The Case for Prefetching and Prevalidating TLS Server Certificates

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Transport Layer Security

- Want to secure traffic between web browsers and servers
- One problem is latency from TLS handshake

The TLS handshake

The TLS handshake

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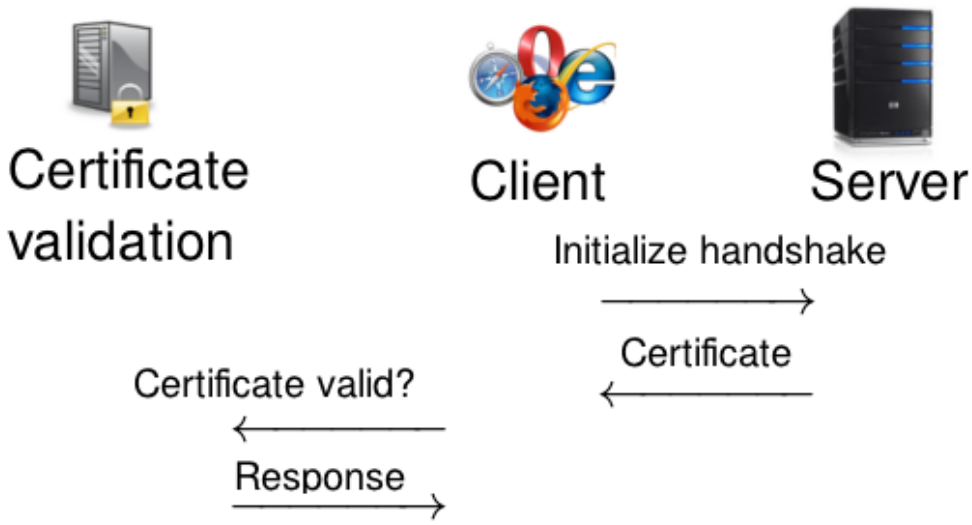

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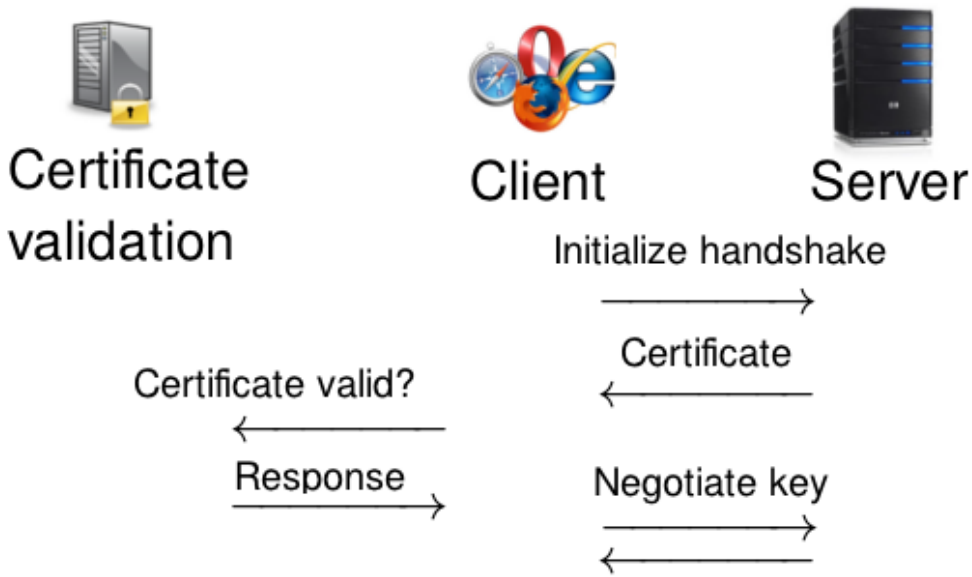

