Loophole: Timing Attacks on Shared Event Loops in Chrome

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DISCLAIMER:

CRYPTACUS

DISCLAIMER:

~~CRYPTA~~CUS

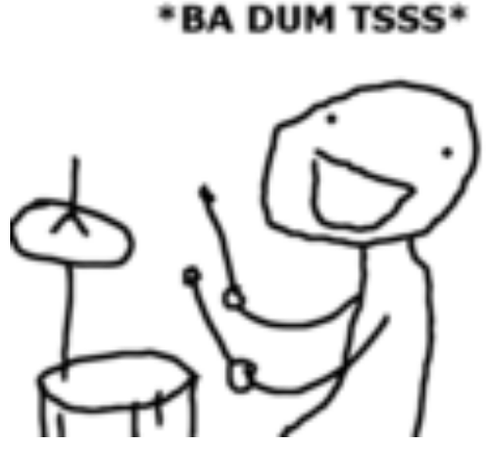
DISCLAIMER:

(it’s funny because it’s very ubiquitous…)

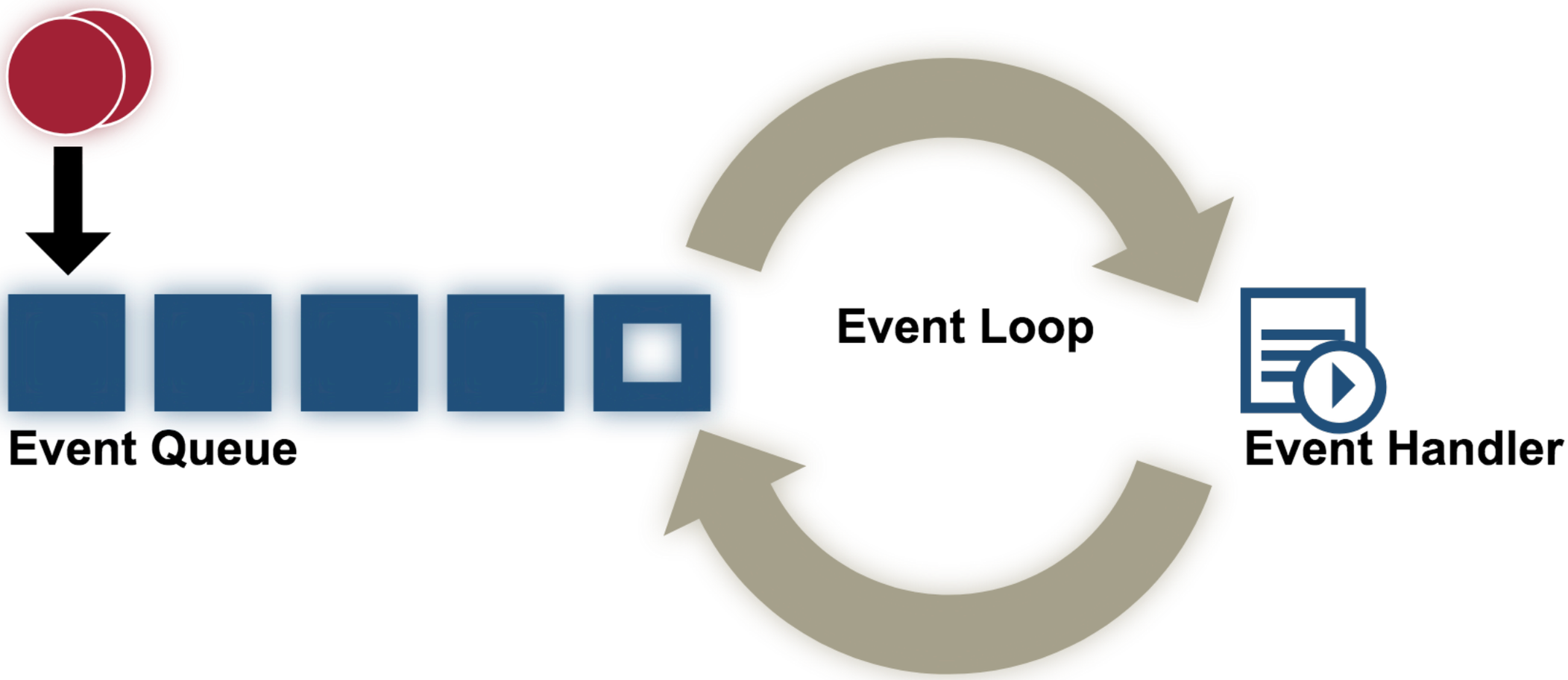
DISCLAIMER:

CUS

(it’s funny because it’s very ubiquitous…)



