Playback: A TLS 1.3 Story

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Cisco

Who are we?

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Introducing TLS 1.3

- The Good
  - KISS – Only 5 ciphers supported
  - No vulnerable to known attacks against previous versions of TLS
  - Welcome Forward Secrecy
  - Formal security analysis performed to the protocol

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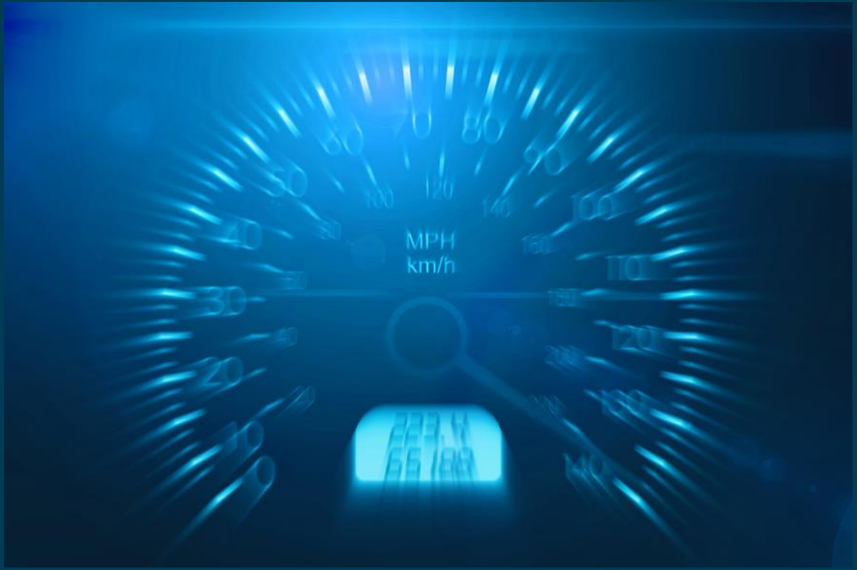
Introducing TLS 1.3

- The Bad
  - Protocol tainted due to “compatibility issues”

Introducing TLS 1.3

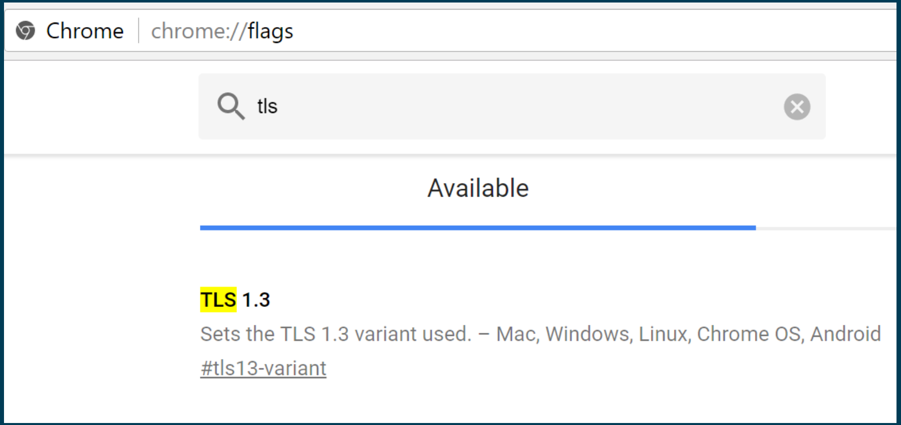
- The Ugly
  - New protocol feature: 0-RTT

0-RTT: Tough decisions



Why should I care?

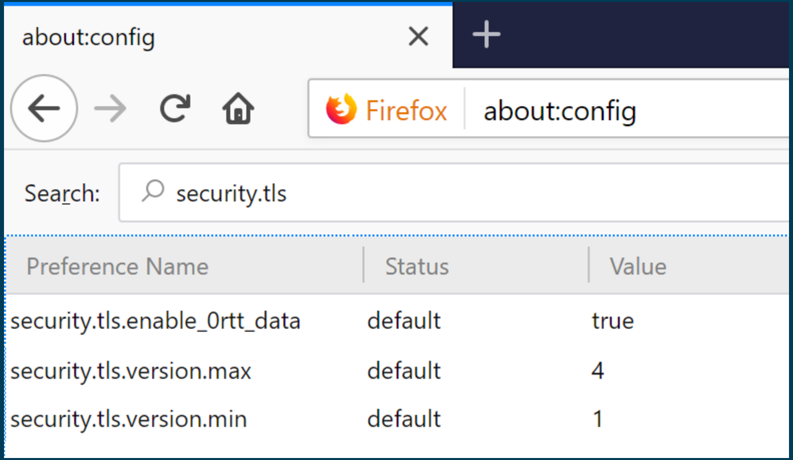
"Your browsers…



TLS 1.3

Sets the TLS 1.3 variant used. – Mac, Windows, Linux, Chrome OS, Android

#tls13-variant



Search: security.tls

Preference Name	Status	Value
security.tls.enable_0rtt_data	default	true
security.tls.version.max	default	4
security.tls.version.min	default	1

Why should I care?

… implementations …

OpenSSL
Cryptography and SSL/TLS Toolkit

BoringSSL

Why should I care?

… and CDNs may be supporting TLS 1.3 with 0-RTT”

TLS 1.3 Handshake

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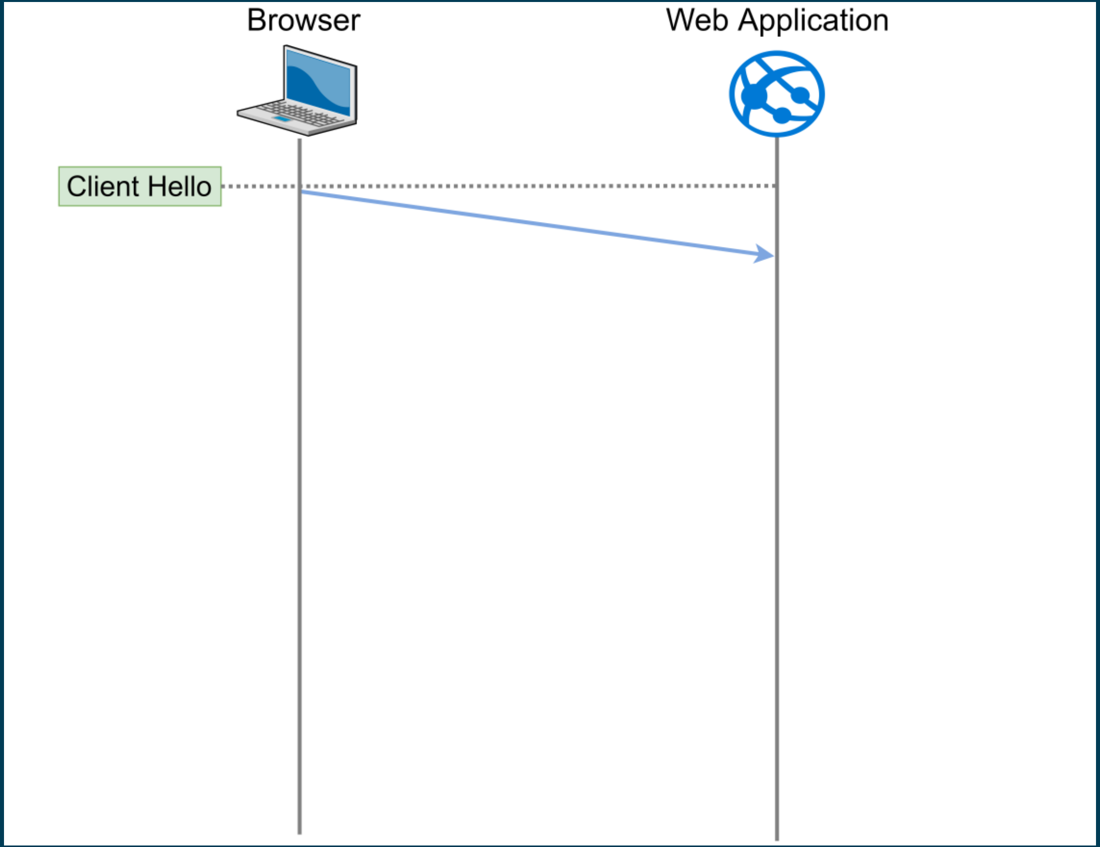

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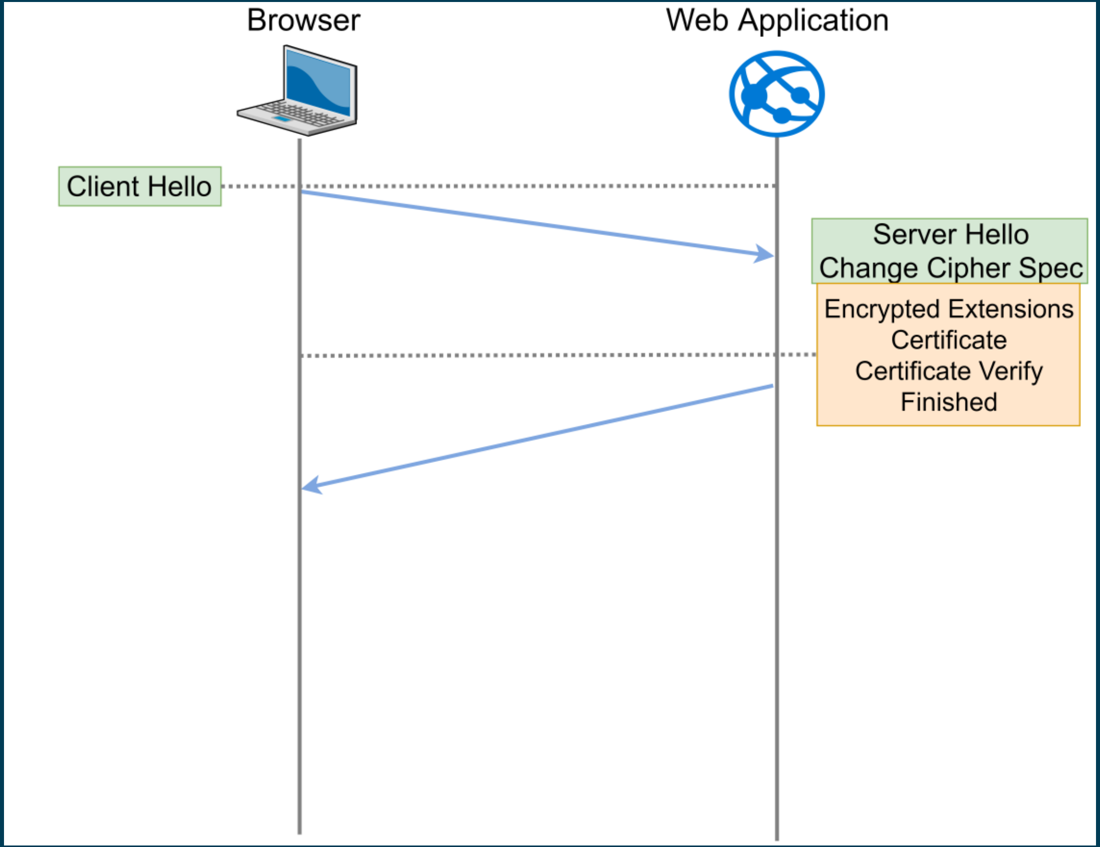