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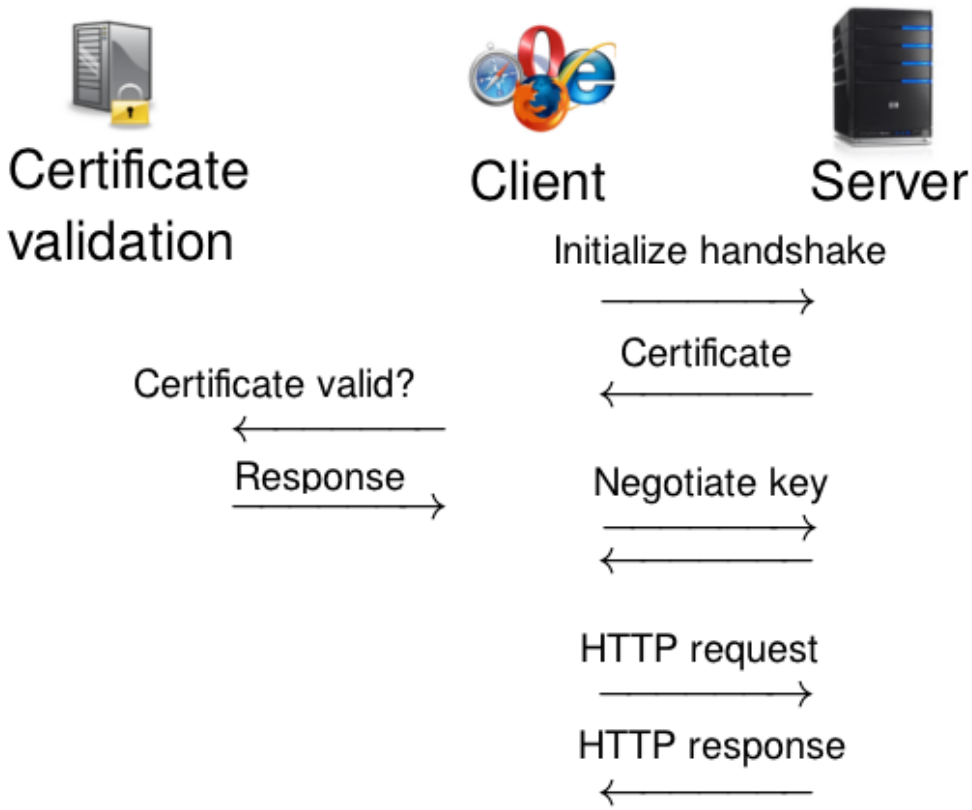

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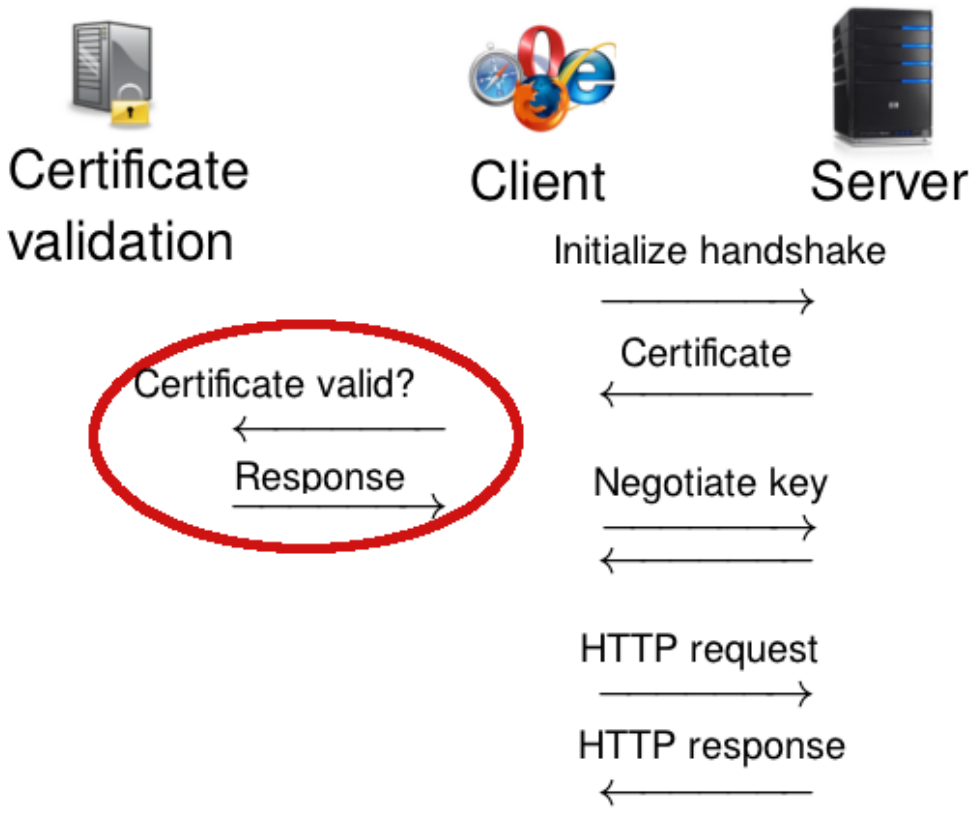

