Flow-based Identification of Failures Caused by IPv6 Transition Mechanisms

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Overview

- Motivation and Goals
- Investigated v4-to-v6 Transitioning Technologies
  - NAT64
  - Dual-Stack Lite
- NetFlow and NFQL
- Experimental Setups and Results
- Failure Analysis
- Conclusion

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an Inflection Point

[1, 2]

- (1990s)

  IETF defined IPv6

  ⋮

- (Feb 2011)

  IANA exhausts its pool of IPv4 addresses

- (April 2011)

  APNIC released its final /8 block; last stage

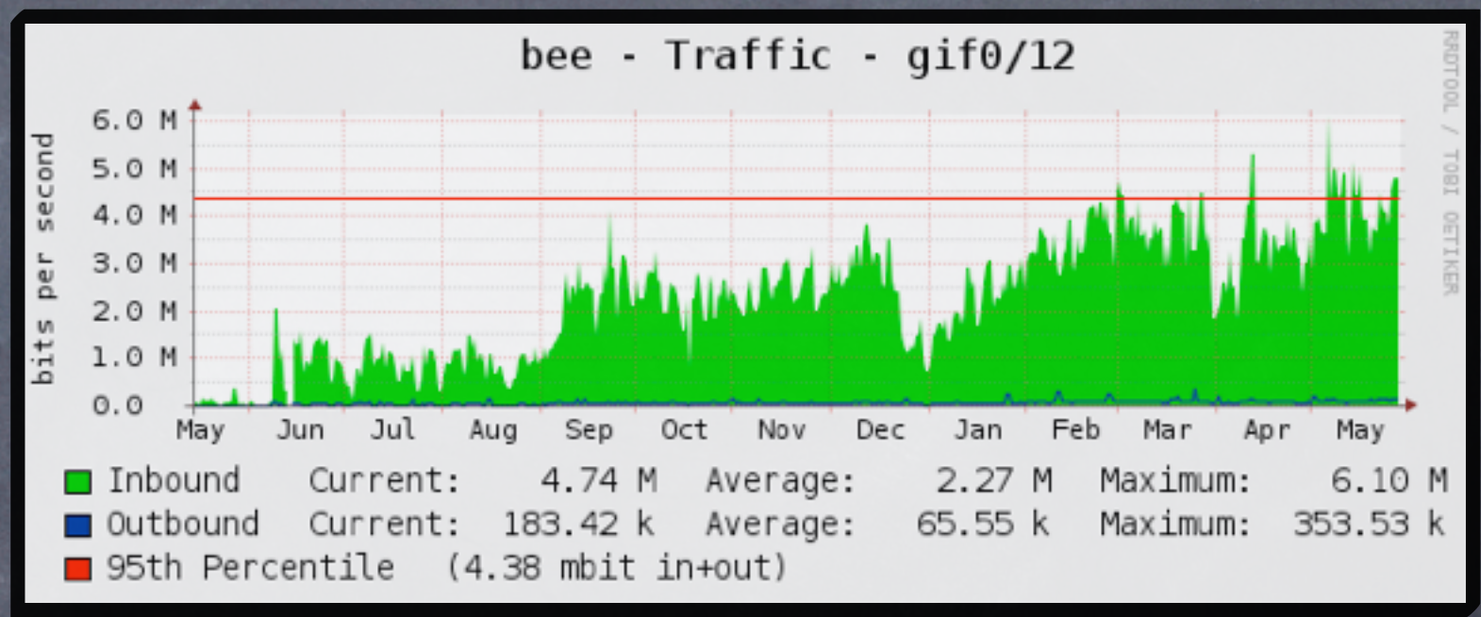
an Inflection Point

- Why the delay?
  - lack of any economic advantage to deploy IPv6
  - lack of IPv6-only killer applications
  - huge amount of IPv4-only content
  - large number of legacy IPv4-only applications

- Possible solutions?
  - wider/layered NAT deployments
  - transitioning mechanisms that do NOT disrupt IPv4 content delivery over IPv6

Events Enabling the Migration

- (June 2012)
  World IPv6 Launch Day
- (June 2011)
  World IPv6 Day
- (January 2009)
  Google over IPv6 [3, 4]



- (By 2009)
  Production quality IPv6 implementations available on all major OS
- (Since 2004)
  Native IPv6 available at Jacobs University Bremen

Goals

- detect which applications, protocols and online services fail when operating under IPv6 transitioning mechanisms.
- investigate whether it's possible to automate the failure identification by formulating queries on generated NetFlow flow records.

