Performance Implications of Unilateral Enabling of IPv6

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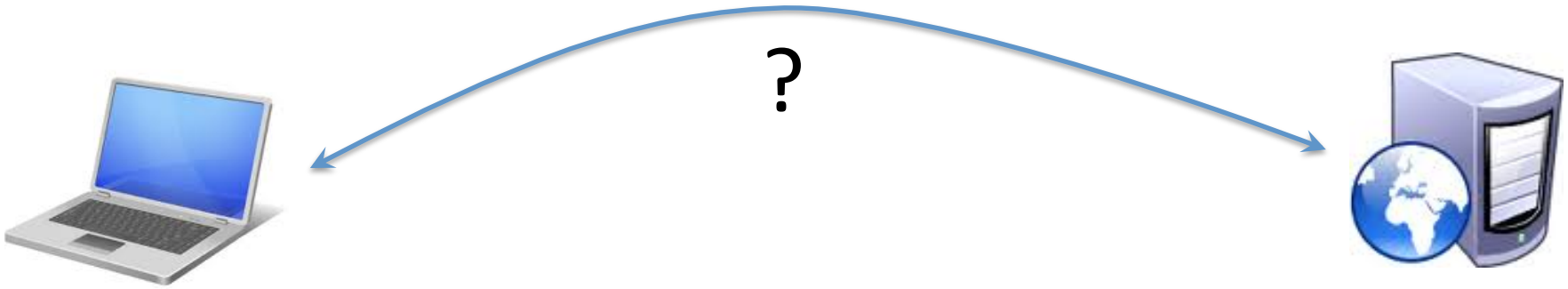
IPv6 Transition Issue

- IPv4 is practically exhausted
  - IANA allocated last /8 blocks on Feb. 3, 2011
  - Regional registries are running out
- Temporary mitigations
  - Aggressive NAT use
  - Unused address reclamation
  - IP address markets
- Permanent solution
  - Transition to IPv6

Transition Growing Pains



- Dual-stack end systems are common
- End-to-end IPv6 paths are not
- Dual-stack Internet server perspective:
  - Can always tell IPv6-enabled clients by AAAA-type DNS queries
  - Cannot tell end-to-end connectivity

Internet Server Strategies

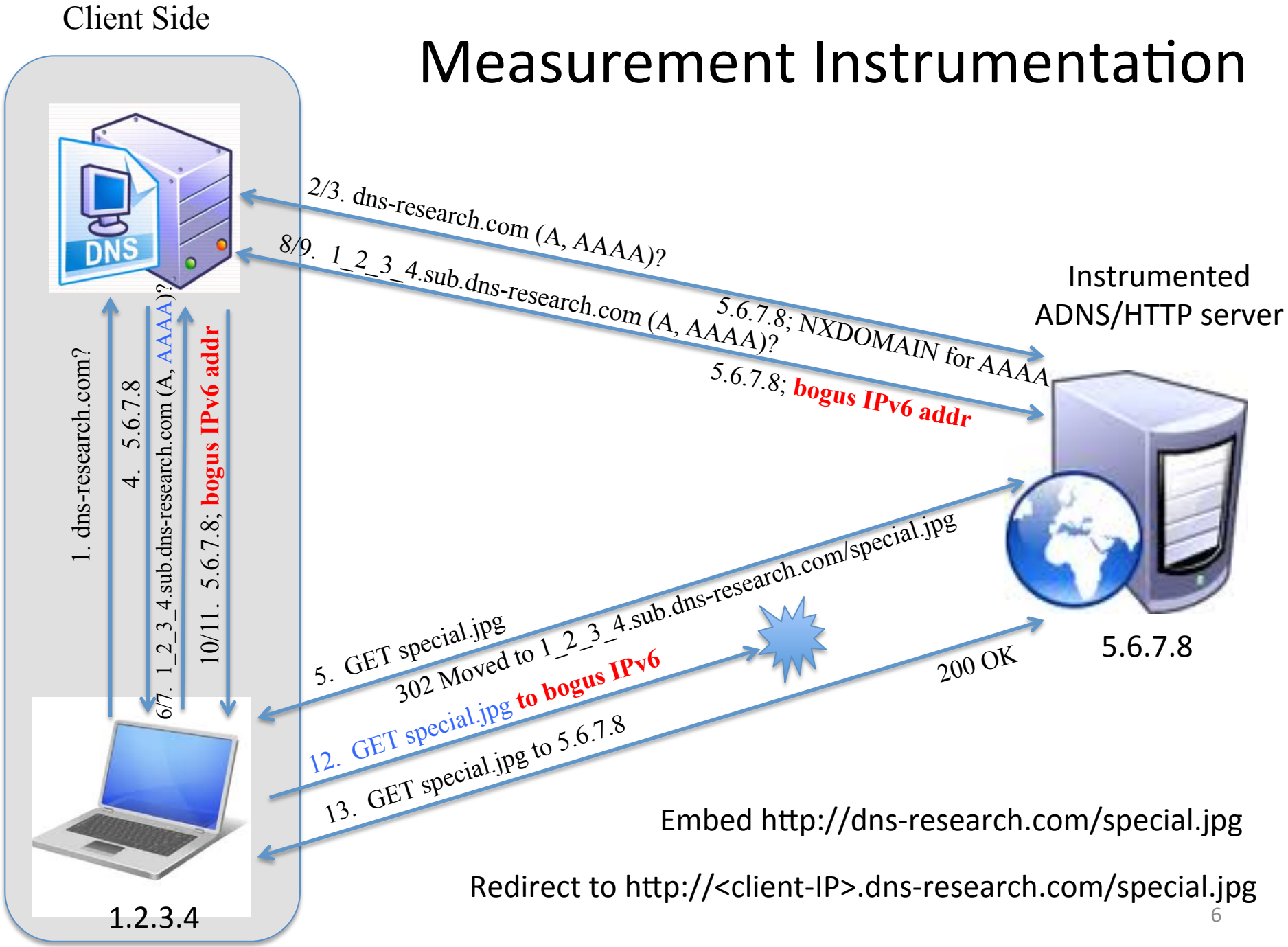
- If client asks for AAAA address, give it to it!
  - Smart clients will fall over to IPv4 if no connectivity
  - But we do not if they would or how quickly
  - Unilateral approach to transition
- Play it safe!
  - Only honor AAAA queries for clients with verified connectivity
  - Clients must opt-in
  - Google's approach
  - Transition relies on client-server cooperation

