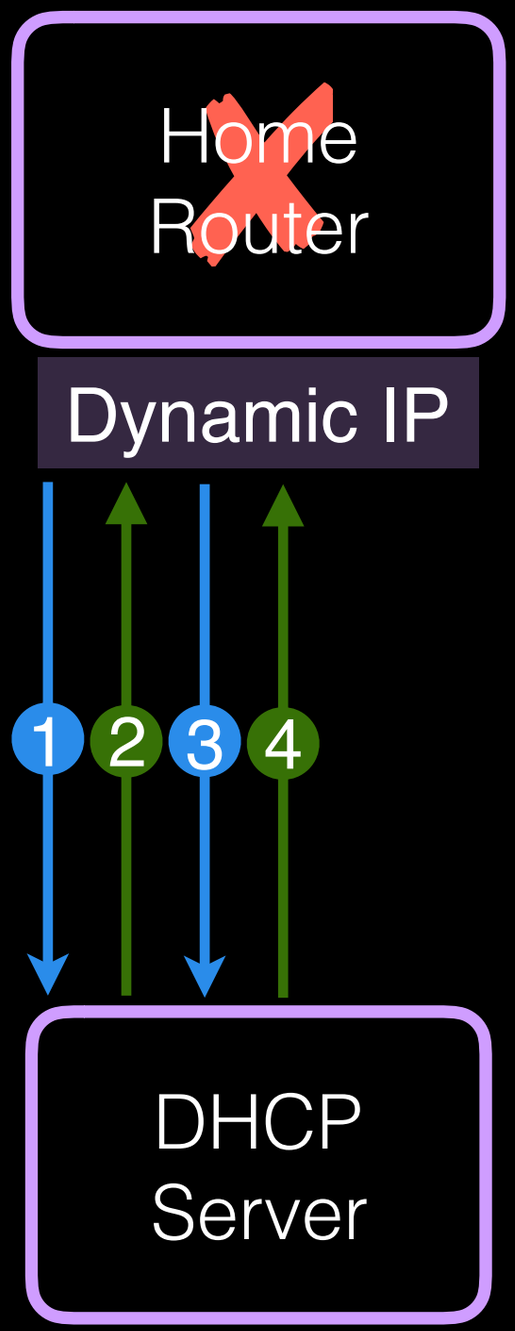

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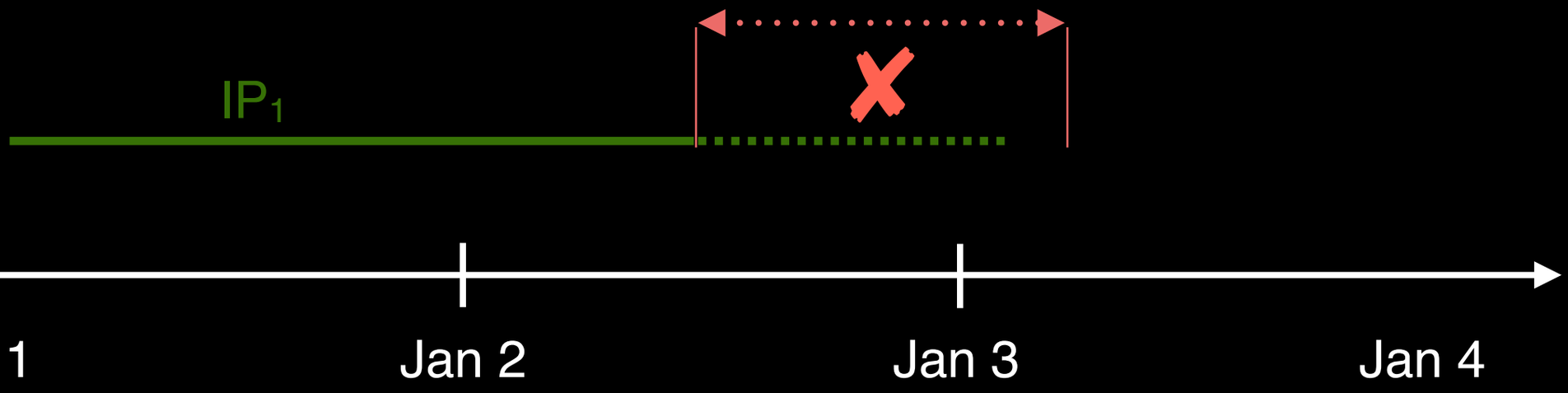

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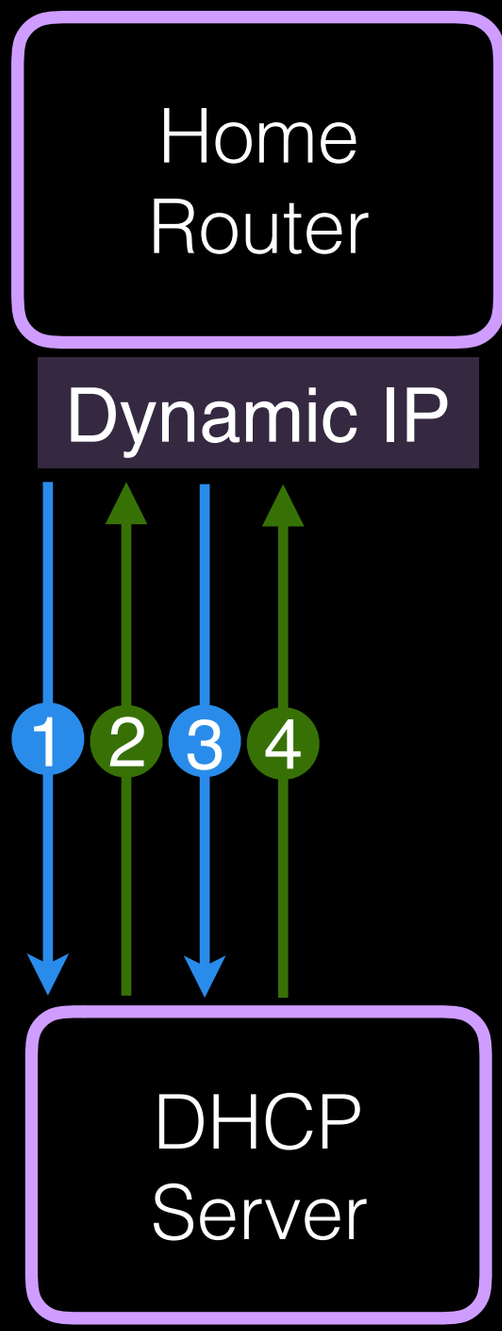

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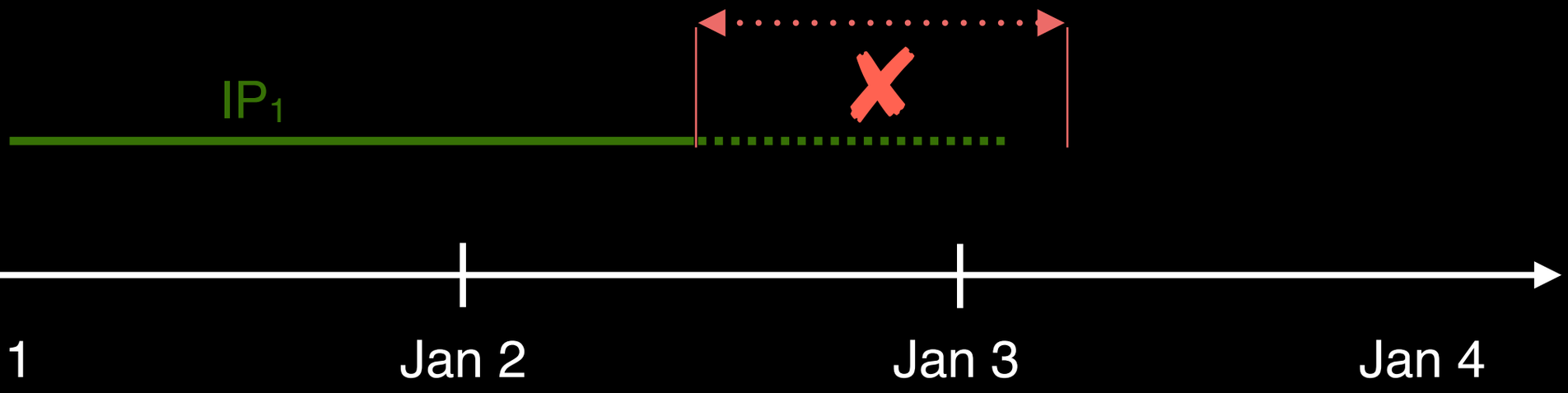

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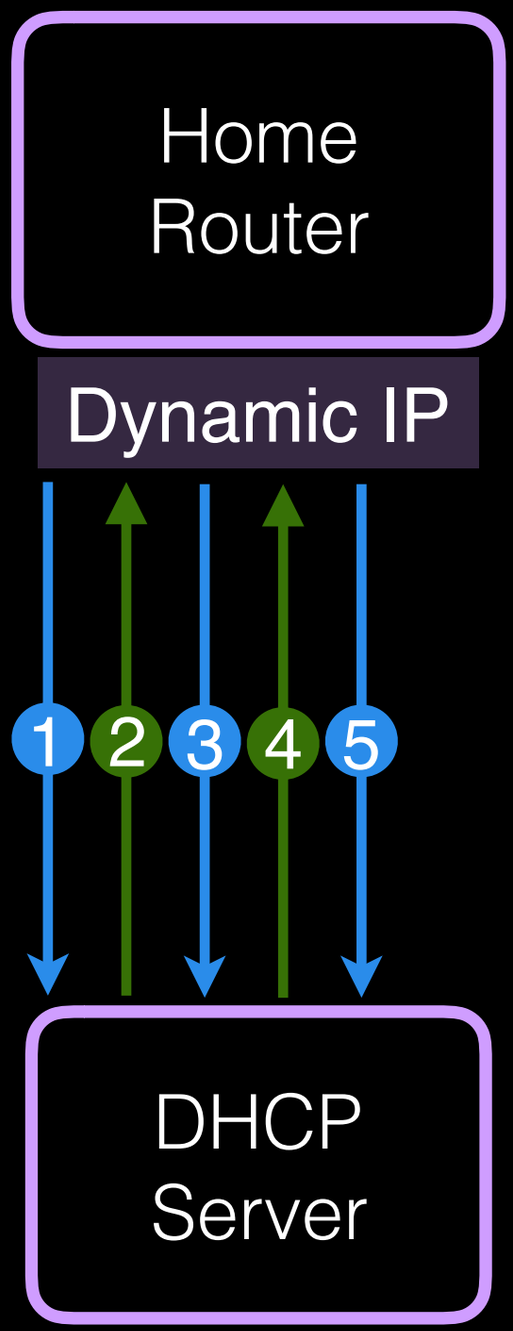

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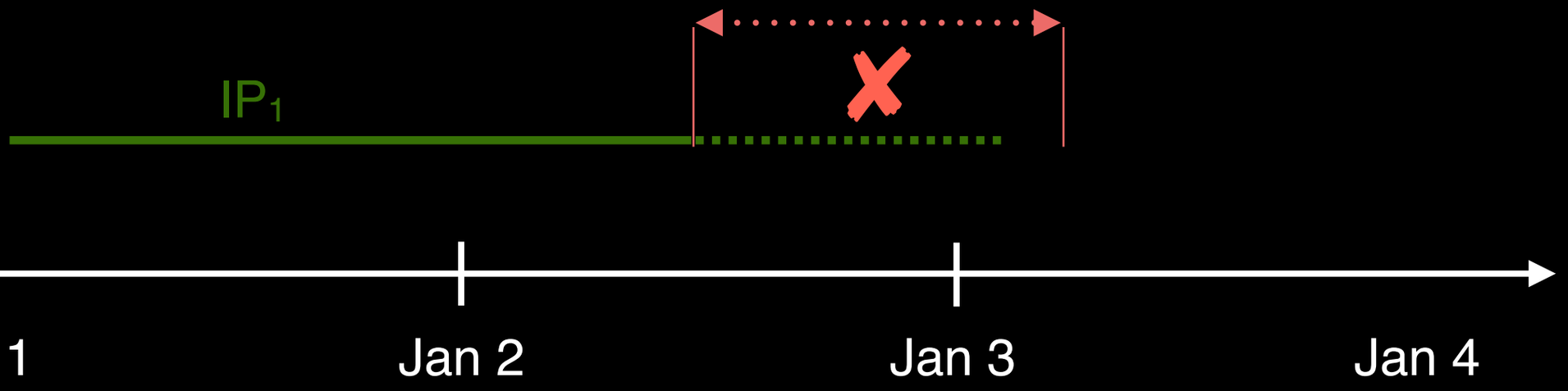

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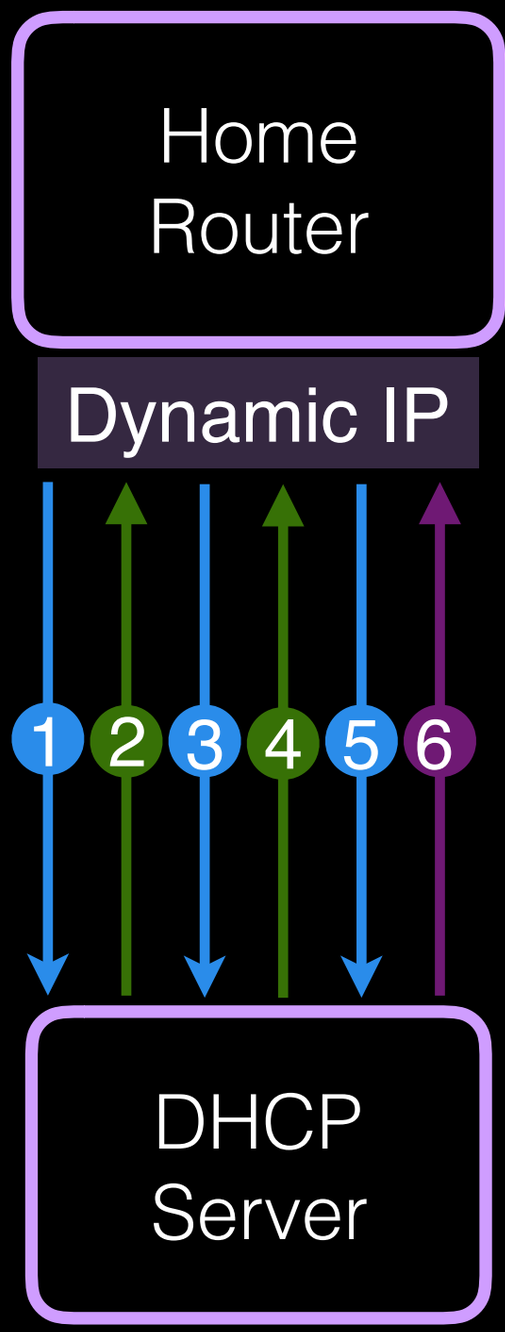

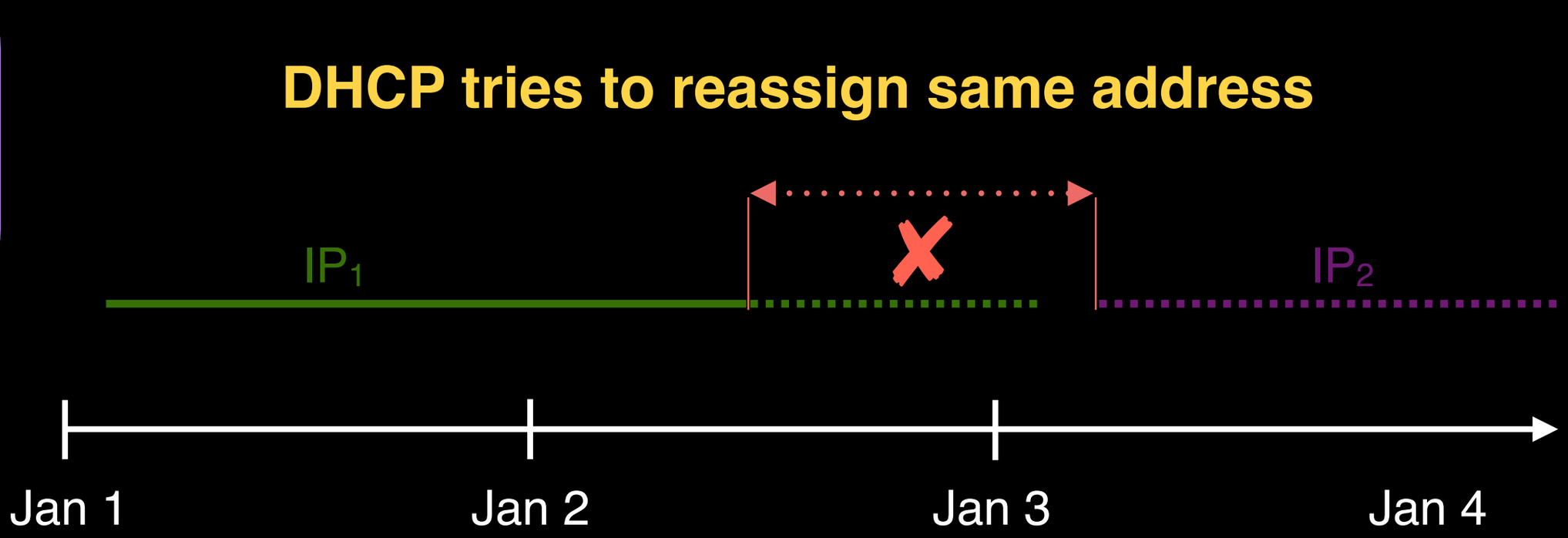

1. Request address
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Find causes of address changes

Periodic

Renumbering after a specific duration

Home router outage

Renumbering upon outage event at home router

Find causes of address changes

Multiple home routers in an ISP

Periodic	Renumbering after a specific duration
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Find causes of address changes

Multiple home routers in an ISP

Periodic

Renumbering after a specific duration

Events occurring on home routers

Home router outage

Renumbering upon outage event at home router

Find causes of address changes

Multiple home routers in an ISP

Events occurring on home routers

Data from RIPE Atlas

Periodic

Renumbering after a specific duration

Home router outage

Renumbering upon outage event at home router

RIPE Atlas

RIPE Atlas gives ‘probes’ to volunteers

Probes conduct measurements (pings, traceroutes, DNS)

https://atlas.ripe.net/docs/rest/

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Analyze **periodic**

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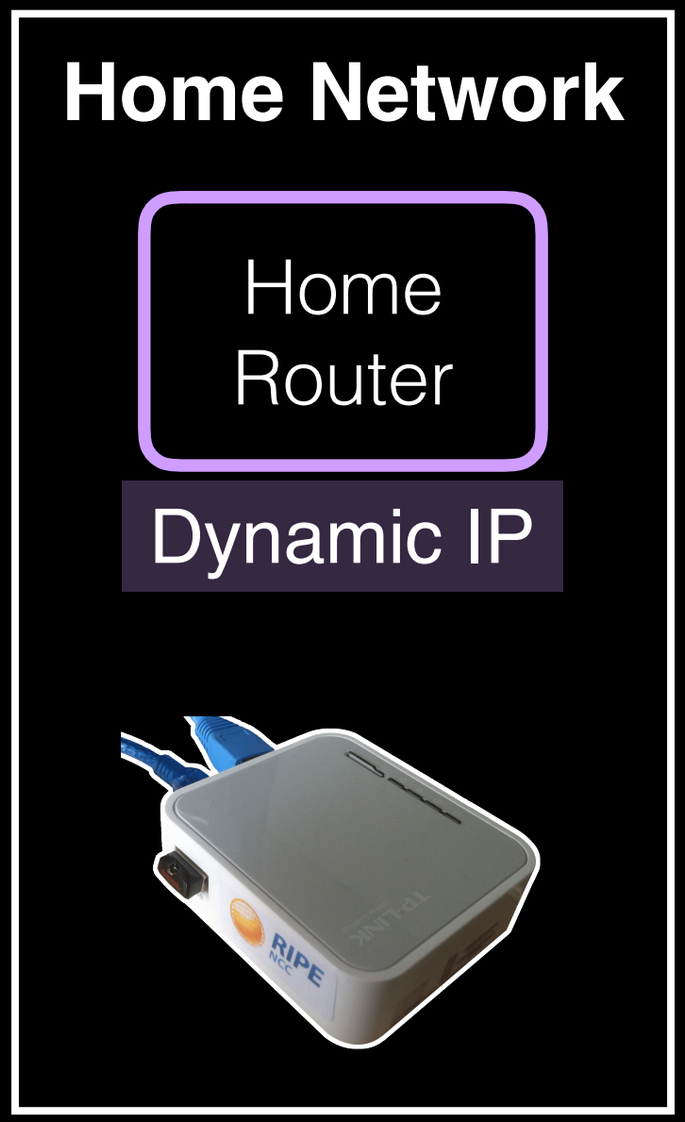
Finding address changes using connection logs



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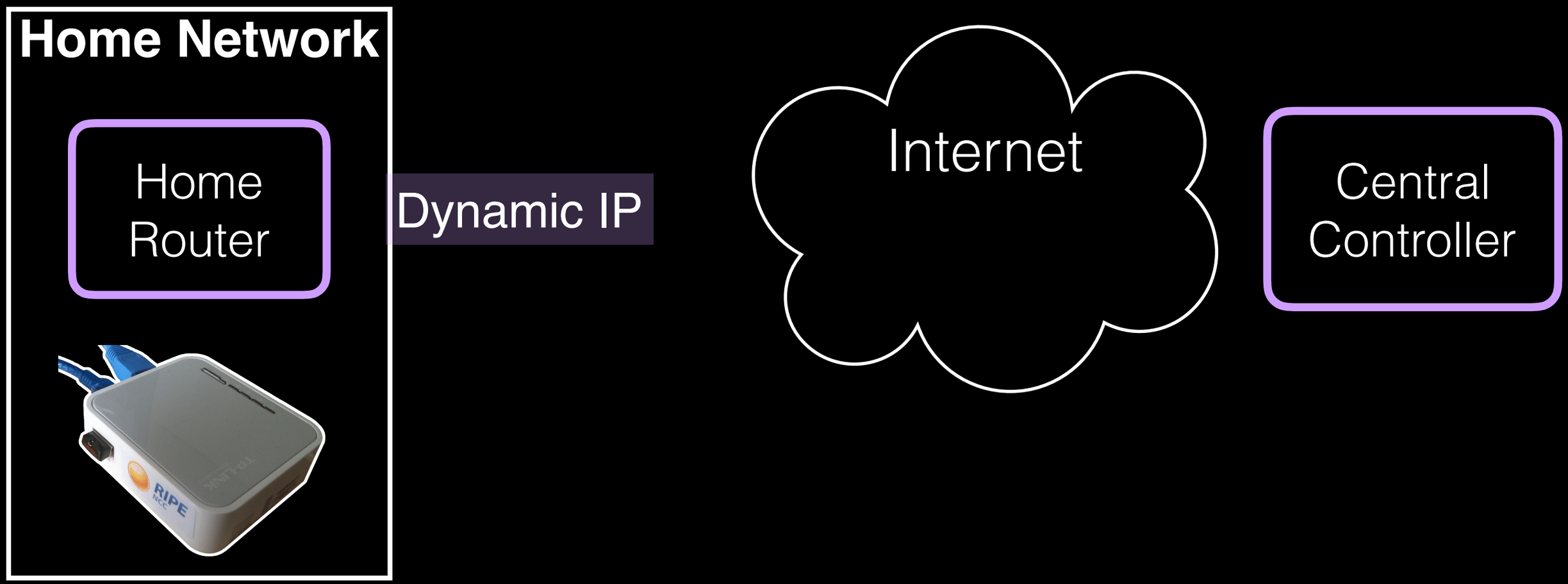
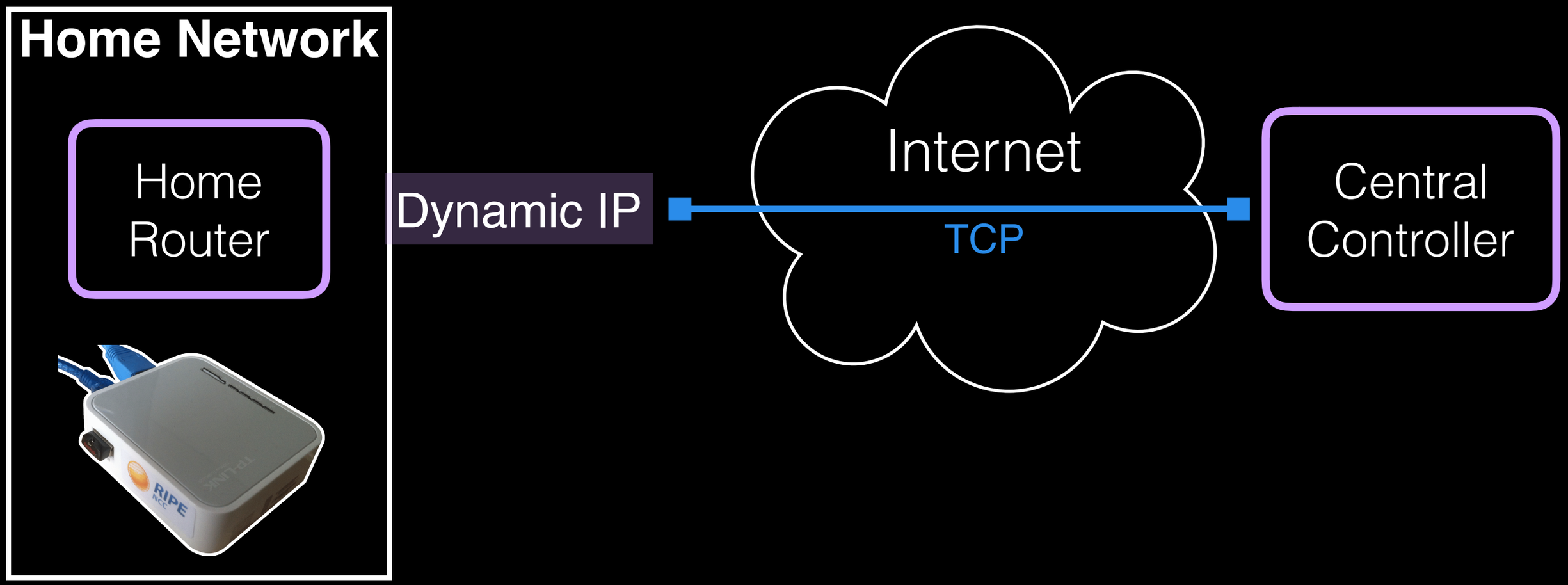