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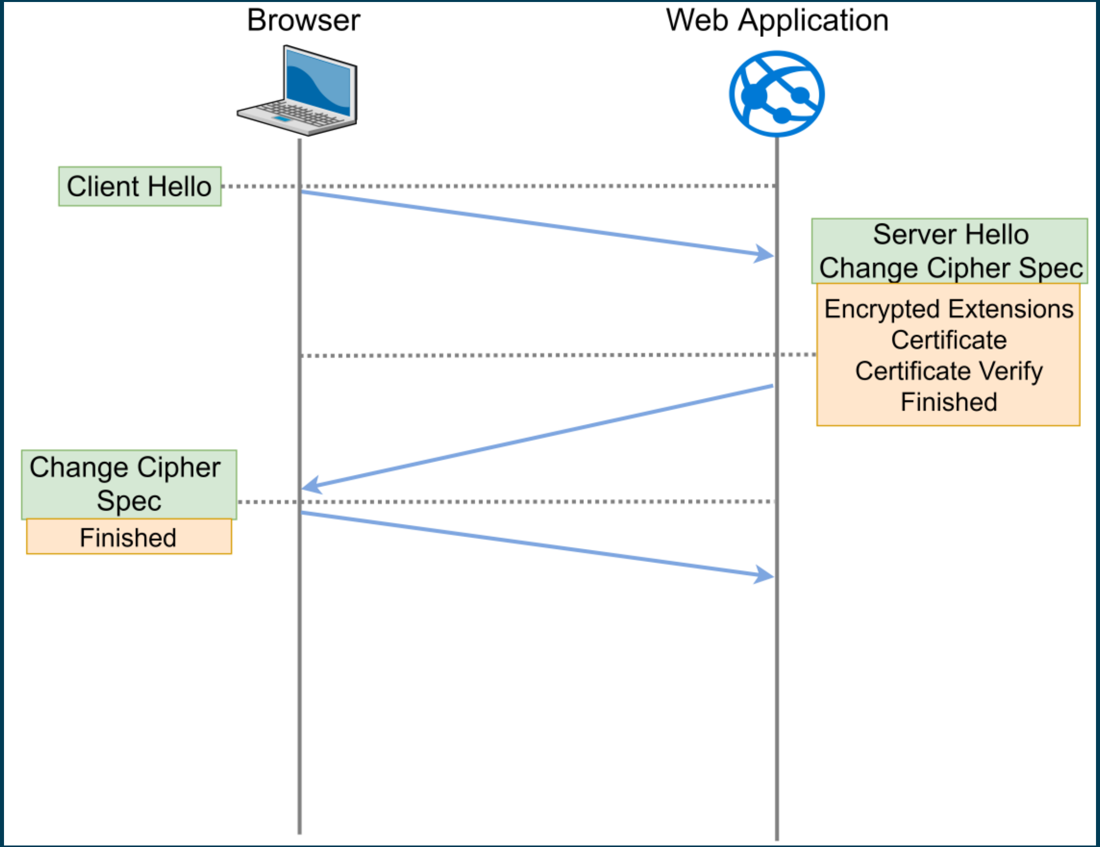

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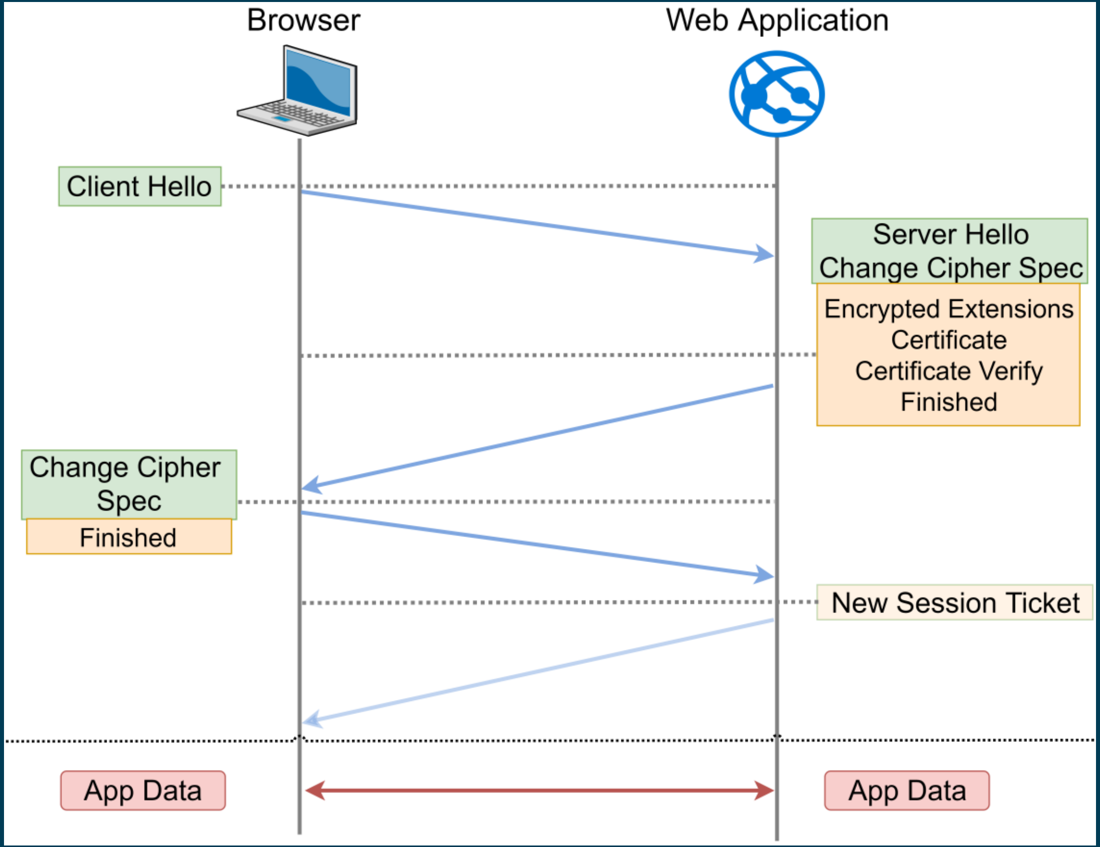

TLS 1.3 0-RTT

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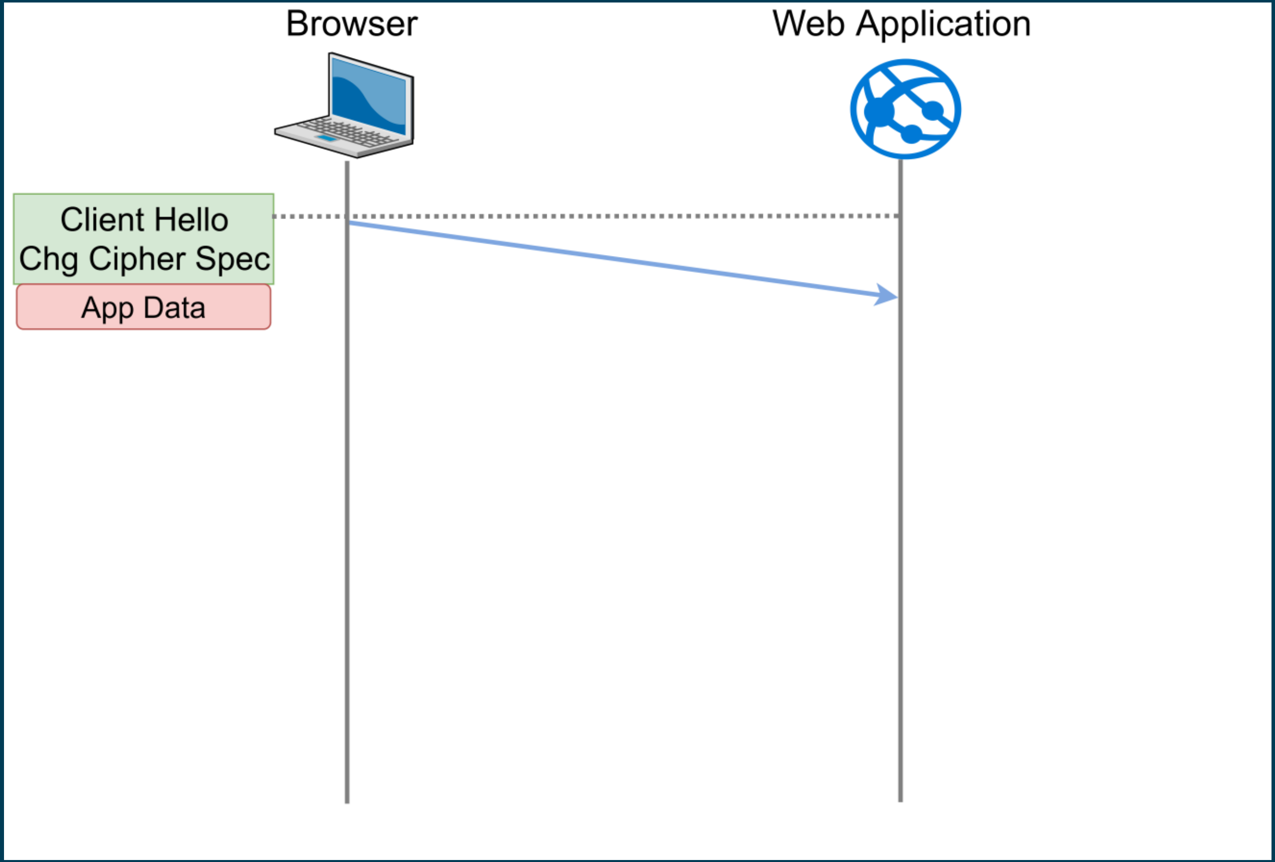
Browser
Web Application
Client Hello
Chg Cipher Spec
App Data

