Analyzing IPv6 address assignment practices

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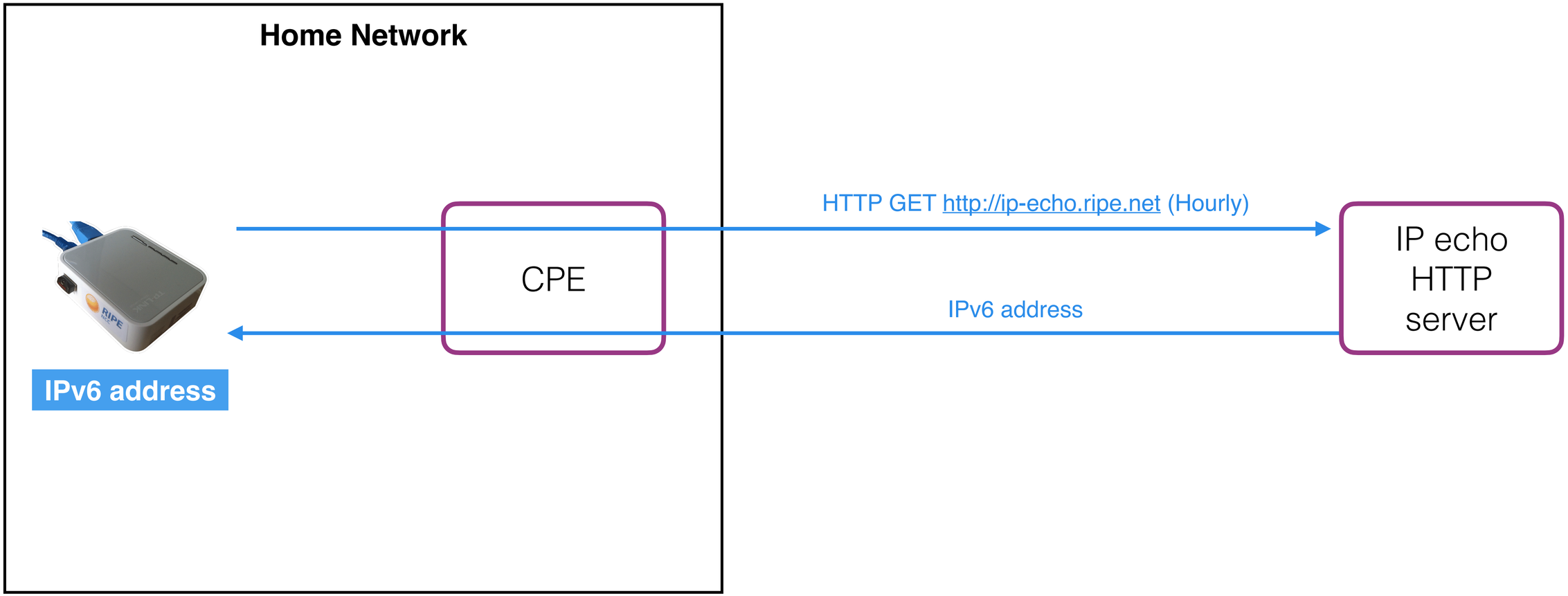
Goal: Understand the stability of IPv6 addresses

- How long do devices retain their IPv6 addresses?
- If the device's address changes, how far away in the address space is the new address?