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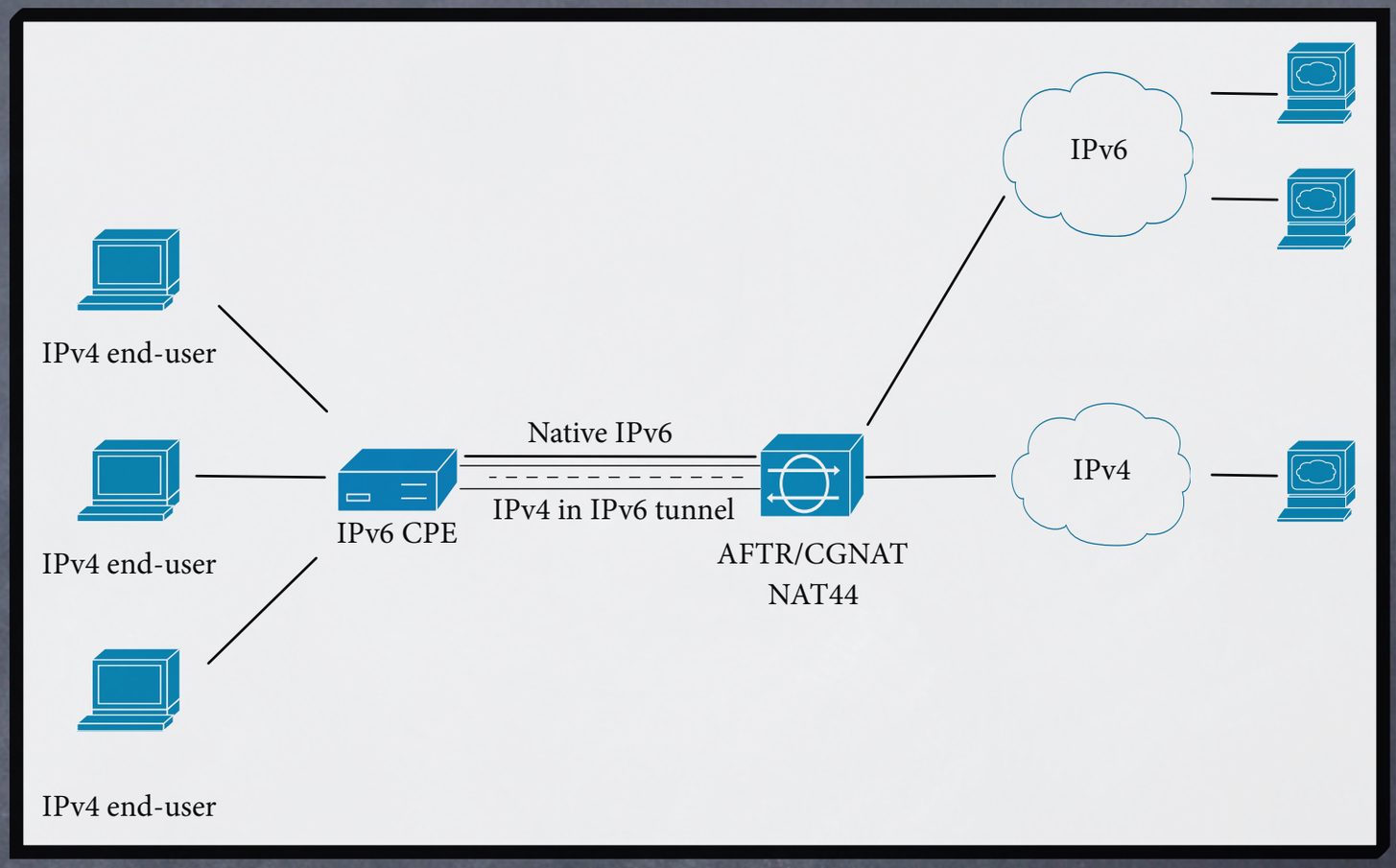
Dual-Stack Lite[5]

IPv6-only link between the customer and ISP.

IPv4-in-IPv6 encapsulation at the CPE.

Decapsulation and NAT44 at the ISP CGNAT.