Probes report measurements to central controller over TCP

Controller records these TCP connections in connection logs

Finding address changes using connection logs



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Find address changes using probes' TCP connection logs

Central
Controller

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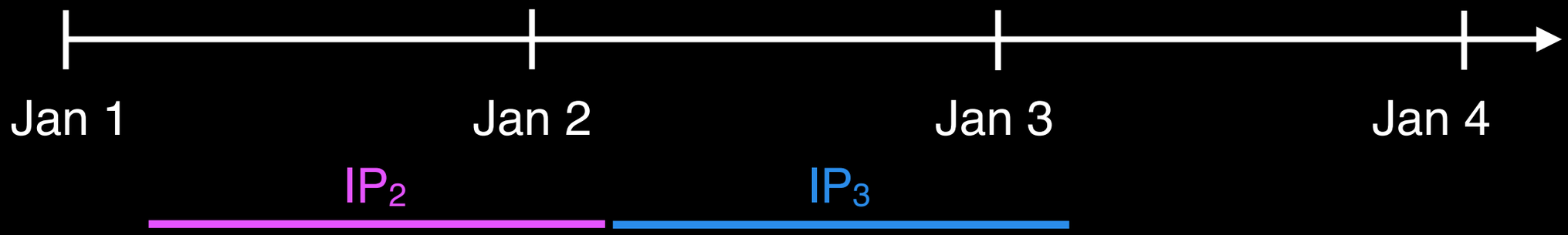

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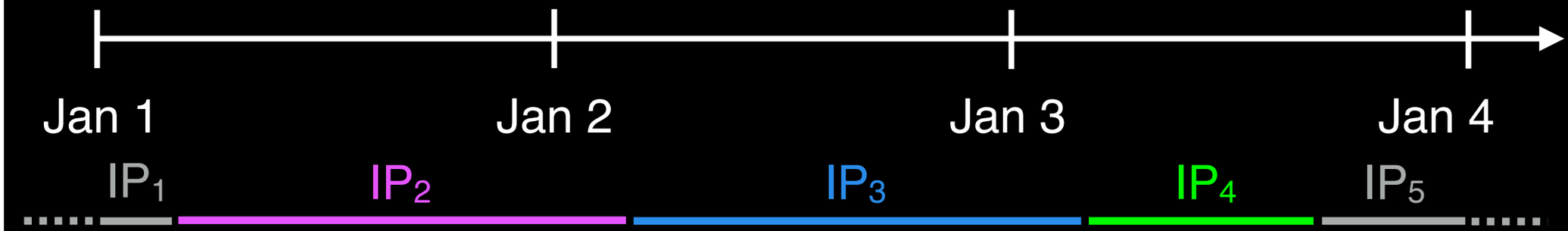

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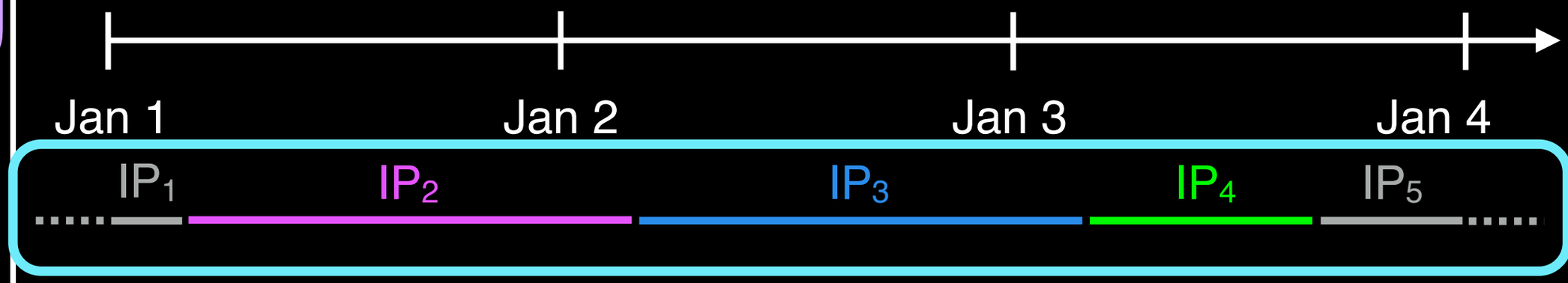

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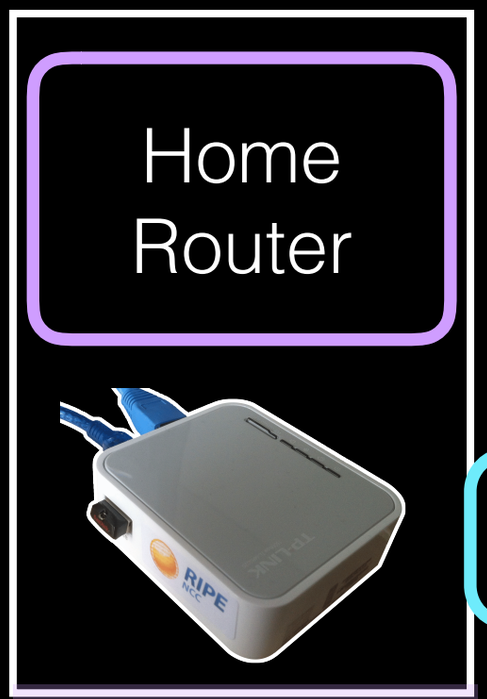
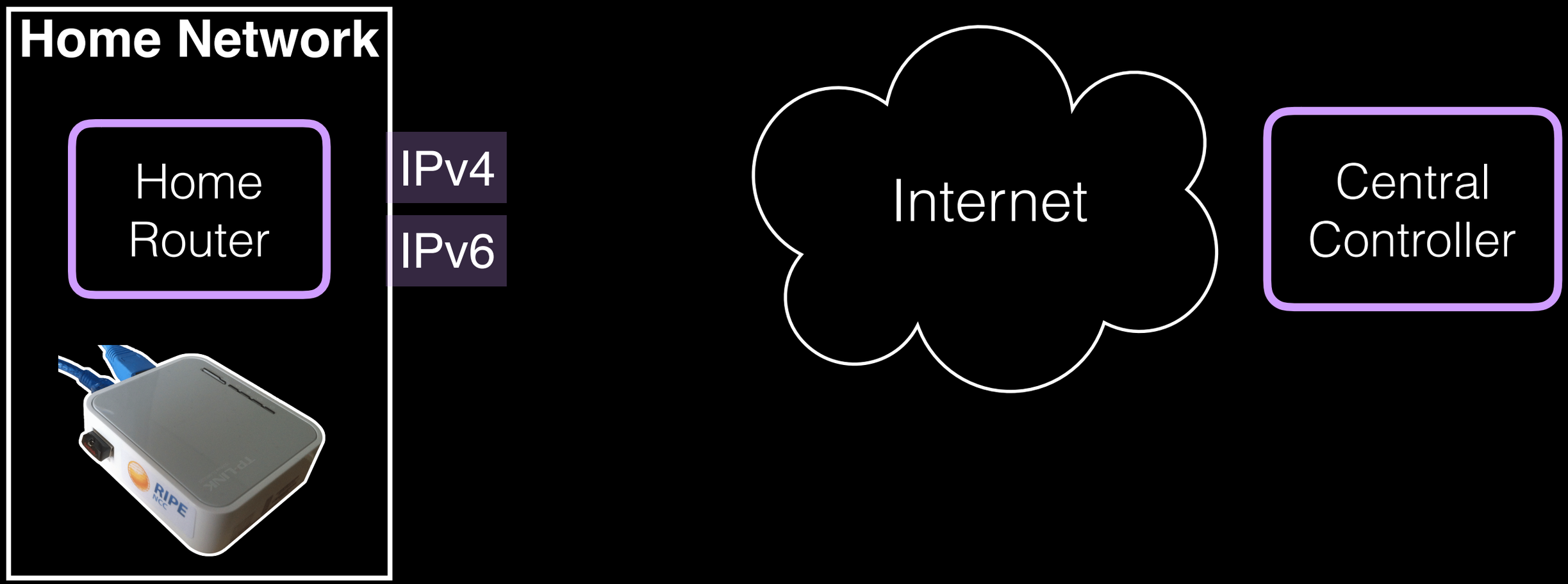


Connection logs cannot give address change info for dual-stack devices



Dual stack devices have more than one address

Connections can be made over either address

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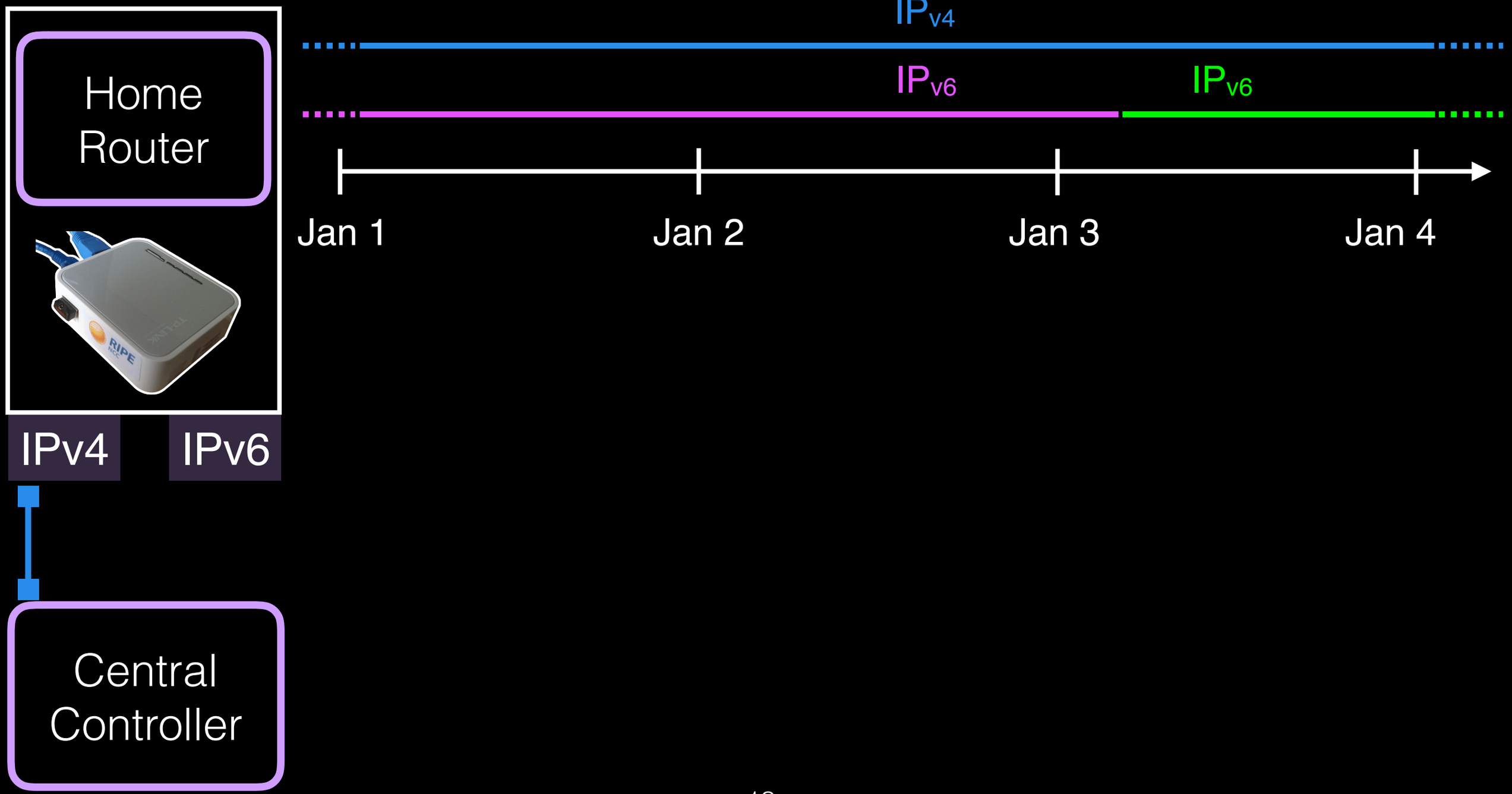

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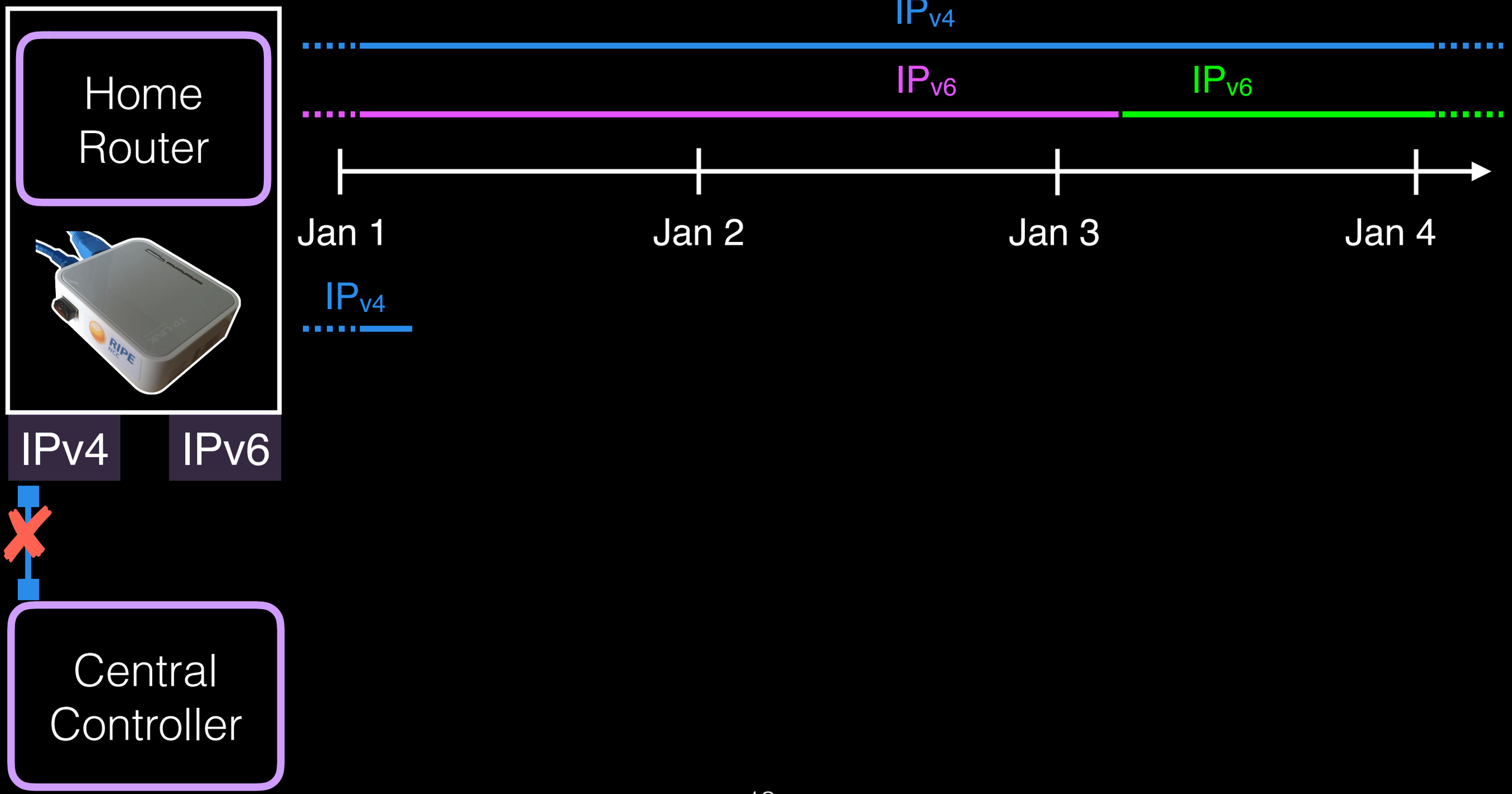

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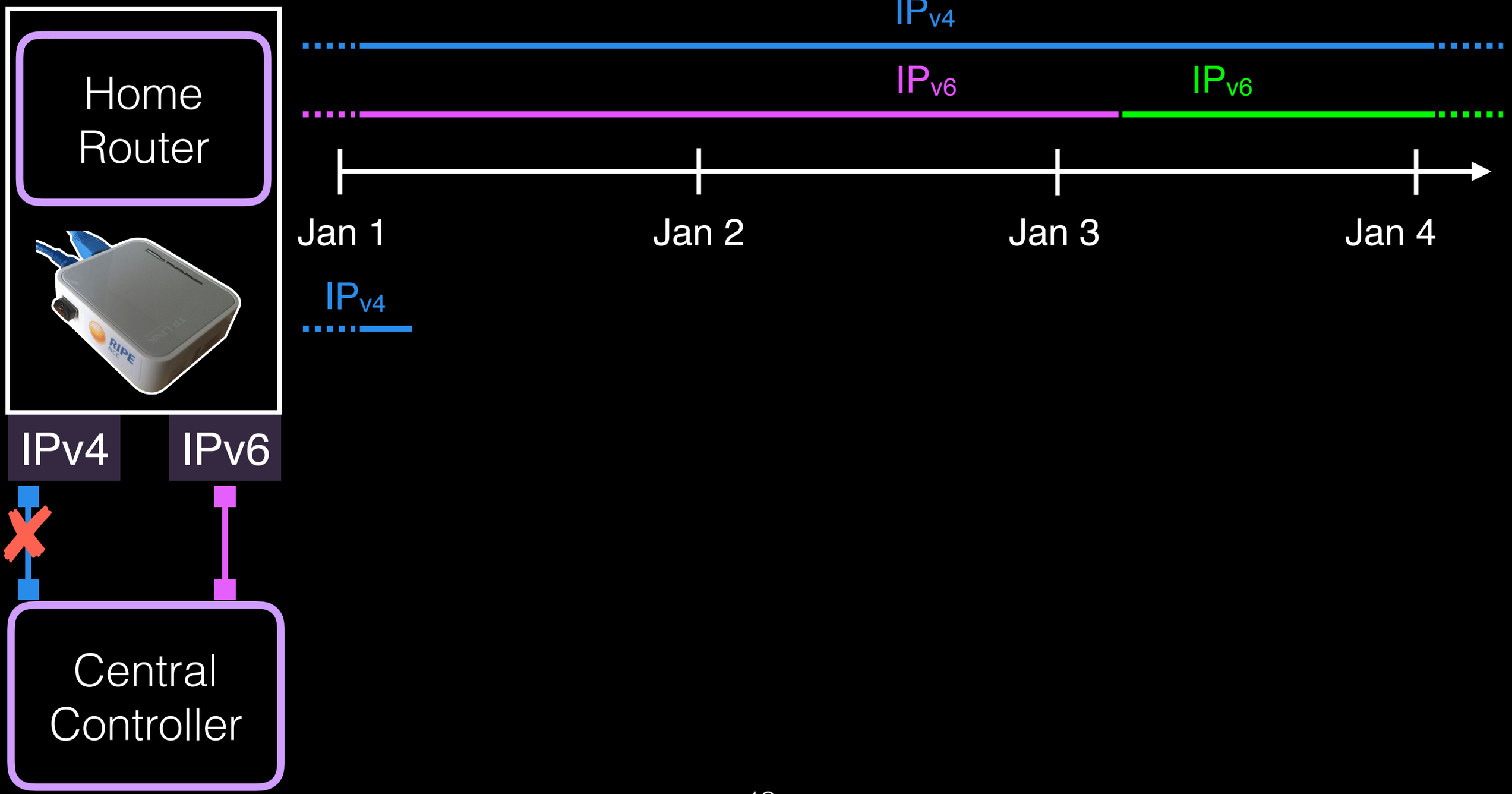

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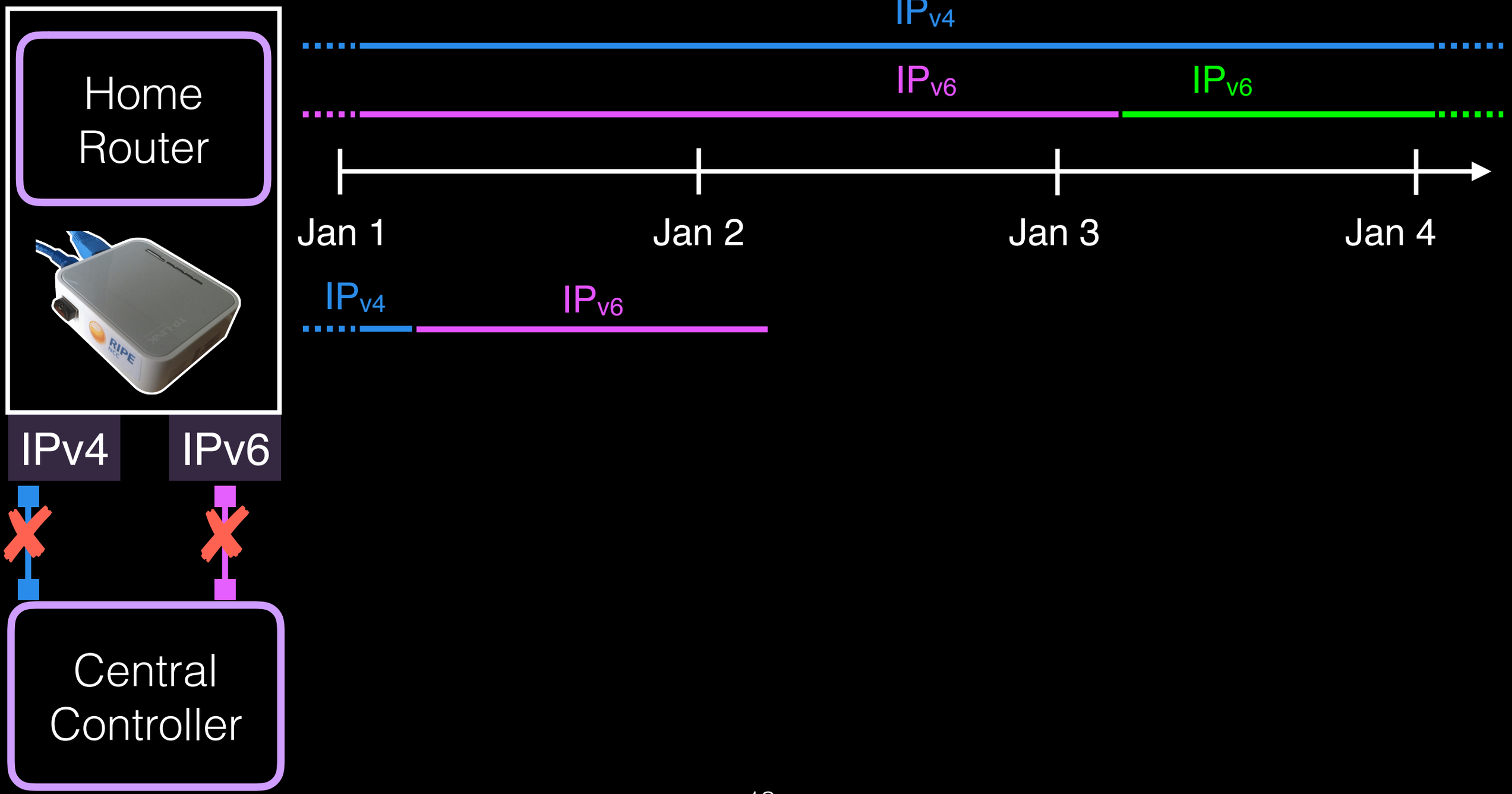