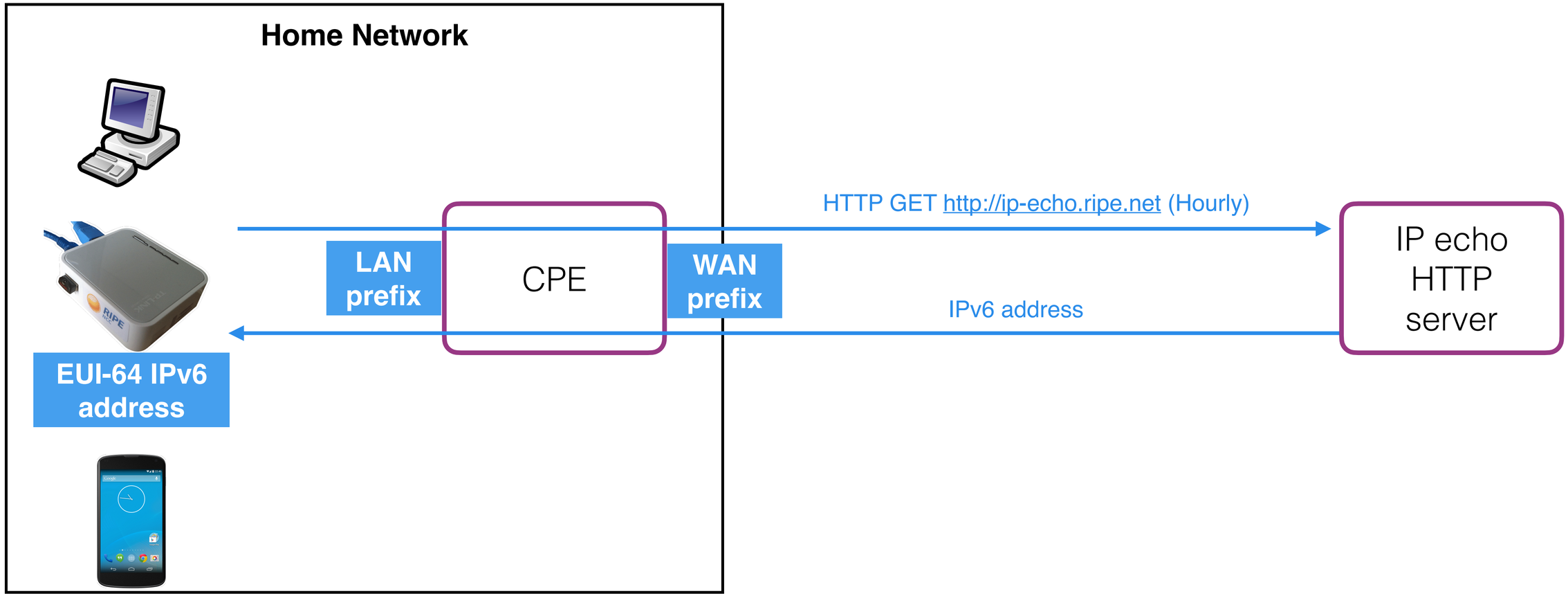
Motivating applications

- Host reputation, tracking
  - This work can inform how long to consider an IP address “risky”
- Identifying candidate addresses for active probing
  - Prior work generates hitlists of addresses
  - If a device’s address changes, this work can inform where to look for the device

Dataset: RIPE Atlas
“IP echo” measurements



The IP echo dataset allows measuring properties of the CPE's LAN prefix



The IP echo dataset allows measuring properties of the CPE's LAN prefix

- We used IP echo measurements from August 2014 to December 2019
- We find an address change when a probe reports a different address in the IP echo measurement
  - Since probes use EUI-64 addresses, address changes indicate changes in the CPE's LAN prefix
  - ~3000 probes observed at least one address change

Atlas probes' IPv6 addresses are typically temporally stable

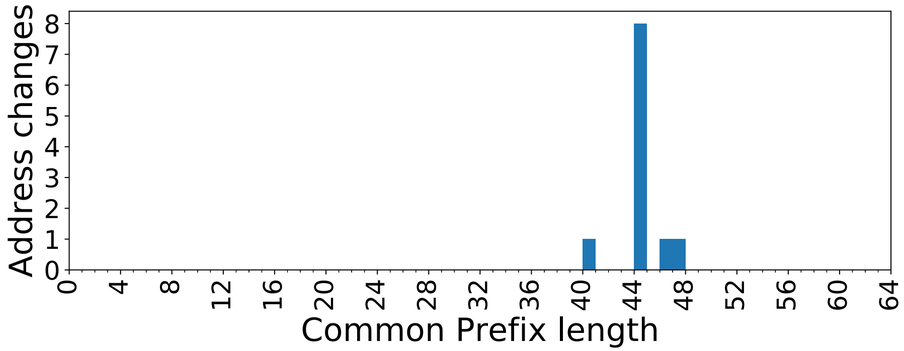
- In previous work, we found that IPv4 addresses in many ASes are short-lived
  - Assignment durations tended to be O(weeks)
  - Many ASes reassigned addresses periodically
- Comparatively, IPv6 addresses are long-lived
  - Durations tend to be O(months)
  - Only a few ASes reassign addresses periodically: DTAG, Versatel, Netcologne, ANTEL, Global Village

How can we find a device after its address changes?