\+ public IPv4 address shared between several customers

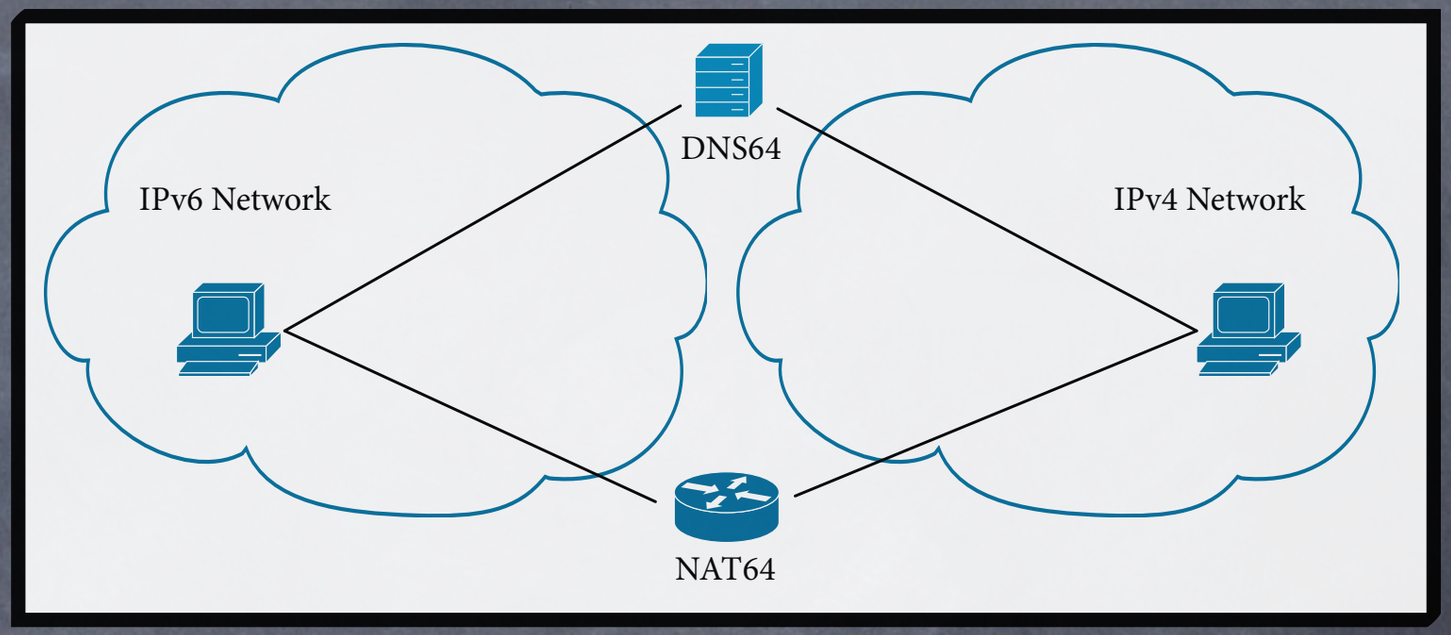
\- customers end needs an upgrade with the CPE functionality

NAT64/DNS64[6]

clients are IPv6-only.

DNS64 generates fake AAAA records for a v4 destination

v6 to v4 packet header translation at NAT64



- all devices and applications in NAT64 domain must be v6 ready.
- applications using direct v4 literals will fail.
- DNSSEC validation will fail.