Certificate validation: OCSP

- Online certificate status protocol

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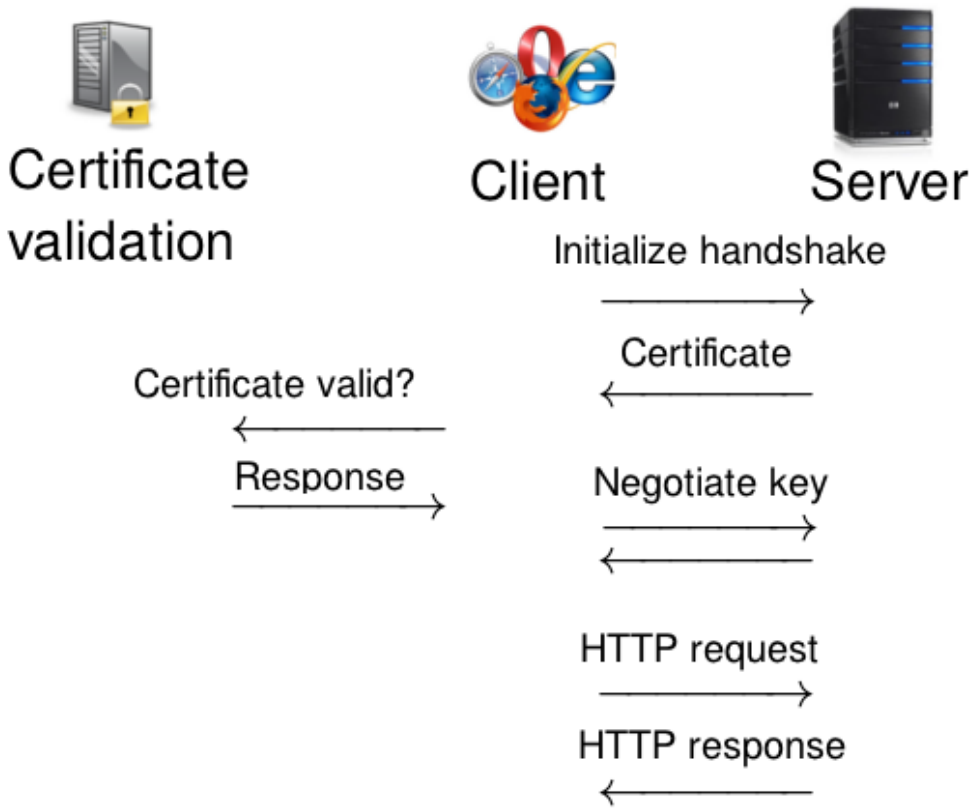
Certificate validation: OCSP

- Online certificate status protocol
- Server certificate specifies OCSP responder
- Clients asks responder whether cert is valid
- Responder specifies how long response is valid for