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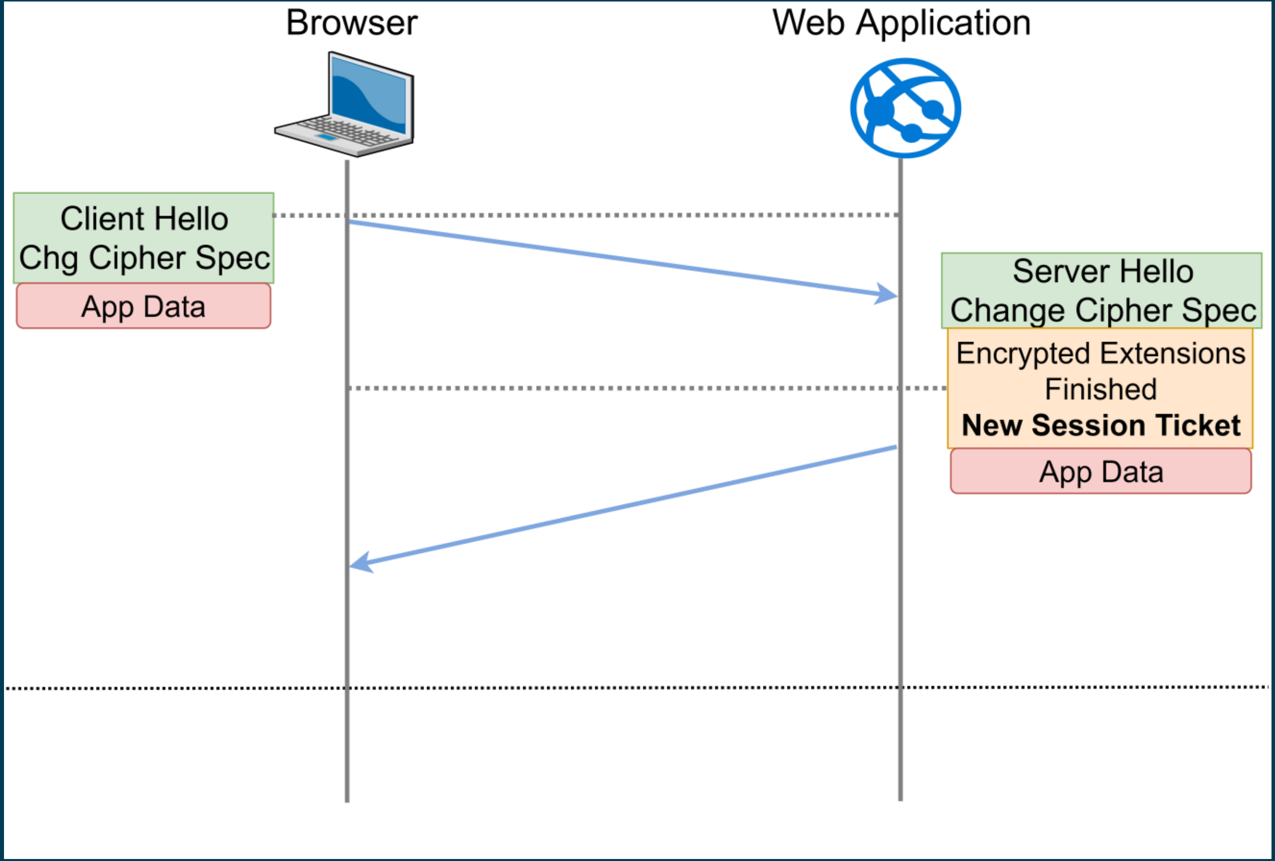
Browser
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Client Hello
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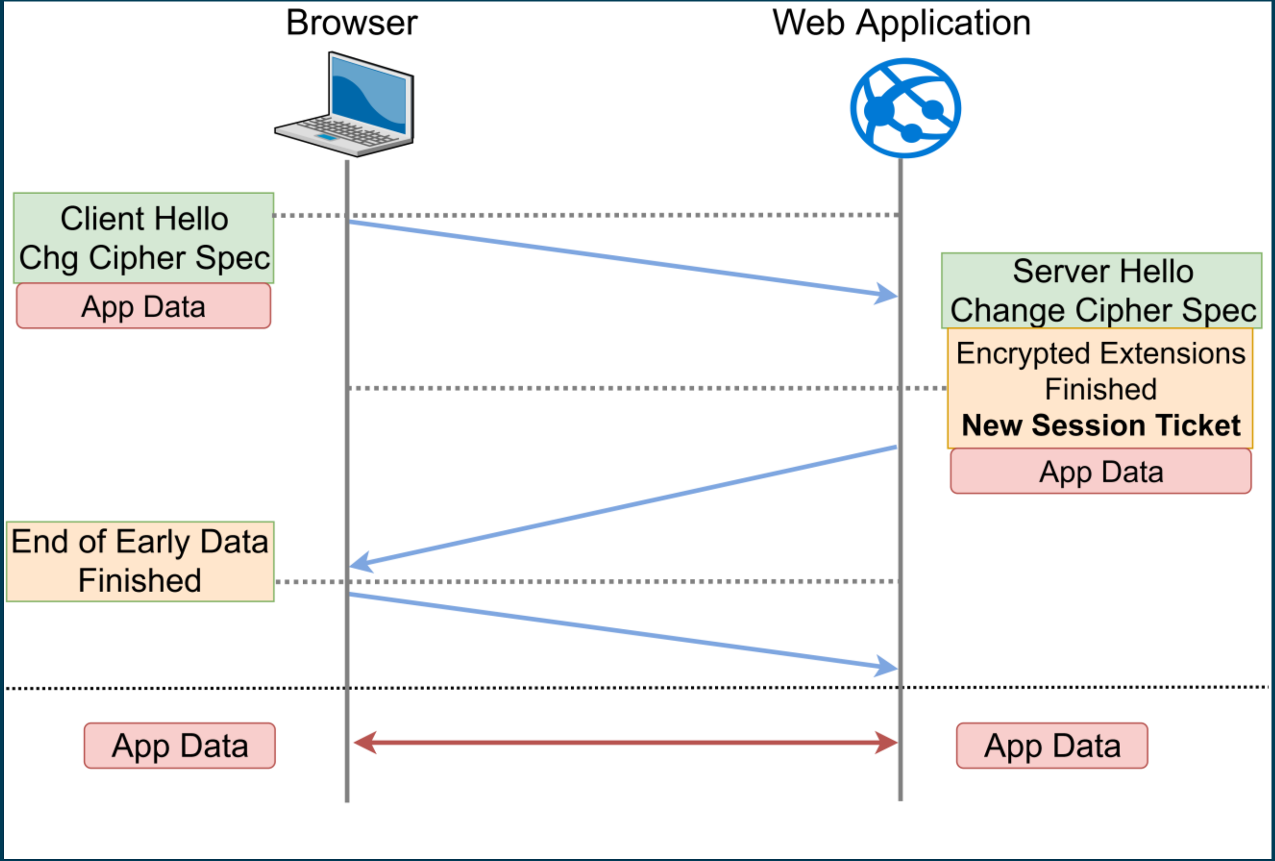
Server Hello
Change Cipher Spec
Encrypted Extensions
Finished
New Session Ticket
App Data

TLS 1.3 0-RTT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End of Early Data
Finished
App Data
App Data

As you can see…

it may be possible to do REPLAY
REPLAY
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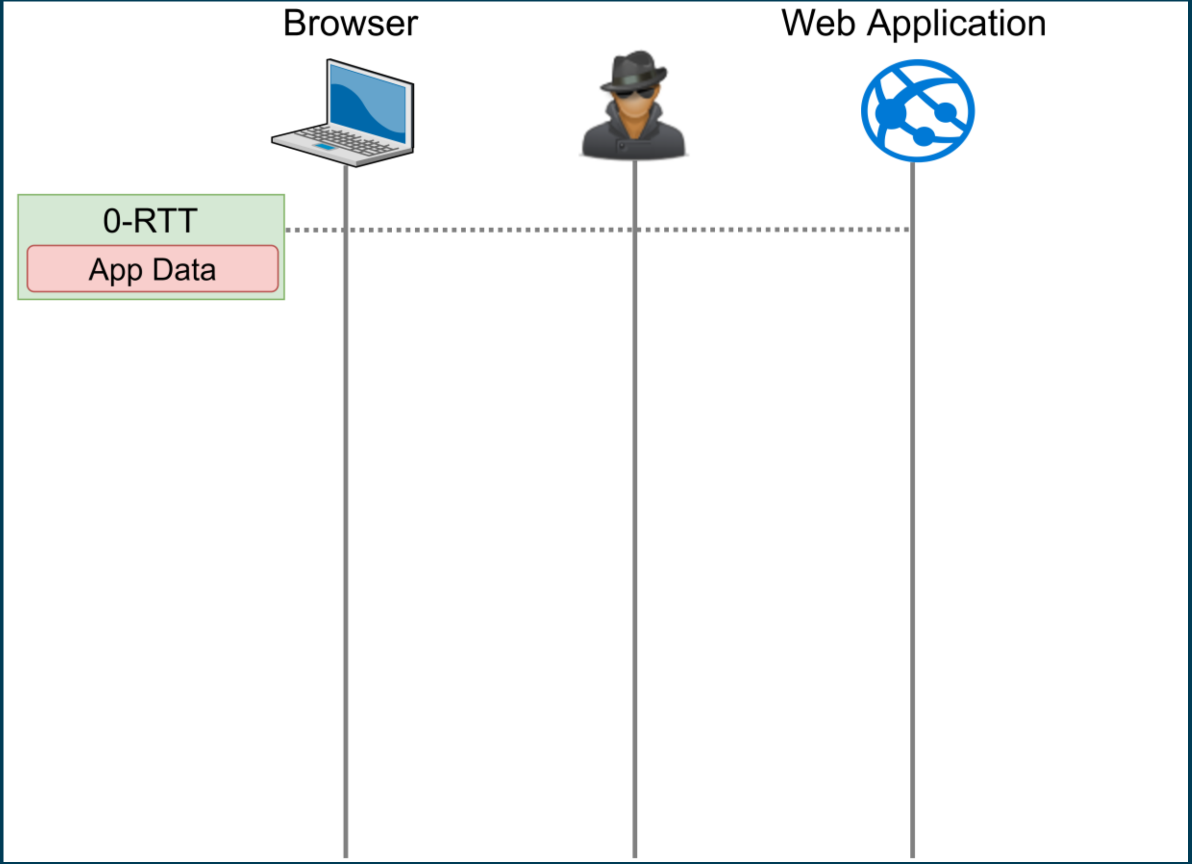
REPLAY
REPLAY attacks!