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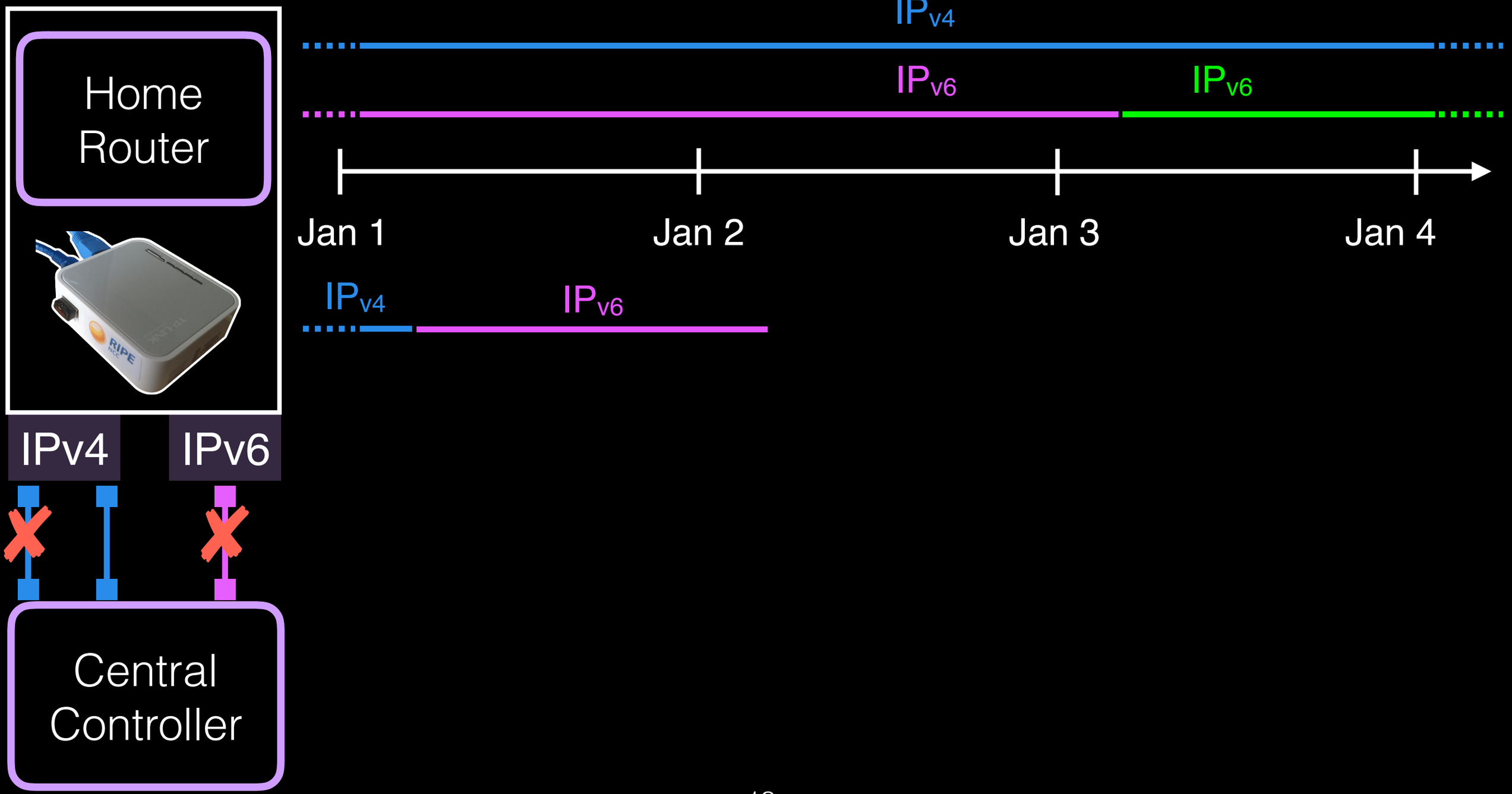

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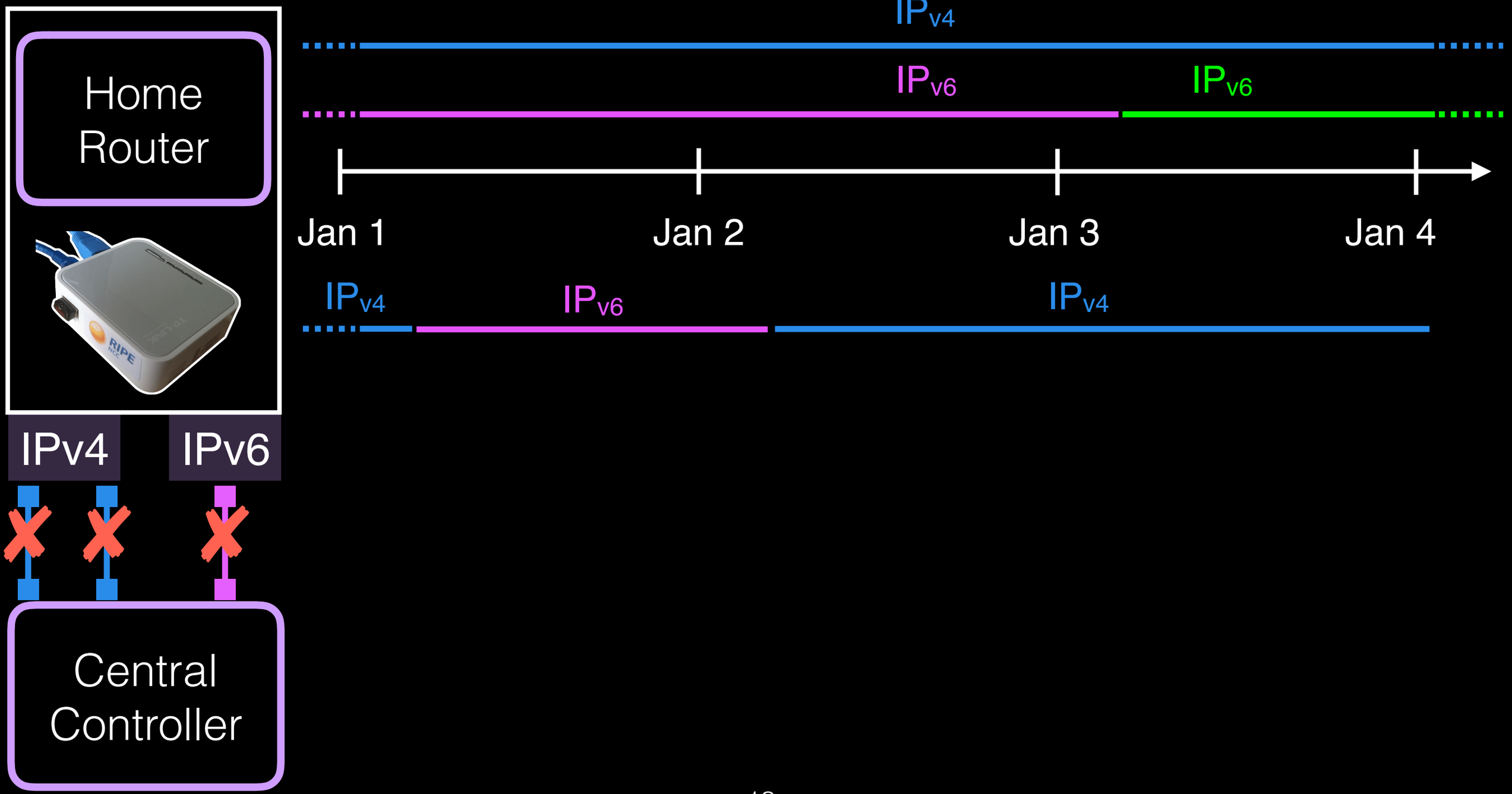

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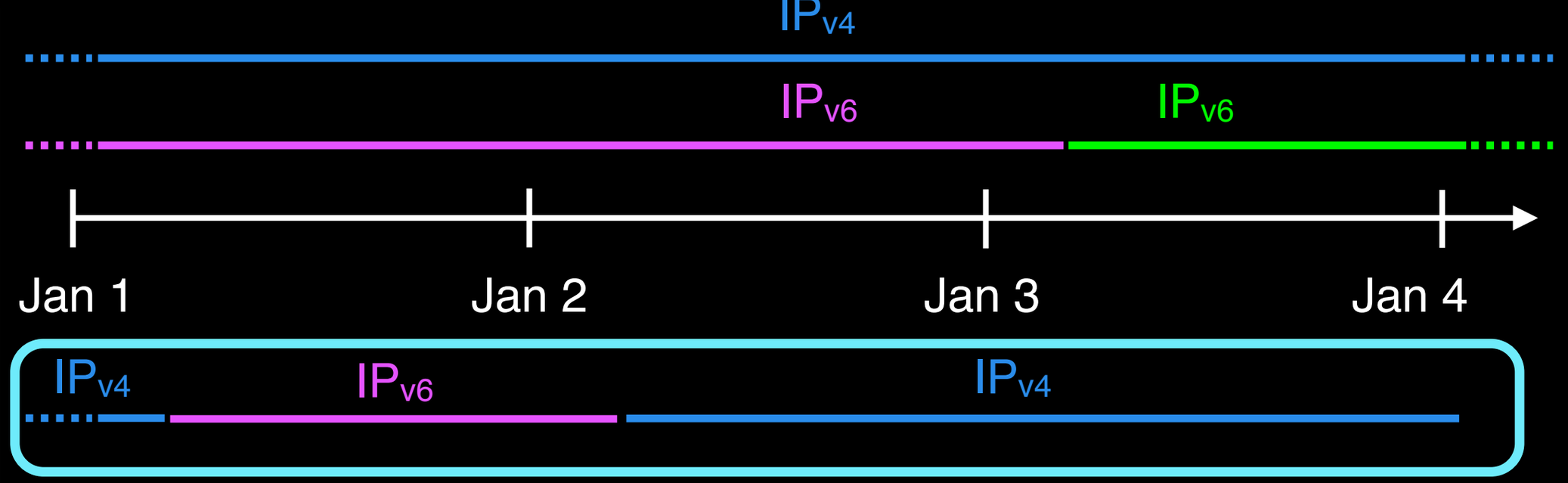

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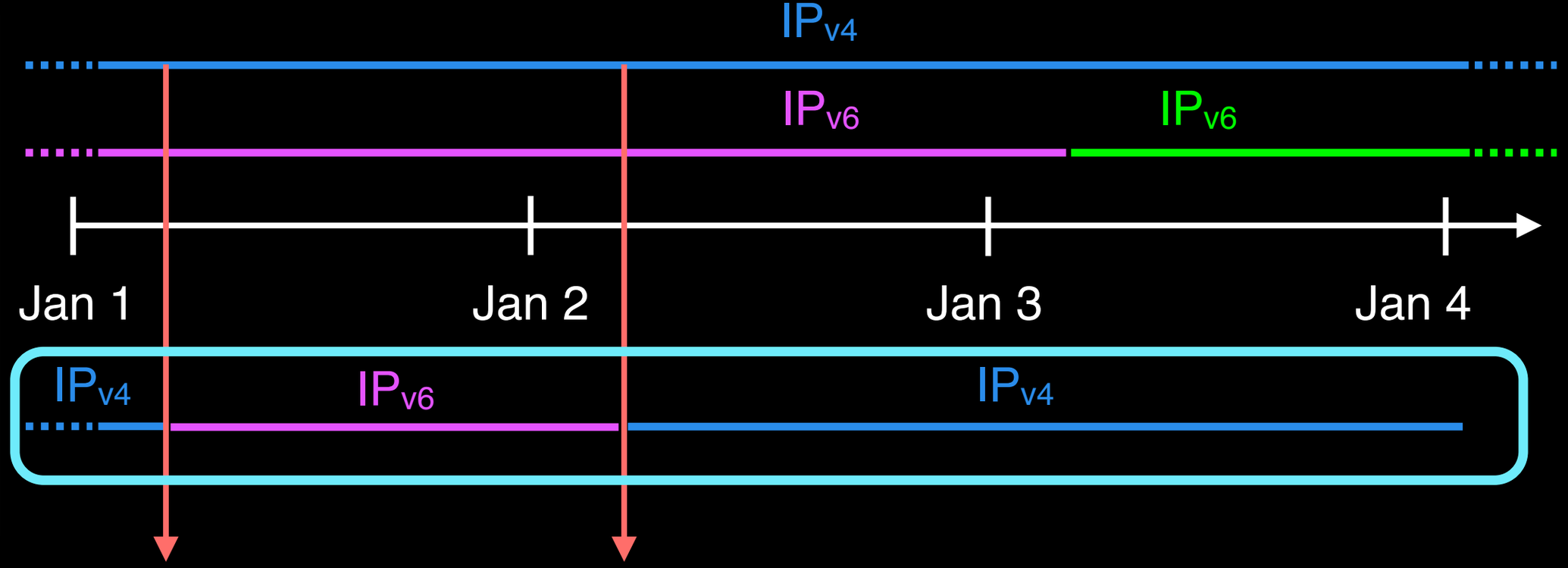

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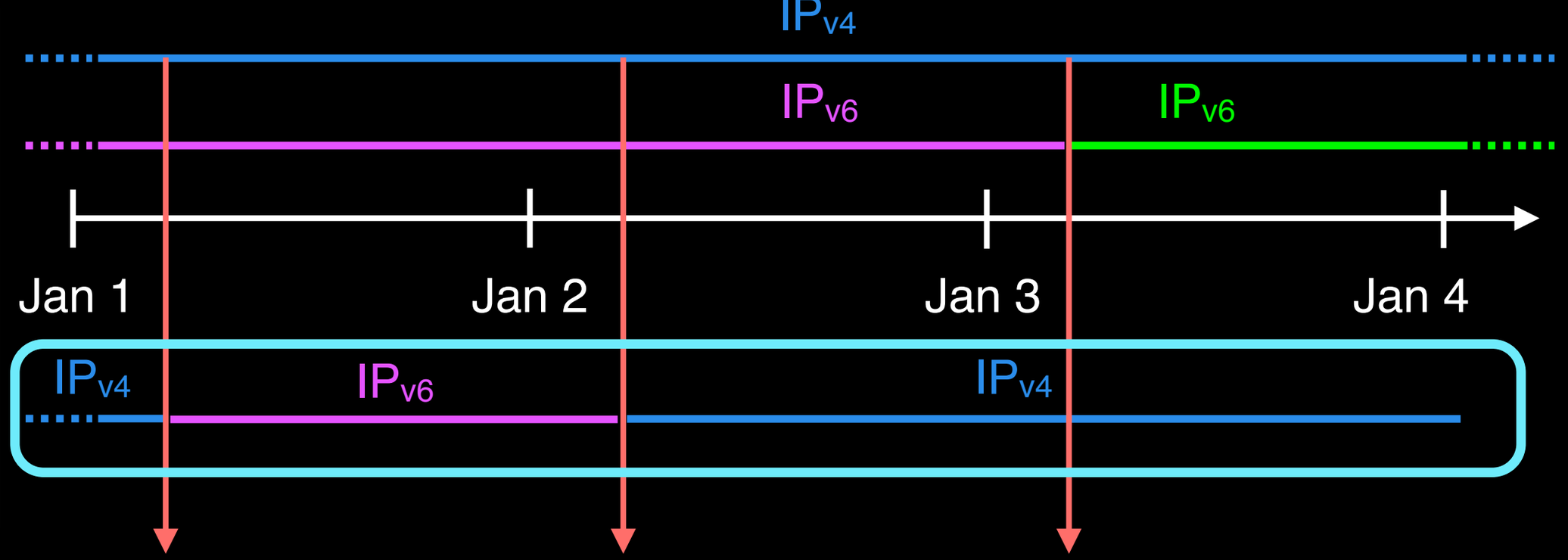

We analyzed connection logs through all of 2015 for all active probes

Category	Probes
Total	11K
Dual stack/ multihomed	5K
Never changed	3K
Changed	3K

Five ISPs with the most probes with address changes

AS	Name	Country	# Probes
AS3215	Orange	France	122
AS3320	Deutsche Telekom (DT)	Germany	63
AS2856	British Telecom (BT)	UK	67
AS6830	Liberty Global (LGI)	EU	92
AS701	Verizon	US	40

How long can dynamic IP addresses be end-host identifiers?

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Analyze **periodic**

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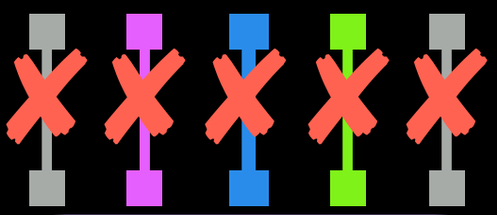
Dynamic IP



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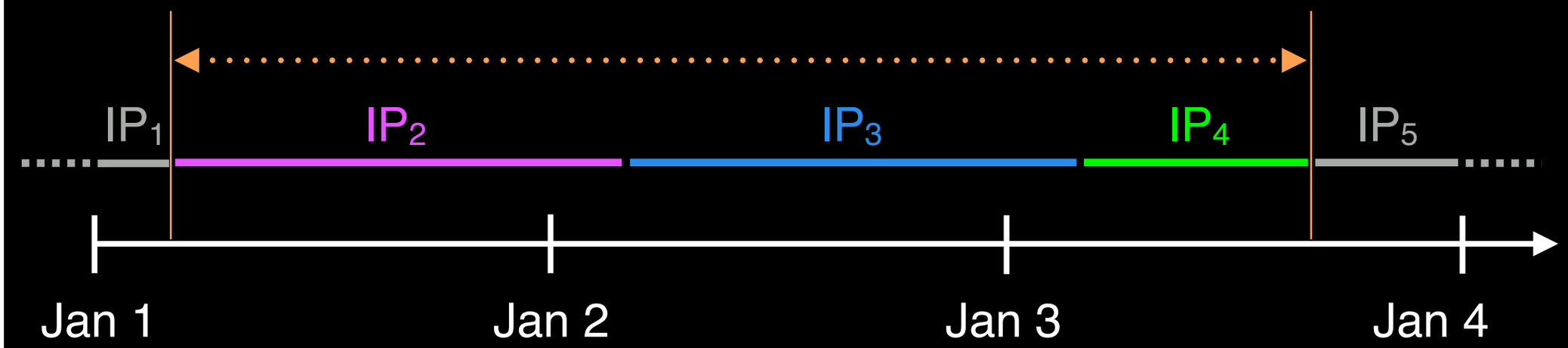
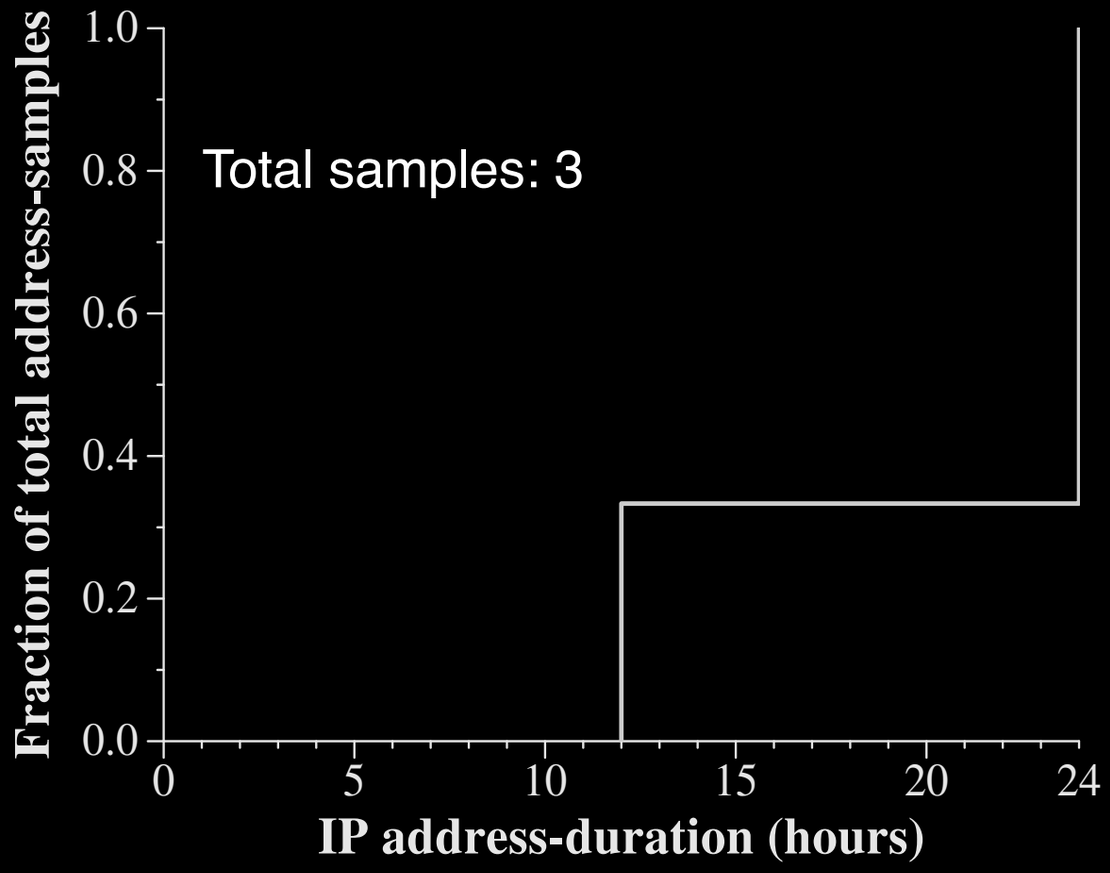


	Duration (hours)
IP_1	NA
IP_2	24
IP_3	24
IP_4	12
IP_5	NA

Can plot CDF…



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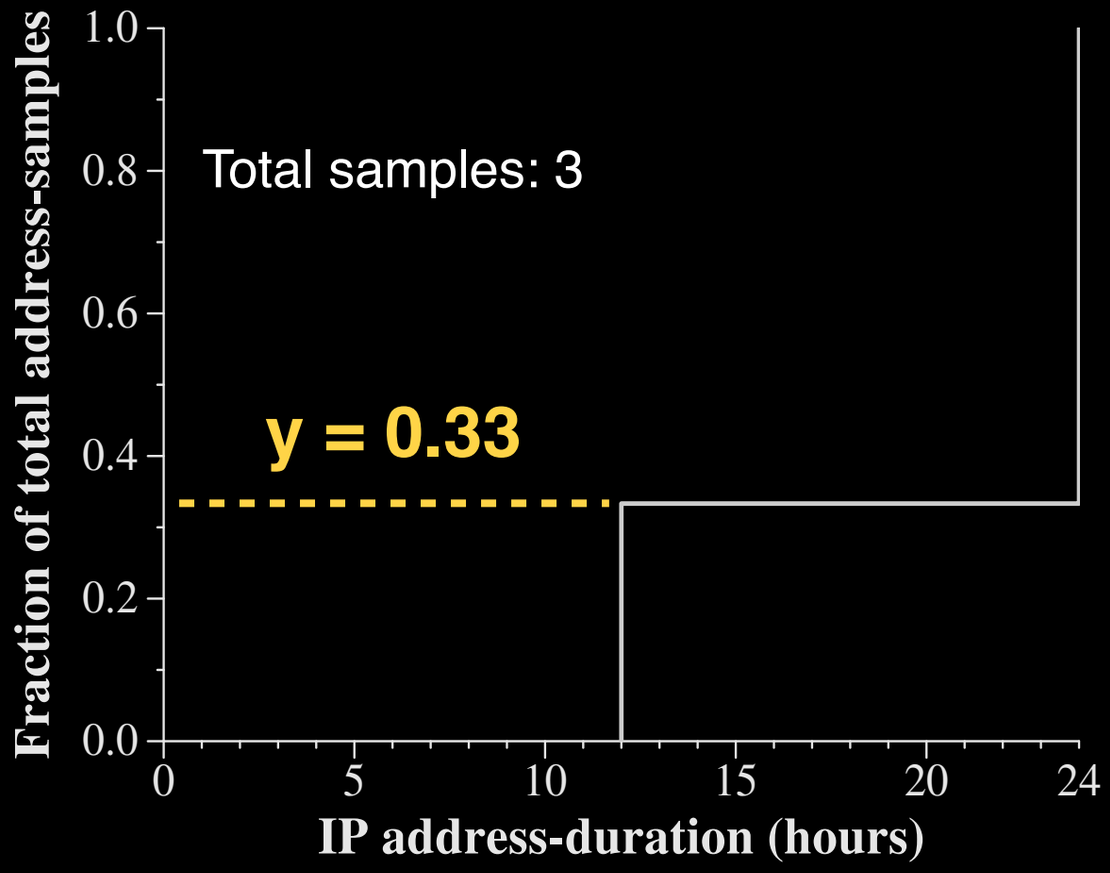

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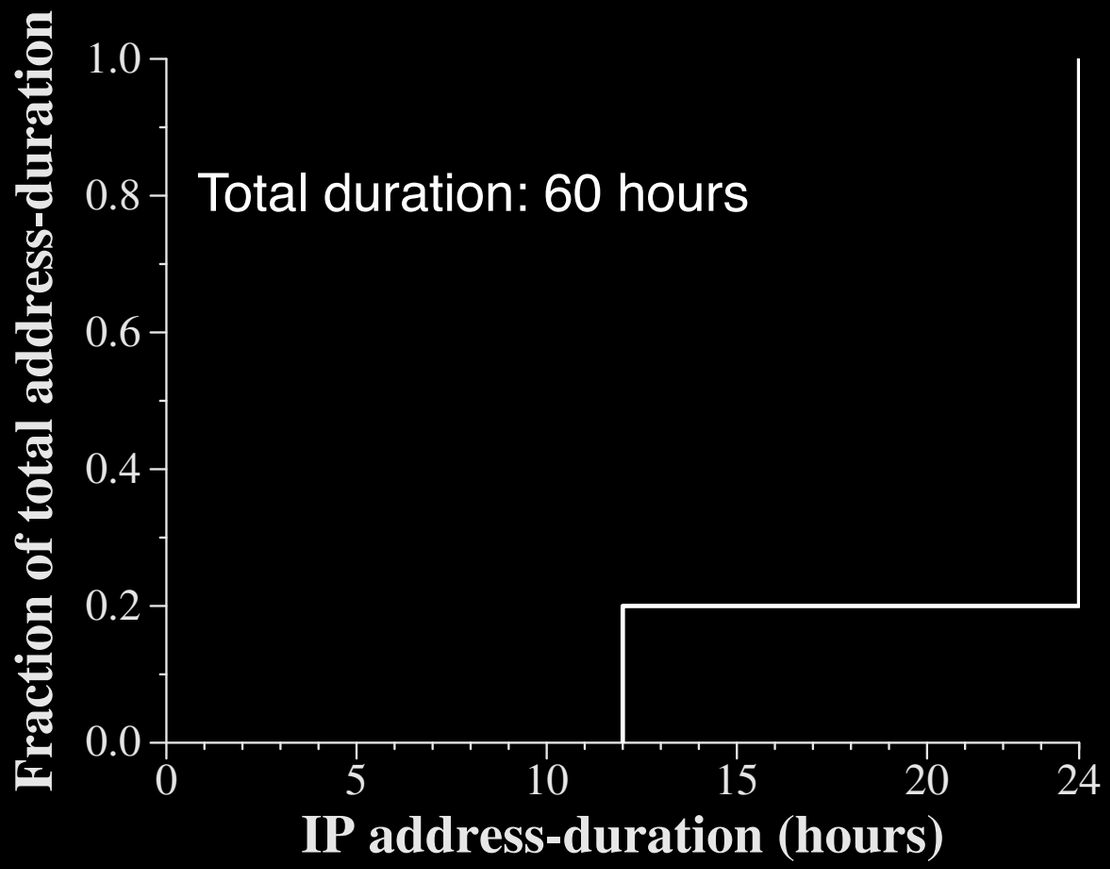
Weight by duration and plot distribution