- Suppose we want to track an EUI-64 device
- If its CPE LAN prefix changes, where in the address space do we look for the device?
  - Can be a function of ISP property + CPE property
  - ISP may choose to delegate a new prefix to the CPE
  - CPE may choose to advertise a new prefix within ISP delegated prefix

We first analyze the common prefix lengths between successive addresses

Find how many bits match in successive addresses assigned to the same probe	Common prefix length
2a02:908:0d83:c780:6666:b3ff:feb0:ede8	44
2a02:908:0d88:d9a0:6666:b3ff:feb0:ede8	44
2a02:908:0d82:b2c0:6666:b3ff:feb0:ede8	46
2a02:908:0d81:a3e0:6666:b3ff:feb0:ede8	47
2a02:908:0d80:8840:6666:b3ff:feb0:ede8	44
2a02:908:0d89:9940:6666:b3ff:feb0:ede8	44
2a02:908:0d80:8840:6666:b3ff:feb0:ede8	44
2a02:908:0d88:0ba0:6666:b3ff:feb0:ede8	44
2a02:908:0d82:7120:6666:b3ff:feb0:ede8	40
2a02:908:0d76:fb40:6666:b3ff:feb0:ede8	44
2a02:908:0d78:2520:6666:b3ff:feb0:ede8	44



Upon address change, search for the device within the same /44

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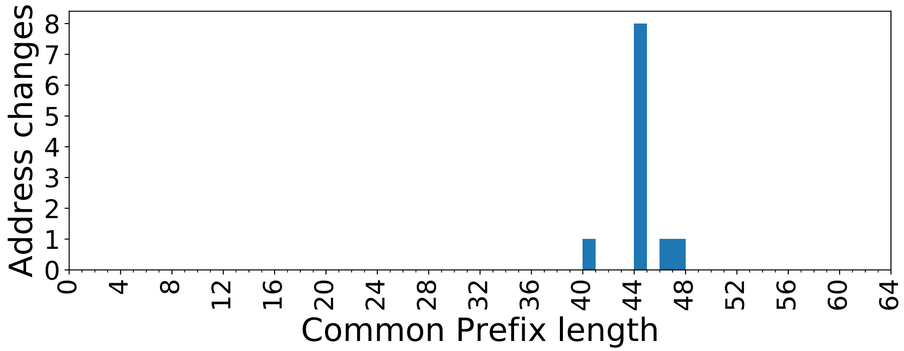
2a02:908:0d82:b2c0:6666:b3ff:feb0:ede8	46
2a02:908:0d81:a3e0:6666:b3ff:feb0:ede8	47
2a02:908:0d80:8840:6666:b3ff:feb0:ede8	44
2a02:908:0d89:9940:6666:b3ff:feb0:ede8	44
2a02:908:0d80:8840:6666:b3ff:feb0:ede8	44
2a02:908:0d88:0ba0:6666:b3ff:feb0:ede8	44
2a02:908:0d82:7120:6666:b3ff:feb0:ede8	40
2a02:908:0d76:fb40:6666:b3ff:feb0:ede8	44
2a02:908:0d78:2520:6666:b3ff:feb0:ede8	44