TLS 1.3 0-RTT replay attack

TLS 1.3 0-RTT Replay



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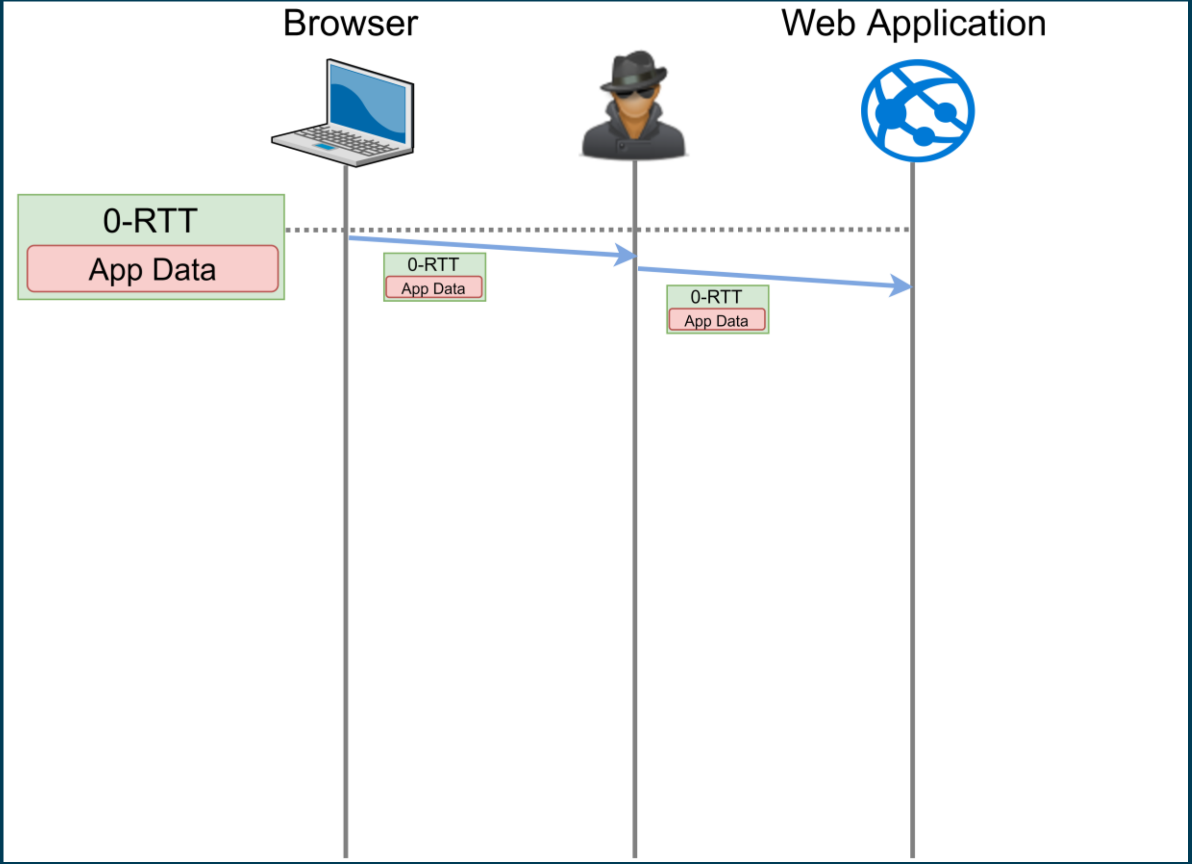

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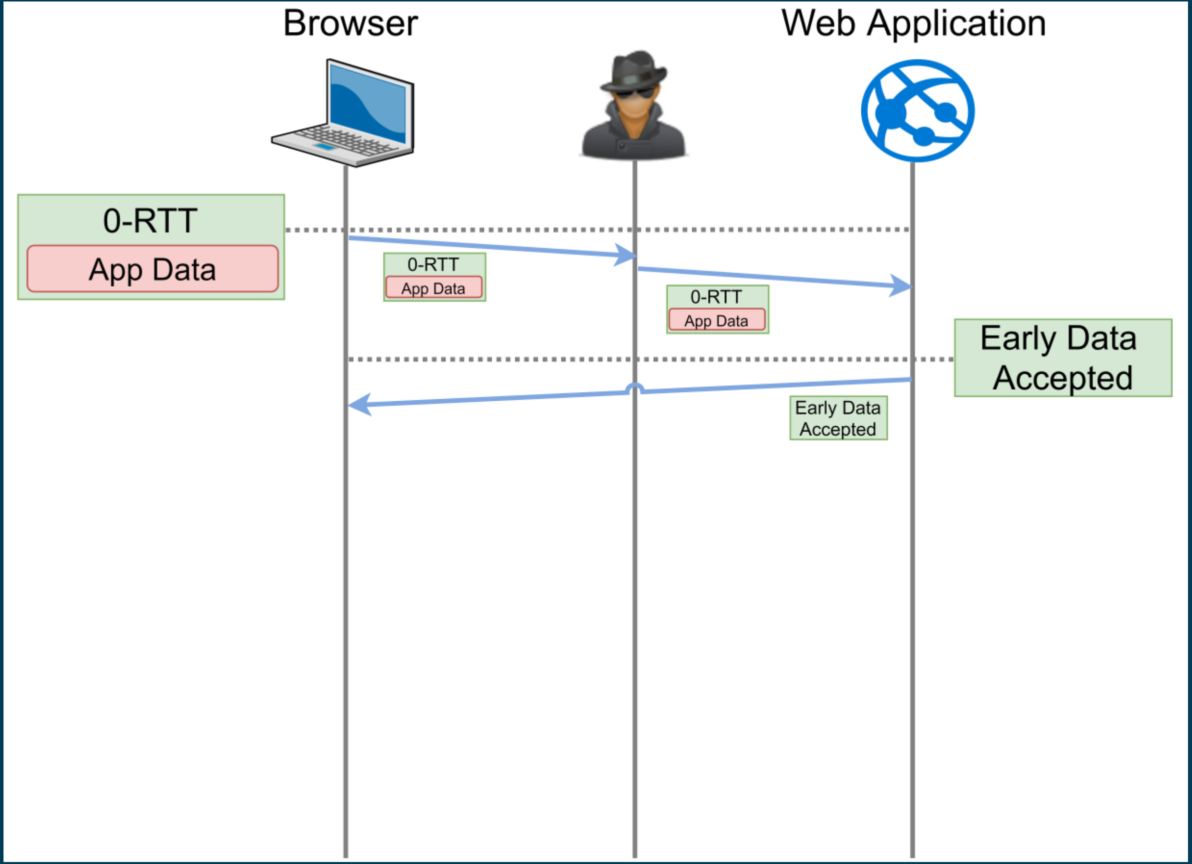

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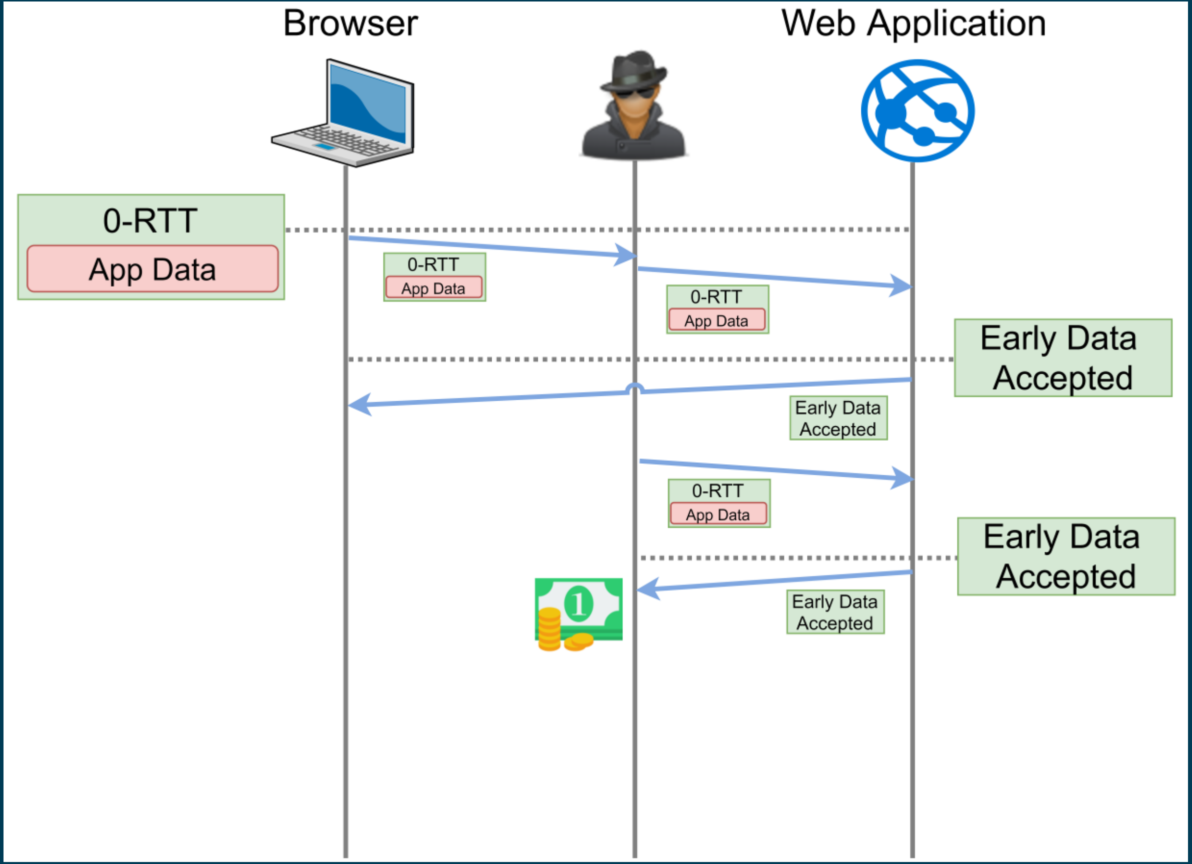