The TLS handshake



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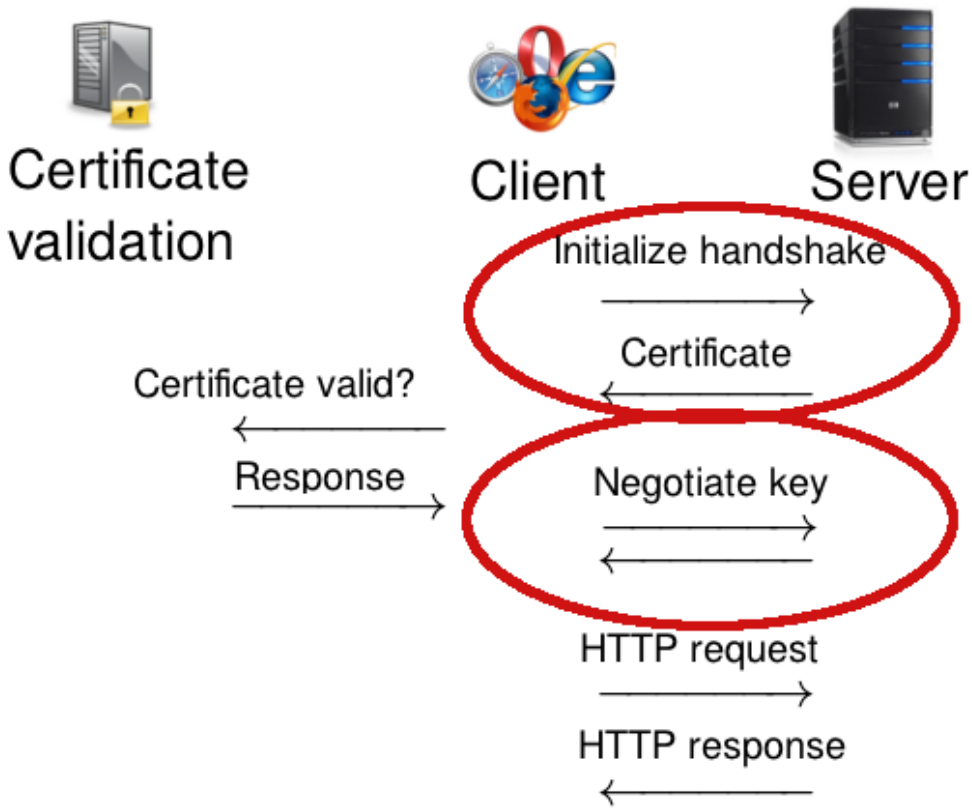

Removing round trips

Previous proposal, TLS Snap Start

- Zero round trip handshake

Removing round trips

Removing round trips

Initialize handshake
Snap Start extension
HTTP request
→
HTTP response
←

Snap Start challenges

- Client must know server certificate
  - Cached from previous visit

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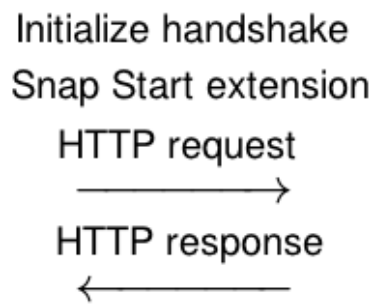

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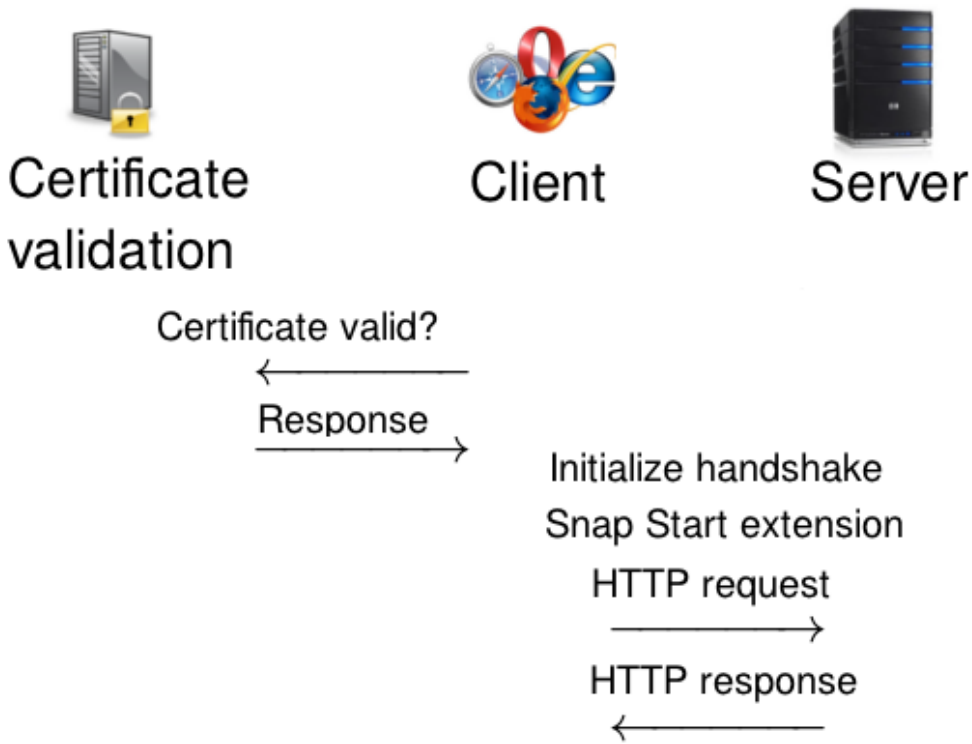