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Weighted distribution shows fraction of total time spent in each duration

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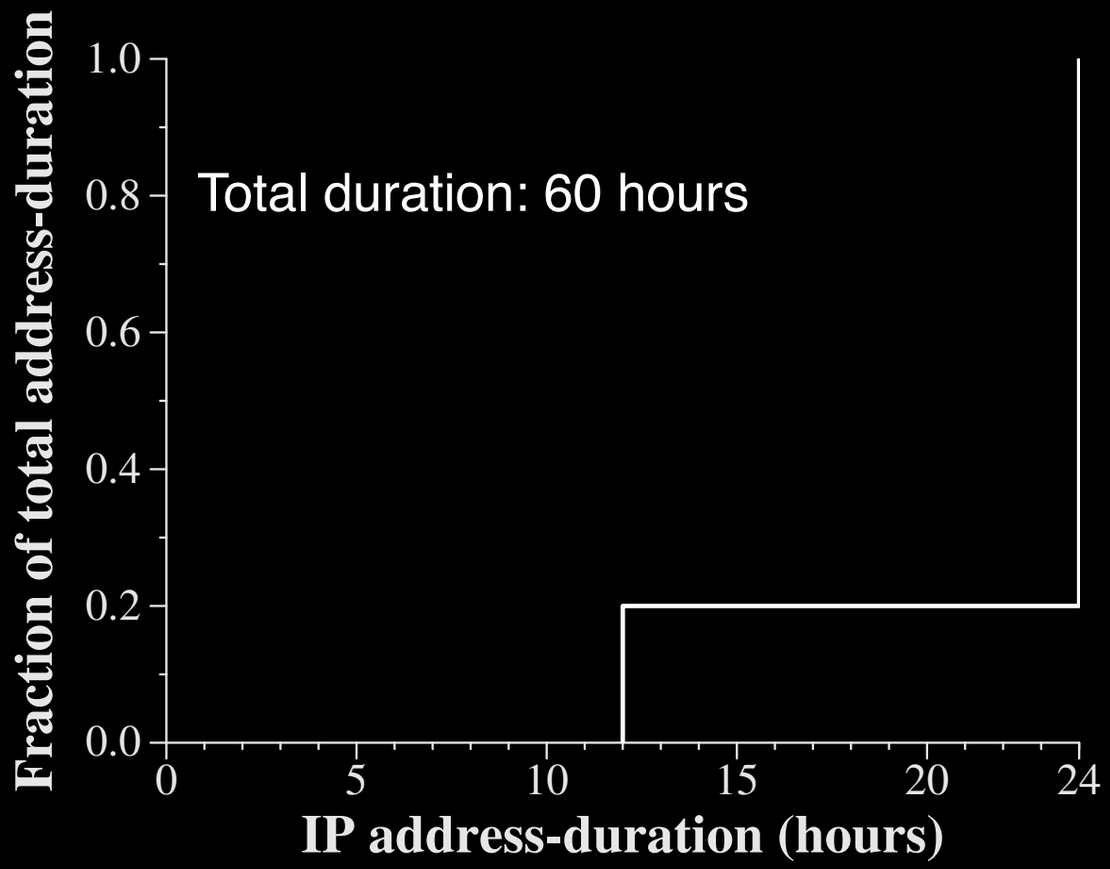

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Σ time: 60

Weighted distribution shows fraction of total time spent in each duration

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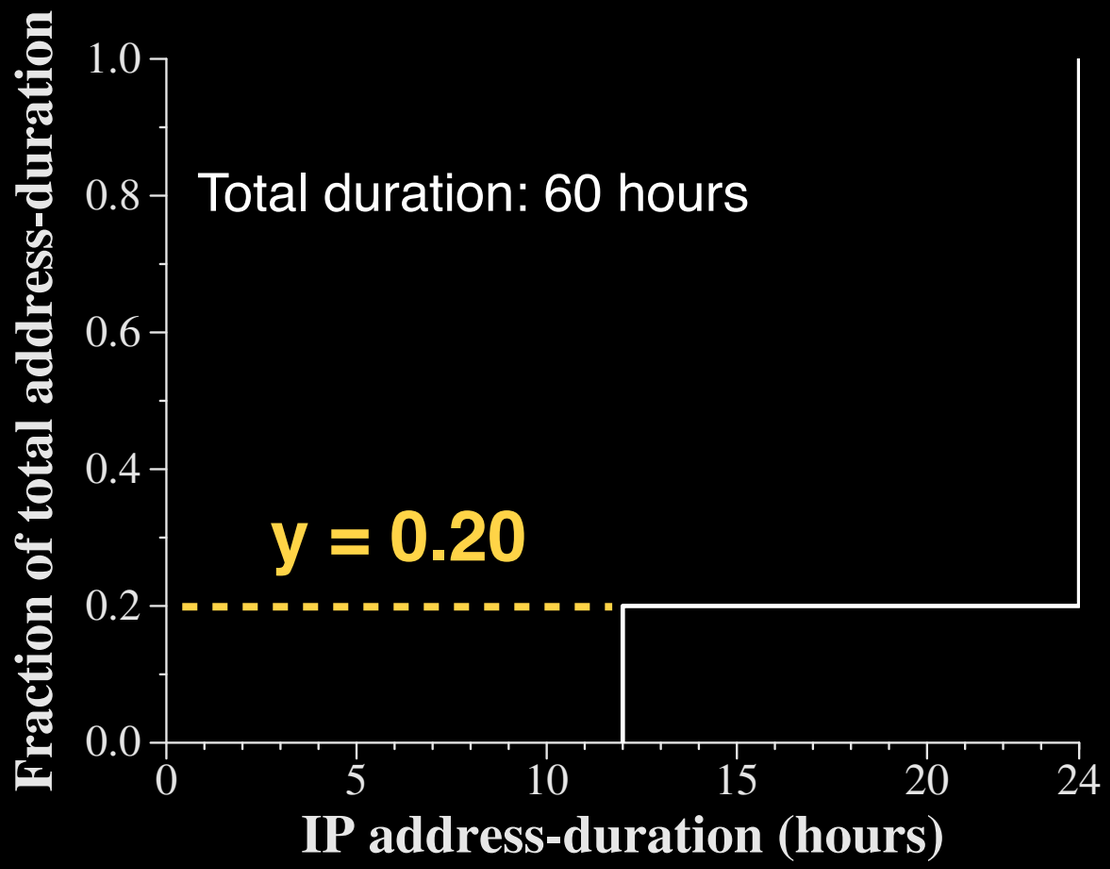

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Suppose we add 100 new durations of 1 minute each

	Duration (hours)
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IP_2	24
IP_3	24
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IP_5	NA

Suppose we add 100 new durations of 1 minute each

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IP_1	NA
IP_2	24
IP_3	24
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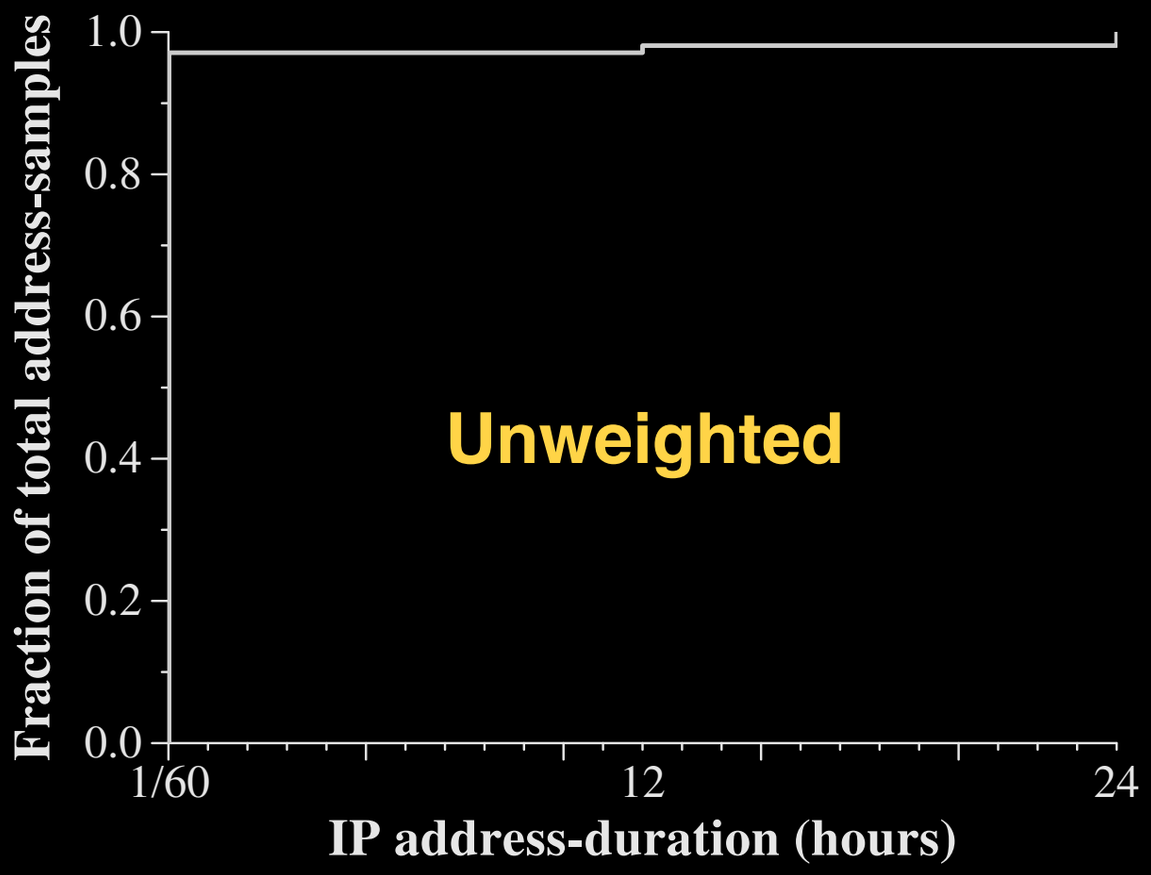
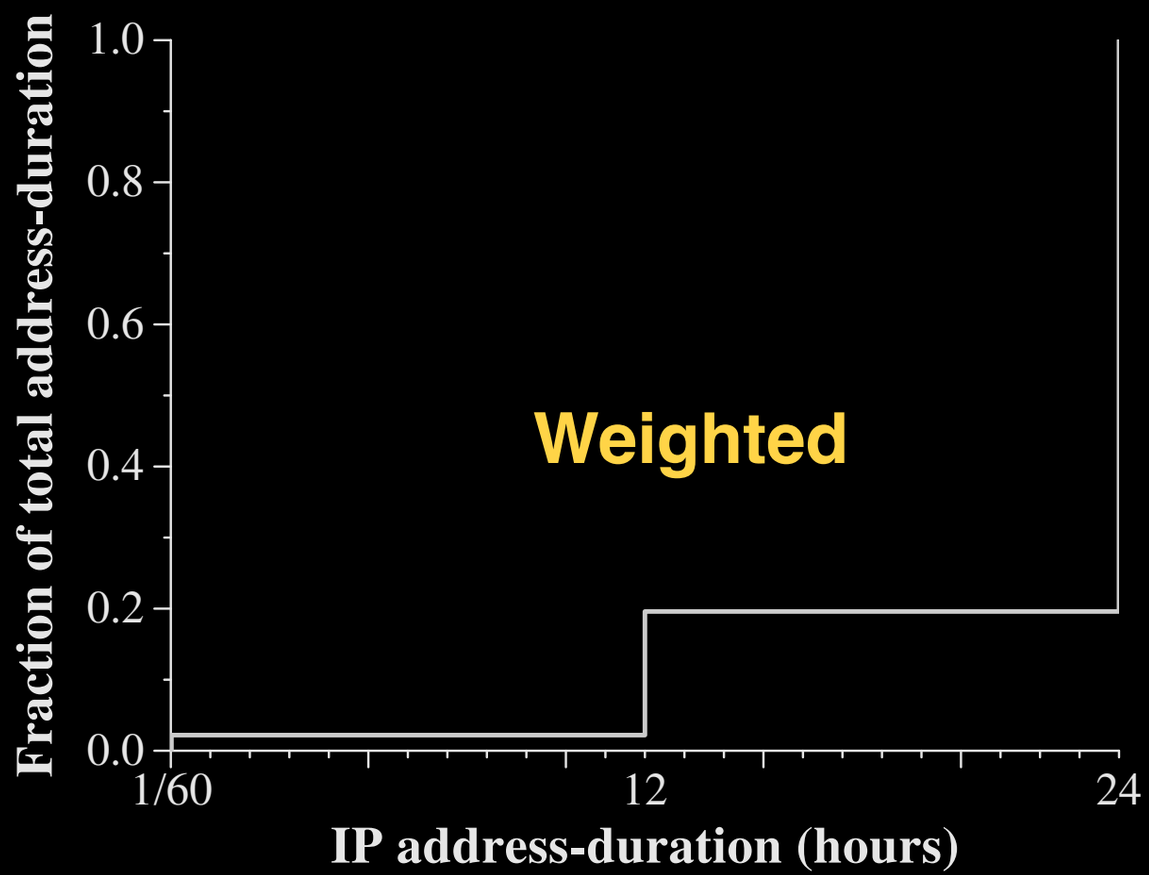
IP_5	NA
IP_6	1/60
IP_7	1/60
…	1/60
IP_{104}	1/60
IP_{105}	1/60

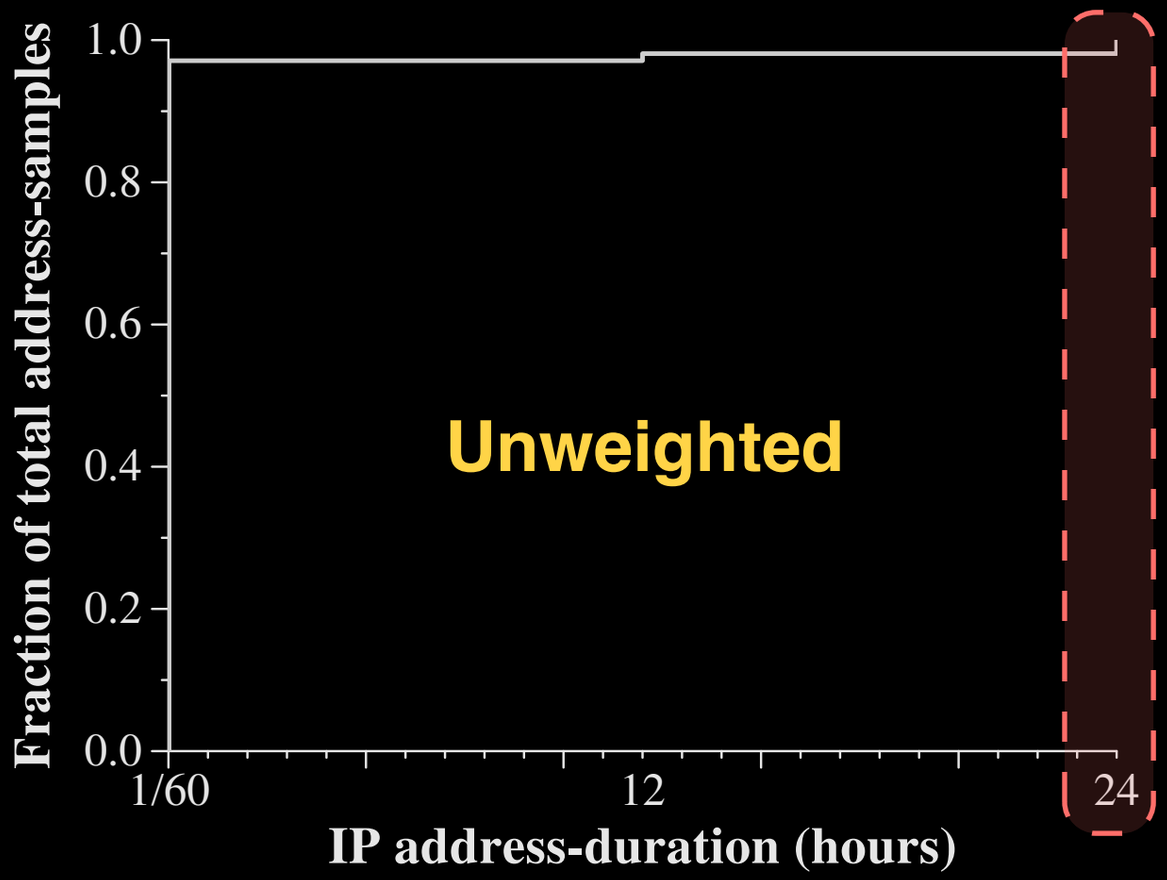
Weighted distribution shows probability that an address lasted X hours

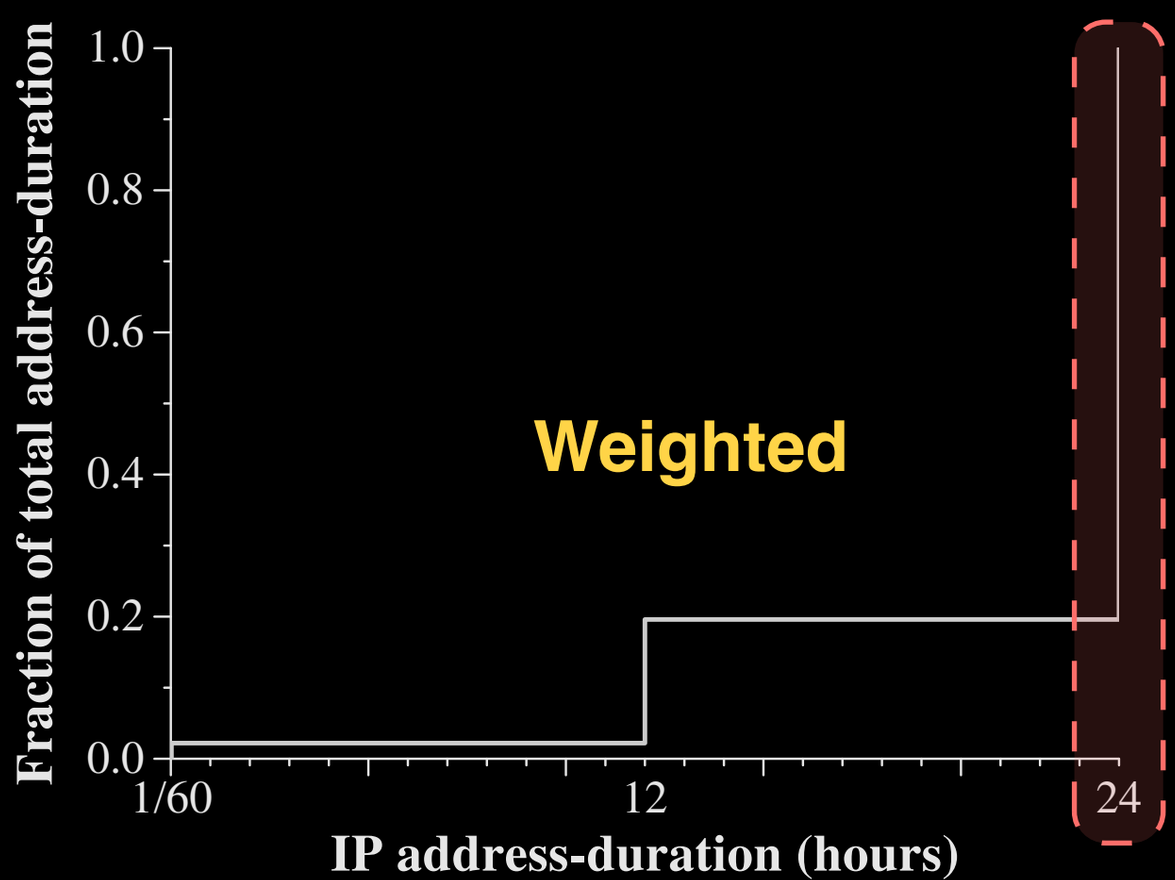




If we blacklist an IP address, how long to keep it in the blacklist?