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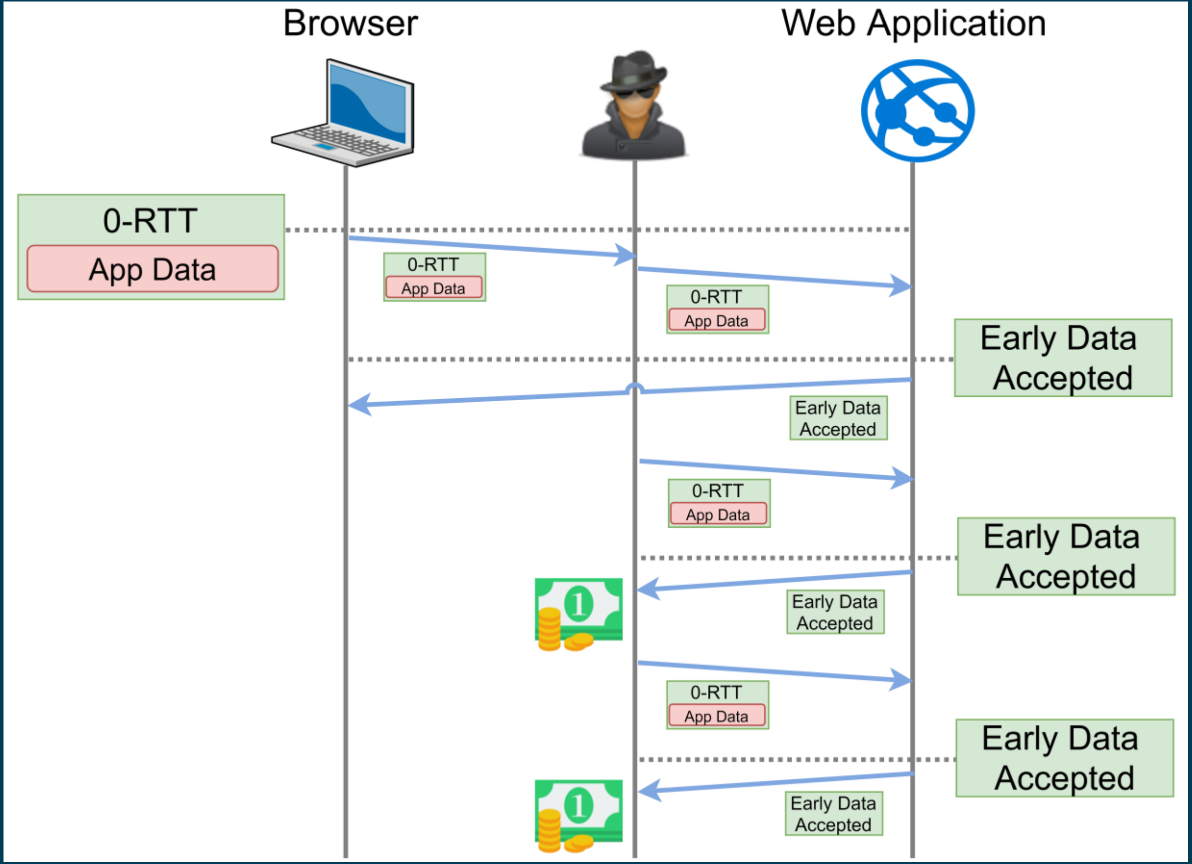

Anti-replay protections

Single-Use Tickets

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Client-Hello Recording

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Application profiles

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Anti-replay protections and mitigations

Anti-replay PROTECTIONS (Jul-2018)

	Single-Use Tickets	Client-Hello Recording	Application Profile	Other protections
OpenSSL Cryptography and SSL/TLS Toolkit	✓		n/a	Different API for handling 0-RTT
BoringSSL			n/a	0-RTT disabled by default
CLOUDFLARE	✓		Partial (HTTP Header)	0-RTT disabled. “safe” methods, no params
	n/a		n/a	0-RTT not available
	n/a		n/a	0-RTT only on “safe” methods

Anatomy of an attack

- **Vantage point** in the network
- Browser and server with TLS 1.3 and 0-RTT enabled
- GET not being a “*safe method*” (a.k.a. RFC meets reality)

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The browser behaviour

- **The browser decides** when to send 0-RTT data, which reduces the window for attacks

DEMO

Improving our attack

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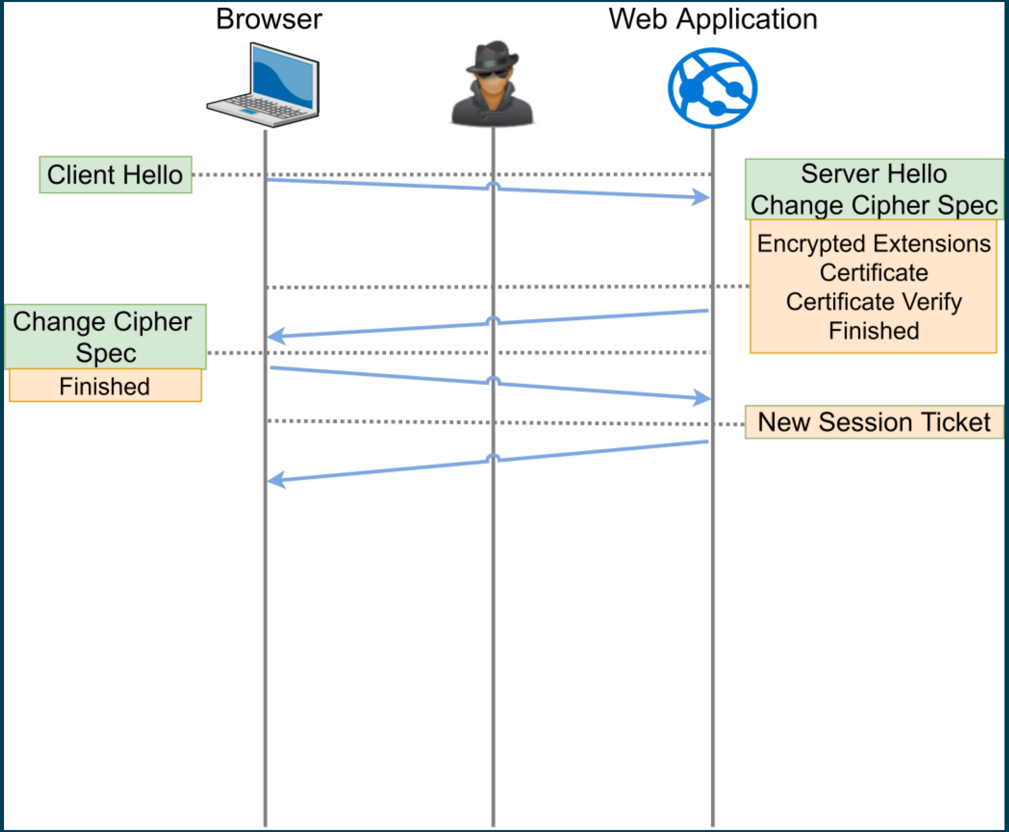

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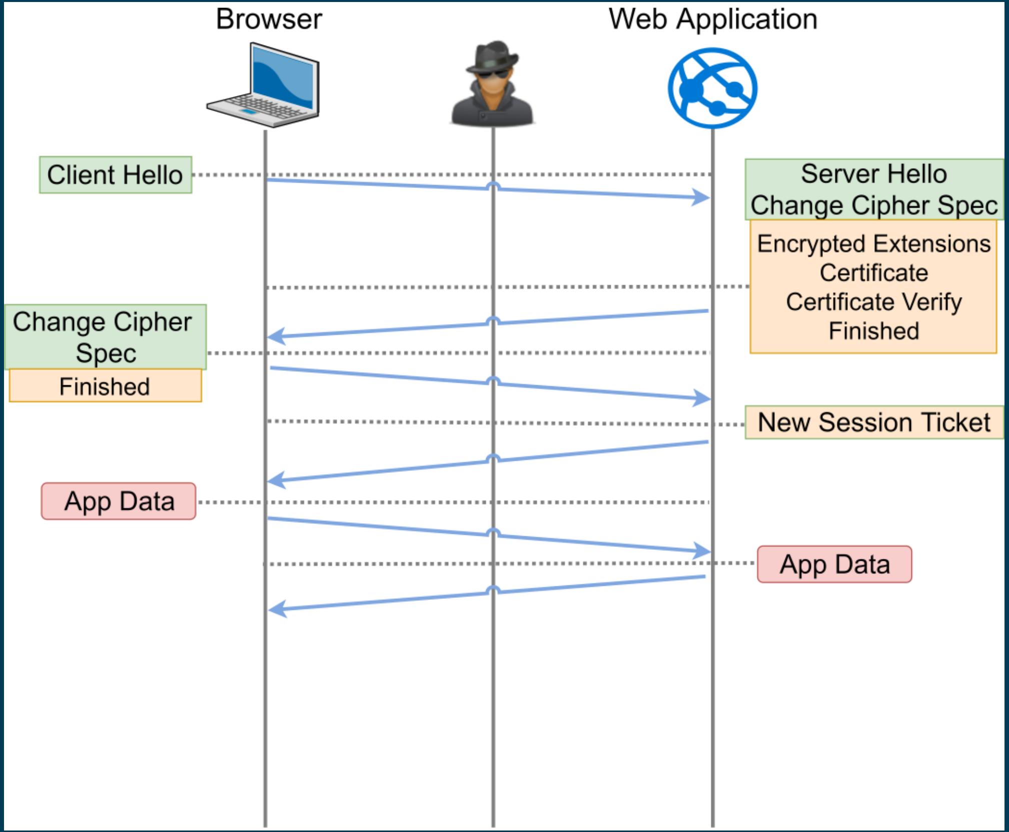

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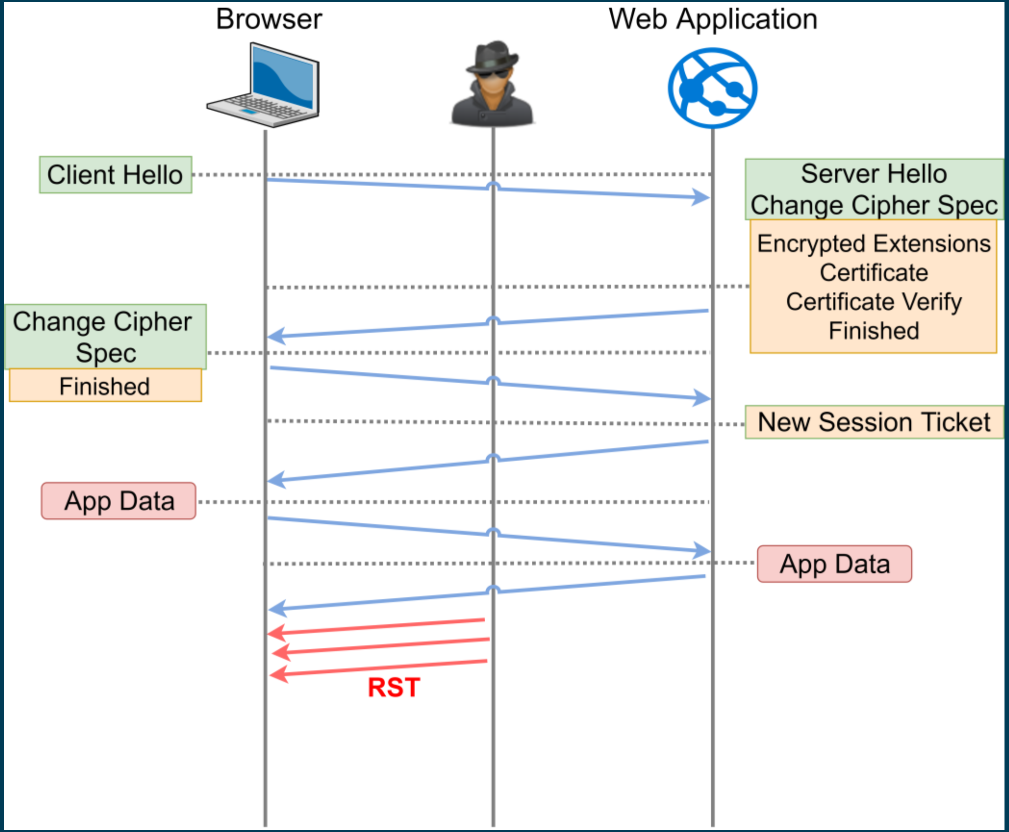