Problem

- TLS imposes extra latency due to retrieving and validating server certificate
  - How to obtain certificate to do Snap Start handshake?
  - How to validate without extra latency?

Contribution

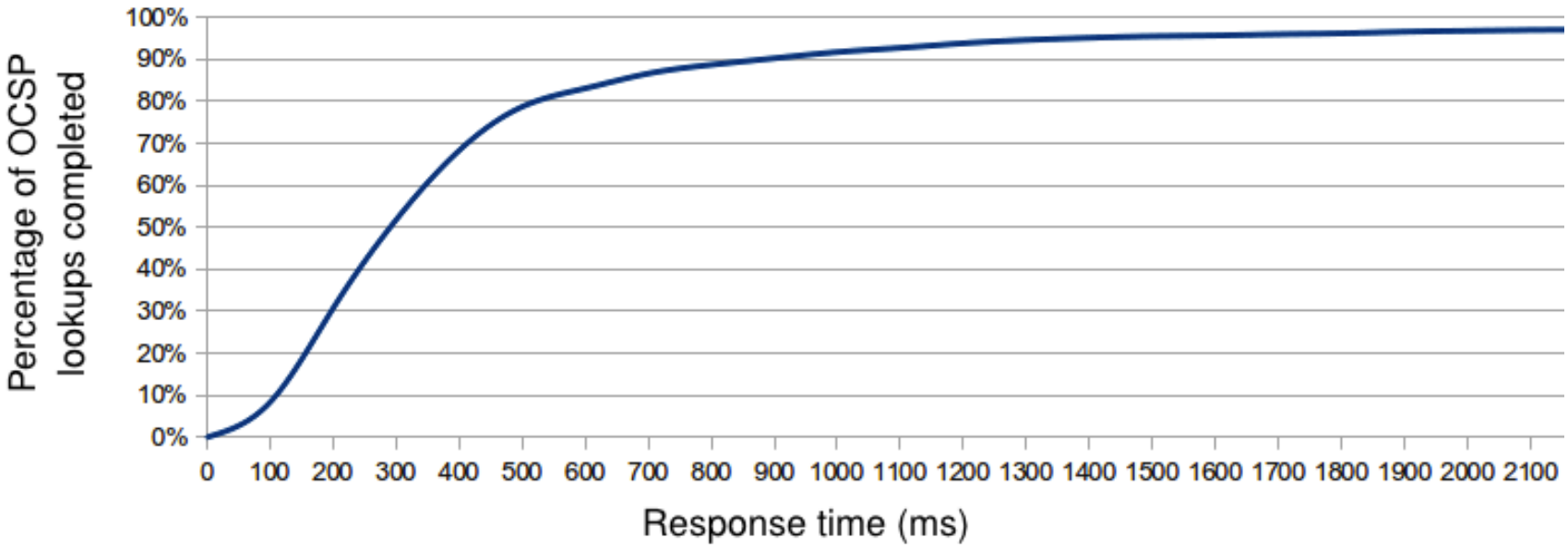
- Real world study of OCSP response times
- Certificate prefetching and prevalidation
  - Propose four prefetching strategies
  - Analysis of effectiveness
  - Prototype implementation

How long does OCSP take in the real world?