Question: what are the implications of unilateral approach?

Plausible Scenarios

- Parallel IPv6 and IPv4 attempts
  - Parallel A and AAAA DNS queries
  - Parallel TCP handshakes
  - Reset IPv4 connection if IPv6 connection succeed
  - Described in RFC 6555
- Sequential IPv6 -> IPv4 attempts
  - Delay penalty
- Macro-behavior the result of complex interactions
  - Browser, OS, DNS resolvers

Measurement Instrumentation



Embed http://dns-research.com/special.jpg

Redirect to http://<client-IP>.dns-research.com/special.jpg

The Dataset

- 28-day measurement (Jan 5 to Feb 1, 2011)
  - Over 34M DNS and 56M HTTP interactions
  - Over 11M client IP addresses
  - Almost 300K LDNS IP addresses
  - Over 21M unique client/LDNS associations
- IPv6 usage

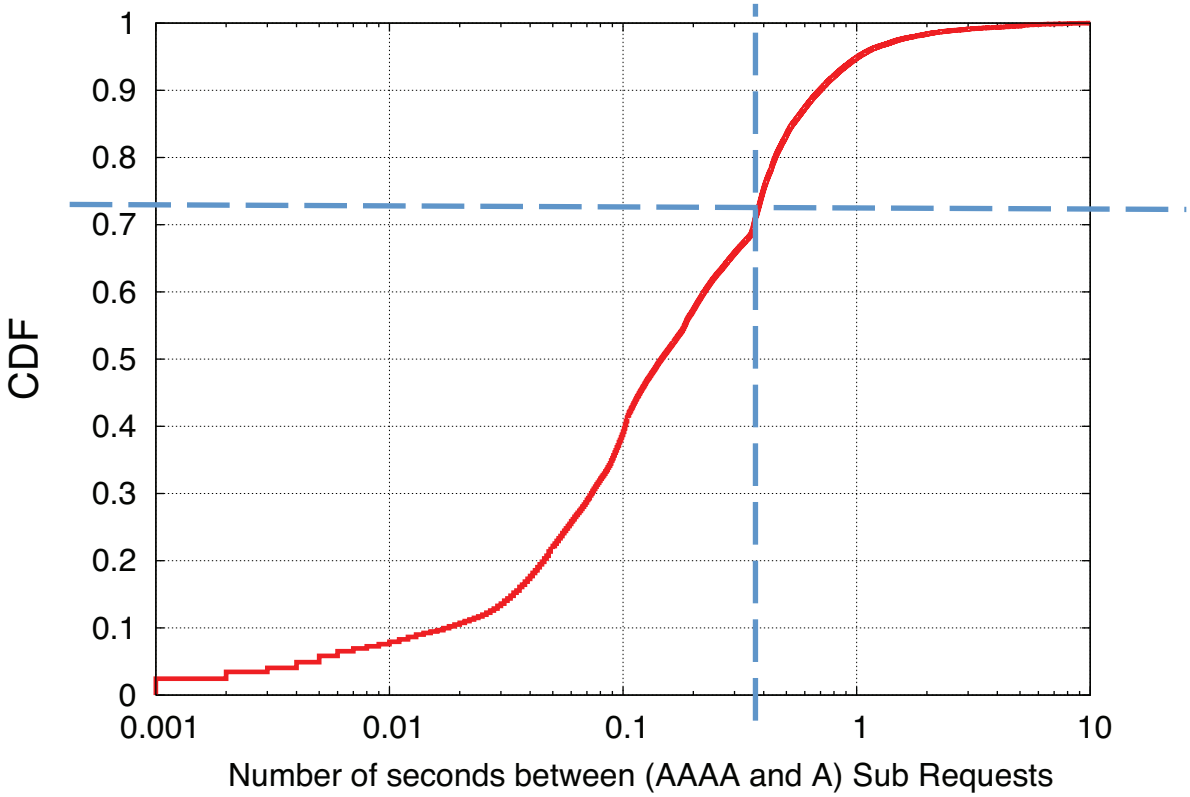
	Base DNS Requests	"Sub" DNS Requests
# Requests	19,945,037	2,398,367
LDNS IP addrs	59,978	32,291
Client IP addrs	No data	1,134,617