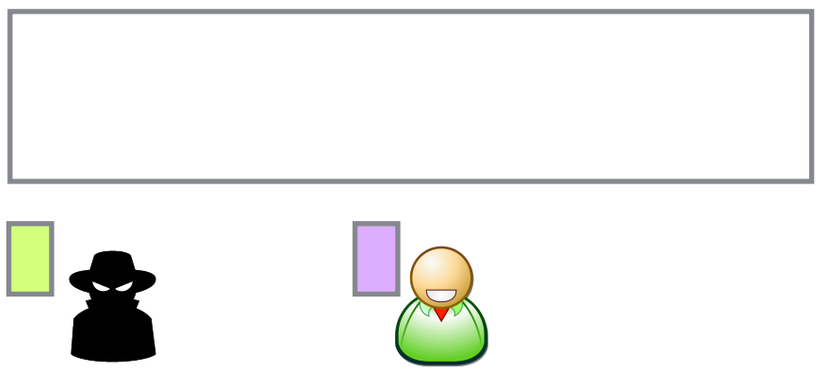
Event-driven programming



Source: http://berb.github.io/diploma-thesis/original/042_serverarch.html

Shared Event Loop

FIFO queue

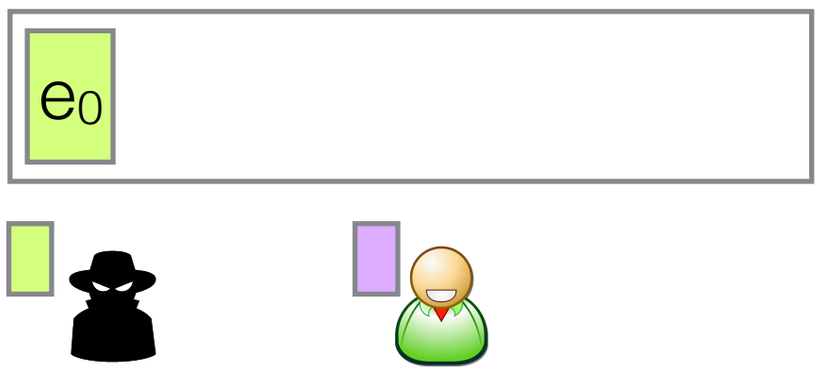


Dispatcher

time

Shared Event Loop

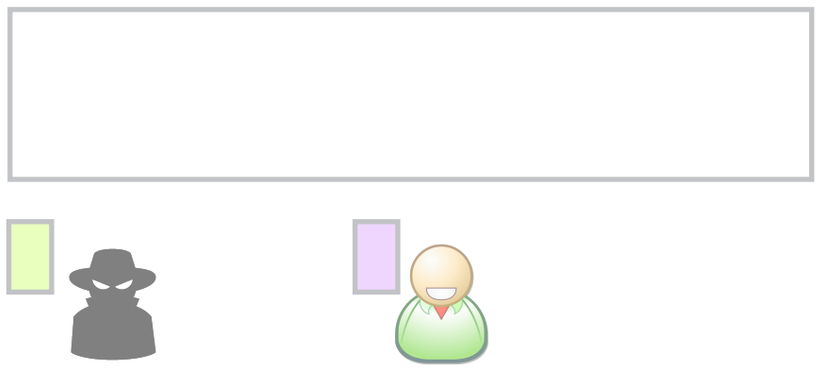
FIFO queue



Dispatcher

Shared Event Loop

FIFO queue

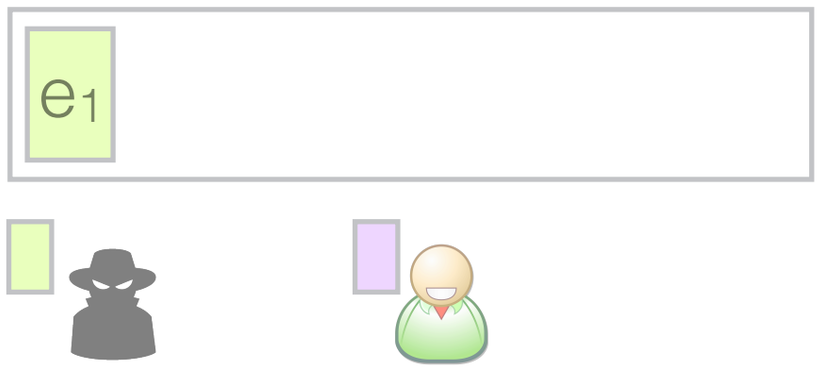


Dispatcher

e_0

Shared Event Loop

FIFO queue



Dispatcher

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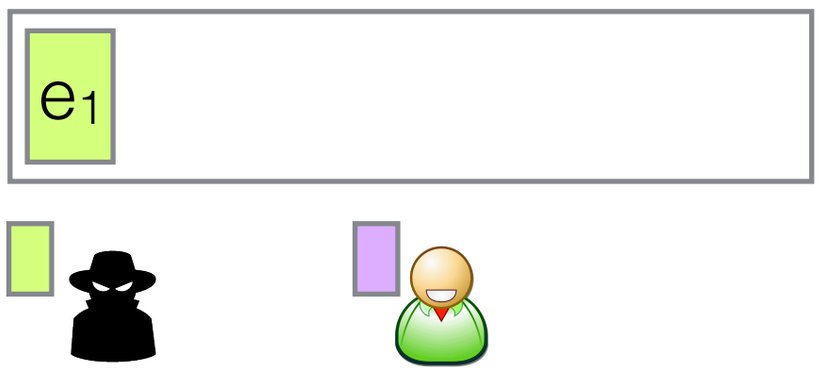
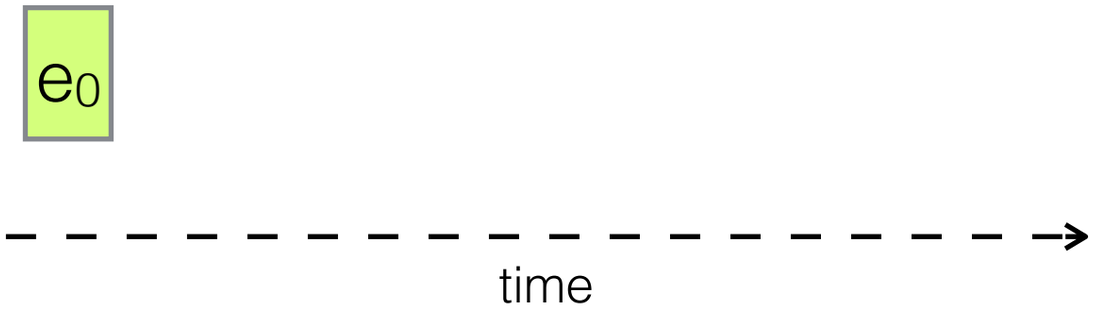
FIFO queue



Dispatcher 



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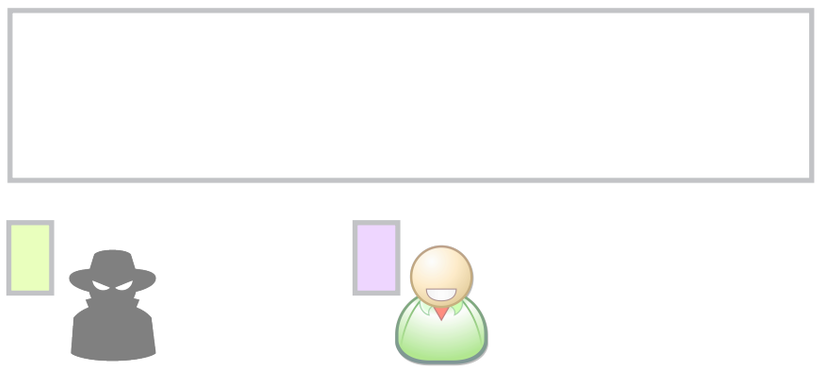


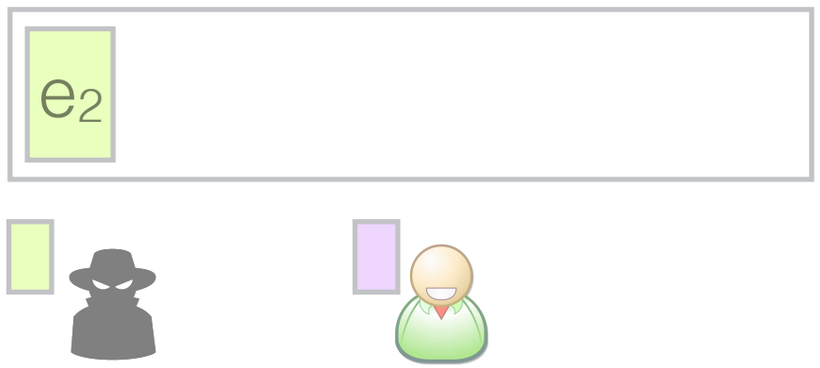
Dispatcher

e_1

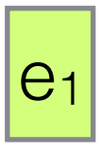
e_0

Shared Event Loop

FIFO queue

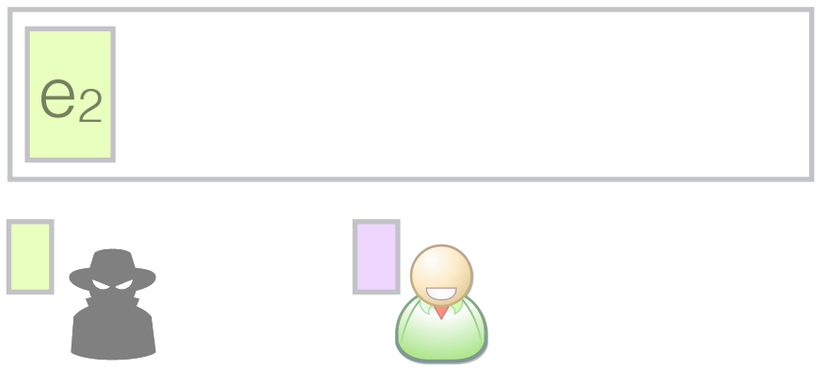


Dispatcher

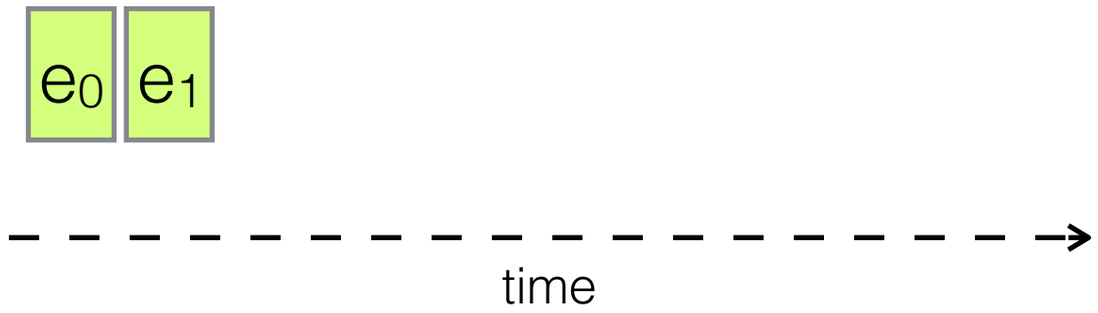


Shared Event Loop

FIFO queue

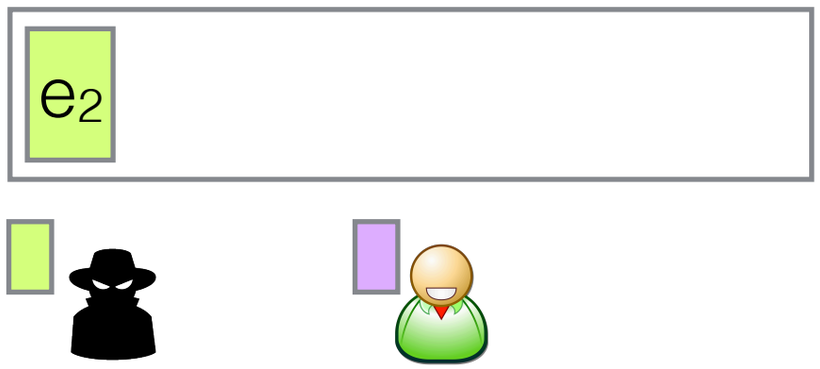


Dispatcher

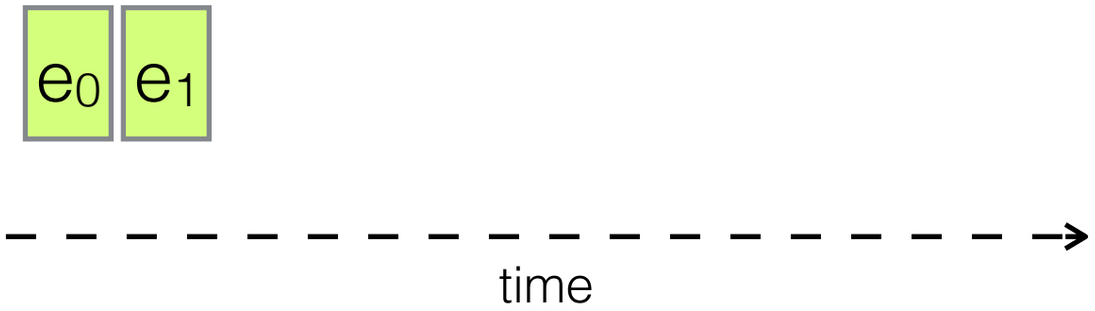


Shared Event Loop

FIFO queue



Dispatcher



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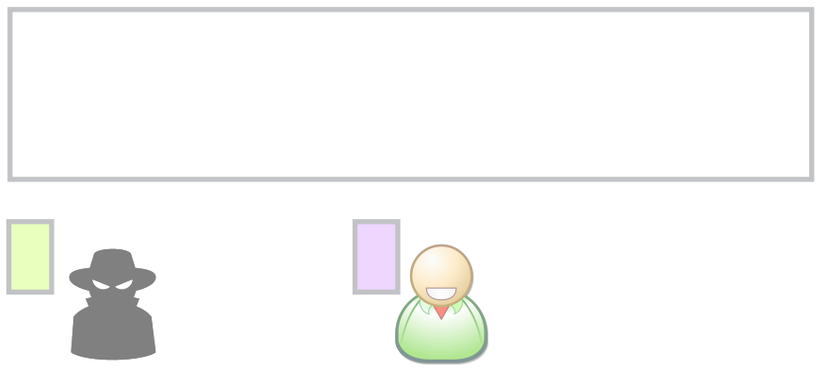
FIFO queue