Weighted distribution shows probability that an address lasted X hours





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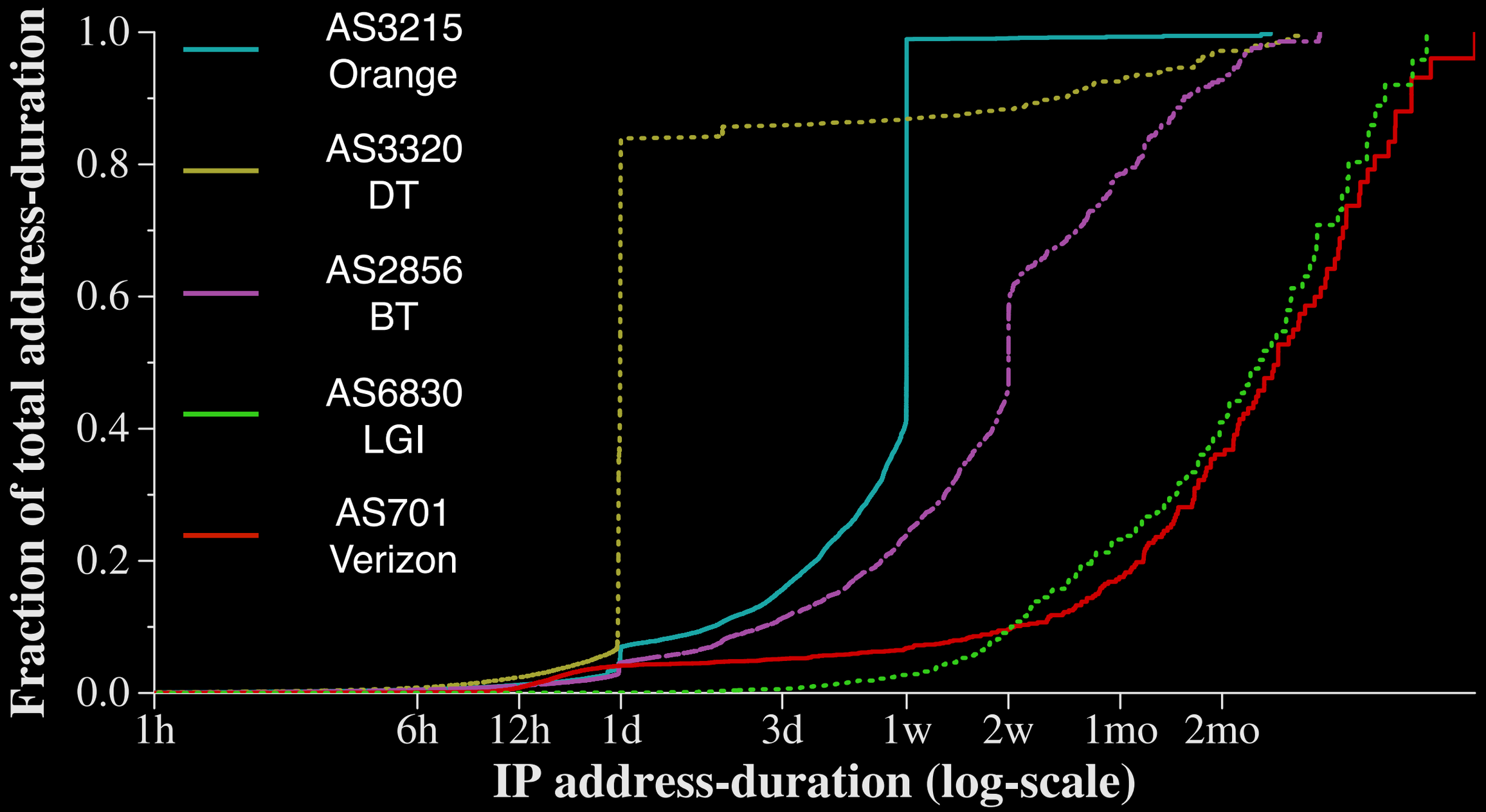
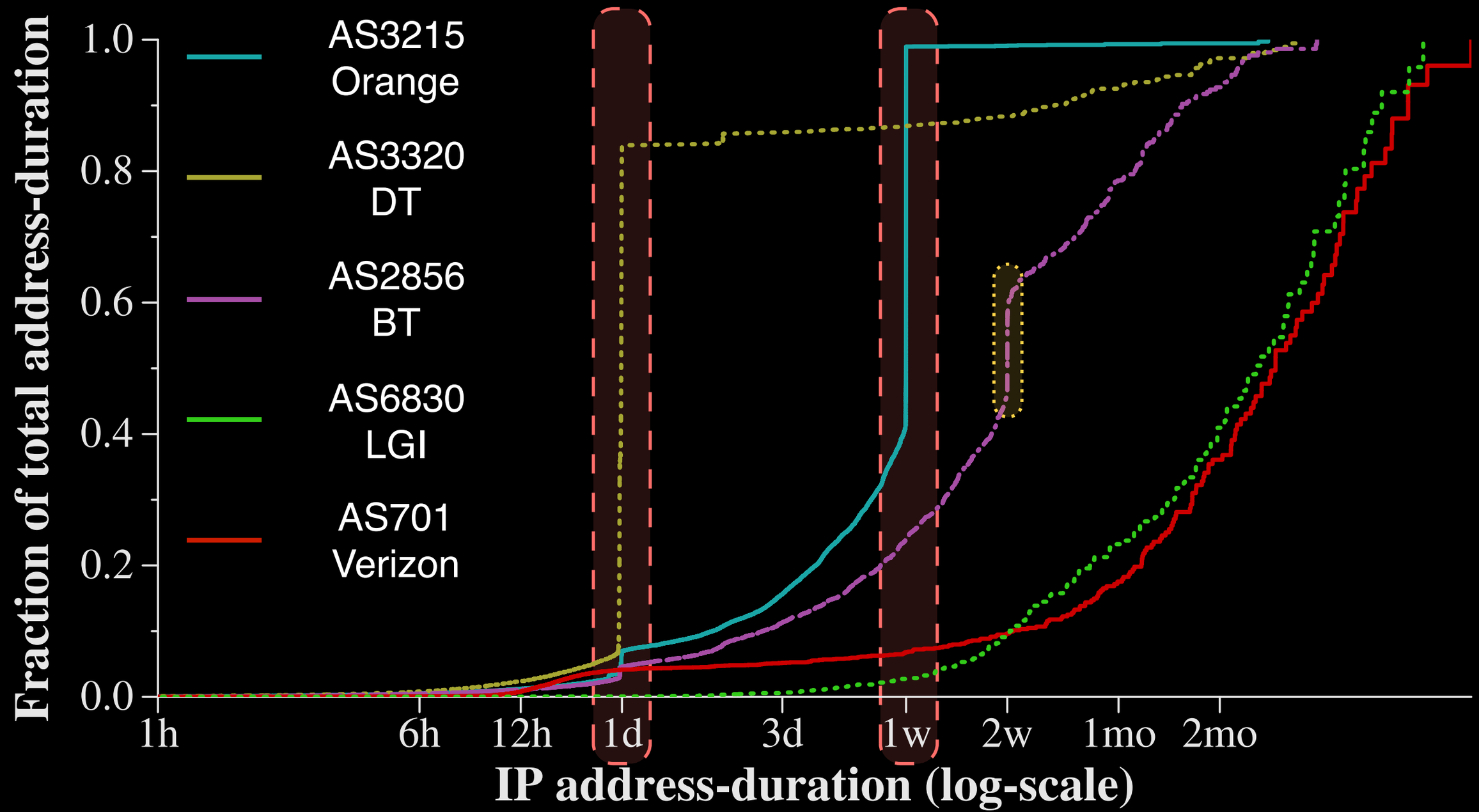
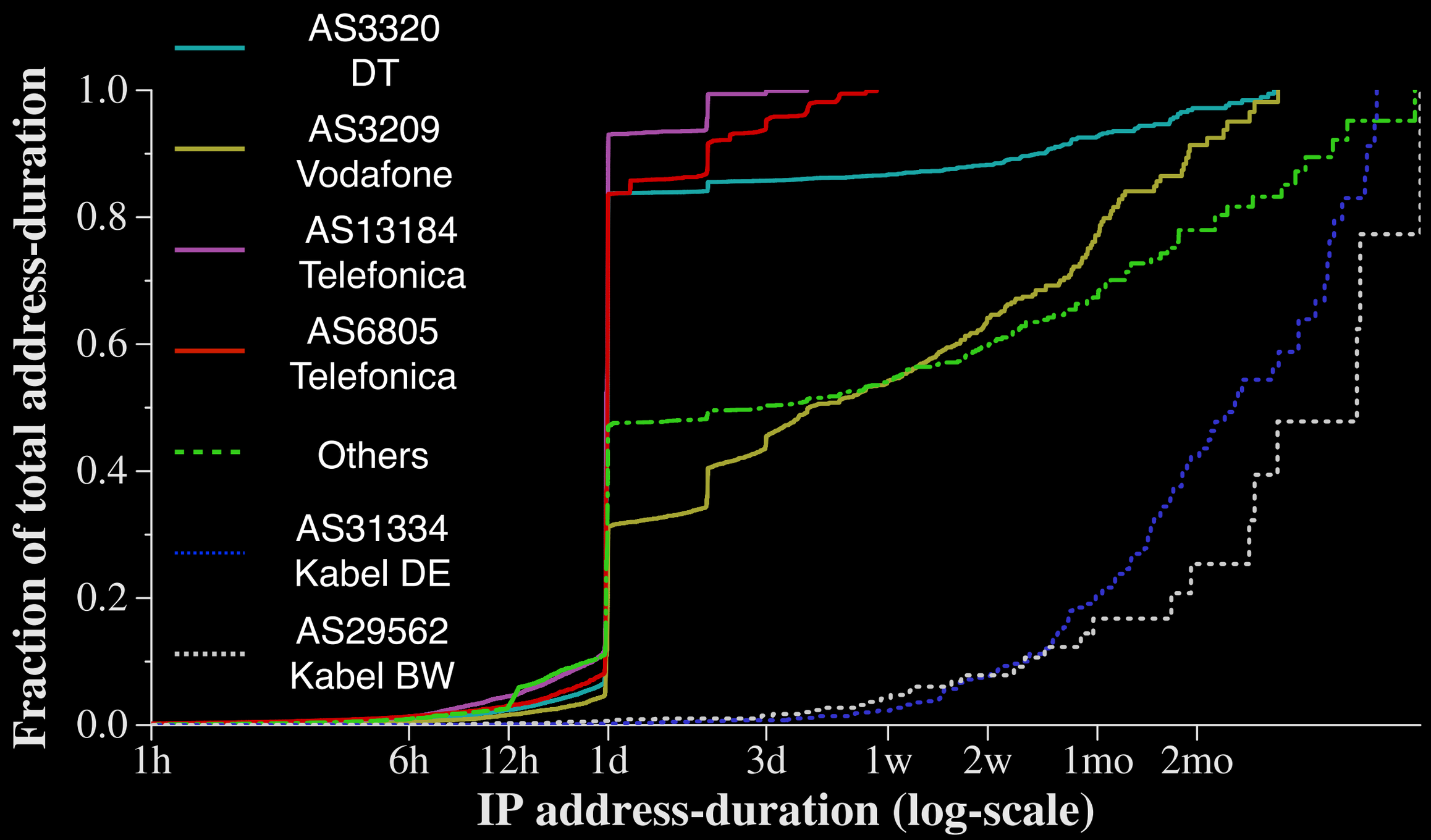
Orange, DT have periodic address durations



Orange, DT have periodic address durations



Periodic address durations of 24 hours common in Germany



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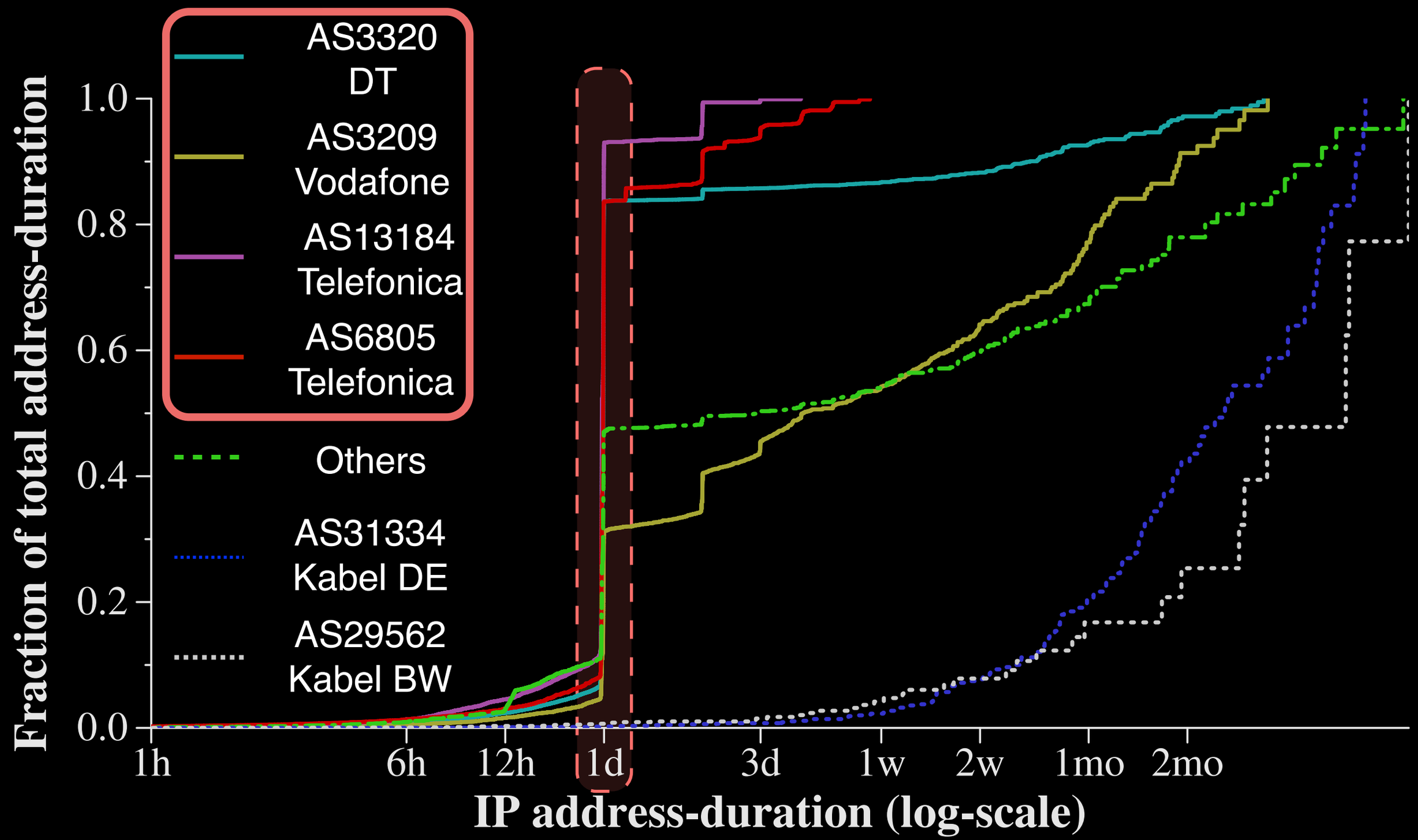

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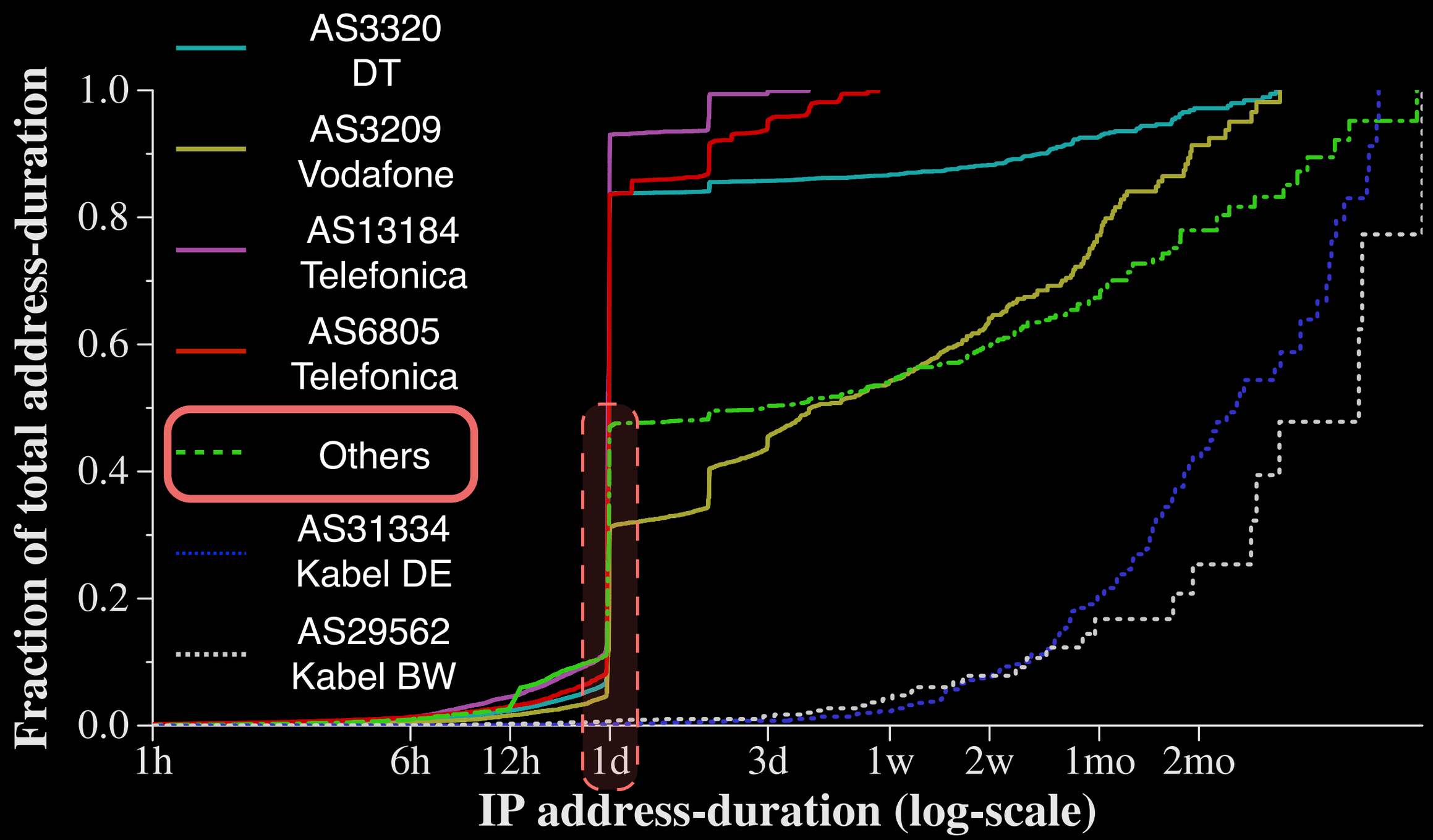

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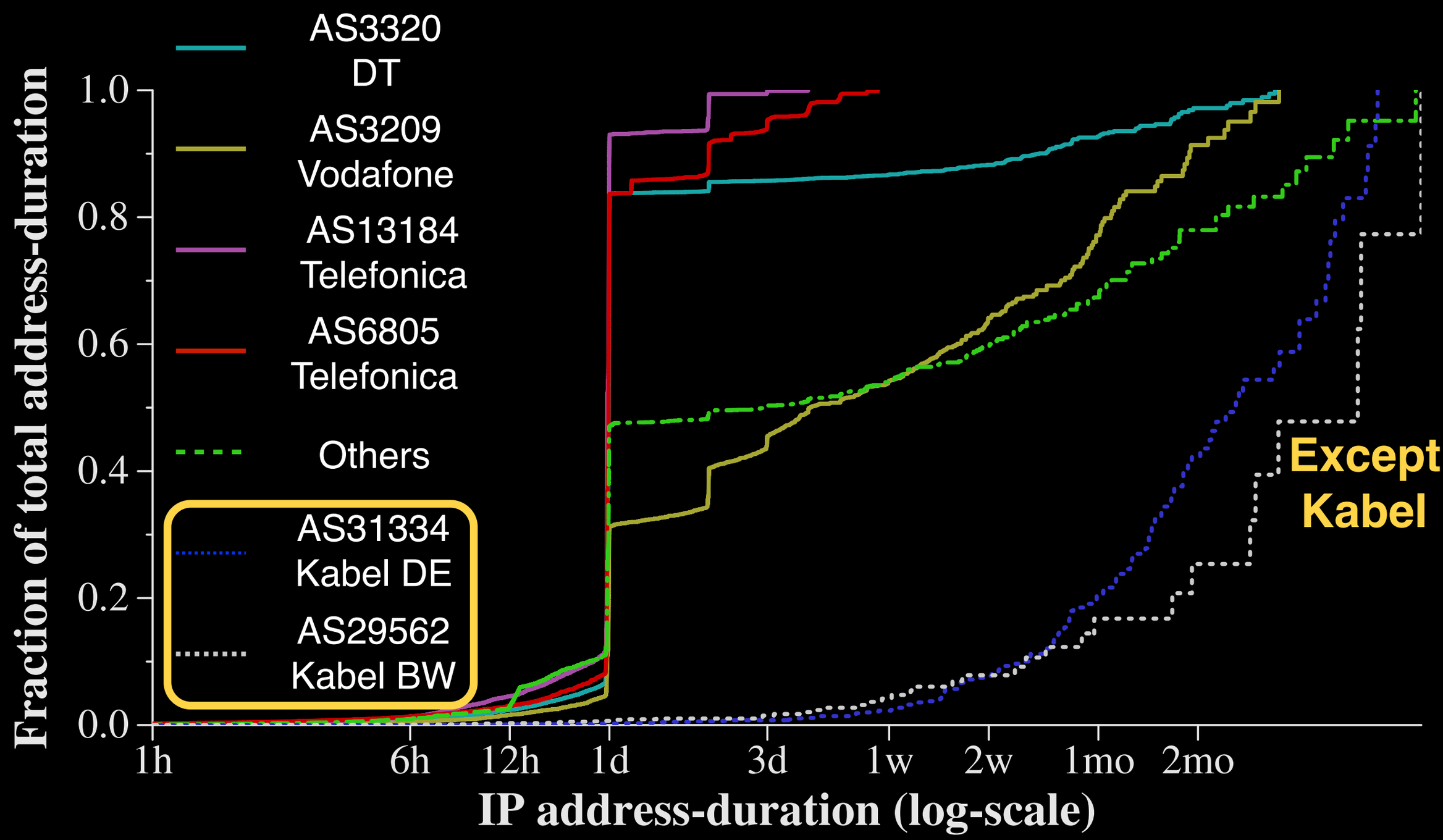


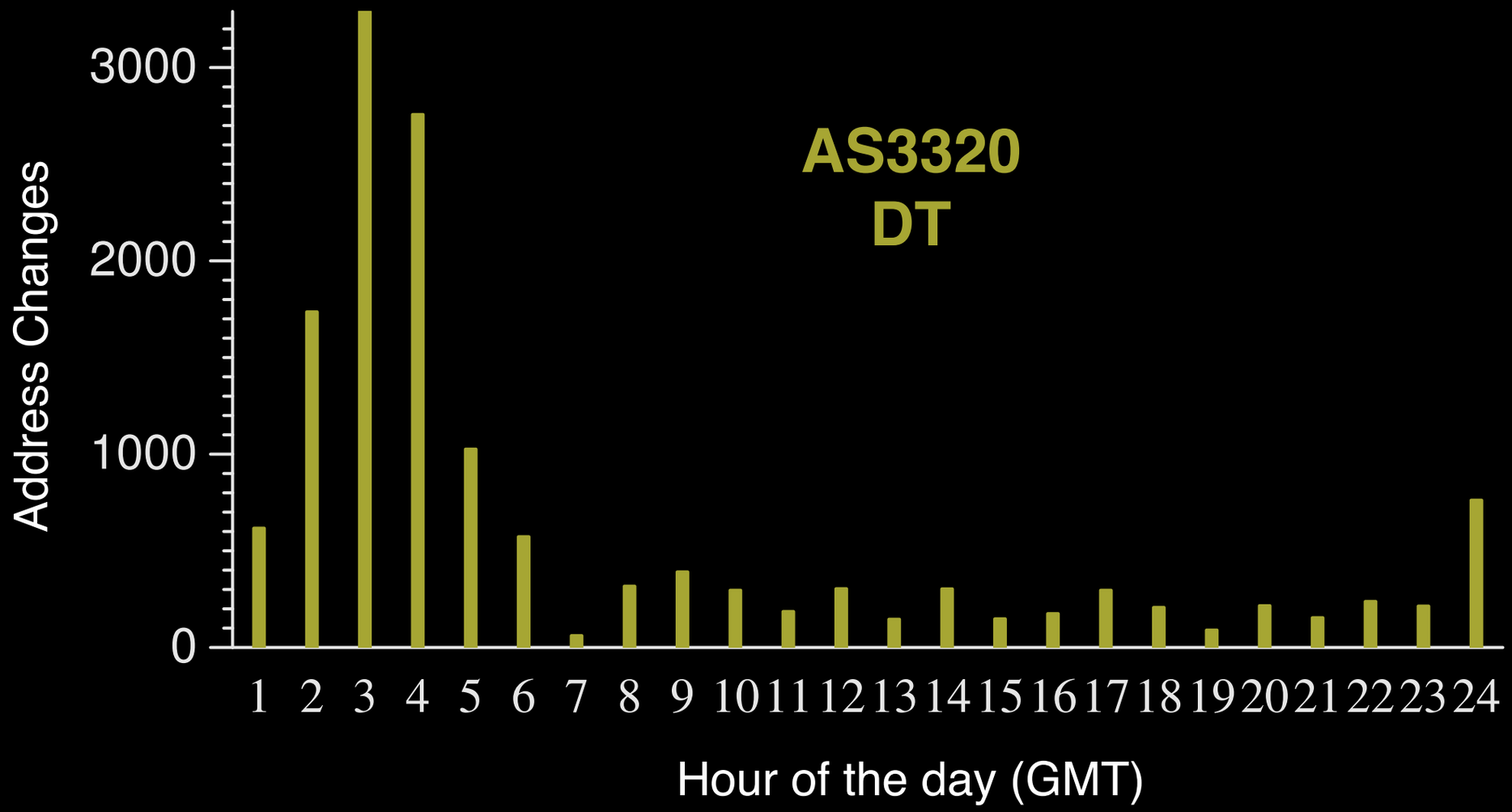
Are periodic address changes synchronized in time?

- If so, we can potentially predict when an address is likely to change

- Find hour of the day when the address changed after **periodic** duration

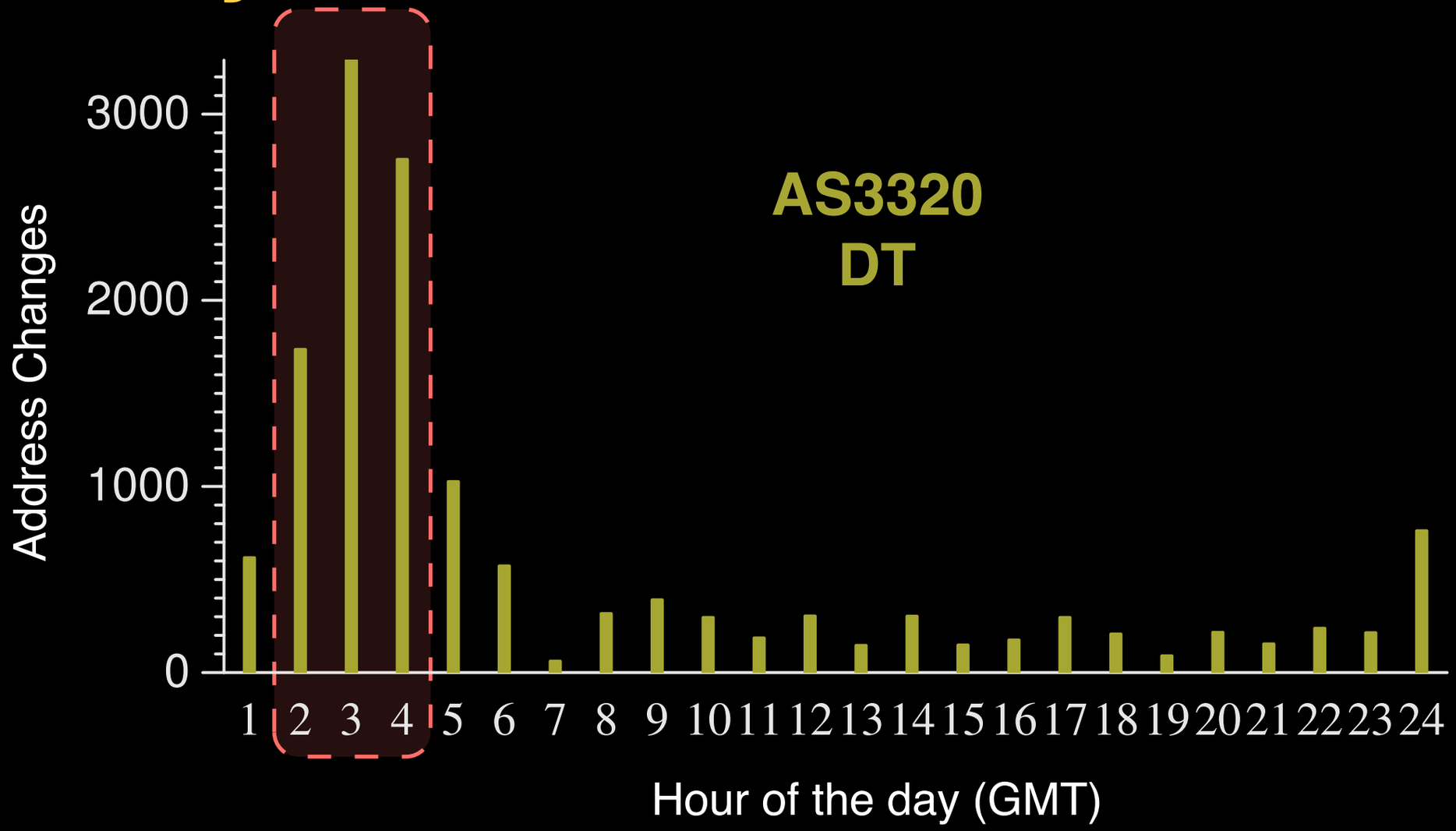
- Plot histogram

Are periodic address changes synchronized in time?



For some ISPs, we can predict hours when address changes are more likely

Are periodic address changes synchronized in time?



For some ISPs, we can predict hours when address changes are more likely

Periodic address changes: Summary

Of 95 ISPs with at least 5 probes, 20 renumber periodically

Typical **periods** are multiples of 24 hours

Many ISPs renumber in a synchronized manner

For periodic ISPs we can predict the maximum duration that current address is assigned

How long can dynamic IP addresses be end-host identifiers?

Background

Detecting address changes

Analyze **periodic**

Analyze **outage**

Conclusions

How long can dynamic IP addresses be end-host identifiers?