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2a02:908:0d81:a3e0:6666:b3ff:feb0:ede8	47
2a02:908:0d80:8840:6666:b3ff:feb0:ede8	44
2a02:908:0d89:9940:6666:b3ff:feb0:ede8	44
2a02:908:0d80:8840:6666:b3ff:feb0:ede8	44
2a02:908:0d88:0ba0:6666:b3ff:feb0:ede8	44
2a02:908:0d82:7120:6666:b3ff:feb0:ede8	40
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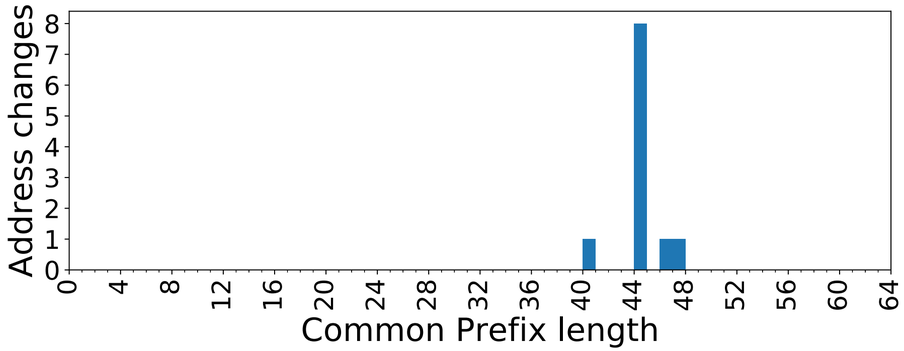
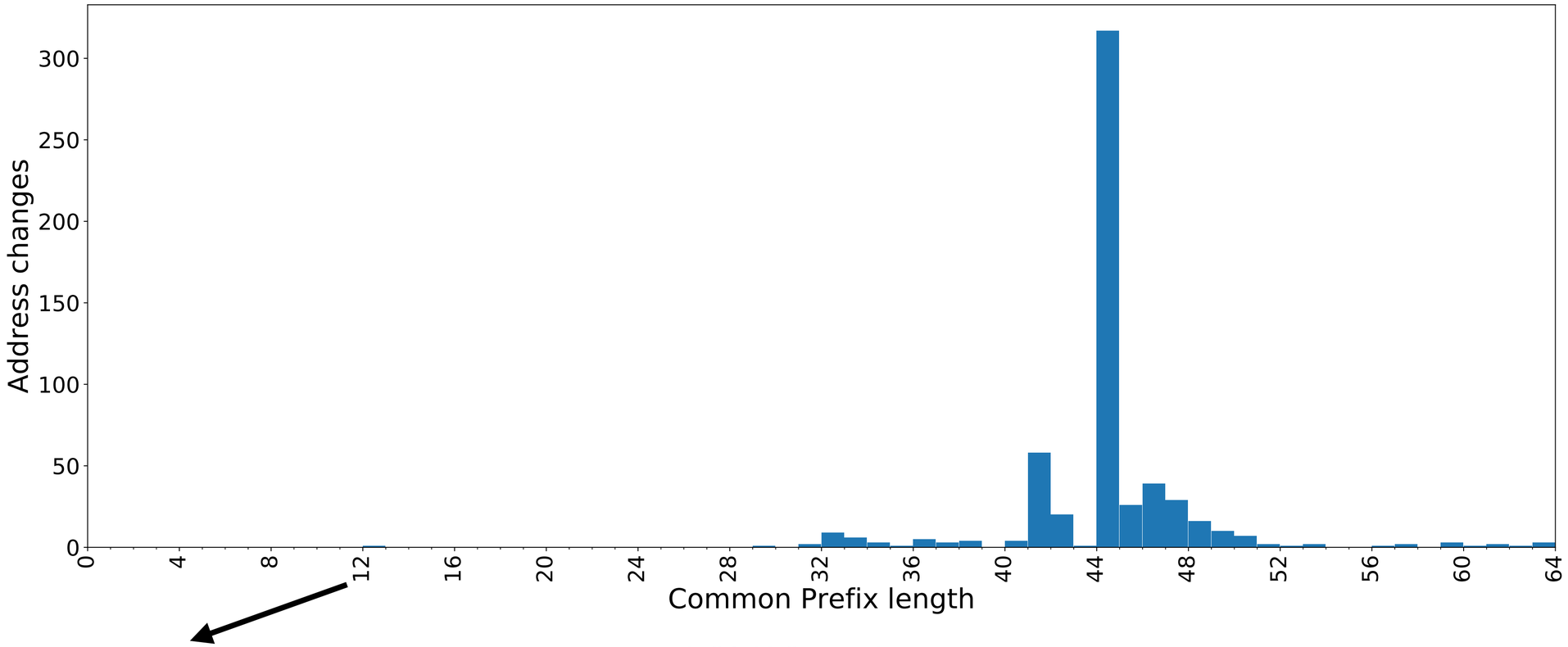