- Experimental setup
  - OCSP response times collected from users running Perspectives browser extensions
  - 242 clients, 4474 certificates, 24 responders

OCSP in the wild

CDF of OCSP response time:



Median: 291 ms, mean: 498 ms

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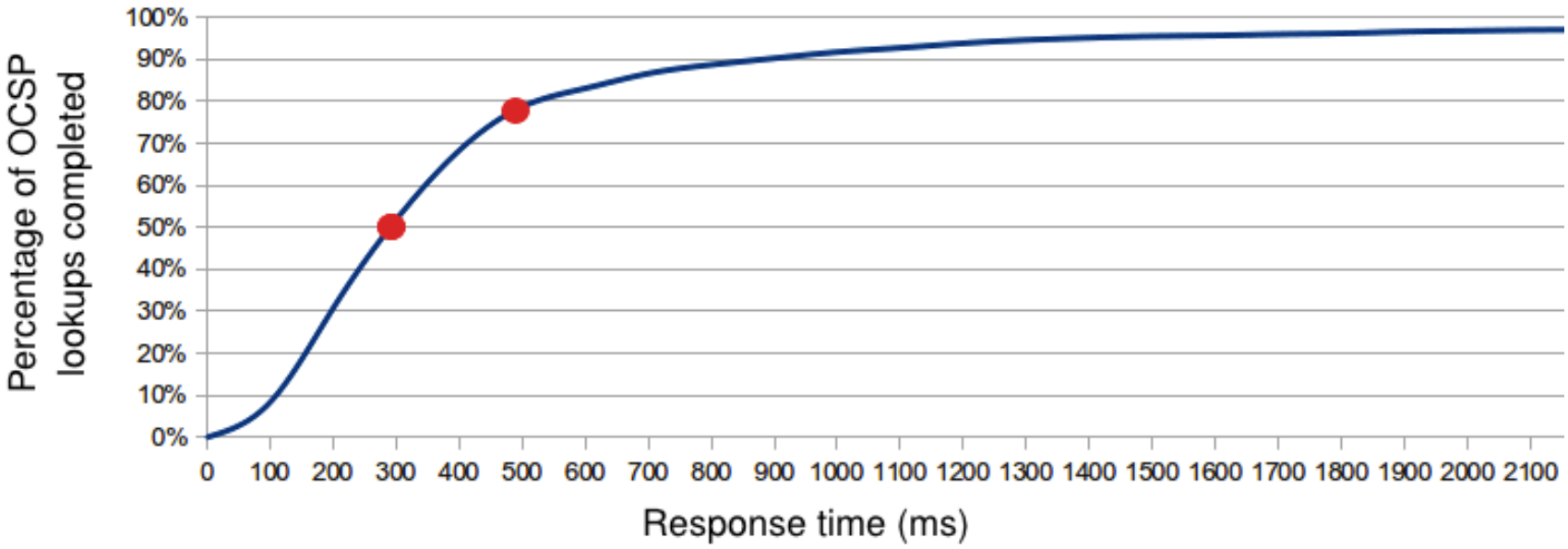

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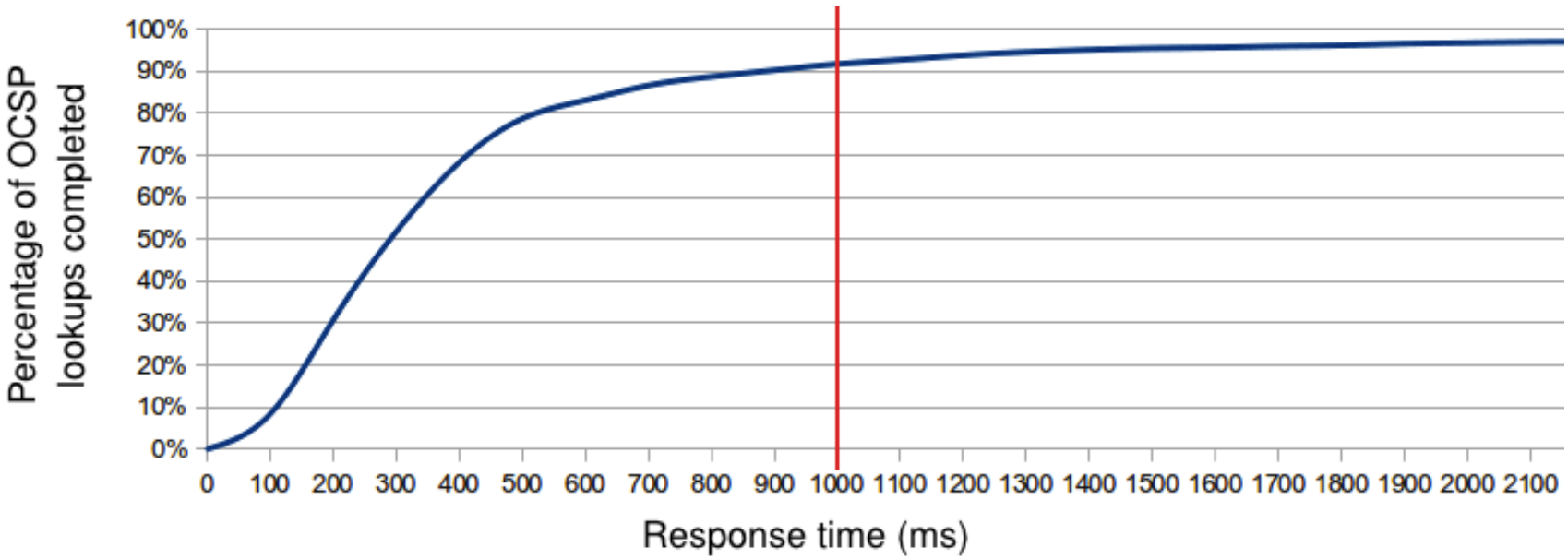