Background

Detecting address changes

Analyze **periodic**

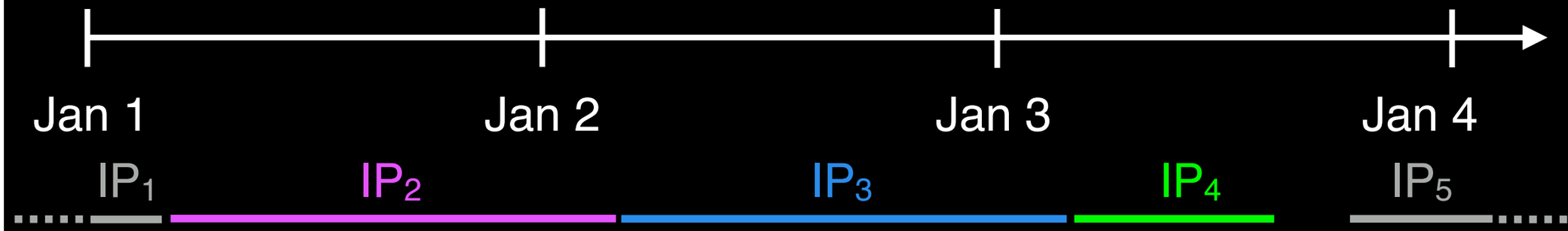
Analyze **outage**

Conclusions

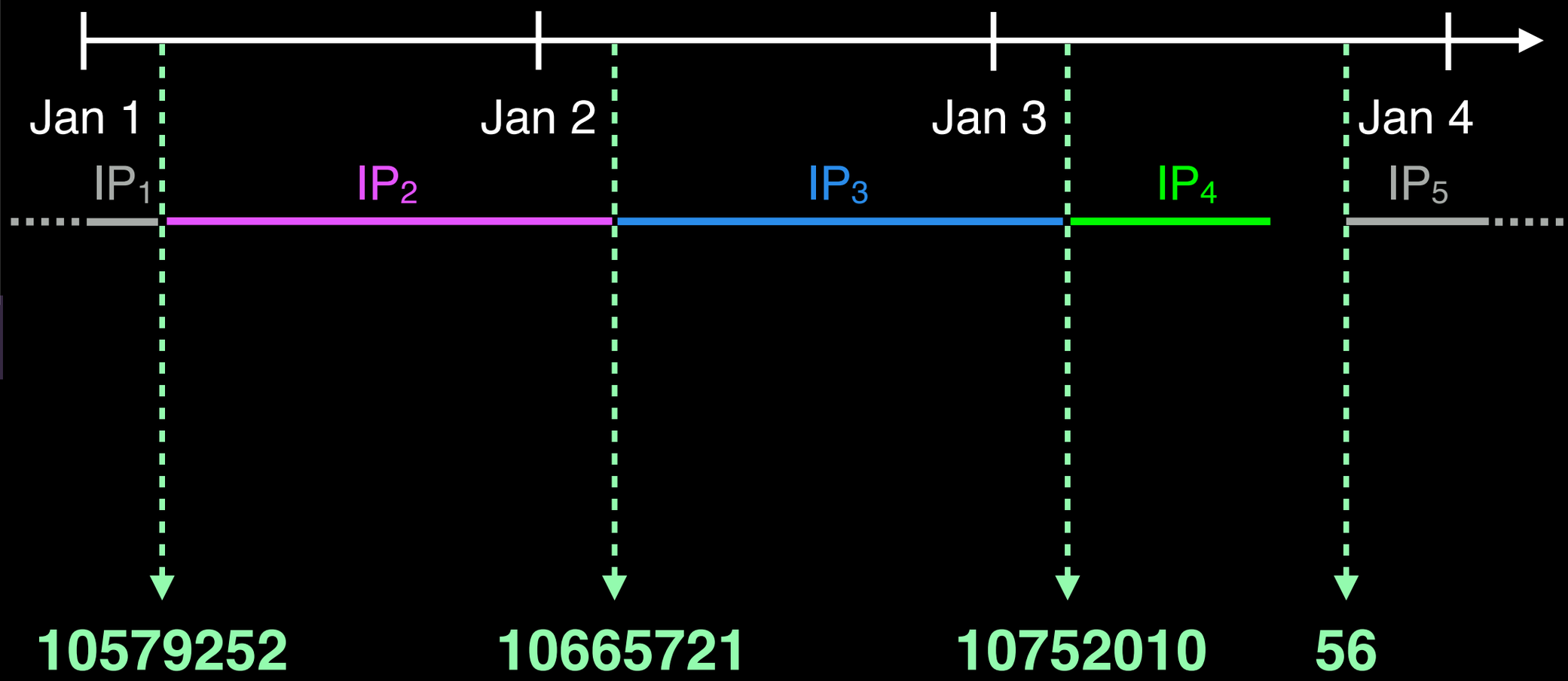
Find power outages using probes' uptime counters and pings to k-root

Home Router

Dynamic IP



Find power outages using probes' uptime counters and pings to k-root



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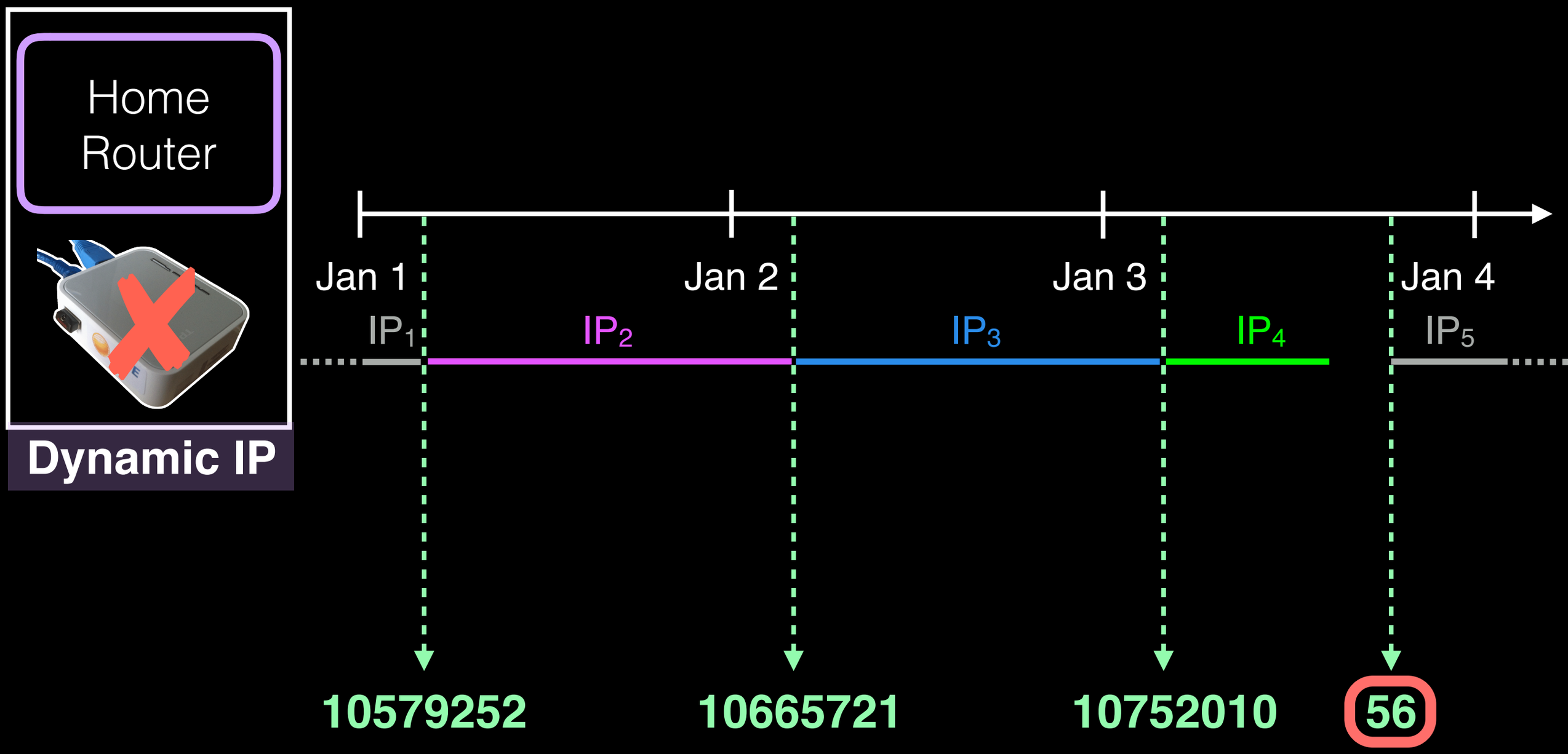

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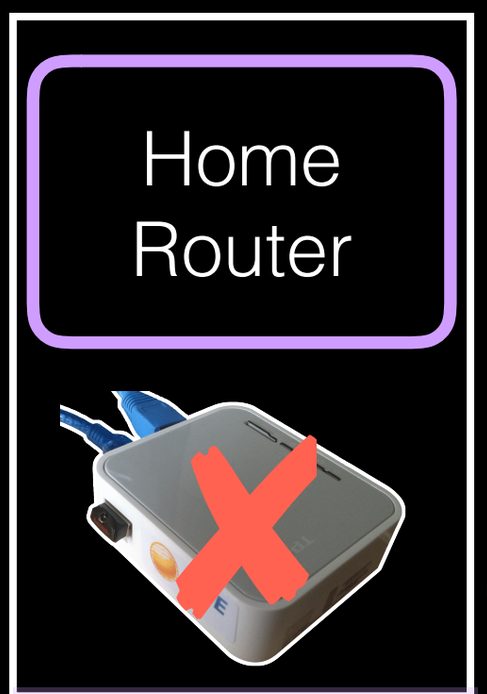
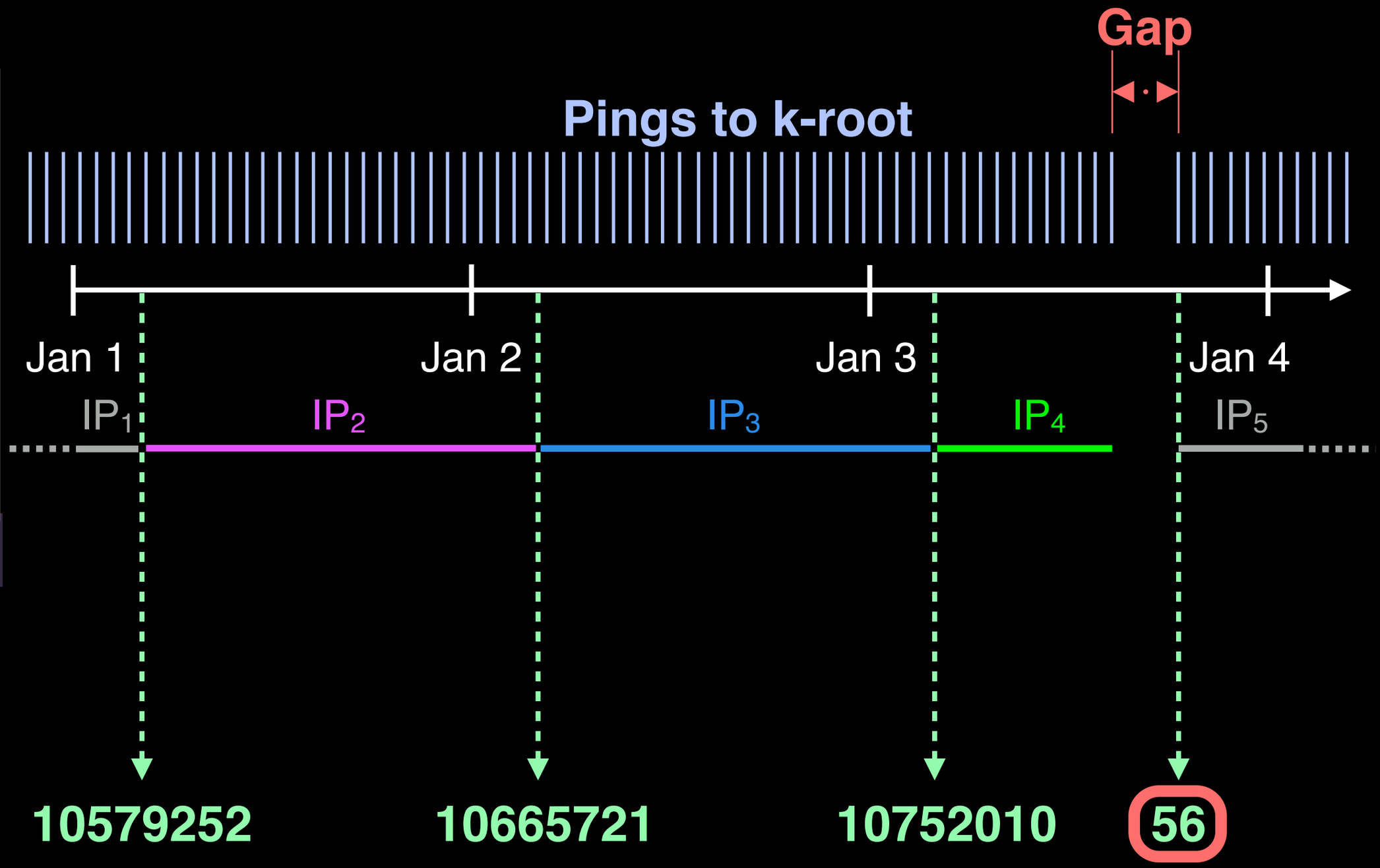
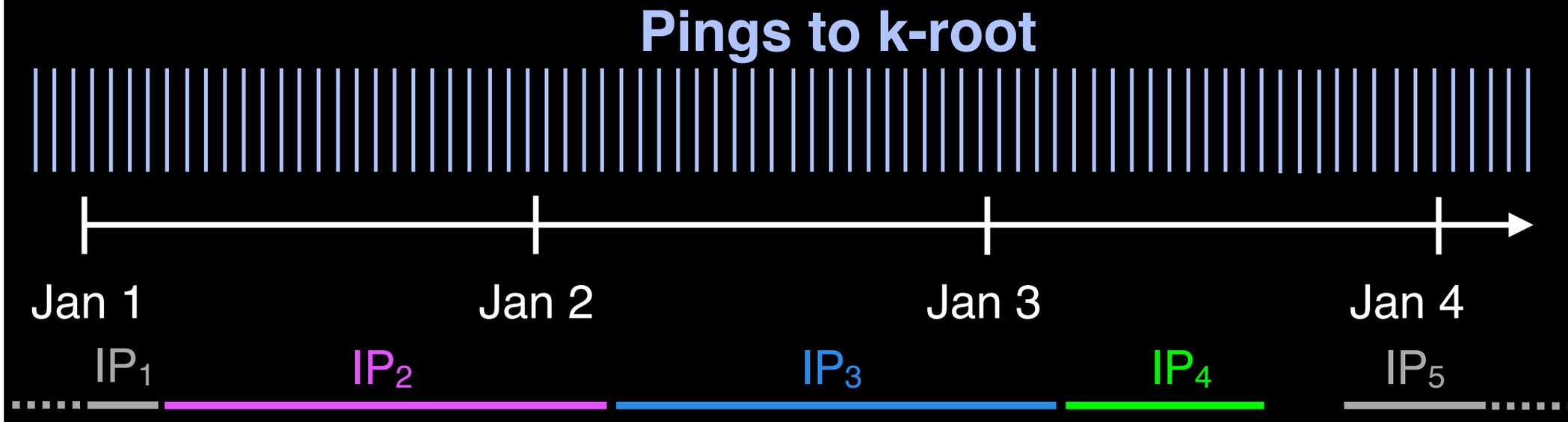




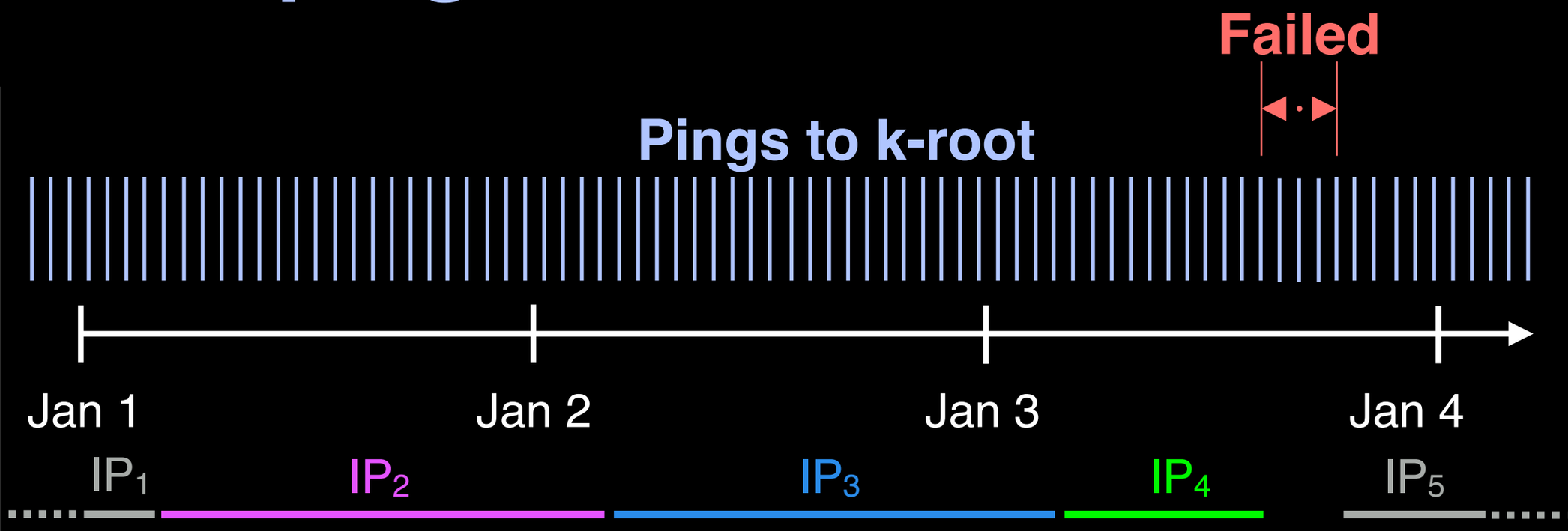
Find network outages using probes' pings to k-root

Dynamic IP



Find network outages using probes' pings to k-root

Dynamic IP

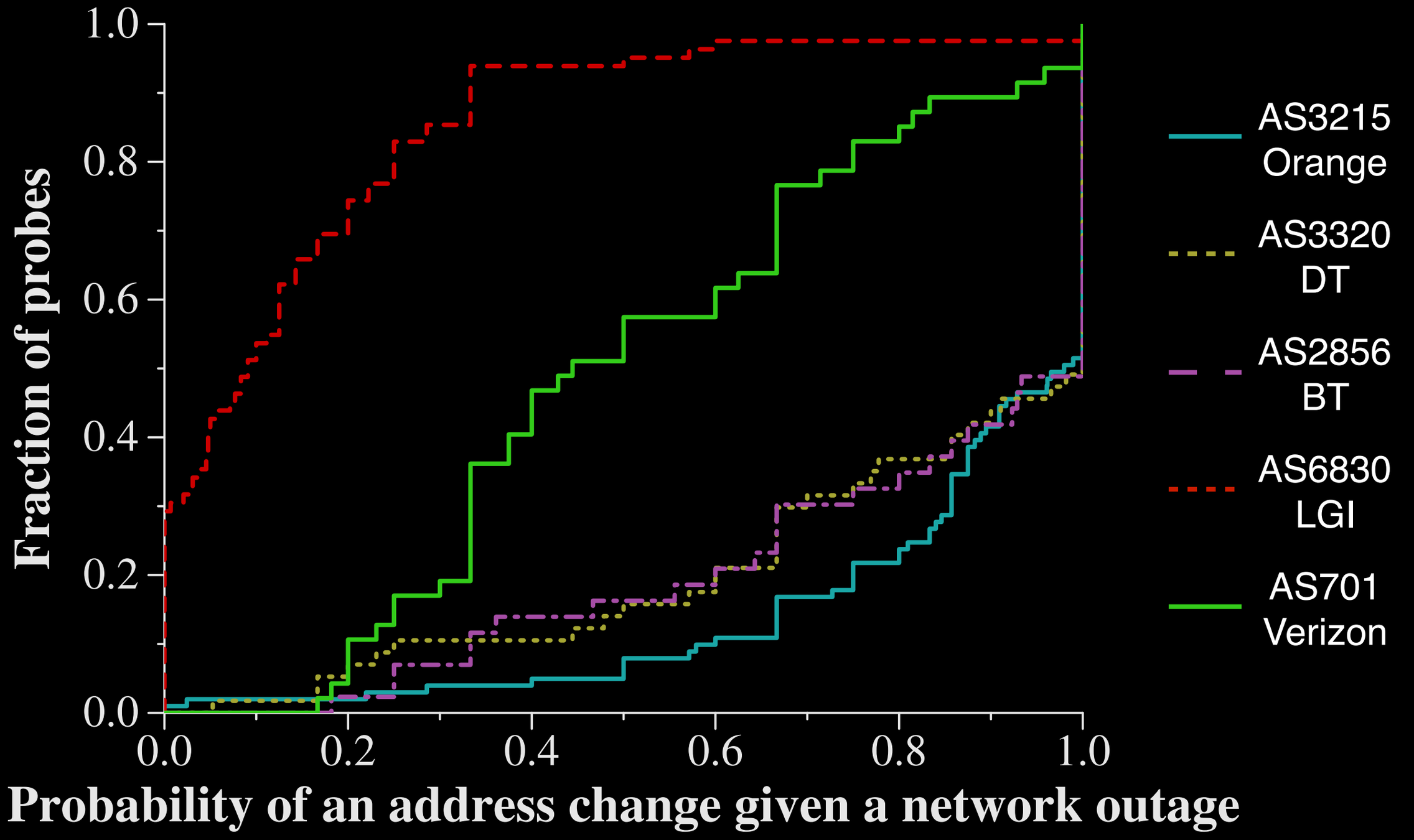


When outages occur, how often do address changes occur?

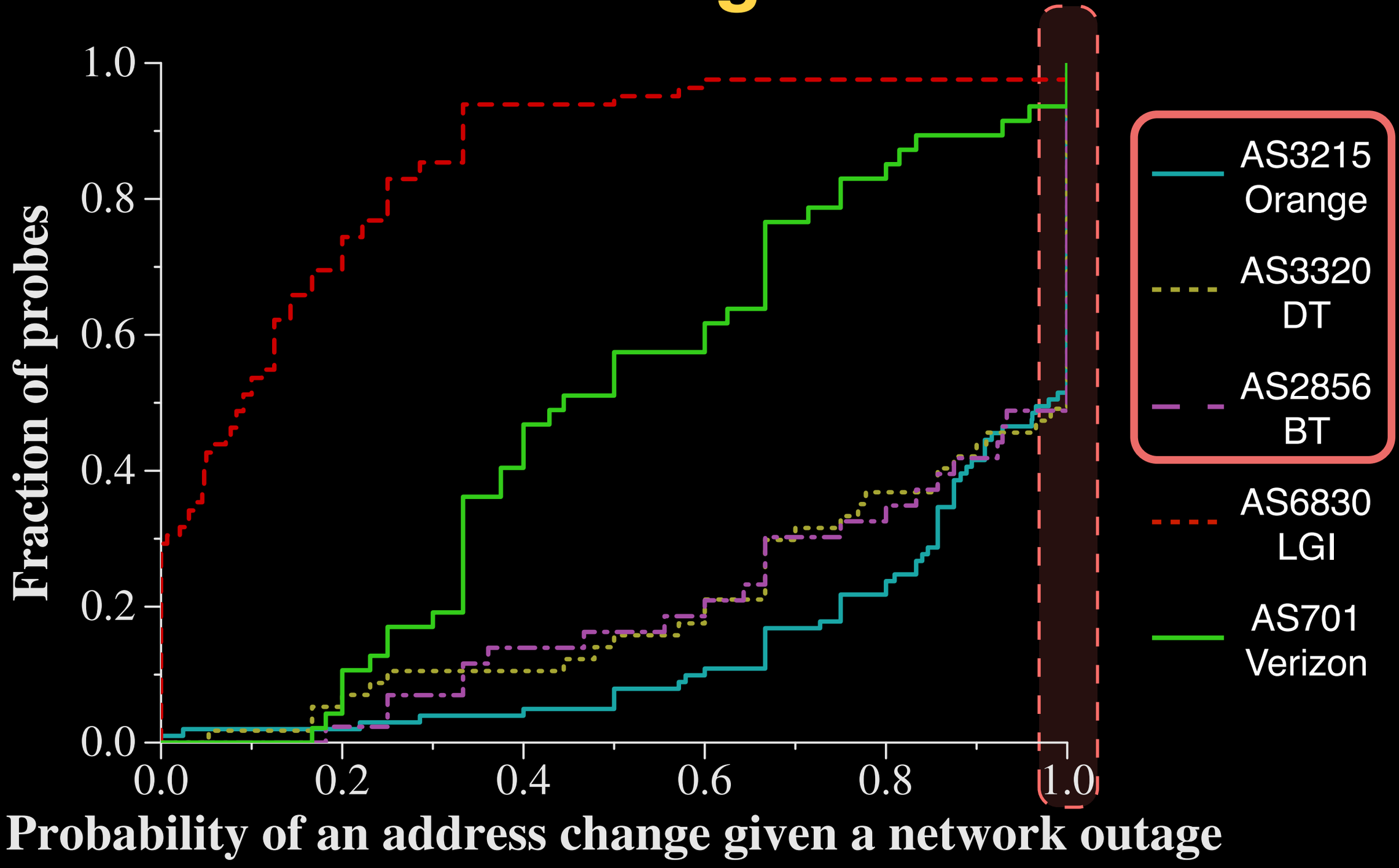
Find probes with at least three **outages**

For each probe, find probability of address change given an outage

When network outages occur, how often do address changes occur?