Dispatcher

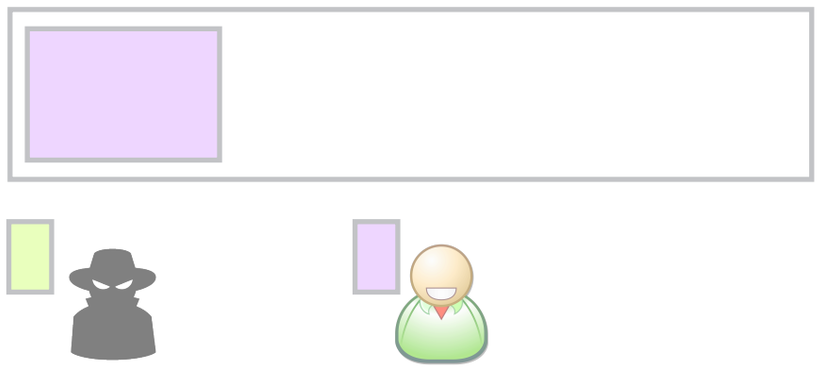
e_2

e_0 e_1

time

Shared Event Loop

FIFO queue



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Shared Event Loop

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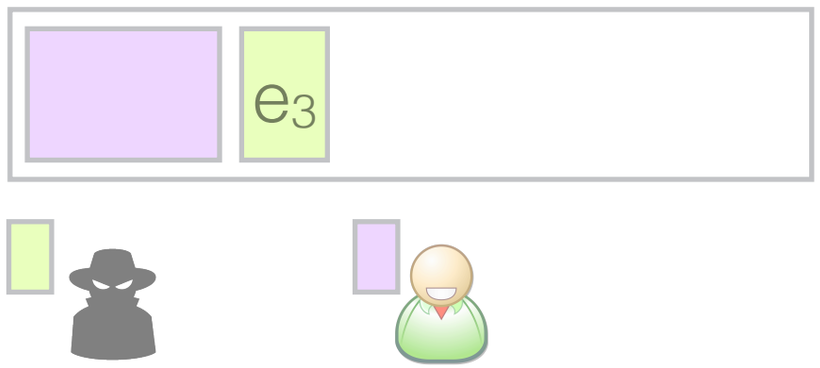

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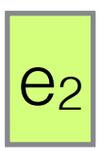
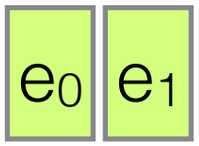
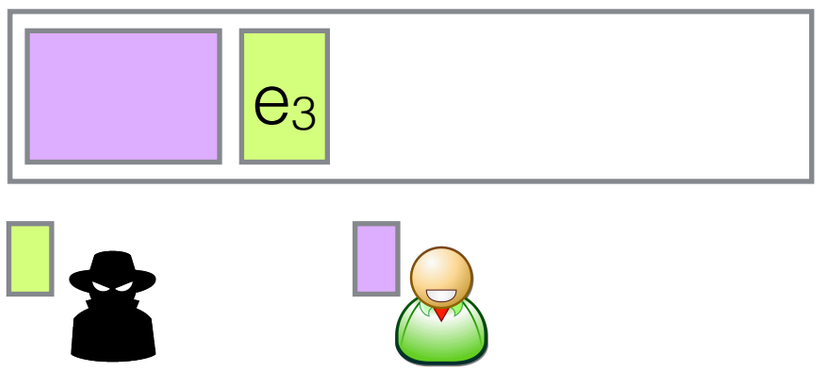


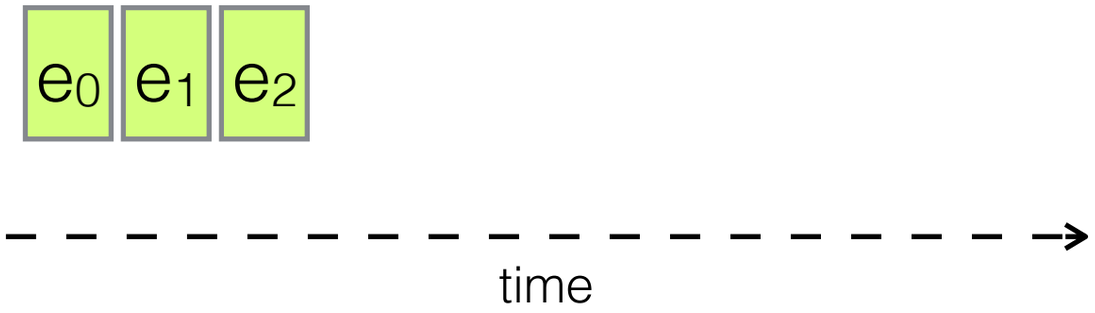


Shared Event Loop

FIFO queue



Dispatcher



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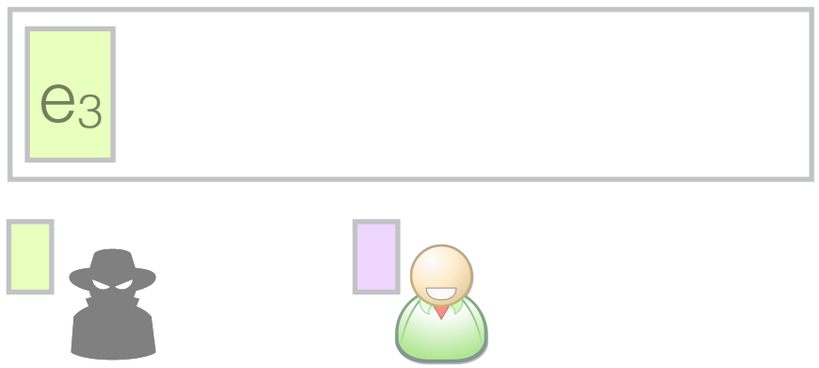
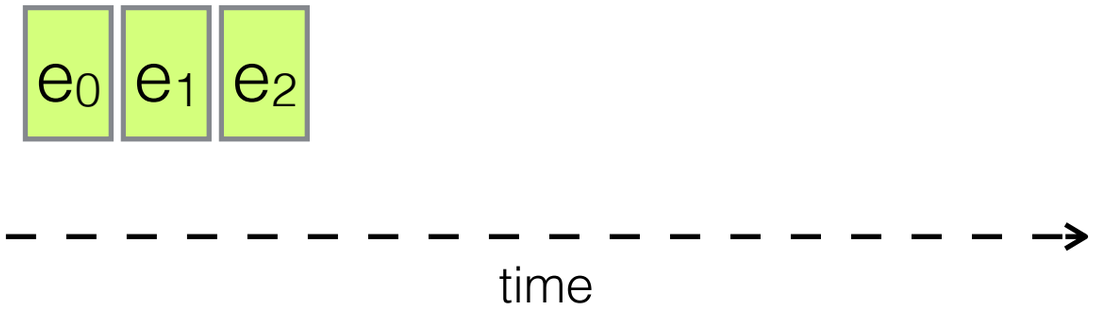


Dispatcher



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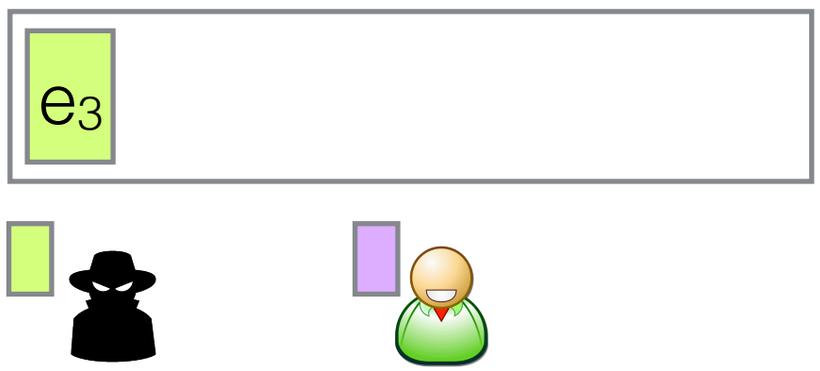
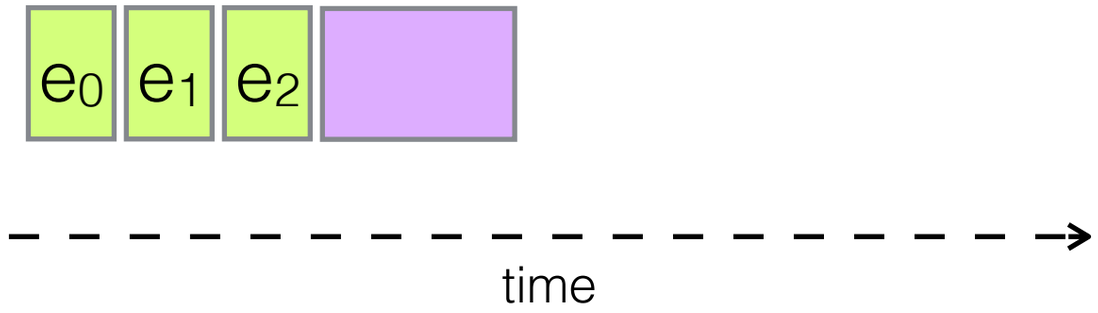