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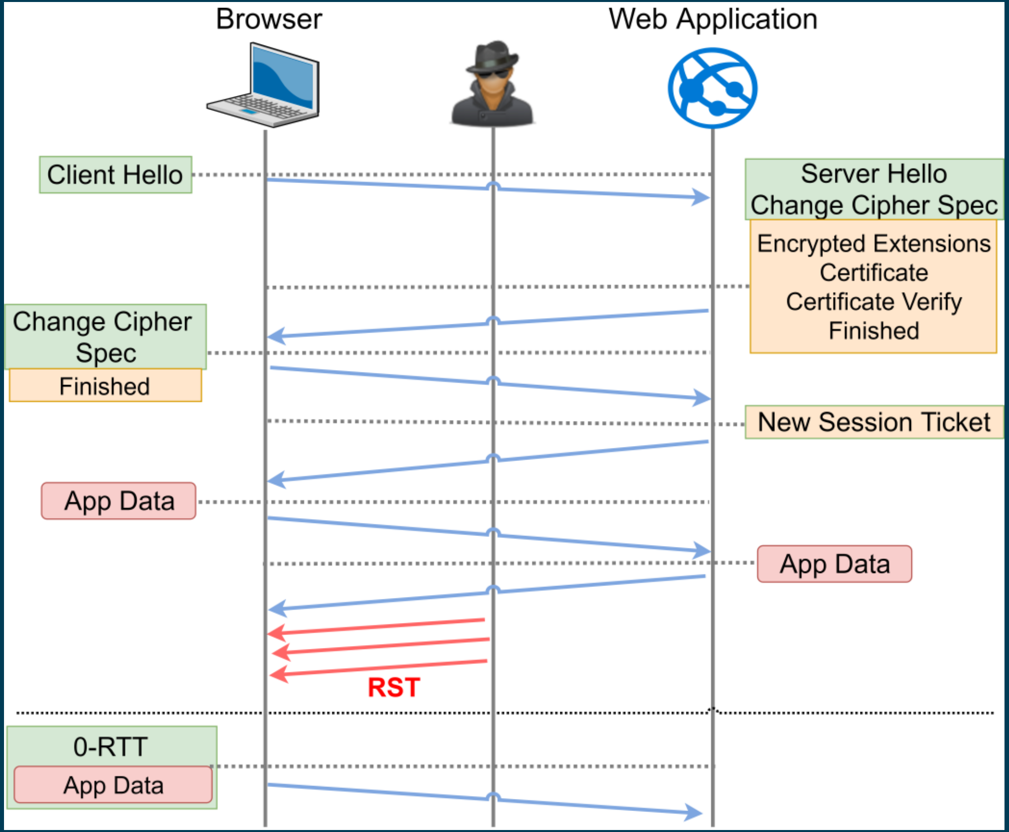

DEMO

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“Freshness” checks

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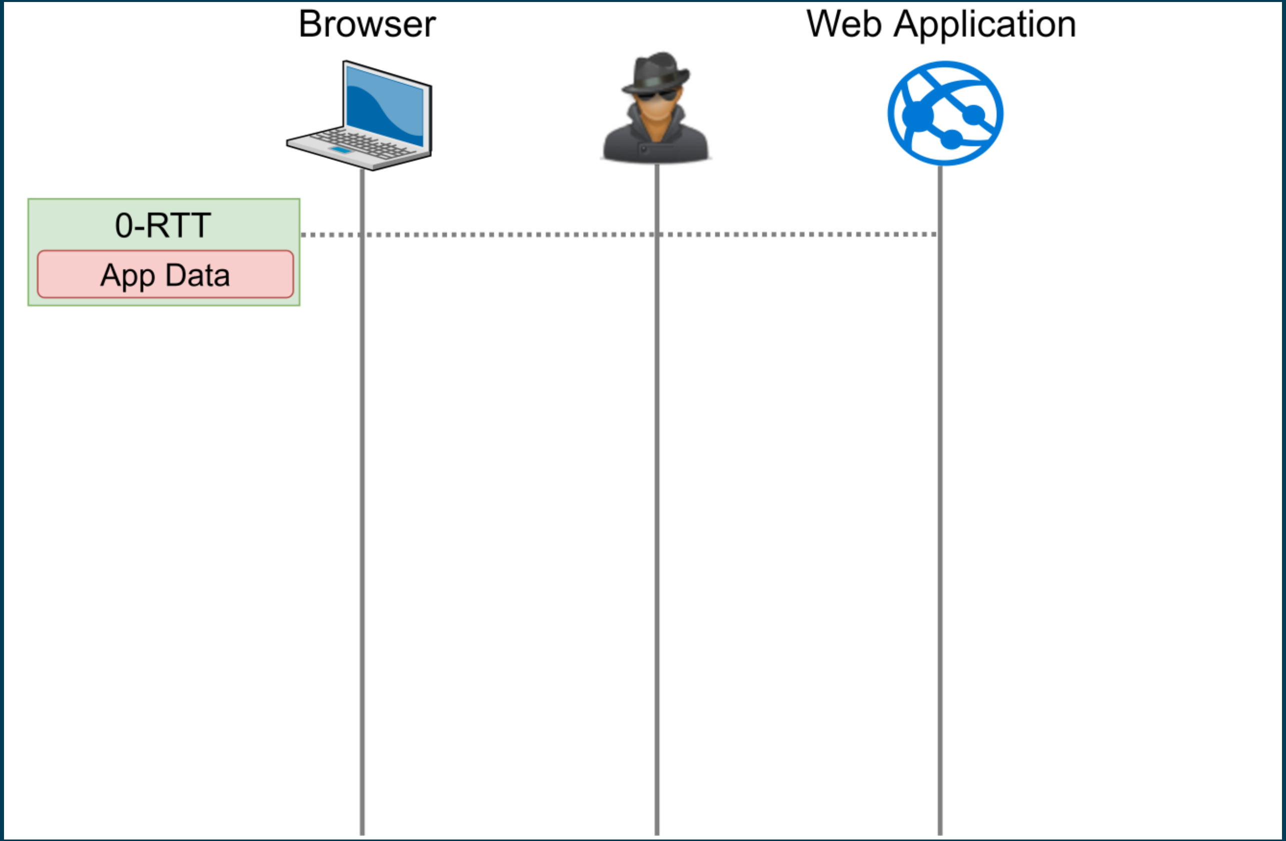
Universal replay attack



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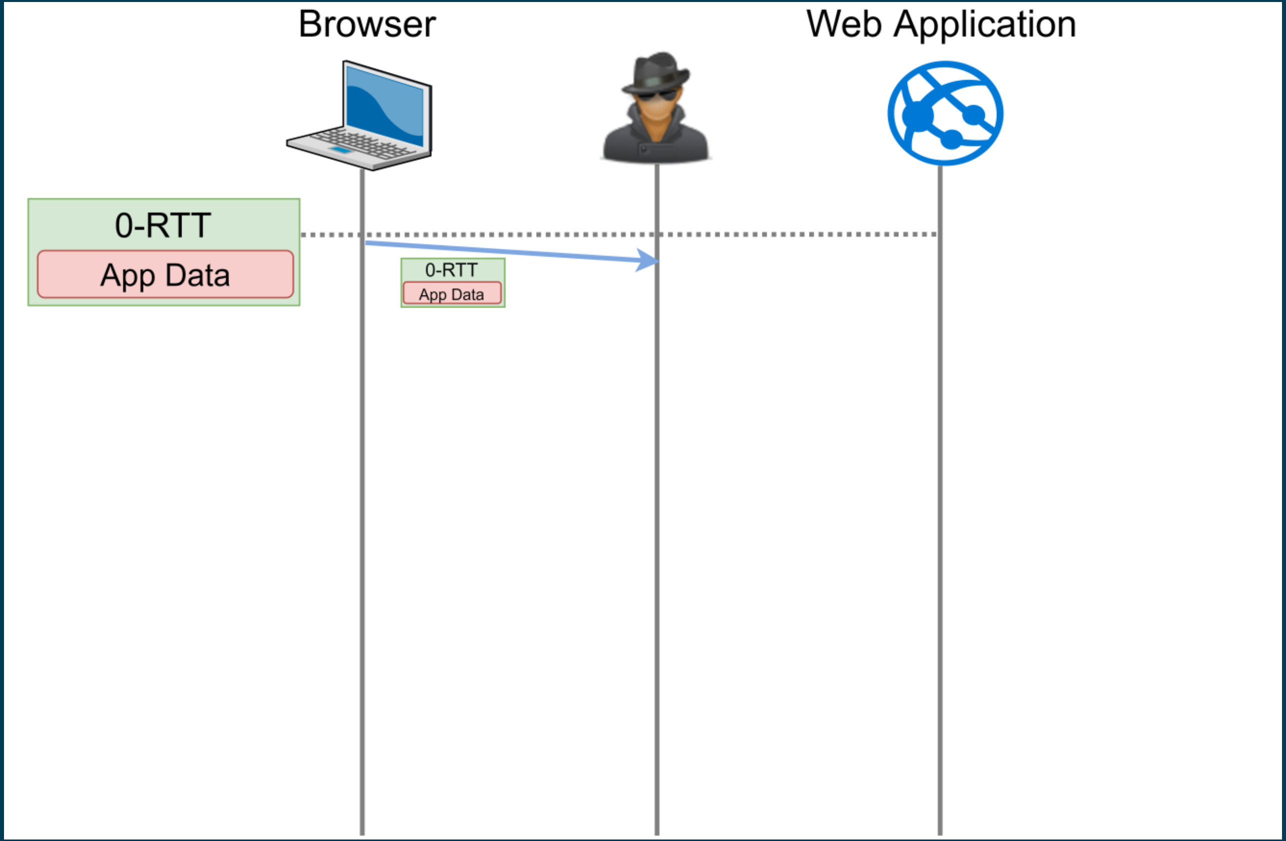