When network outages occur, how often do address changes occur?

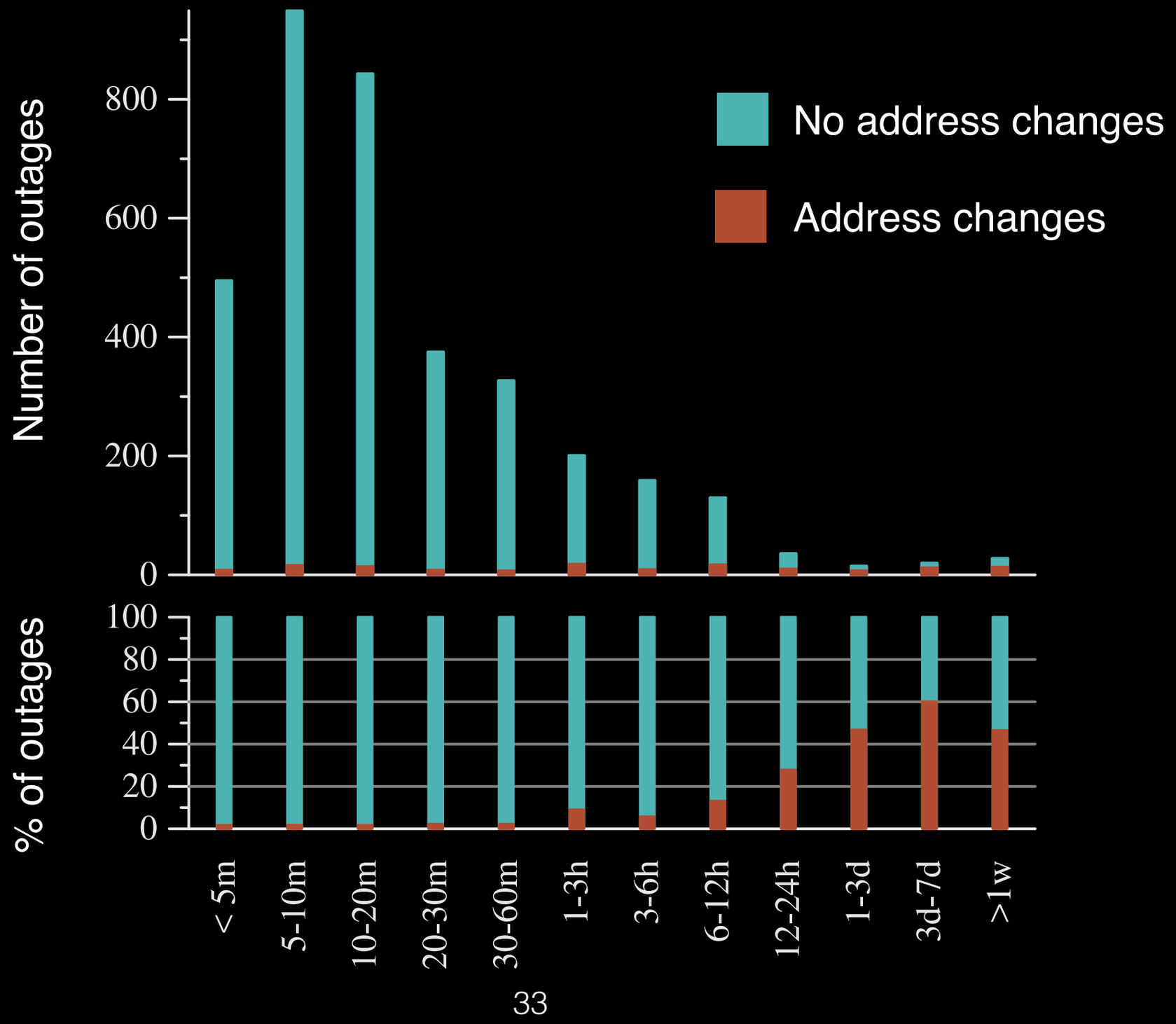


How is the outage duration related to the probability of address change?

If DHCP, an **outage** that lasts longer than lease duration can cause address change

Find **outages** of different durations and inspect probability of address change

For LGI, longer outages are more likely to result in address change



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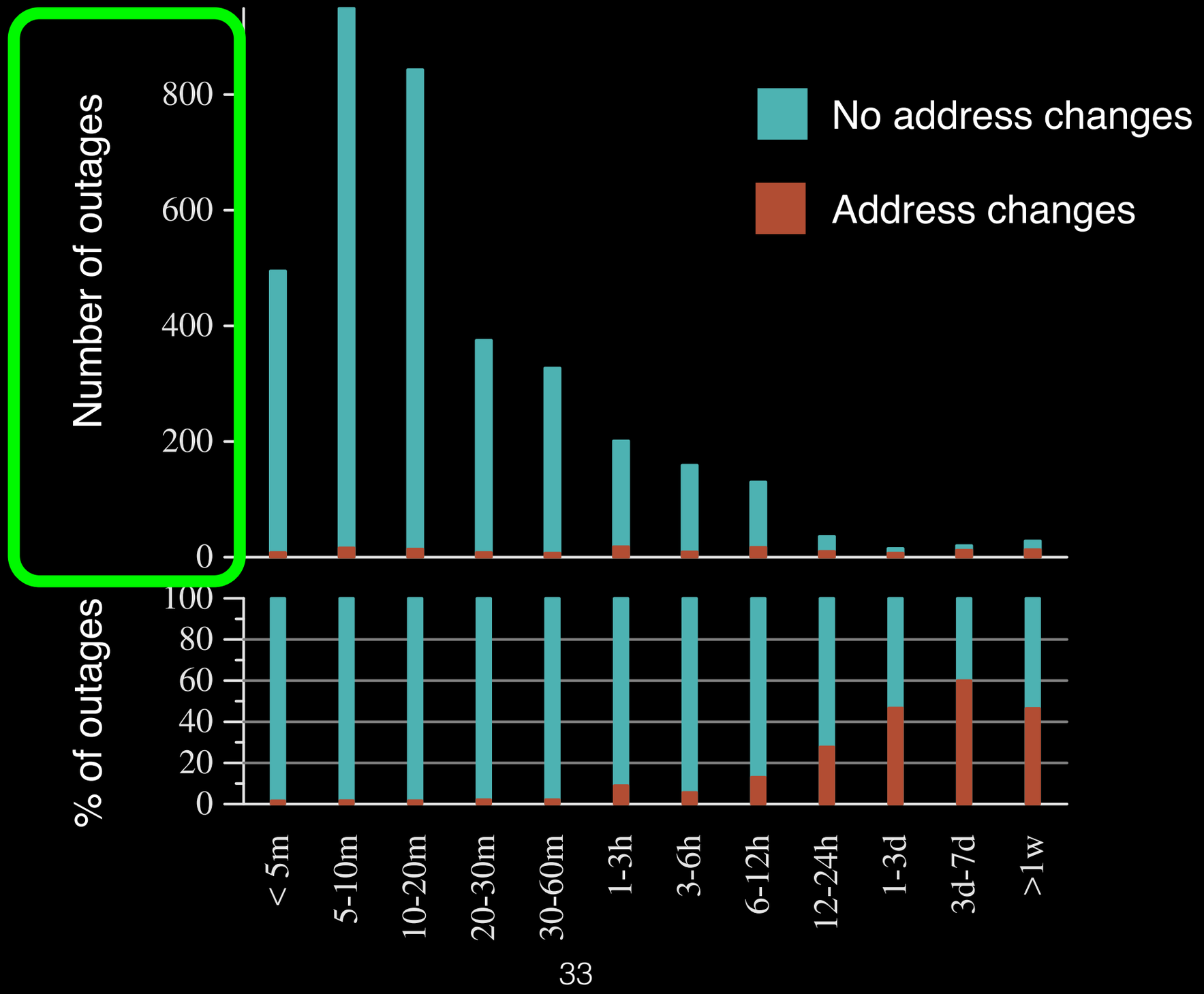

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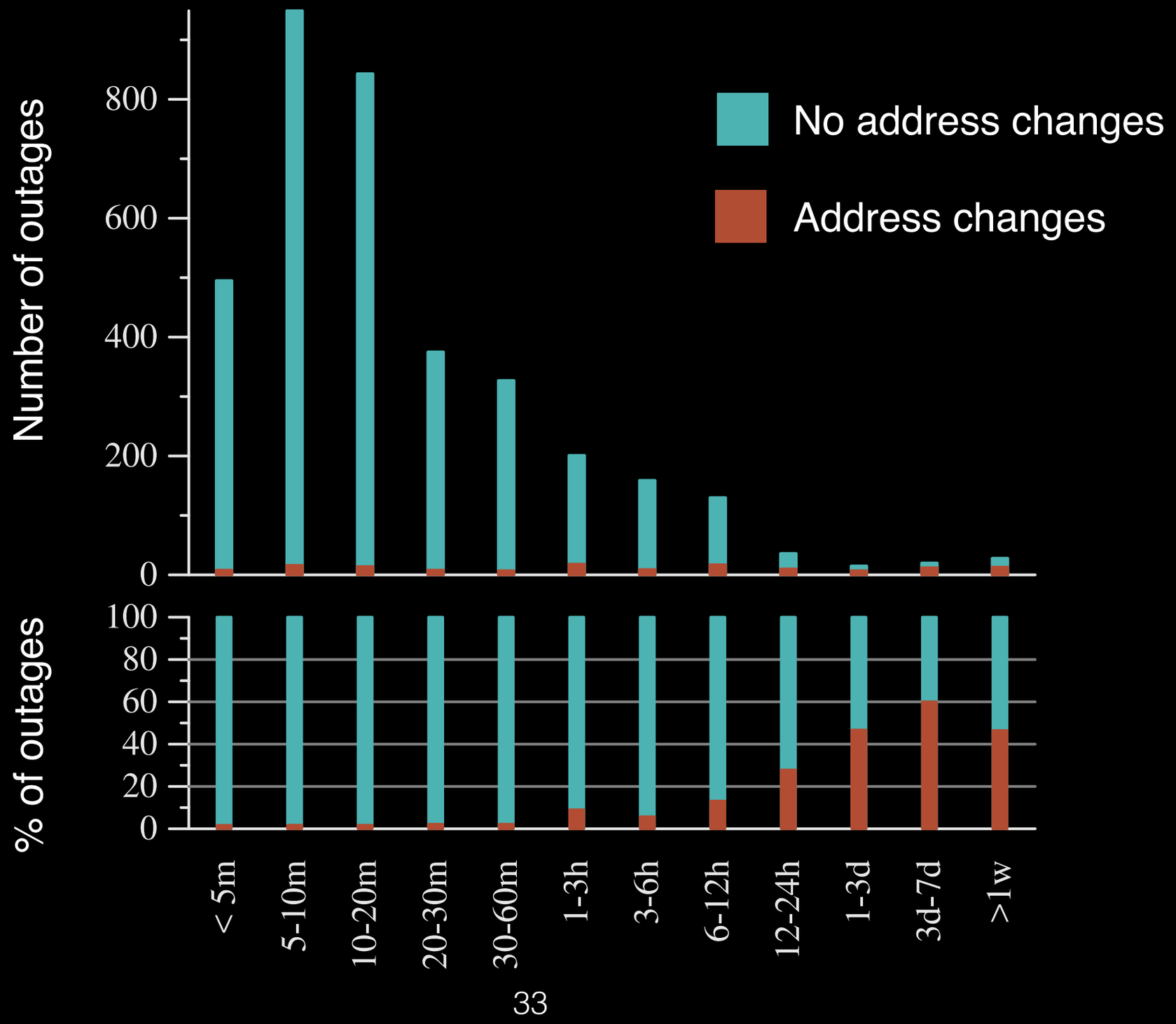


For Orange, even a device reboot can result in an address change!

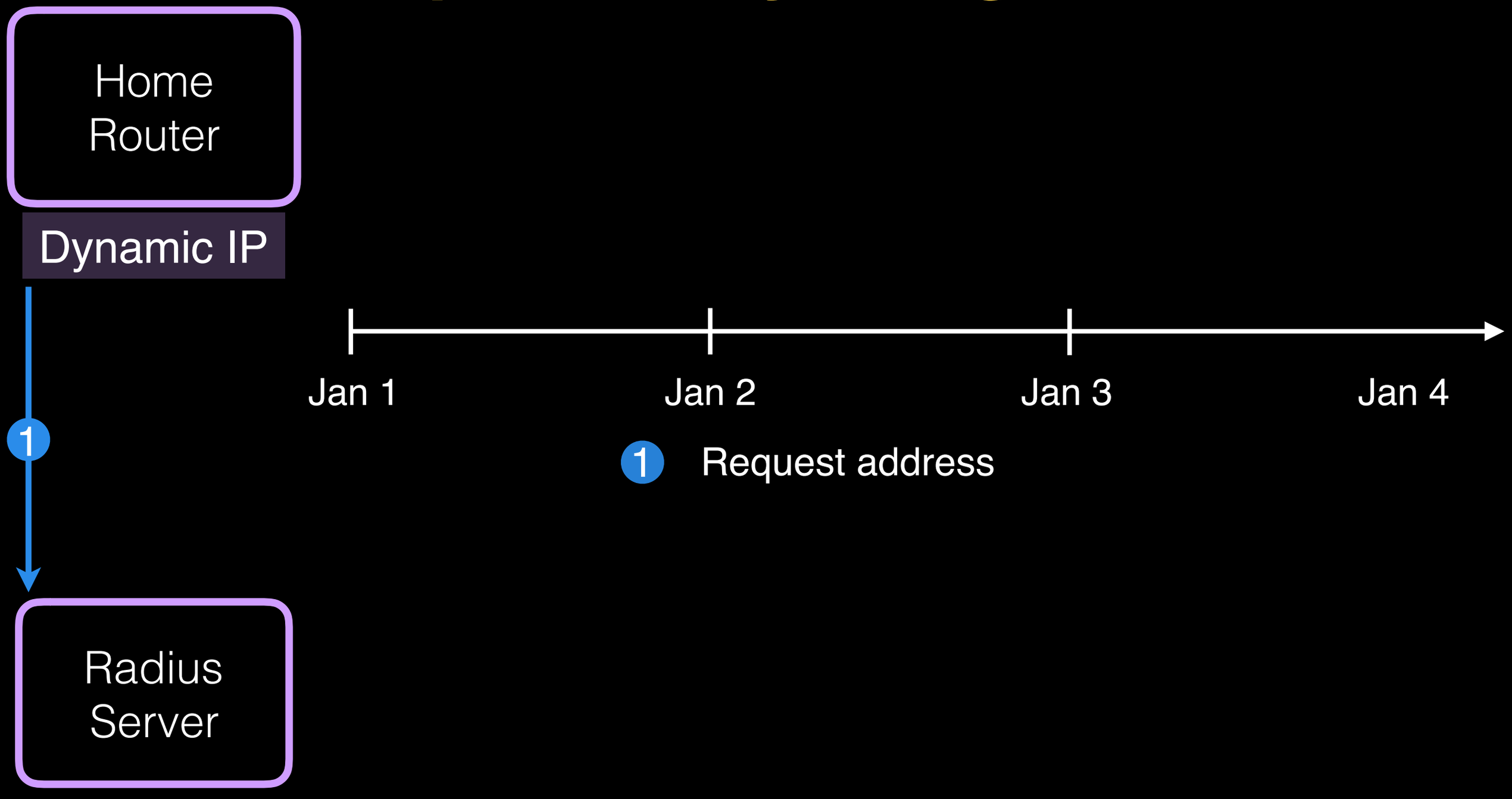
Protocols over PPP do not try to remember previously assigned address

Home Router

Dynamic IP

Radius Server

Protocols over PPP do not try to remember previously assigned address



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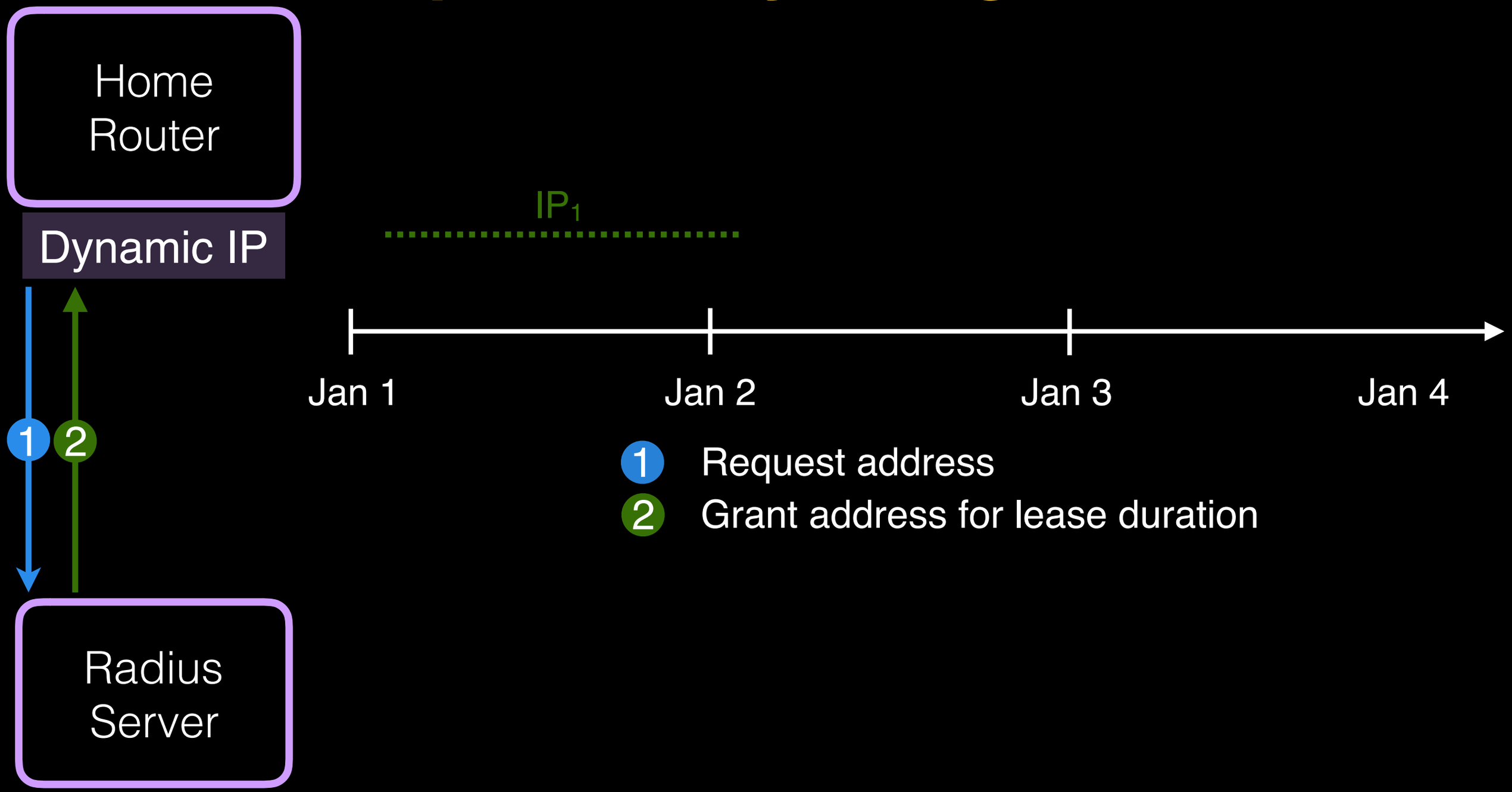

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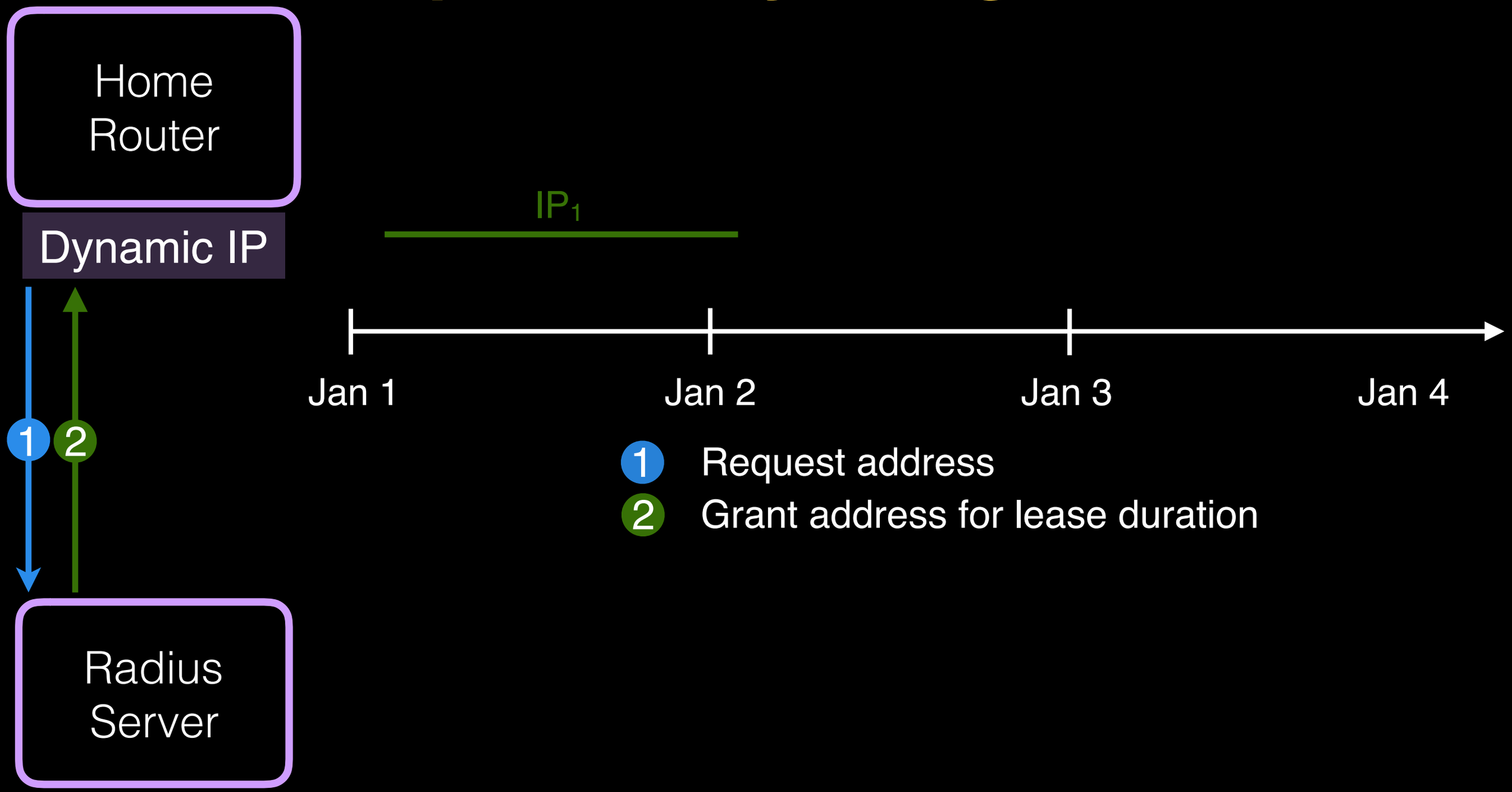