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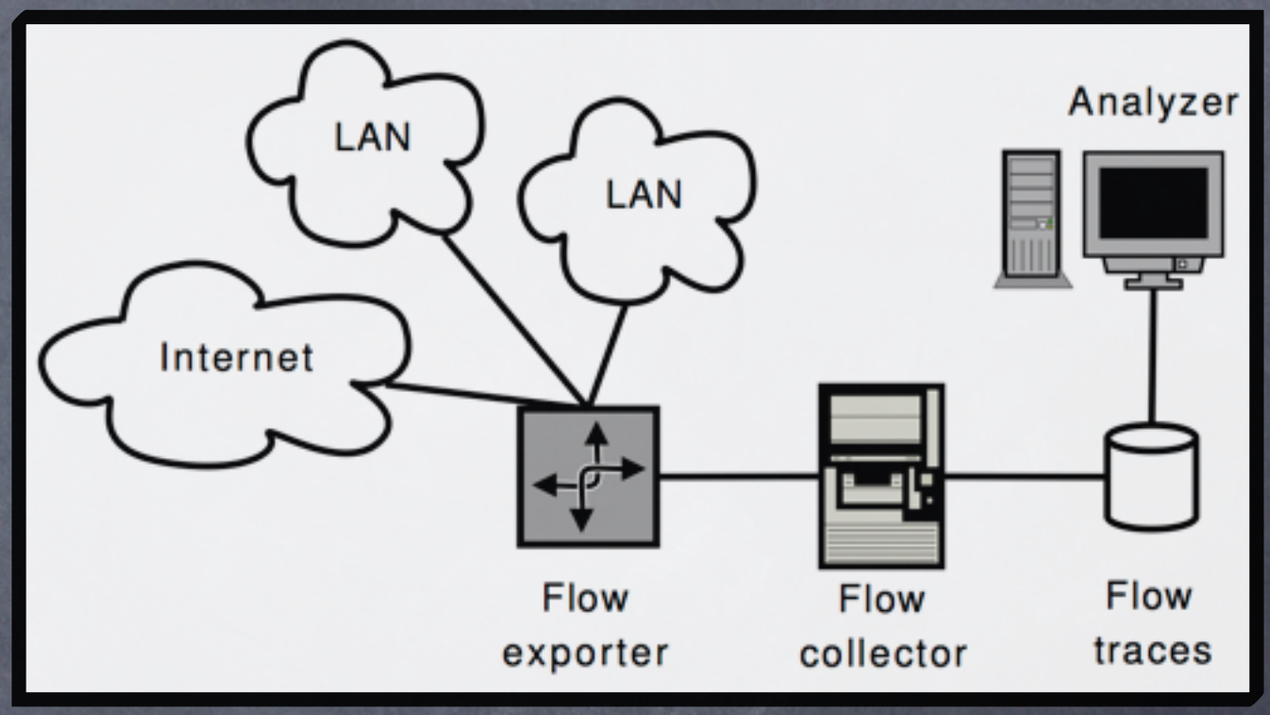
NetFlow and NFQL

Cisco NetFlow:

protocol to aggregate traffic as flow-records sharing some common properties defined by a set of flow-keys

exporter exports flow-records via a predefined expiration rule



NFQL:

a stream-based flow-record query language

helps describe complex relationships among set of flows.

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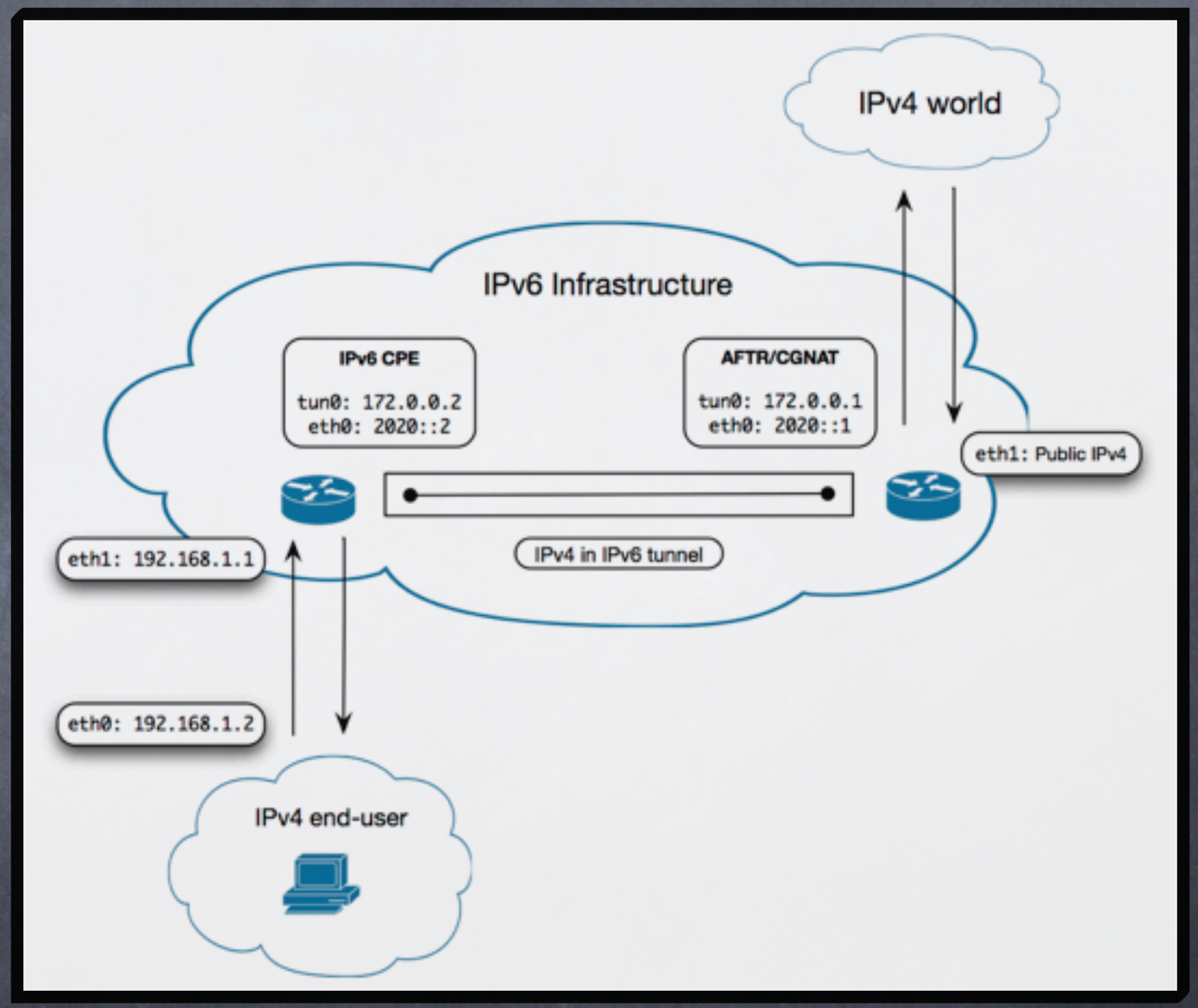
Dual-Stack Lite[5]