Dispatcher 



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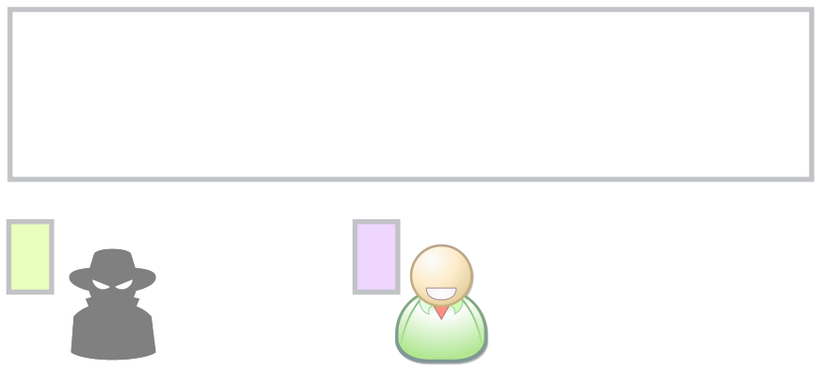
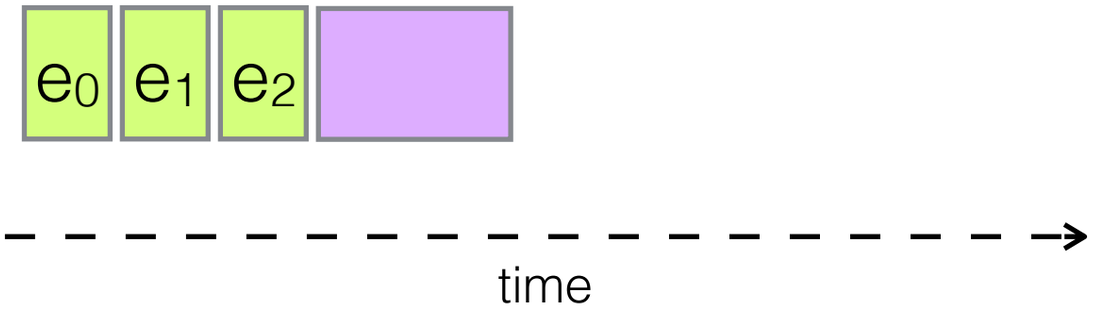


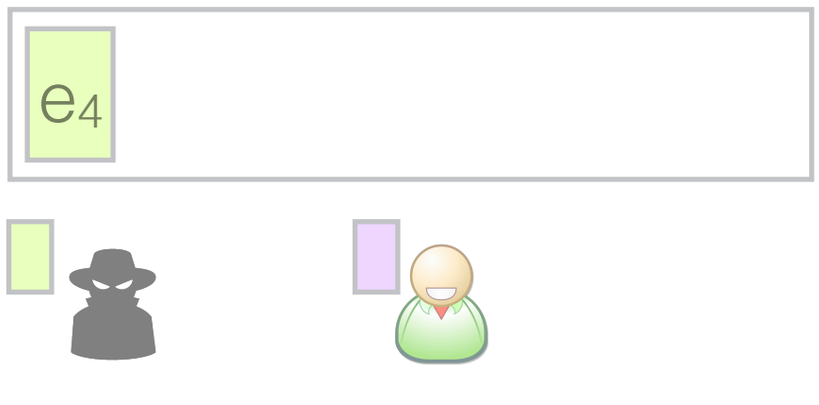
Dispatcher

e_3

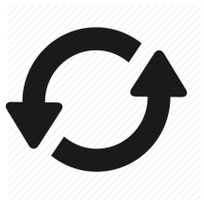


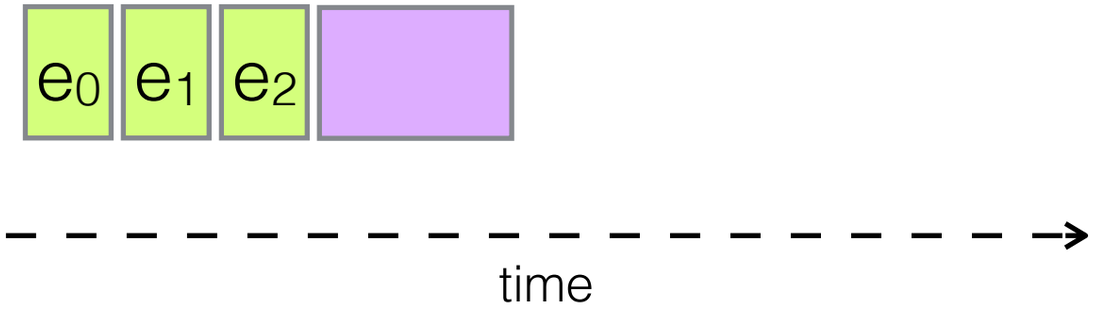
Shared Event Loop

FIFO queue



Dispatcher





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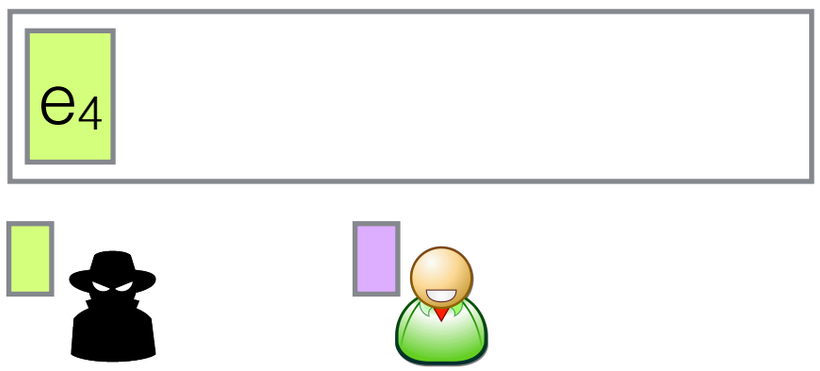

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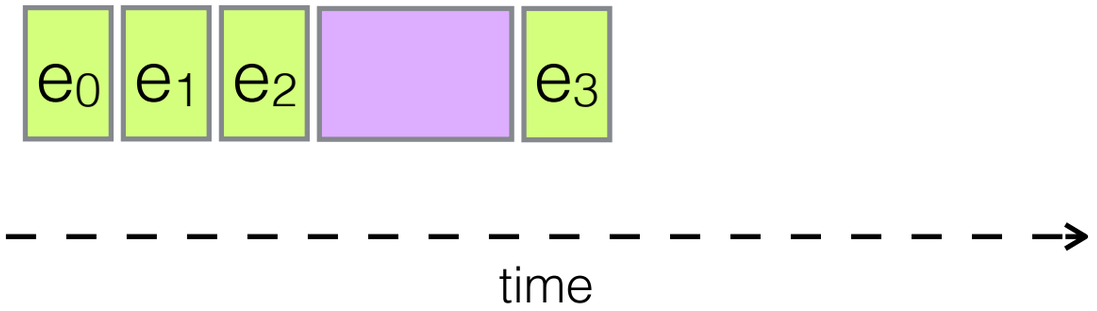
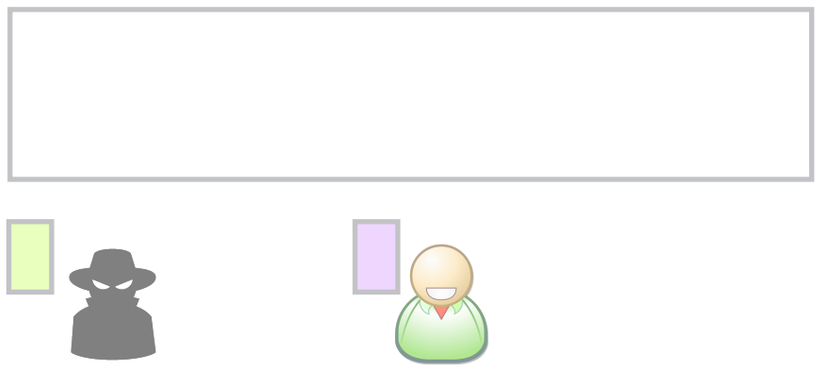