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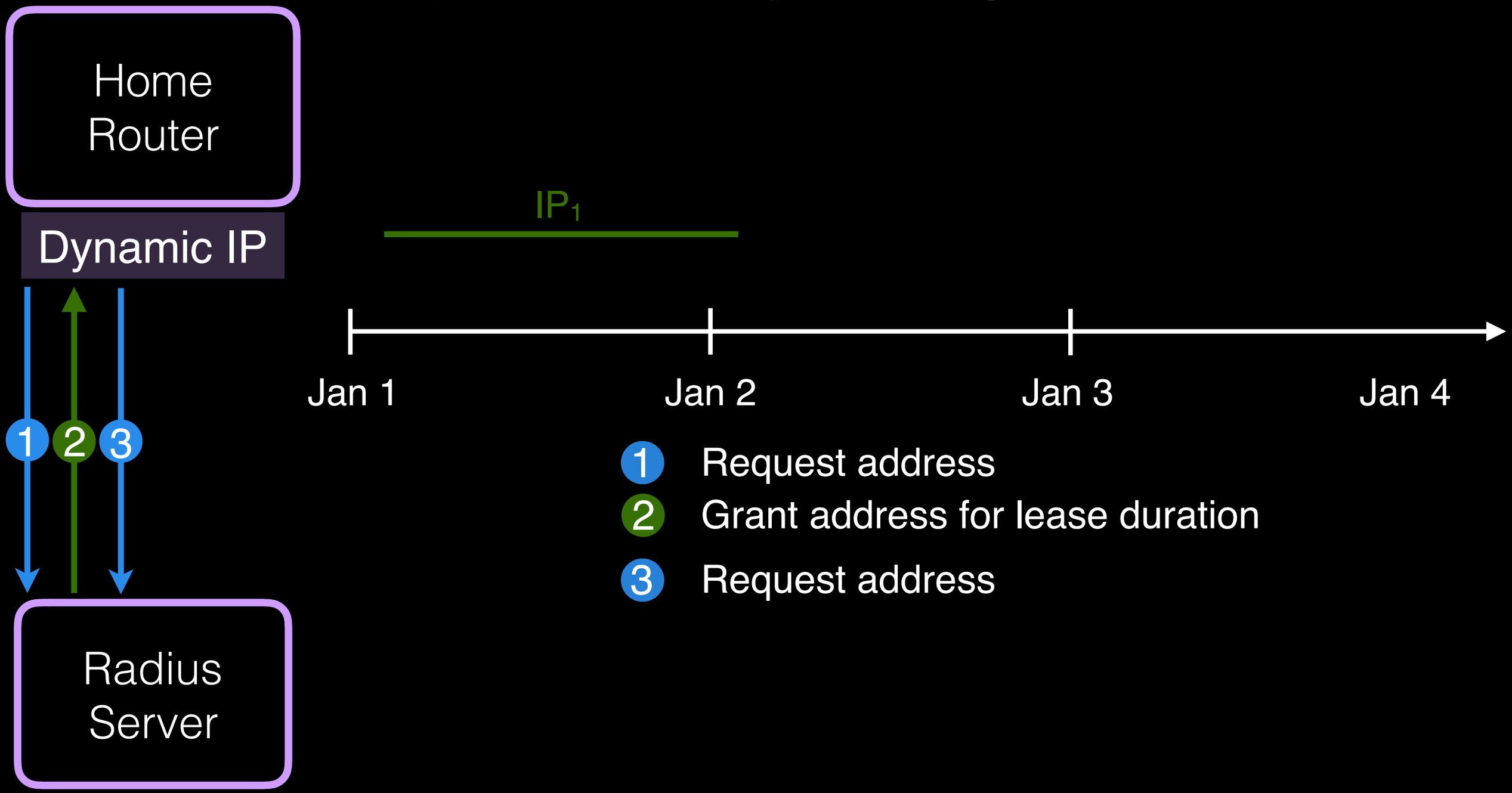
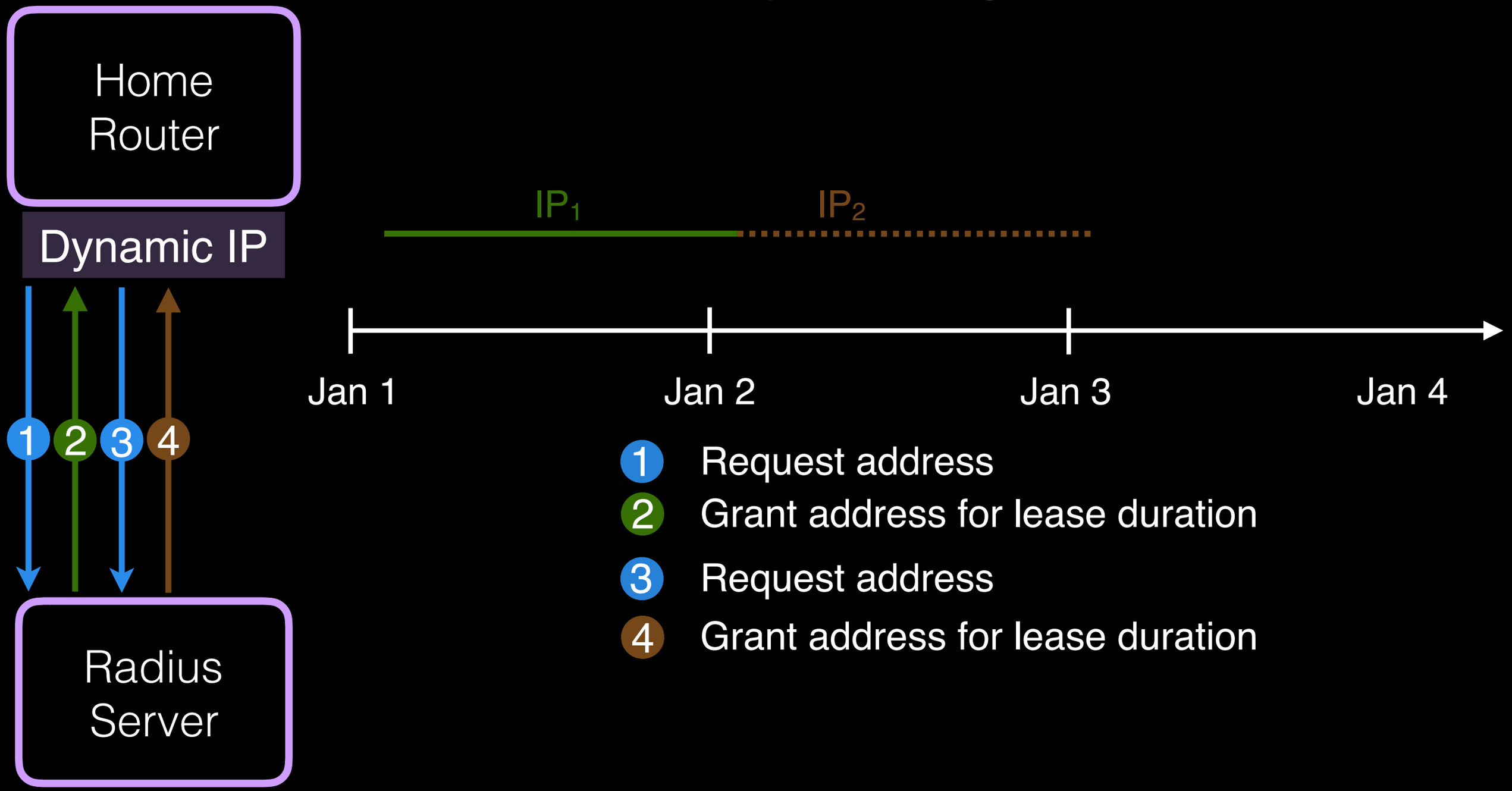


1. Request address
2. Grant address for lease duration
3. Request address

Protocols over PPP do not try to remember previously assigned address



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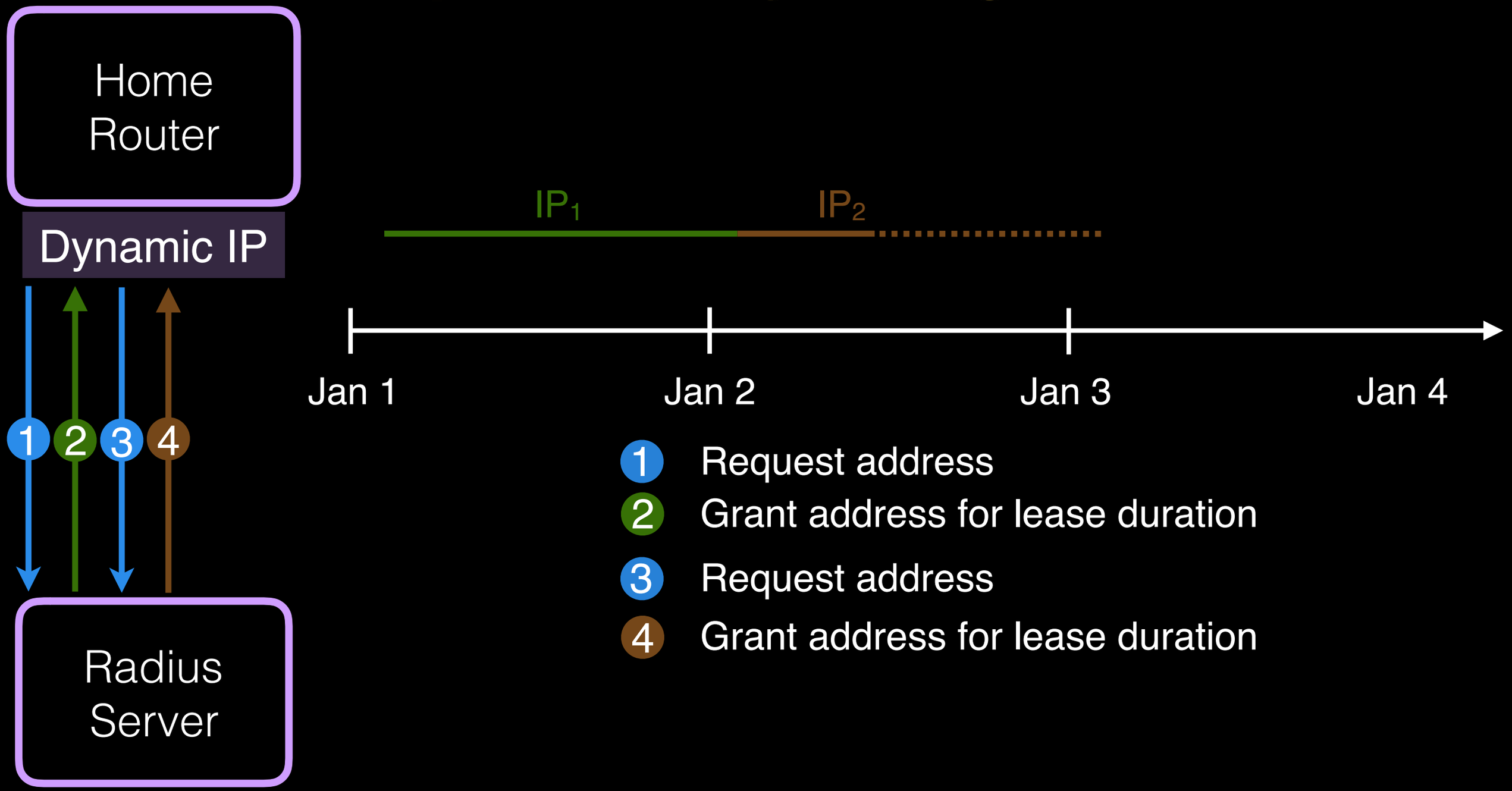

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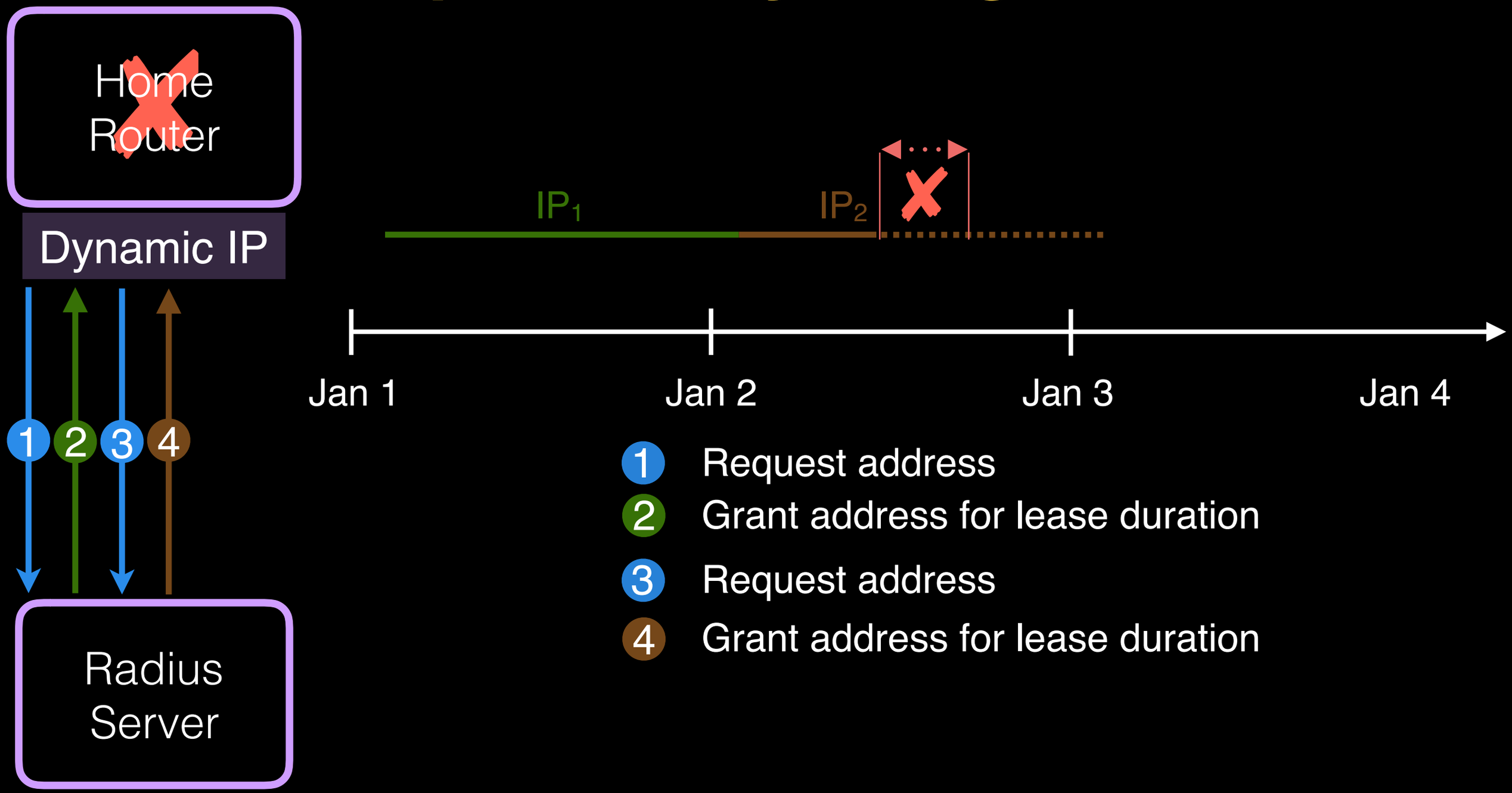

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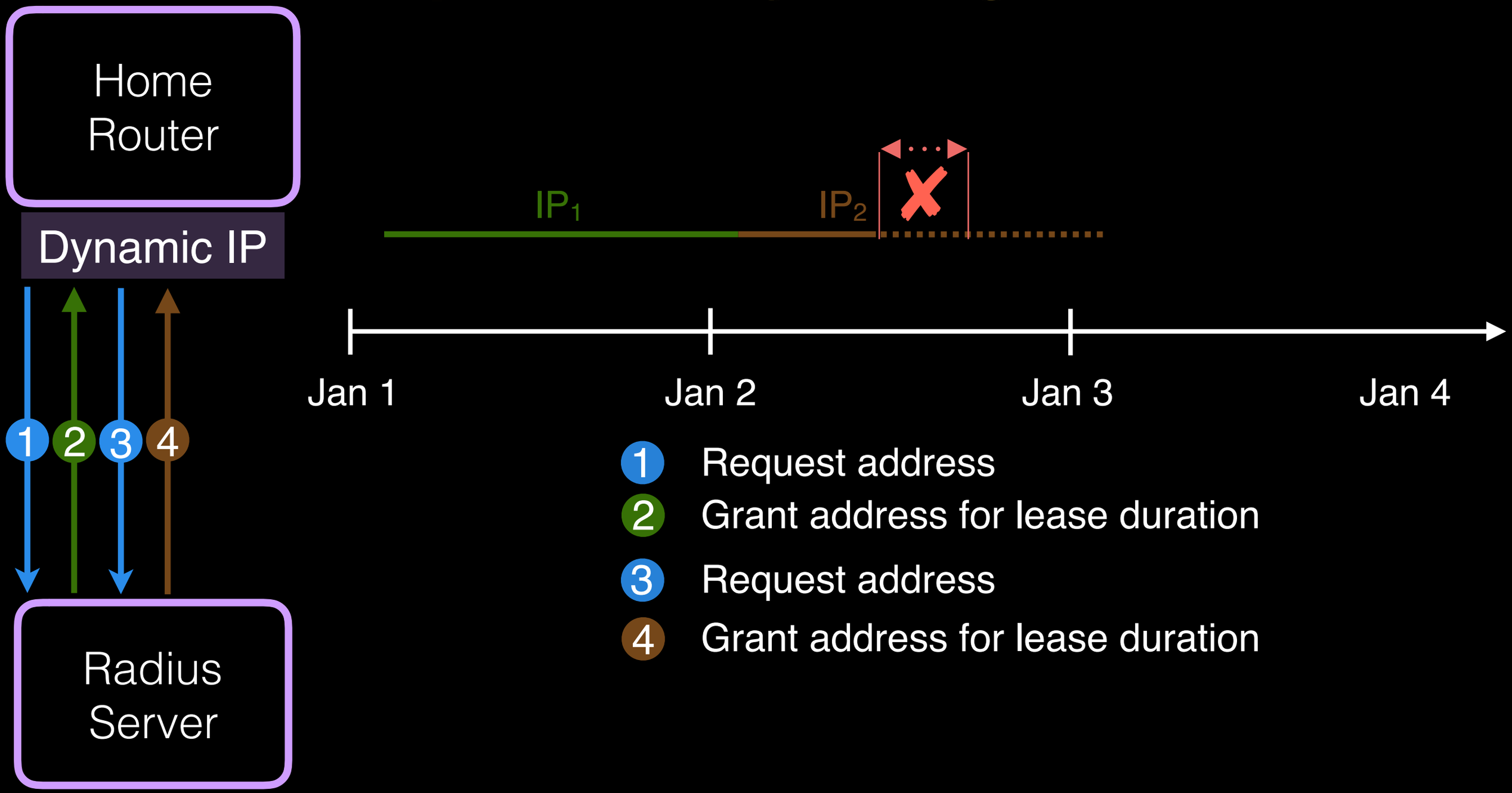

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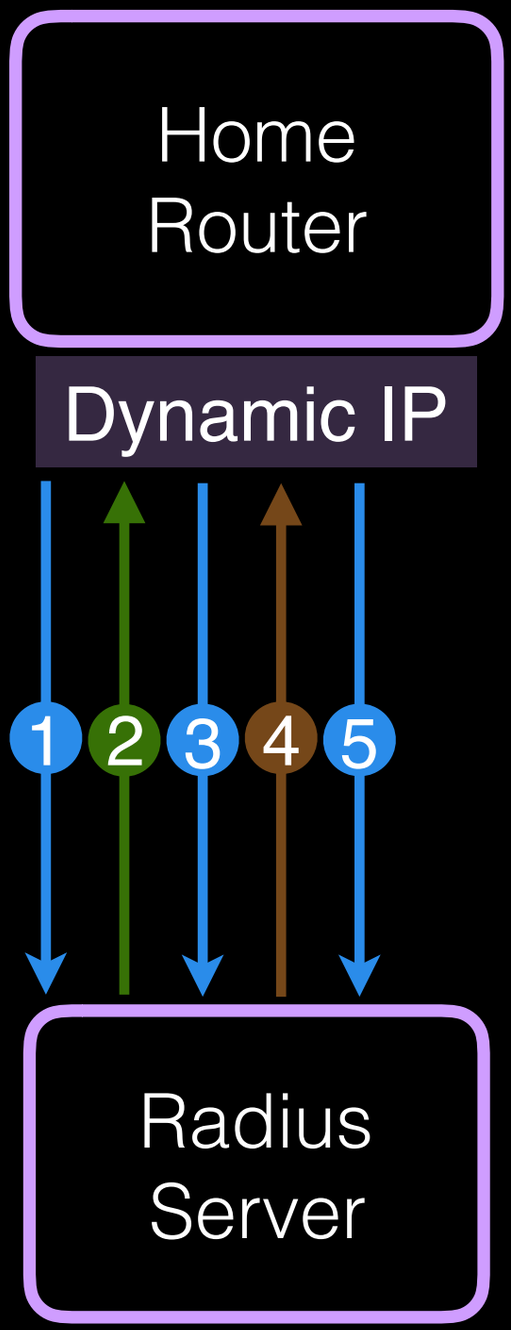

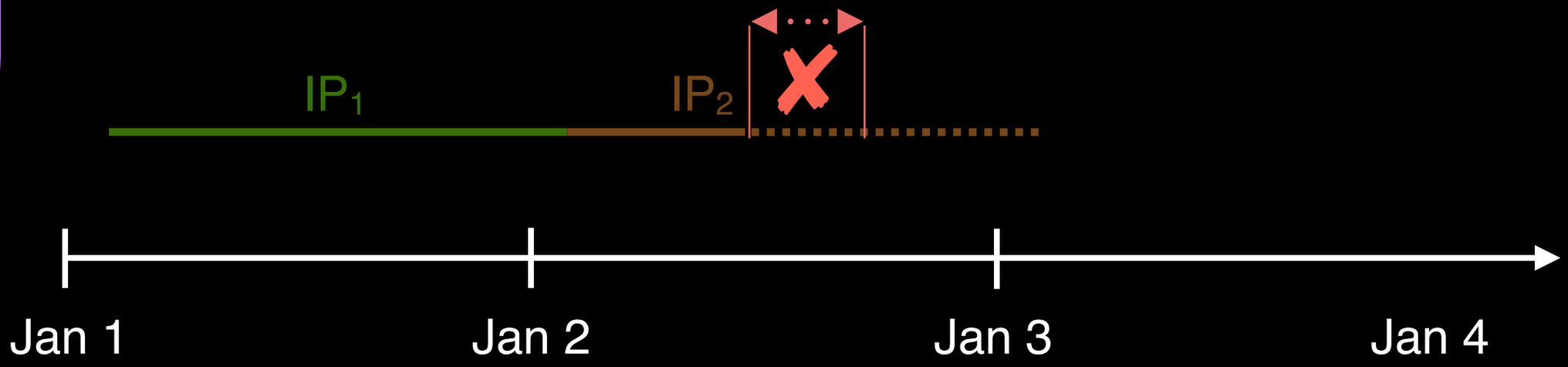

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3. Request address
4. Grant address for lease duration
5. Request address

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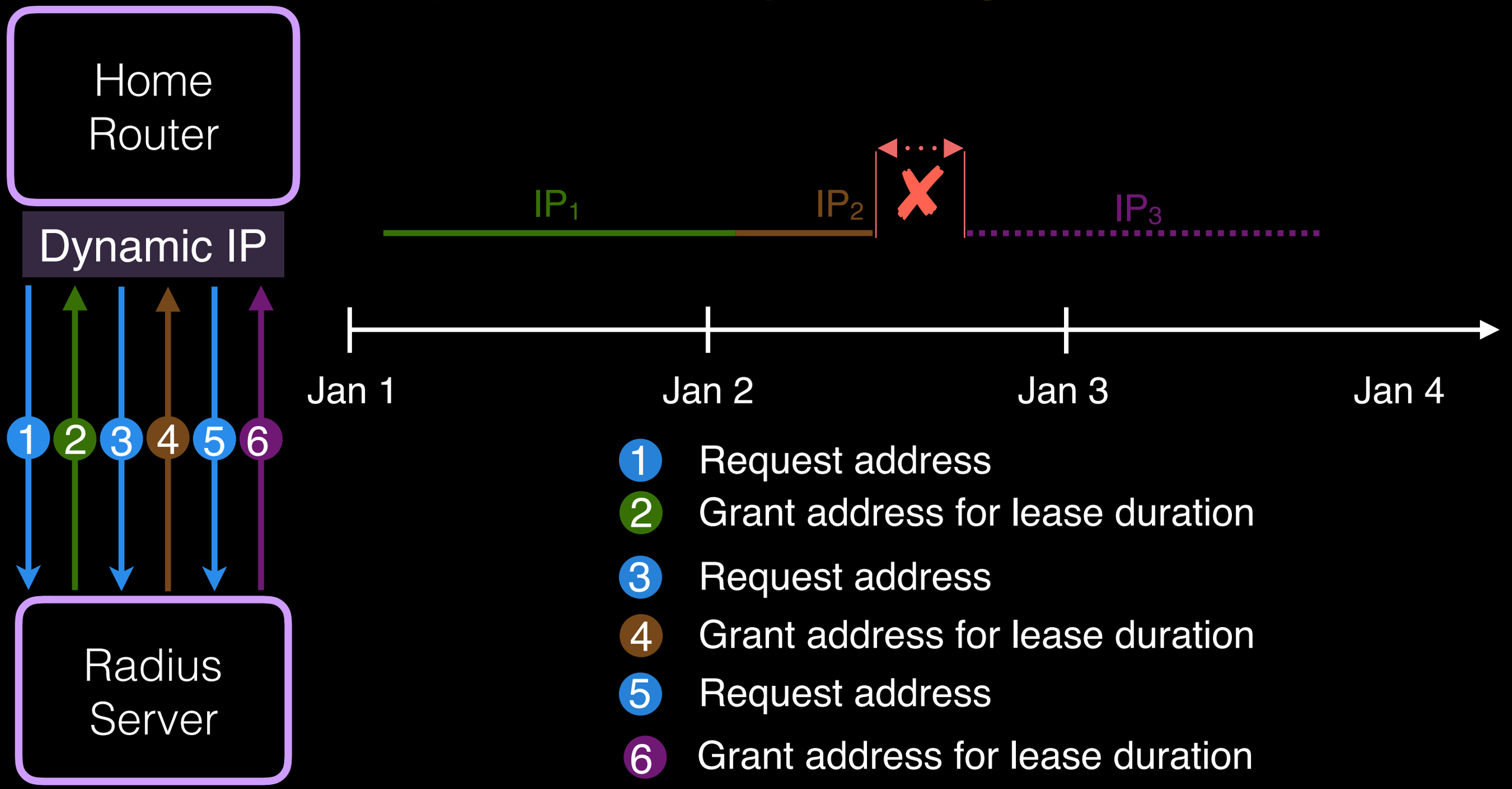

Outage-induced address changes: Summary

Of 95 ISPs with at least 5 probes, 10 ISPs had probes that changed addresses upon most **outages**

7 of them also changed addresses periodically

Perhaps we can use address change behavior to infer link type?

Would blacklisting an entire prefix block a user?

Would blacklisting an entire prefix block a user?

1.2.x.x **Same /16**

1.2.3.4 

1.x.x.x **Same /8**

How many address changes are not across the same prefix?

How many address changes are not across the same prefix?

AS	Diff /16 address changes		Diff /8 address changes	
Orange	6,961	67%	5,513	53%
BT	2,685	68%	1,735	44%
LGI	168	55%	136	45%
DT	5,391	28%	4,610	24%
Verizon	241	23%	209	20%

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Often, successive addresses are assigned from different prefixes!

How long can dynamic IP addresses be end-host identifiers?

Background

Detecting address changes

Analyze **periodic**

Analyze **outage**

Conclusions

How long can dynamic IP addresses be end-host identifiers?

Background

Detecting address changes

Analyze **periodic**

Analyze **outage**

Conclusions

Future Work

- RIPE Atlas deployment is small compared to number of home routers with dynamic addresses
  - Can’t analyze IPv6 with **connection logs**
- Would love to collaborate and put together multiple datasets to build a global dynamic addressing model