Failure Rate

- IPv4-only clients: 0.0038%
  - 1217 out of 32M downloads
- IPv6-enabled clients: 0.0064%
  - 154 out of 2.4M downloads

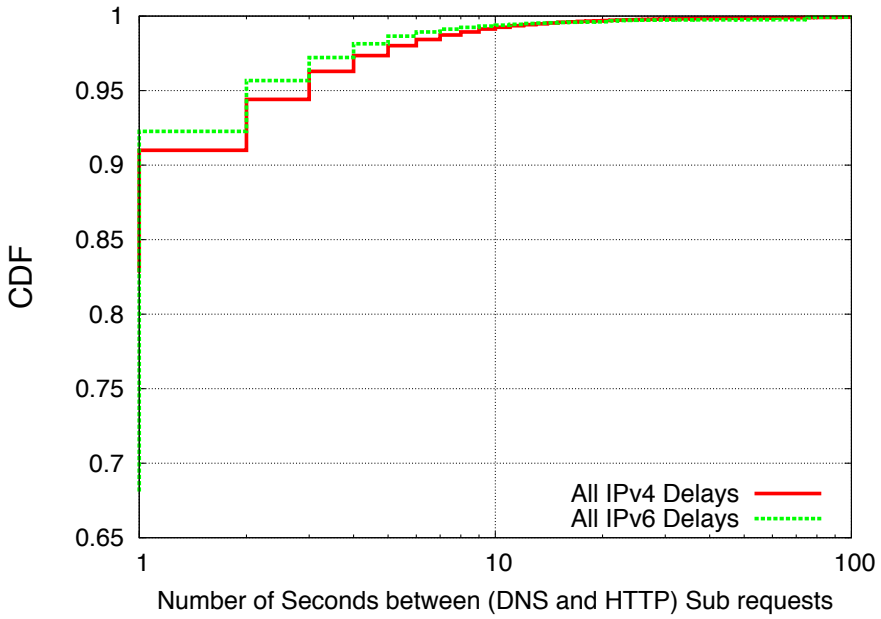
DNS Resolution Penalty

- 88% - *negative* penalty
- Penalty distribution for the remaining 12%:

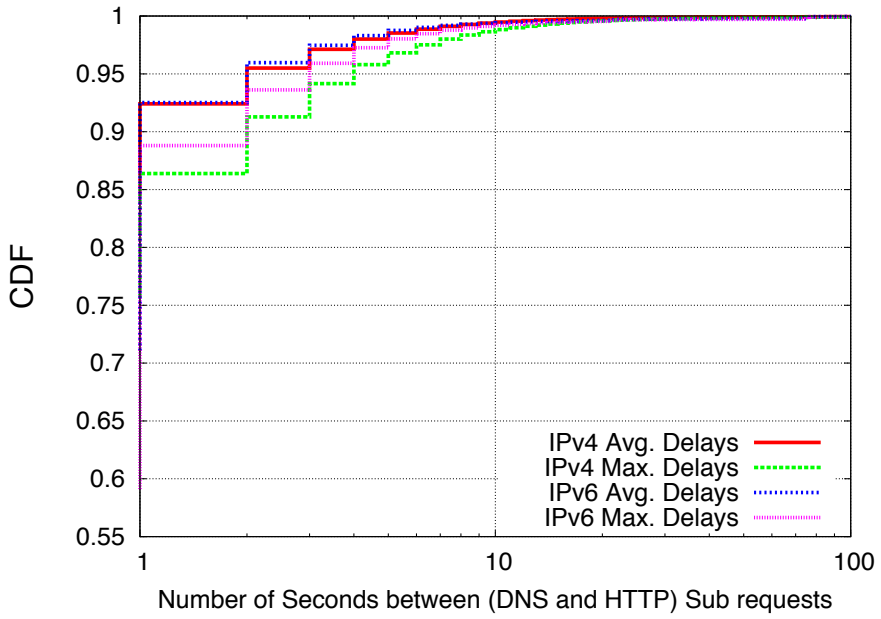


End-to-End Delay

All delays



Per Client Delays



Conclusion

- No evidence of performance penalty for unilateral IPv6 enabling
- Small increase in failure rate
  - From 0.0038% to 0.0064%
- Current study limitation:
  - One-second time measurement granularity