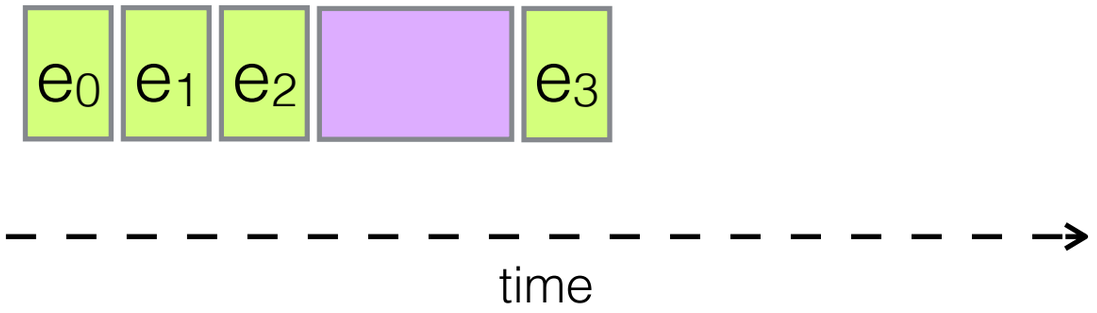
Shared Event Loop

FIFO queue



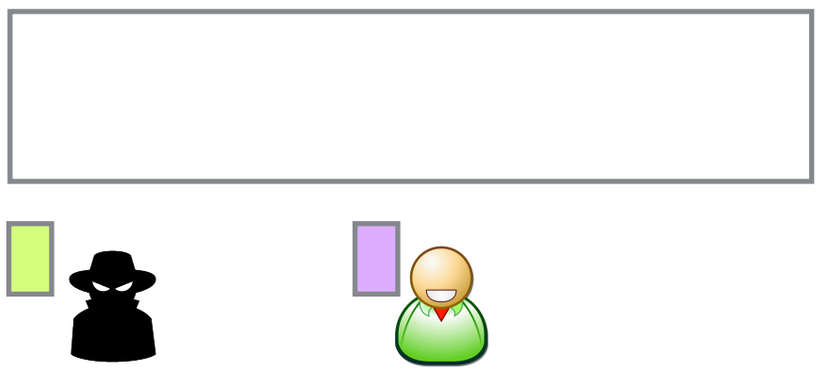
Dispatcher

e_4

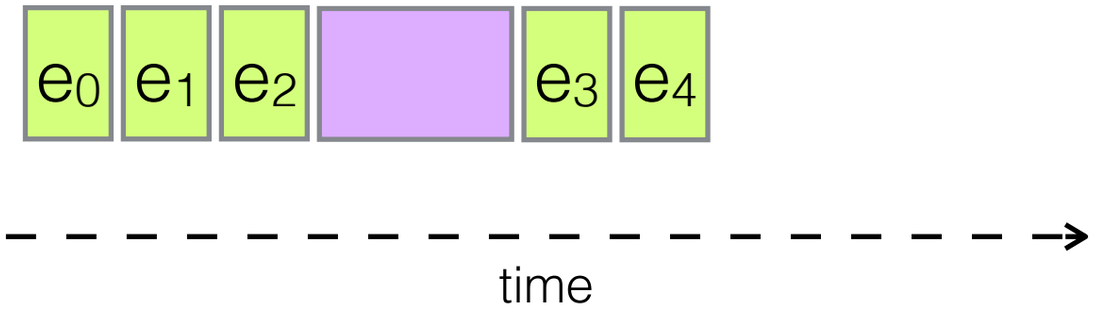


Shared Event Loop

FIFO queue

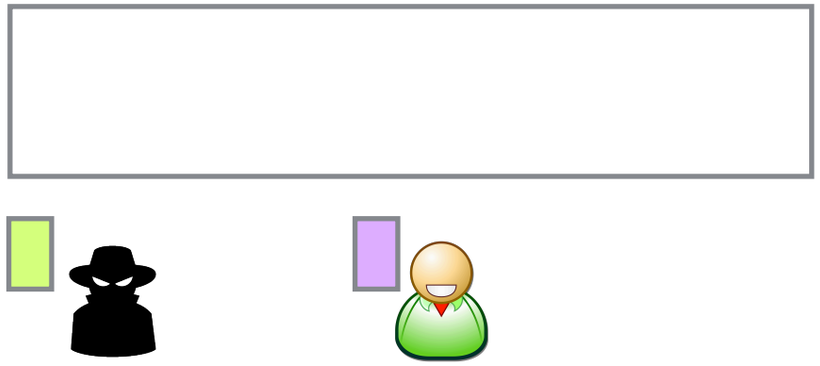


Dispatcher



Shared Event Loop

FIFO queue



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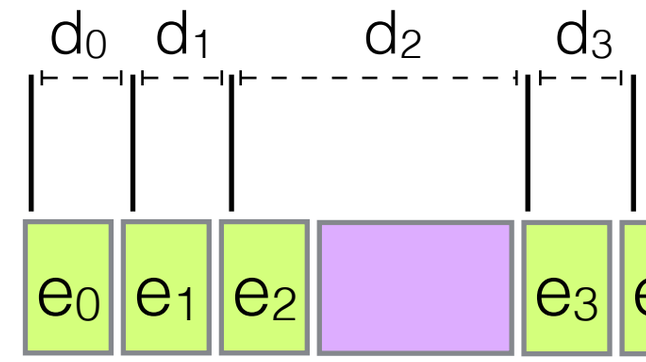

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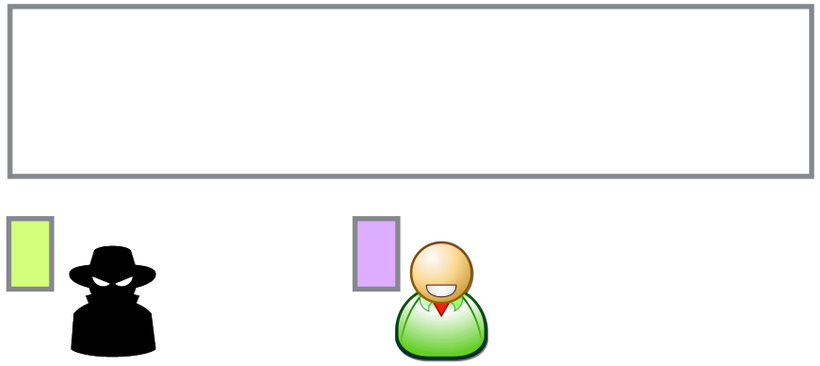
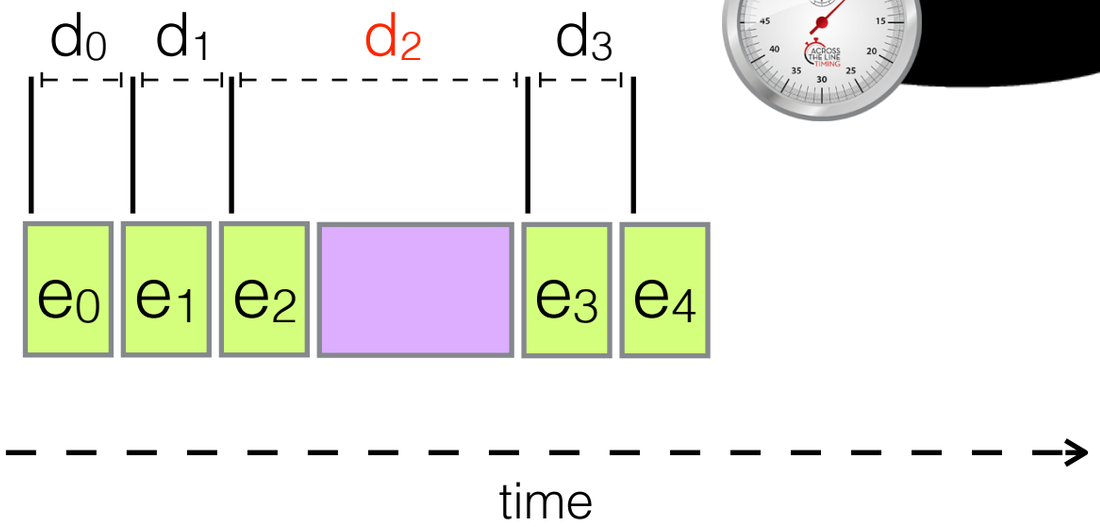


Dispatcher 

Event-delay trace



We exploit 2 different shared Event Loops in Chrome:

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I/O's of the **Host Process**

Main thread's of **Renderers**

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And implement 3 different attacks:

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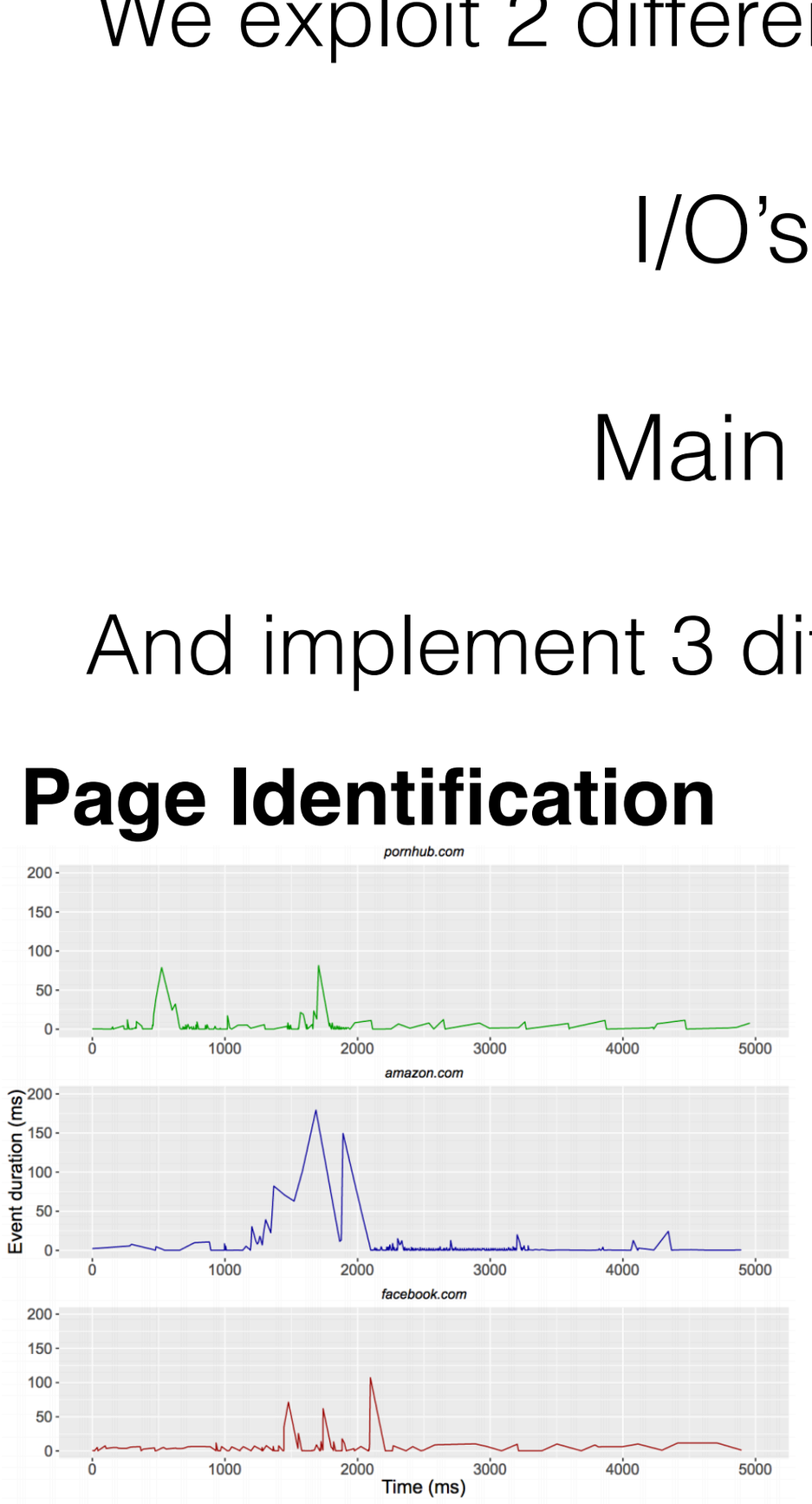

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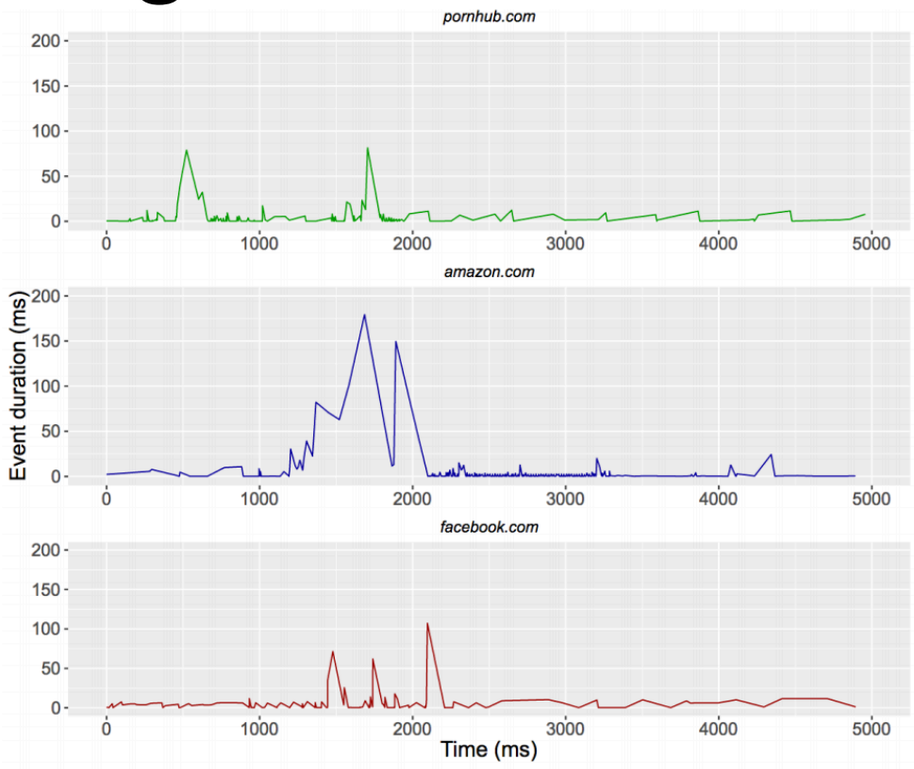
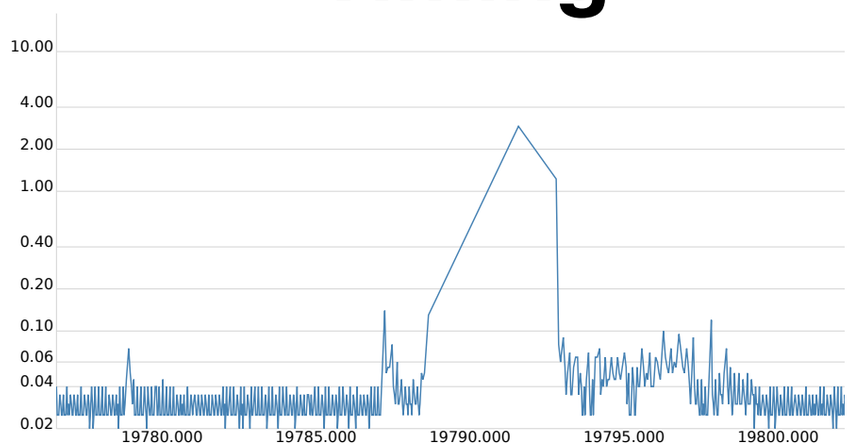


Inter-keystroke Timing



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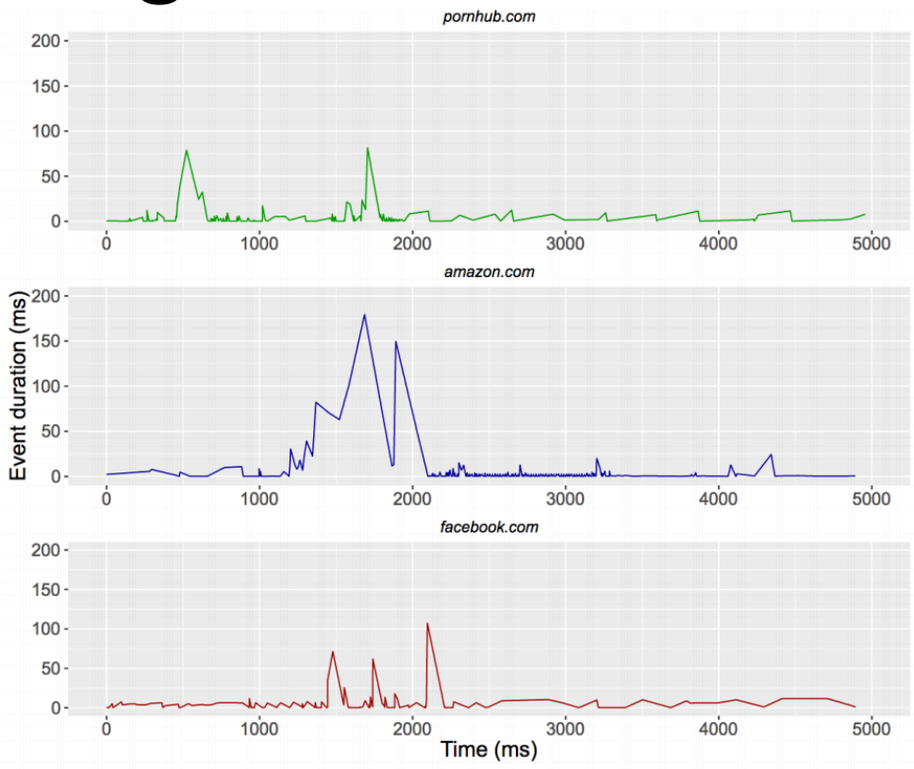