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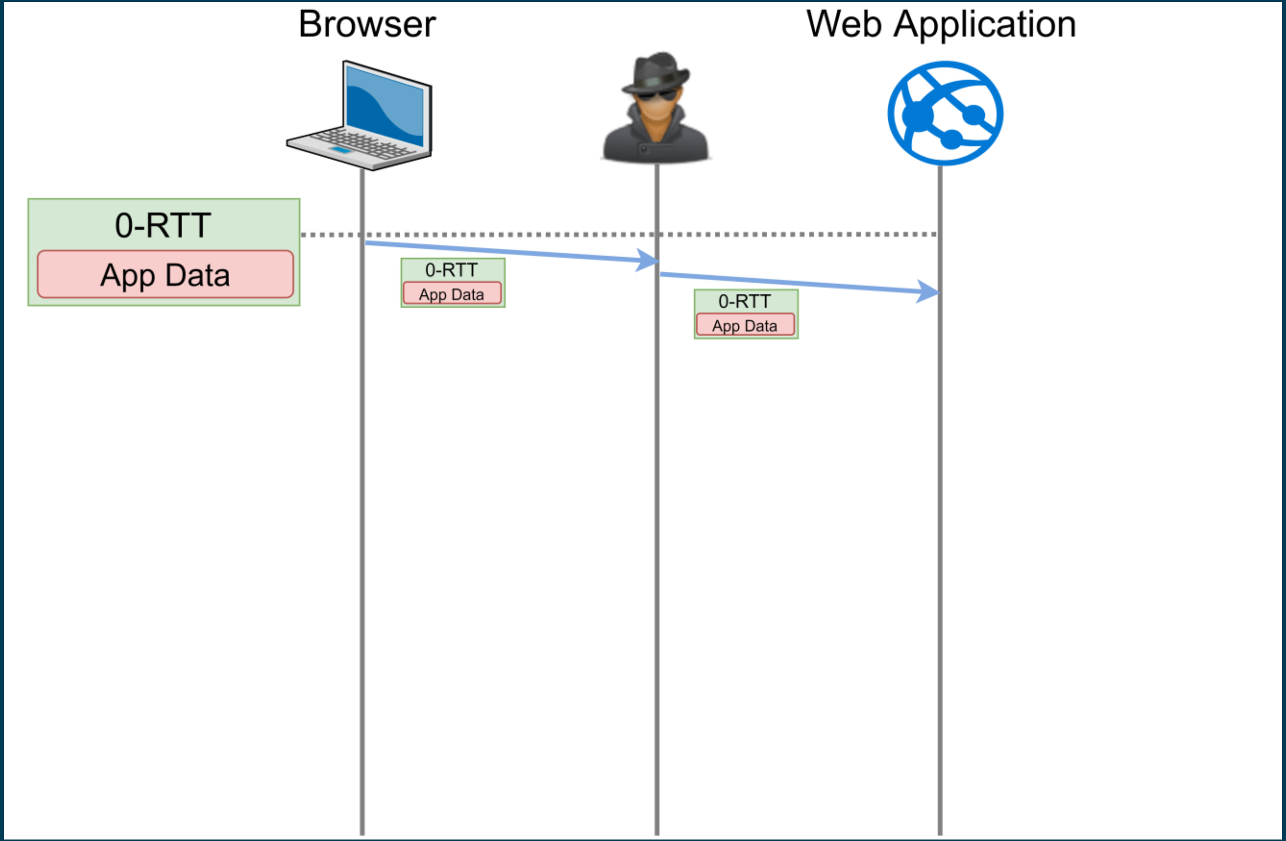

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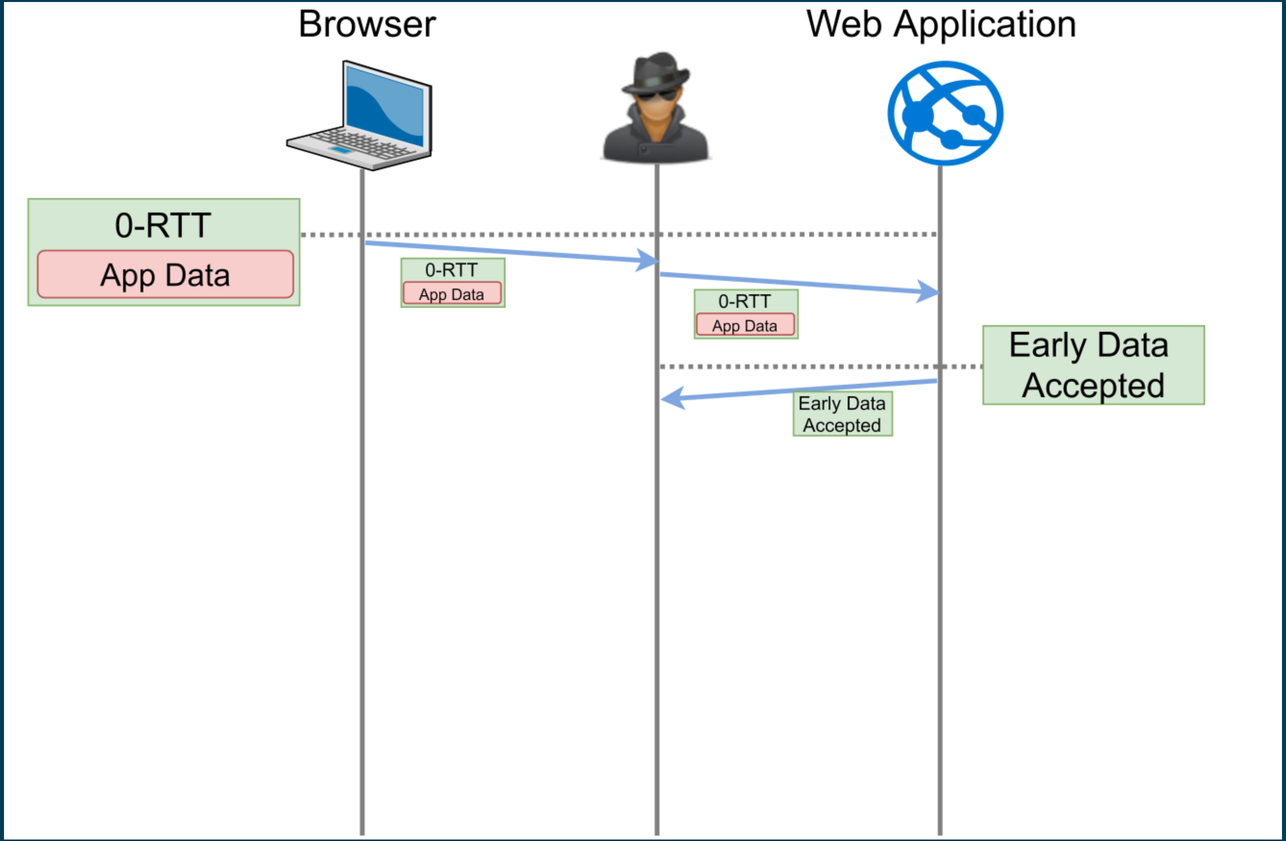

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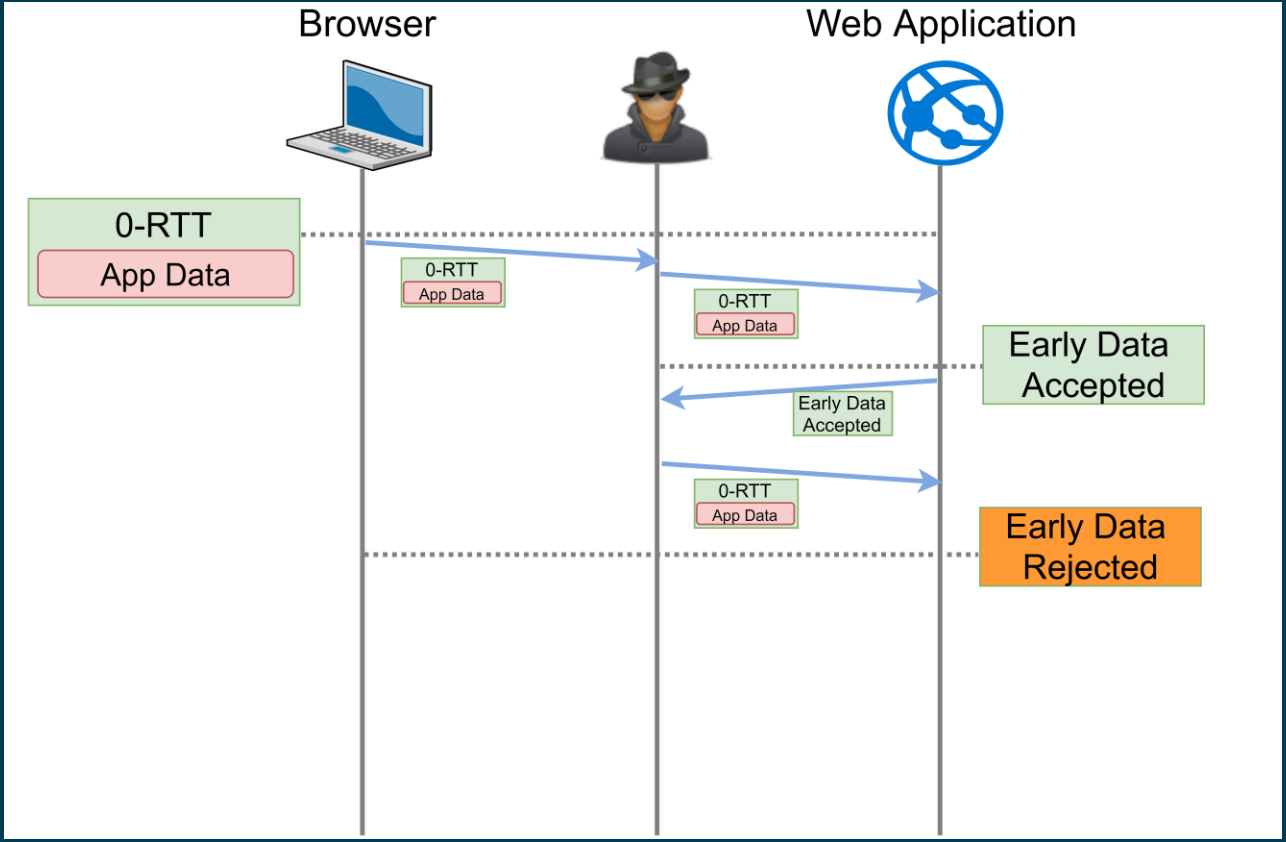