Upon address change, search for the device within the same /44

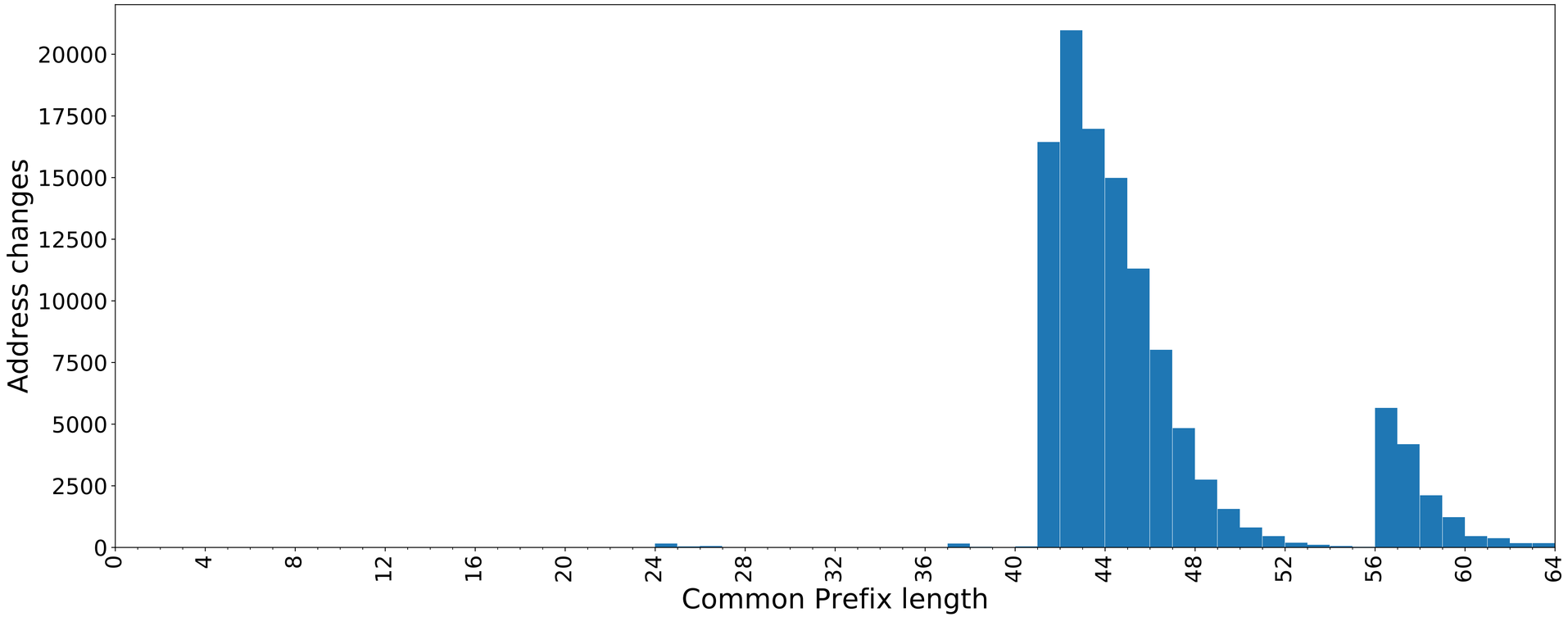
For LGI, subsequent addresses typically belong to the same /44



2a01:5e0:34:ffff:a62b:b0ff:fee0:848
to
2a0b:c180:34:ffff:a62b:b0ff:fee0:848

LGI (AS6830)
103 probes
580 address-changes

Multiple behaviors appear to be occurring in DT



DT (AS3320)
387 probes
114432 address-changes

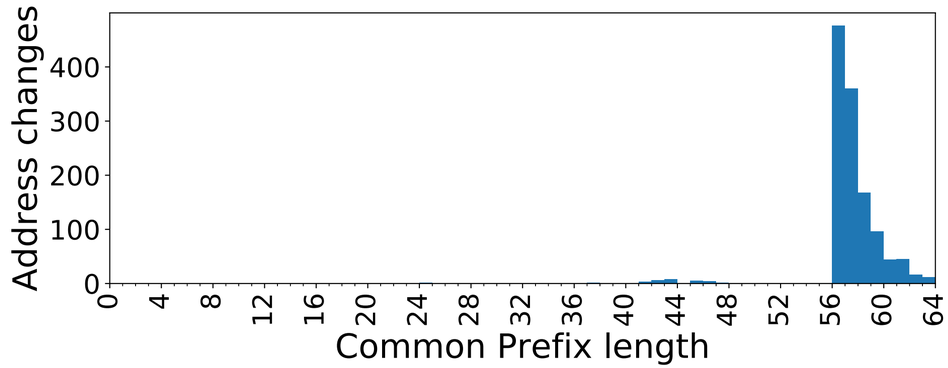
Some probes change addresses mostly within the same /56