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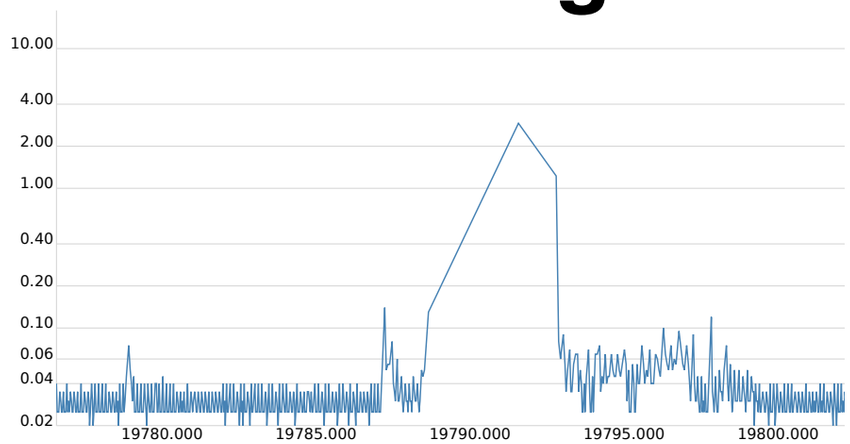
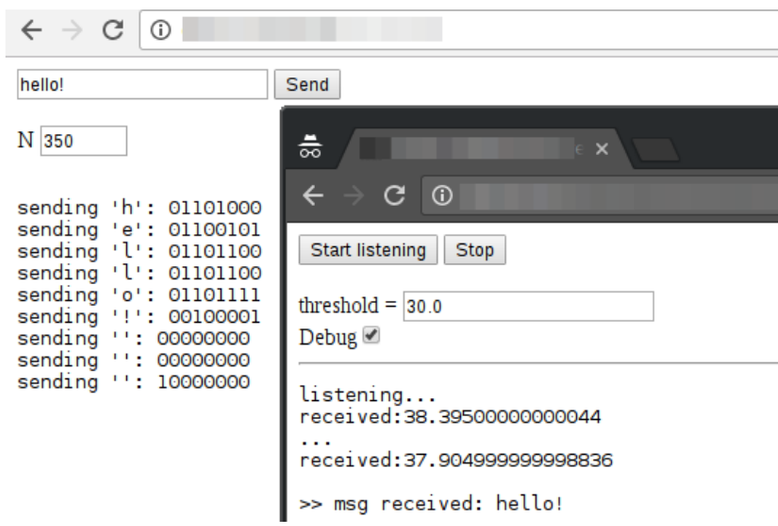
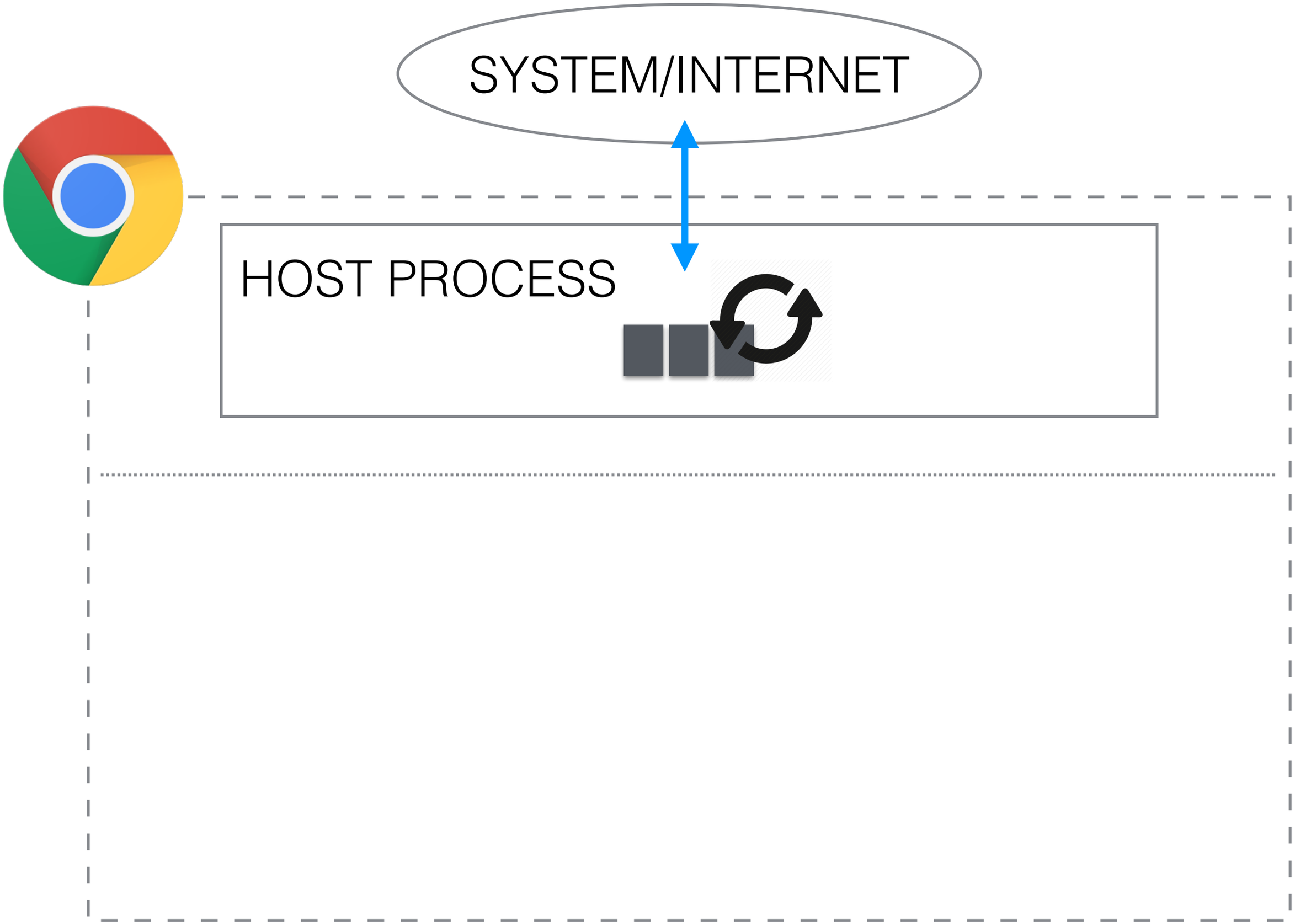


Covert Channel



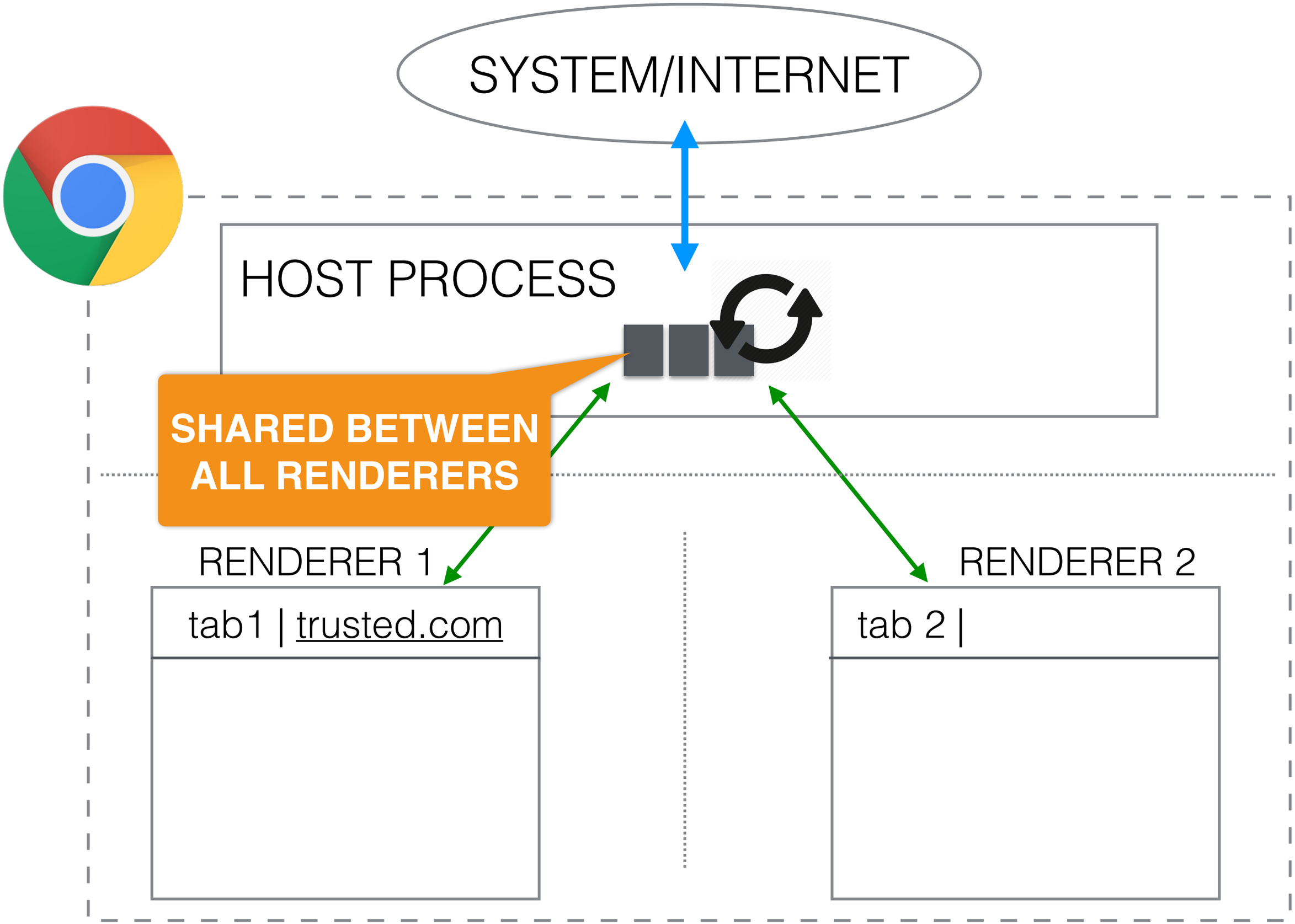
SYSTEM/INTERNET


SYSTEM/INTERNET
HOST PROCESS

SYSTEM/INTERNET

HOST PROCESS

- **NETWORK REQUESTS**
- **IPC COMMUNICATION**
- **DISPATCHES USER ACTIONS**


SYSTEM/INTERNET
HOST PROCESS
SHARED BETWEEN ALL RENDERERS
RENDERER 1
tab1 | trusted.com
RENDERER 2
tab 2 |

SYSTEM/INTERNET

HOST PROCESS

RENDERER 1

tab1 | trusted.com

RENDERER 2

tab 2 |

SYSTEM/INTERNET

HOST PROCESS

RENDERER 1

tab1 | trusted.com

RENDERER 2

tab 2 | evil.com

Spying on the Host

```
<script>
function loop () {
    save(performance.now());
    fetch(new Request("http://0/"))
        .catch(loop);
}
loop();
</script>
```