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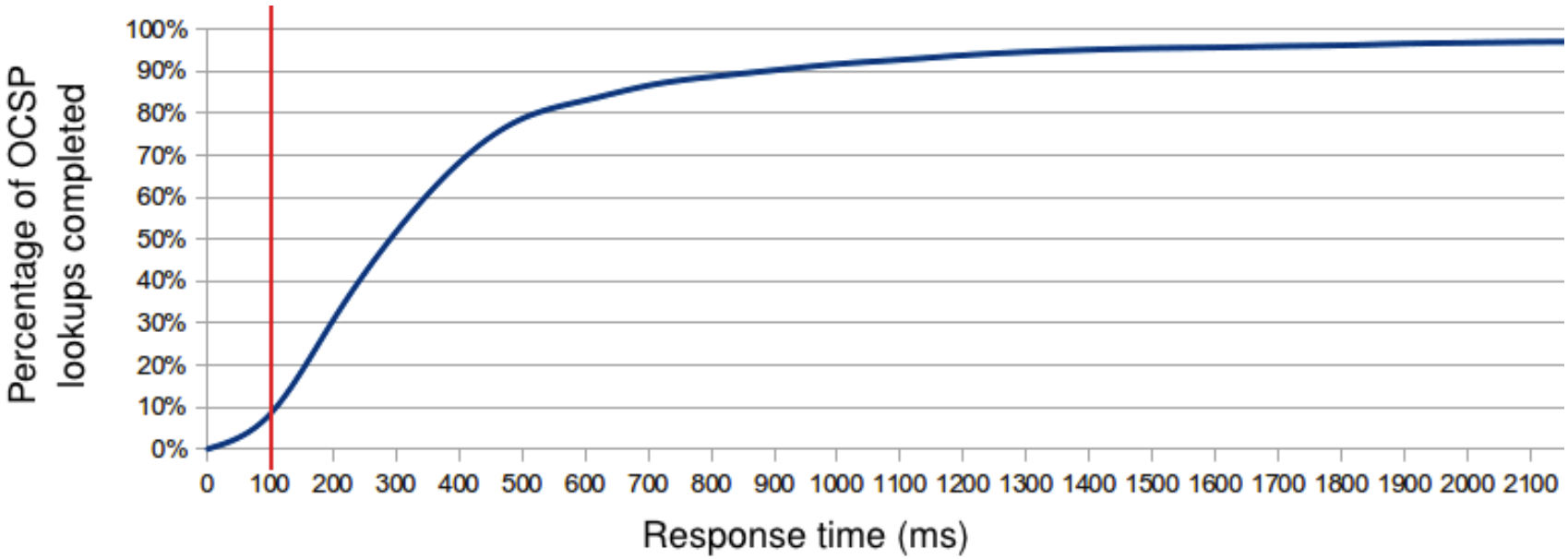

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Design

- Prefetch certificates
  - Enables Snap Start handshakes more frequently
- Prevalidate certificates
  - Removes OCSP lookup from critical path

Design questions

- When to prefetch? When to prevalidate?
- How to obtain certificate?