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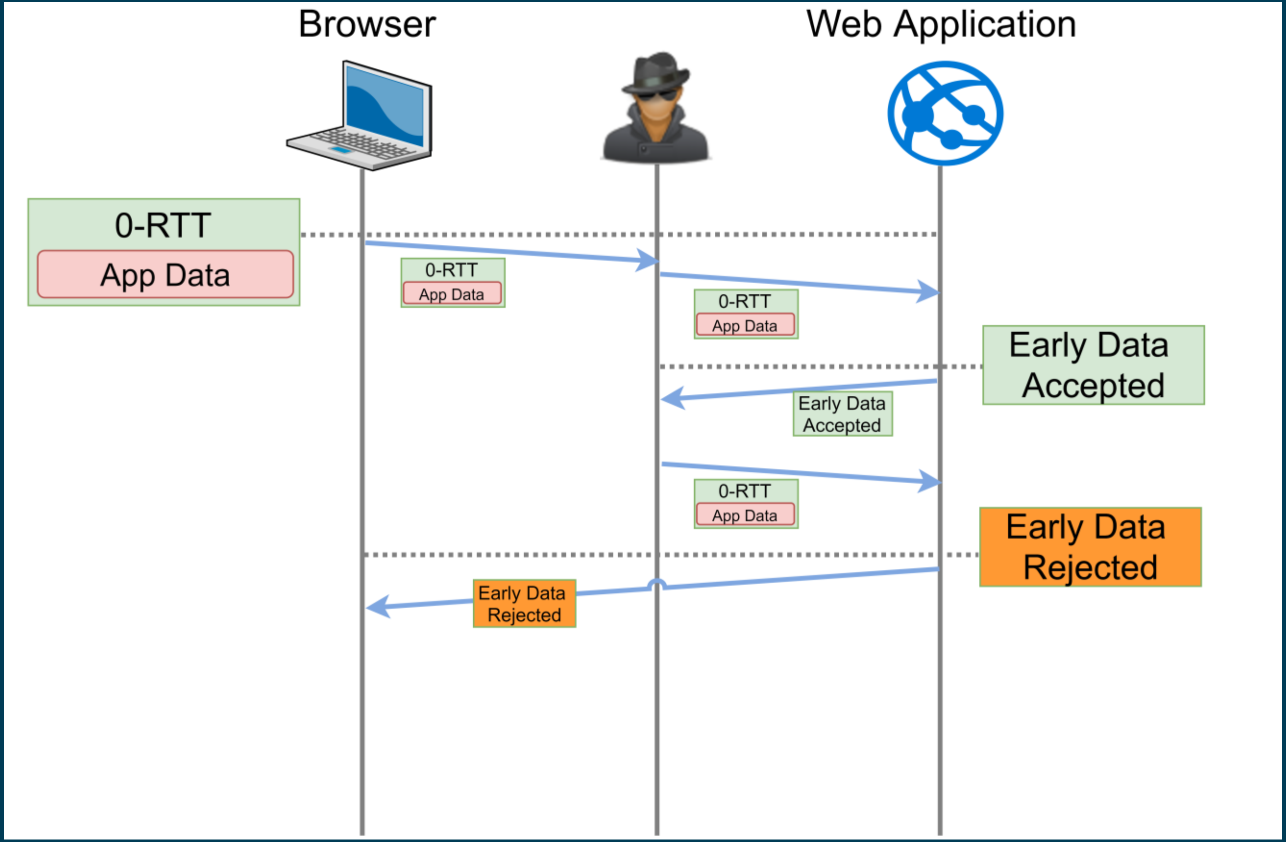

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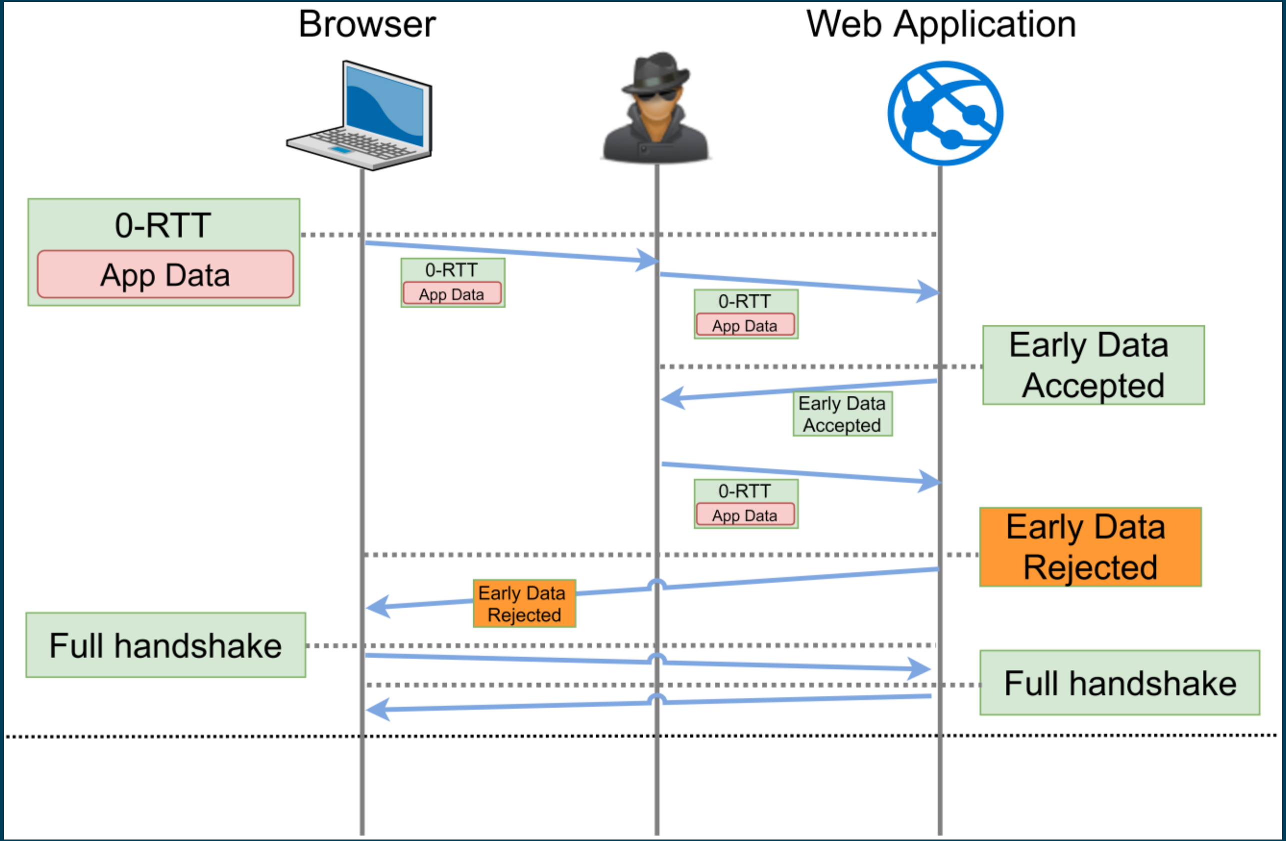

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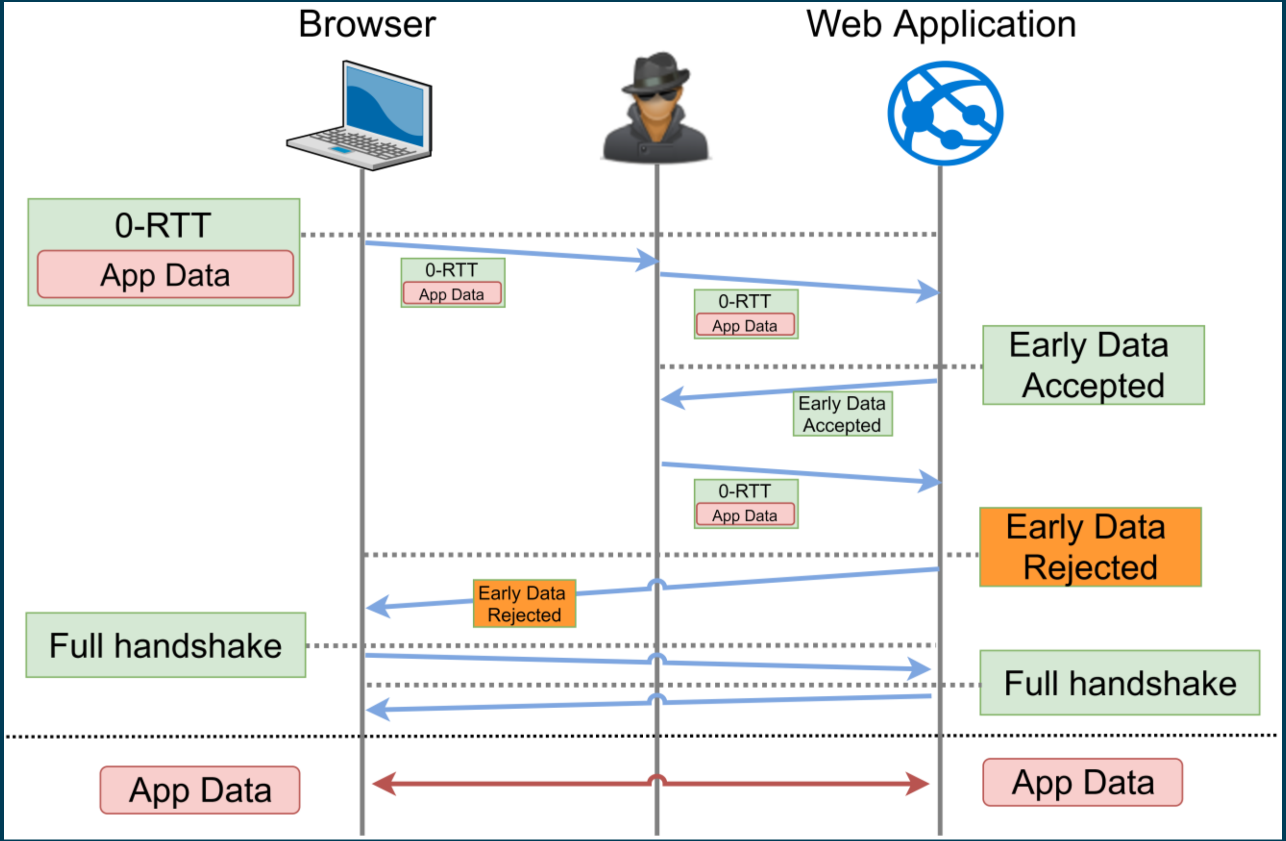

DEMO

Side effects of 0-RTT

- 0-RTT creates a **dependency between the application and** the underlying TLS 1.3 **protocol**
- The application will need to be **0-RTT aware**.
- Enabling 0-RTT could leave you application vulnerable to **replay attacks**
- Ultimately, the **last line of defence** would be the application itself.

Mitigations

- Disable 0-RTT
- Ensure that your application does not allow replays (e.g. CSRF). Ensure that REST services are developed properly
- Create an strict application profile after careful analysis.

Main takeaways

- **Adopt TLS 1.3**, but be aware could lead to a vulnerable application if 0-RTT is being used.
- **Your application needs to be 0-RTT aware** to prevent side effects.
- You will need to **take in account layers below your application**, as its configuration may protect or expose you against replay attacks

Thanks!