Probe ID 2702, 1246 address changes, 30 unique /56s

…

2003:0058:bd1b:06b1:220:4aff:fee0:2171
2003:0058:bd1b:0666:220:4aff:fee0:2171
2003:0058:bd1b:06b8:220:4aff:fee0:2171
2003:0058:bd1b:0617:220:4aff:fee0:2171
2003:0058:bd1b:0631:220:4aff:fee0:2171
2003:0058:bd68:87be:220:4aff:fee0:2171
2003:0058:bd68:8737:220:4aff:fee0:2171
2003:0058:bd68:8710:220:4aff:fee0:2171
2003:0058:bd68:8753:220:4aff:fee0:2171
2003:0058:bd68:87d6:220:4aff:fee0:2171

…



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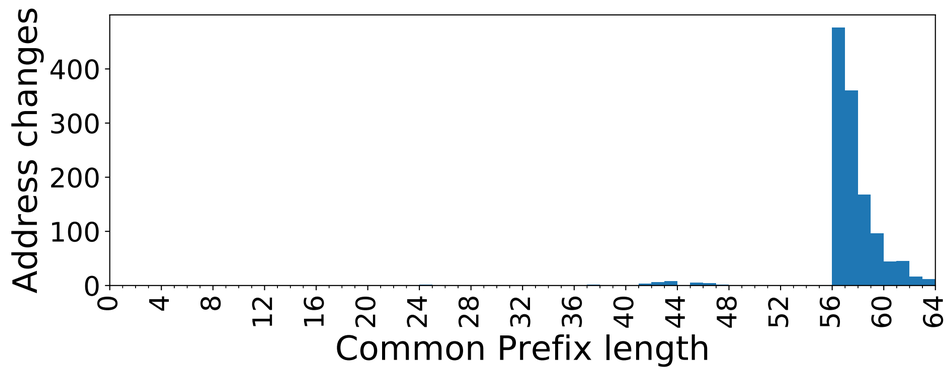
2003:0058:bd1b:06b8:220:4aff:fee0:2171
2003:0058:bd1b:0617:220:4aff:fee0:2171
2003:0058:bd1b:0631:220:4aff:fee0:2171
2003:0058:bd68:87be:220:4aff:fee0:2171
2003:0058:bd68:8737:220:4aff:fee0:2171
2003:0058:bd68:8710:220:4aff:fee0:2171
2003:0058:bd68:8753:220:4aff:fee0:2171
2003:0058:bd68:87d6:220:4aff:fee0:2171

…



Upon address change, search for the device within the same /56

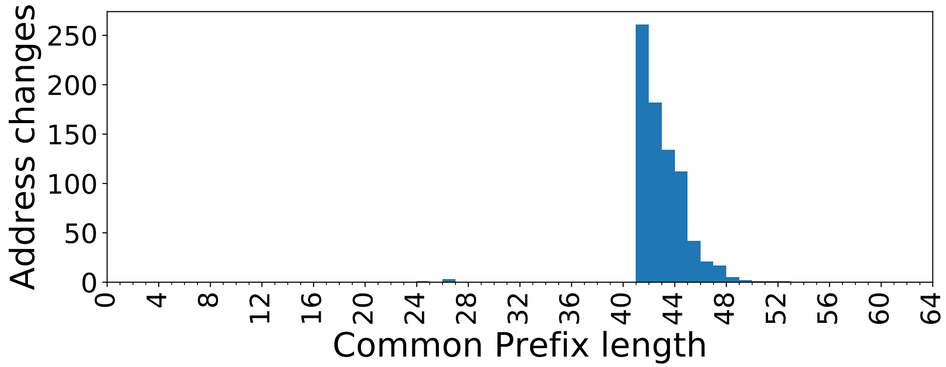
Other probes change addresses mostly within the same /40 but different /56s

Probe ID 23839, 783 address changes, 780 unique /56s, 3 unique /40s

…

2003:007a:0558:e400:16cc:20ff:fe48:d52a
2003:007a:0506:8800:16cc:20ff:fe48:d52a
2003:007a:0510:0500:16cc:20ff:fe48:d52a
2003:007a:056a:7800:16cc:20ff:fe48:d52a
2003:007a:056d:9c00:16cc:20ff:fe48:d52a
2003:00e3:571e:f400:16cc:20ff:fe48:d52a
2003:00e3:5715:e800:16cc:20ff:fe48:d52a
2003:00e3:571c:9700:16cc:20ff:fe48:d52a
2003:00e3:5727:de00:16cc:20ff:fe48:d52a
2003:00e3:572c:8d00:16cc:20ff:fe48:d52a