When to prefetch

Ideas borrowed from DNS prefetching:

- DNS prefetching triggers are effective for certs

When to prefetch

Ideas borrowed from DNS prefetching:

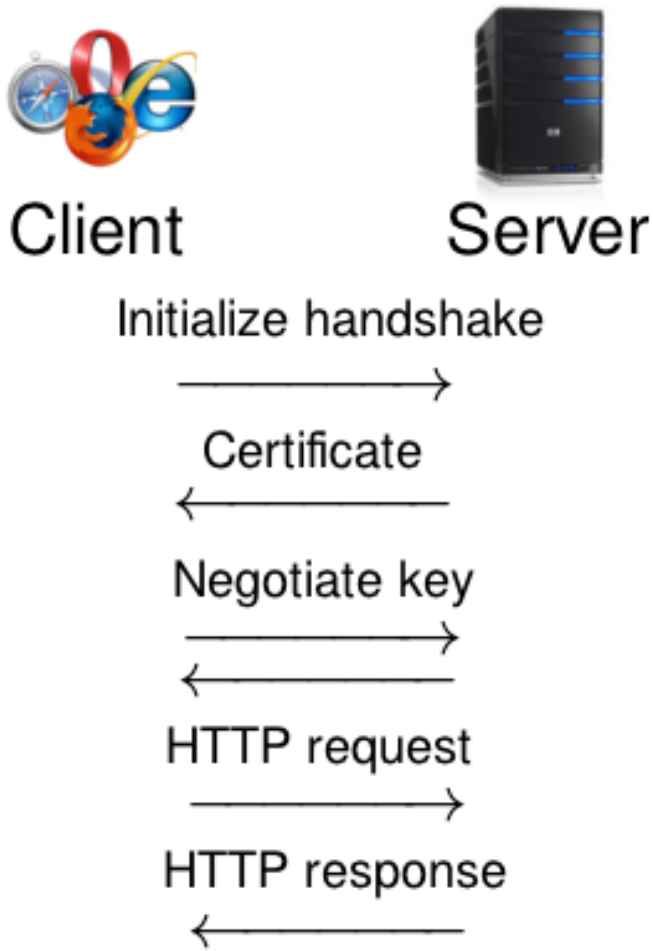
- DNS prefetching triggers are effective for certs
- Could be deployed with HTML hints for effective prefetching

How to prefetch

- Goal: Obtain server certificate
- Challenge: Full TLS handshake is expensive
- Four proposed methods that are more efficient

Prefetching methods

Option 1: Truncated handshake



Prefetching methods

Option 1: Truncated handshake

Prefetching methods

Option 1: Truncated handshake

- No public key crypto!
- Server admin does nothing
- But implementation requires new API in TLS layer

Prefetching methods

Option 2: HTTP GET request

e.g., to `http://www.domain.com/cert`

- Much less load than full TLS handshake, but still impacts the server

Prefetching methods

What if we want no additional load on server?

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Option 3: Retrieve from CDN

- HTTP GET request, avoid hitting web server

Prefetching methods

What if we want no additional load on server?

Option 4: Retrieve from DNS

- DNS TXT record can store certificate
- No impact on web server

Prevalidation

- After prefetching cert, prevalidate it
  - Normal OCSP lookup

Prototype

- Prefetching and prevalidating in Chromium
- Piggyback on DNS prefetching architecture
- DNS and HTTP GET prefetching

Analysis

- How much does prefetching and prevalidating affect handshake latency?

Handshake latency

- Normal TLS handshake: **122 ms**

  ↓ Remove round trips by prefetching cert and using Snap Start

- Snap Start, unvalidated cert: **83 ms**

  ↓ Remove OCSP validation by prevalidating cert

- Snap Start, prevalidated cert: **30 ms**

Server: Ubuntu 10.04, 256MB, Apache 2.2.17, Client: Ubuntu 10.04, 1GB RAM

HTTP GET request: 16 ms

Conclusions

- OCSP latency matters, especially when handshakes have fewer RTTs
- Need prefetched certificate to **enable Snap Start** and for **OCSP prevalidation**
- 4 proposed strategies for prefetching certs
- Reduce TLS handshake by two RTTs and OCSP response time (factor of 4 in our experiments)