IPv6 CPE and CGNAT running Debian while IPv4 only host running Mac OS X

using `ip_tunnel` kernel module to bring up a `ipip6` tunnel

using `iptables` for IPv4 forwarding and NATing with the public IPv4 address



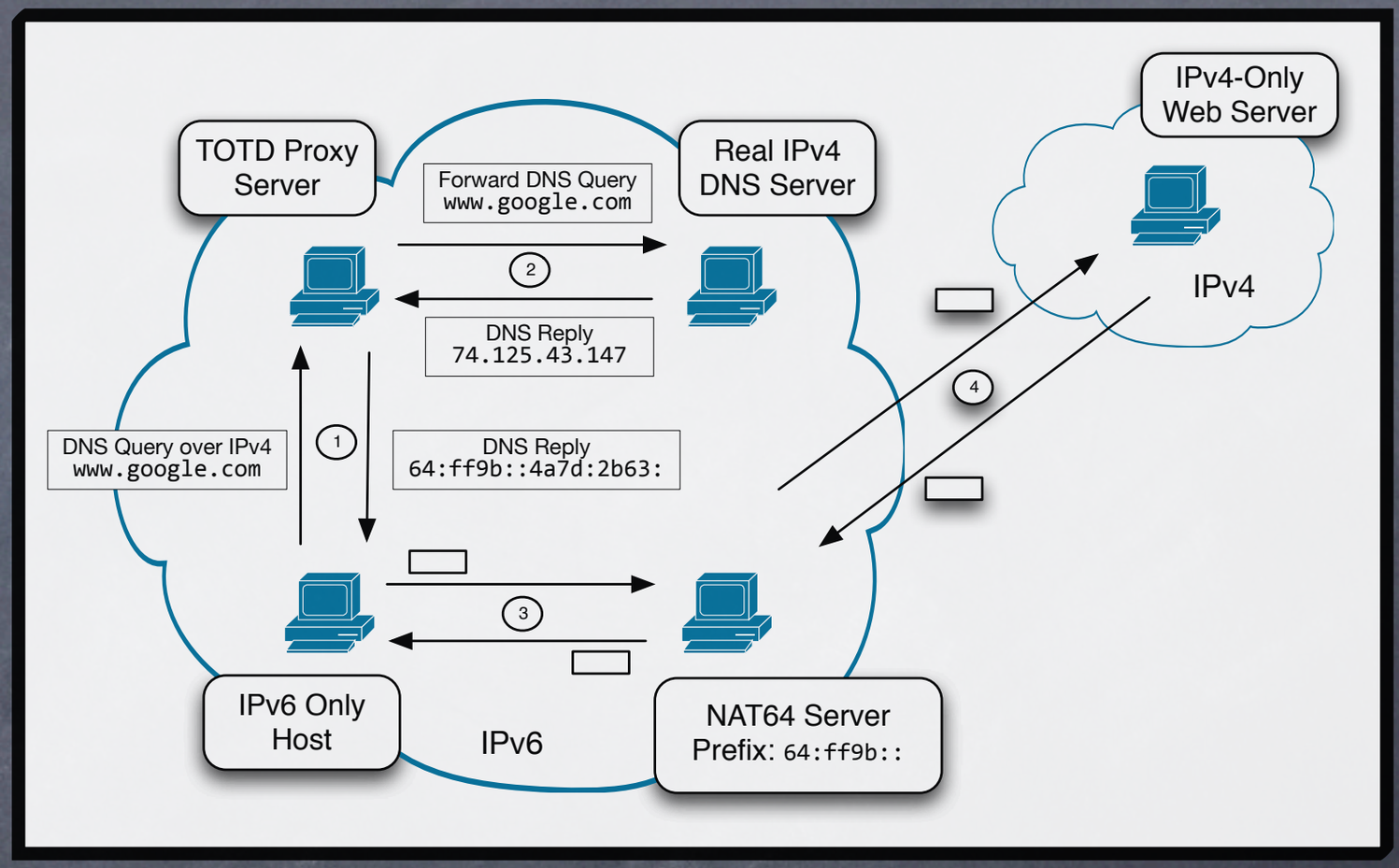
detailed setup instructions are at [7]