…



Upon address change, search for the device within the same /41

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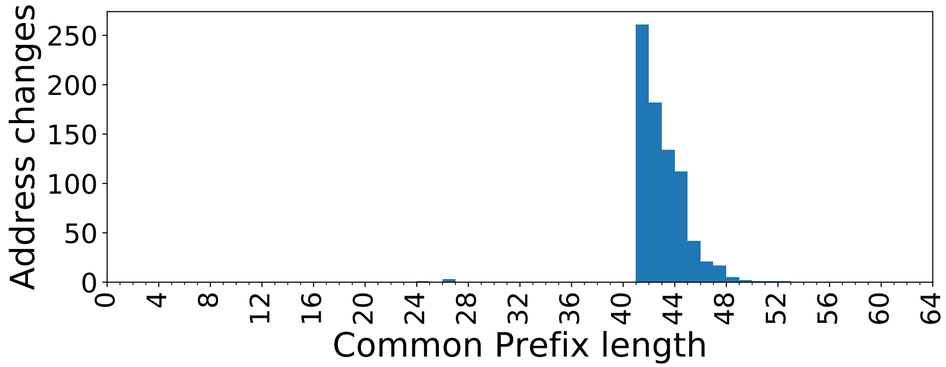
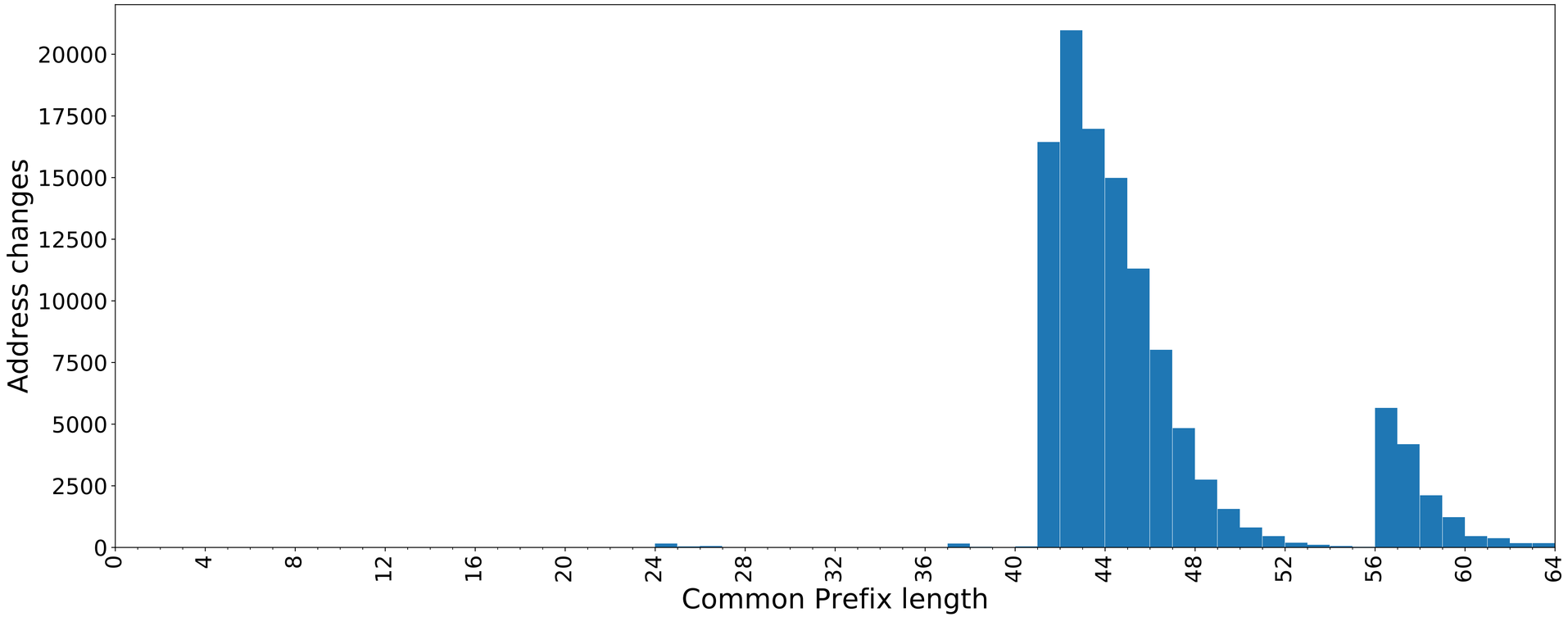
2003:007a:0558:e400:16cc:20ff:fe48:d52a
2003:007a:0506:8800:16cc:20ff:fe48:d52a
2003:007a:0510:0500:16cc:20ff:fe48:d52a
2003:007a:056a:7800:16cc:20ff:fe48:d52a
2003:007a:056d:9c00:16cc:20ff:fe48:d52a
2003:00e3:571e:f400:16cc:20ff:fe48:d52a
2003:00e3:5715:e800:16cc:20ff:fe48:d52a
2003:00e3:571c:9700:16cc:20ff:fe48:d52a
2003:00e3:5727:de00:16cc:20ff:fe48:d52a
2003:00e3:572c:8d00:16cc:20ff:fe48:d52a