NAT64/DNS64 [6]

IPv6-only host runs Mac OS X while DNS64 and NAT64 boxes run Debian

DNS64 box runs `totd` to forward request to 8.8.8.8 and return back a fake IPv6 address

NAT64 box runs `ecdysis` to perform IP-ICMP translation and to maintain a NAT binding table



detailed setup instructions are at [7]

Results

Applications and Services Tested	DS-Lite	NAT64
- Webmail: Gmail using TLSv1 - Media: YouTube (Flash, HTML5) - Google Maps - HTTP and FTP Downloads - Web Chat: Gmail, Yahoo, Freenode IRC	✔	✔
- IMAP: Gmail and Microsoft Exchange - POP3: Gmail - SMTP: Gmail and Microsoft Exchange	✔	✔
- SSH, - IRC, - Git, Mercurial - iChat,	✔	✔
- Skype - Transmission (Bit Torrent) - OpenVPN - SIP (Linphone)	✔	✘

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Failure Analysis for NAT64

- Skype **No IPv6**
  - fails to discover local clients with mDNS due to v4 literals
  - tries contacting the v4 destination login server
    - DNS64 hands in a fake AAAA record
    - all subsequent attempts failed, no v6 support in client.

- Transmission (Bit torrent) **Partial IPv6**
  - successful connection to the tracker
  - retrieves list of peers and seeders.
  - fails to connect to any peer/seeder due to v4 literals.

- OpenVPN **Partial IPv6**
  - fails to connect to the remote endpoint due to v4 literals.

Failure Analysis for NAT64

- SIP (Linphone) **Full IPv6**
  - packet-level analysis (Wireshark)
    - SIP signaling
      - client sends `REGISTER` using its v6 address; receives 606.
      - NAT64 box sends subsequent `REGISTER` ; receives `OK`
      - outgoing call `INVITE` → `TRYING` → `RINGING` → `OK`
      - incoming call `INVITE` → `DIALOG ESTABLISHMENT` → `OPTIONS`
    - RTP streams
      - fails; SDP records identify endpoints using v4 literals

Failure Analysis for NAT64

- SIP (Linphone) **Full IPv6**
  - flow-level analysis
    - challenges:
      - to decide the appropriate export time
      - to distinguish SIP init-teardown from registration
        - registration traffic is implementation specific
        - registrations establish soft states
      - identification of absence RTP flows
        - no fixed port numbers for RTP
        - traffic characteristics of UDP flows depends on codec
    - lead to client-specific NFQL queries
    - such queries have large number of false positives

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Conclusion

- setup of NAT64 and DS-Lite on an experimental testbed
- variety of applications tested on NAT64 and DS-Lite
  - all tested applications passed on DS-Lite
  - some (4) applications failed on NAT64
- identified the causes for each application failure
  - little sense to define failure signatures on 3 of them **No IPv6**
  - SIP failure analysis at both packet and flow level
- SIP failures difficult to identify in flow-records
  - aggregation of traffic in flow-records
  - difficulty to identify invoked SIP methods
  - lack of precision to classify UDP flows as RTP flows

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