…



Upon address change, search for the device within the same /41

Are we observing a combination of CPE + ISP properties?



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387 probes
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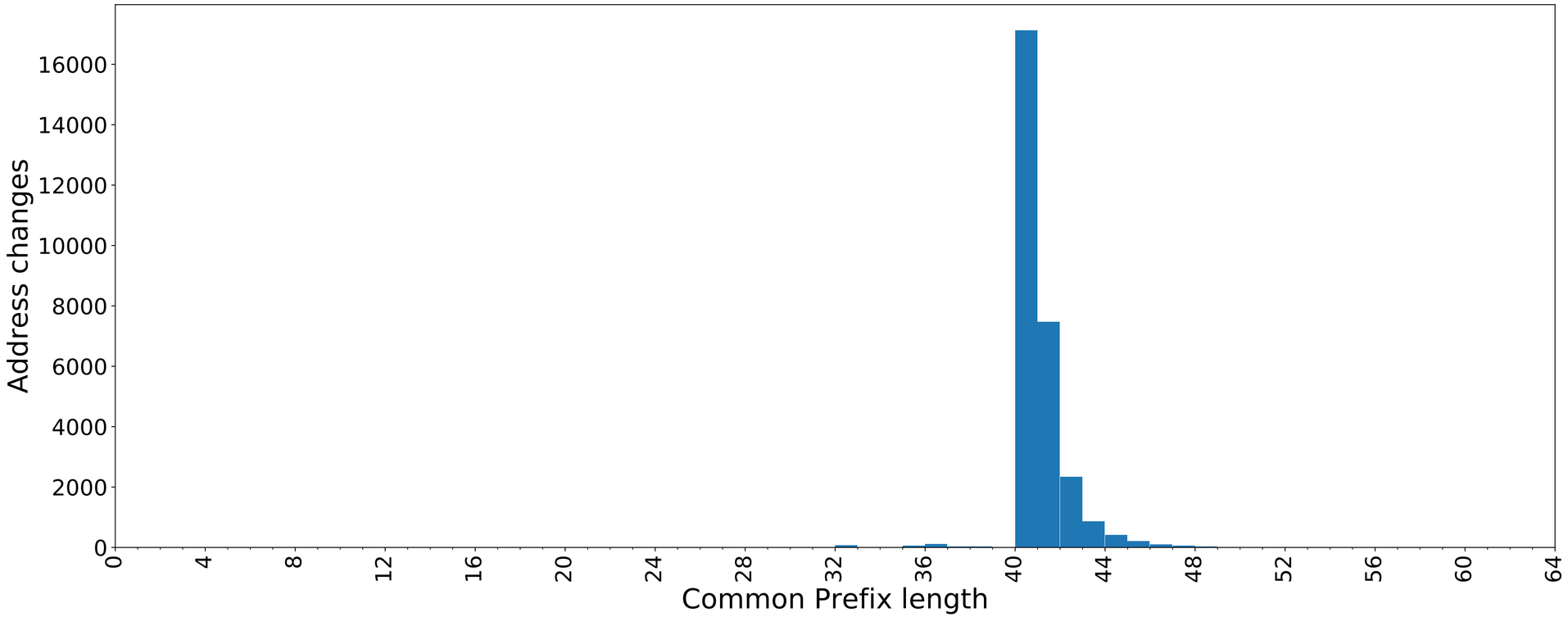
We are looking to collaborate and validate

- Ongoing work
  - Investigate delegated prefix lengths
  - Compare address changes in IPv6 and IPv4
  - Investigate per-prefix properties
- Are there pieces we can work on together?
  - EUI-64 addresses can also serve as host-identifiers (modulo mobility)

Backup slides: Versatel (AS8881)



Versatel (AS8881)
55 probes
28983 address-changes