Timing resolution of ~500 µs

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```

~~Timing resolution of ~500 µs~~

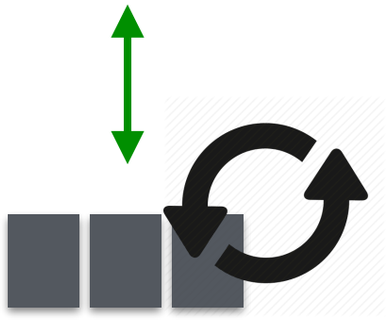
With SharedWorkers we obtain <100 µs

SYSTEM/INTERNET

HOST PROCESS

RENDERER 1

tab1 | trusted.com



SYSTEM/INTERNET

HOST PROCESS

RENDERER 1

tab1 | trusted.com

- **JAVASCRIPT EXECUTION**
- **RESOURCE PARSING**
- **LAYOUT & RENDERING**

SYSTEM/INTERNET

HOST PROCESS

RENDERER 1

tab1 | trusted.com

iframe |

SHARED BETWEEN IFRAMES, POPUPS, MAX #RENDERER EXCEEDED…

SYSTEM/INTERNET

HOST PROCESS

RENDERER 1

tab1 | trusted.com

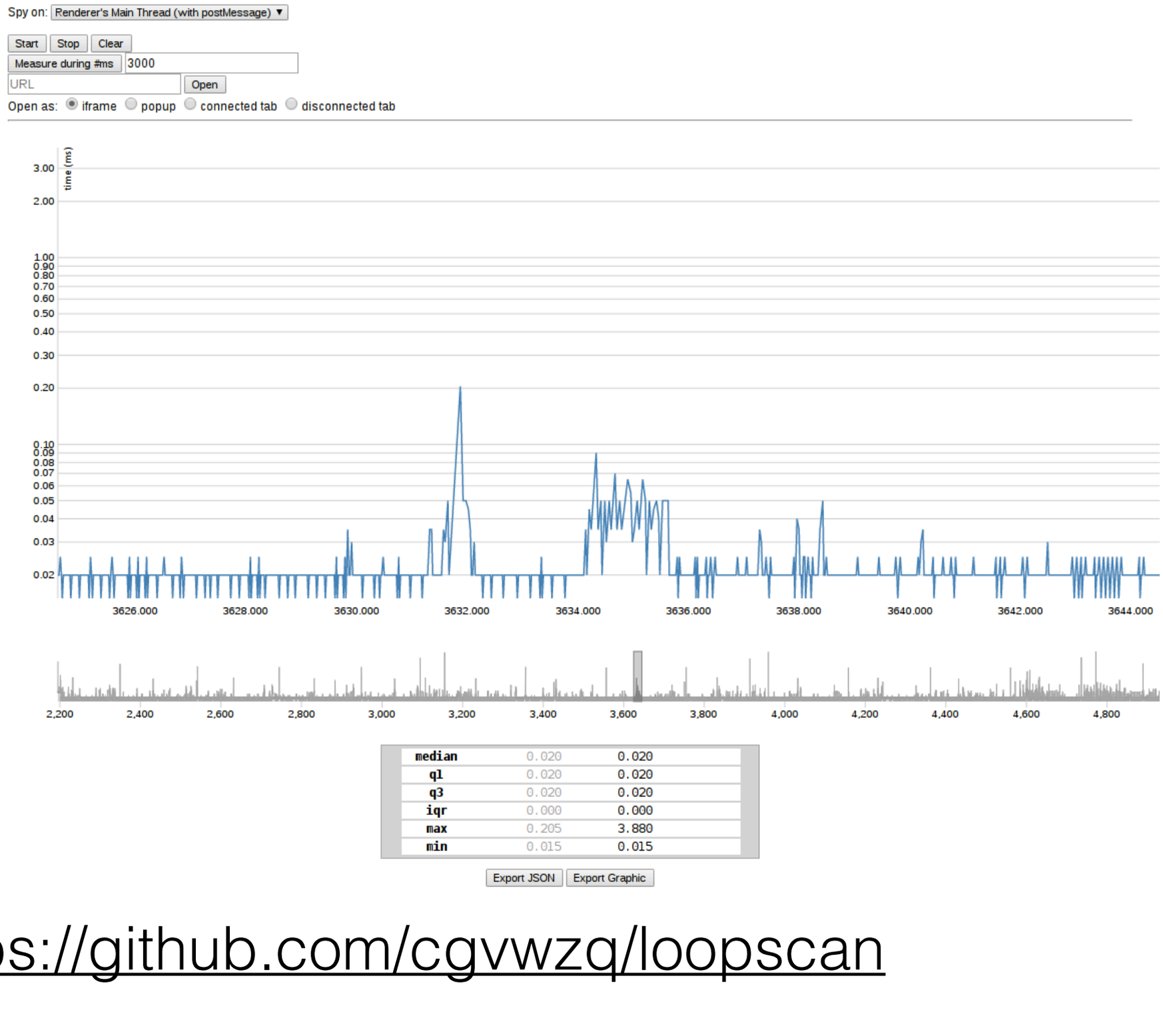
iframe | evil.co

Spying on the Renderer

```
<script>
function loop() {
    save(performance.now());
    self.postMessage(0, "*");
}
self.onmessage = loop;
loop();
</script>
```

Timing resolution of <25 µs

LoopScan Tool

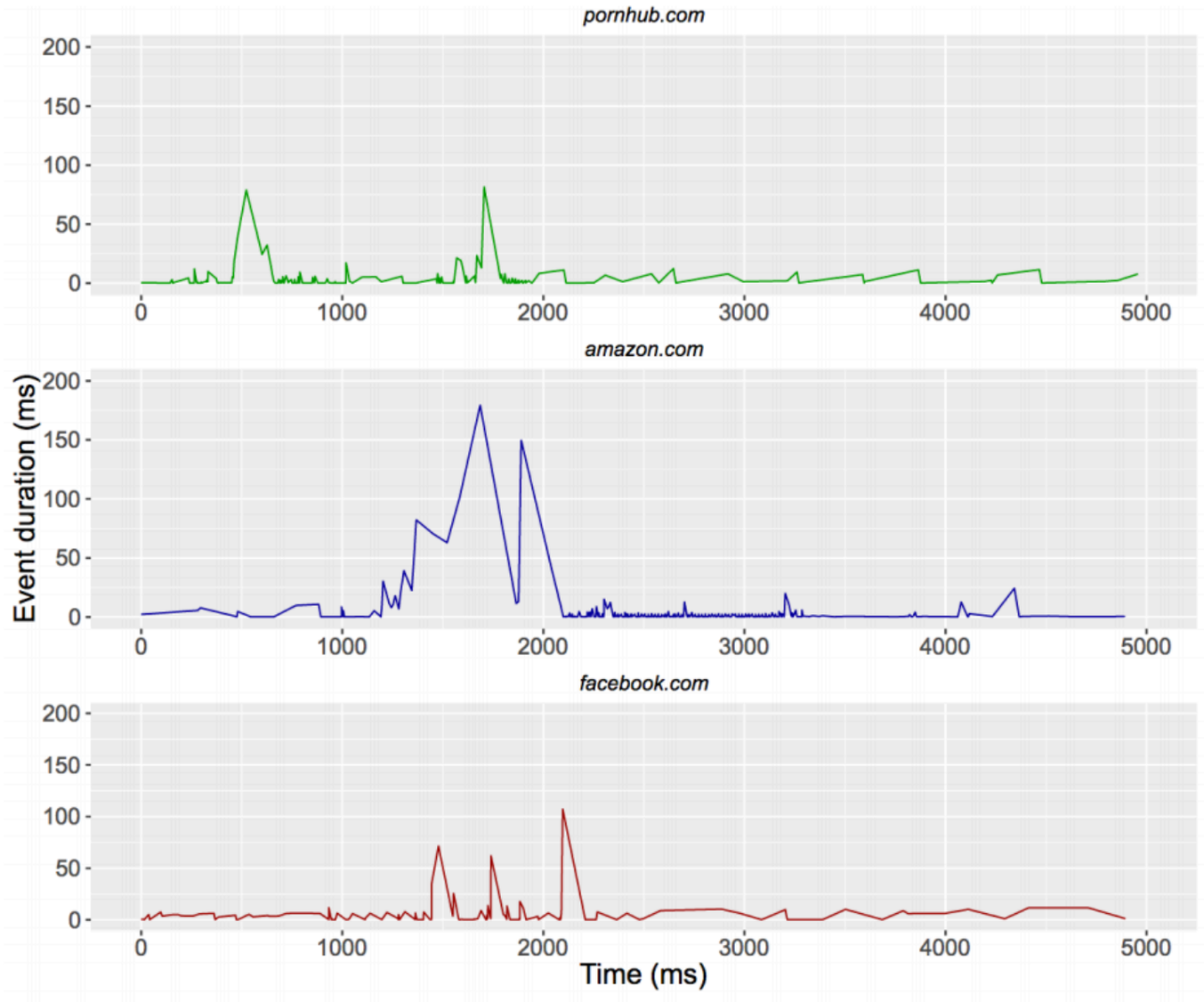


https://github.com/cgvwzq/loopscan

Web Page Identification

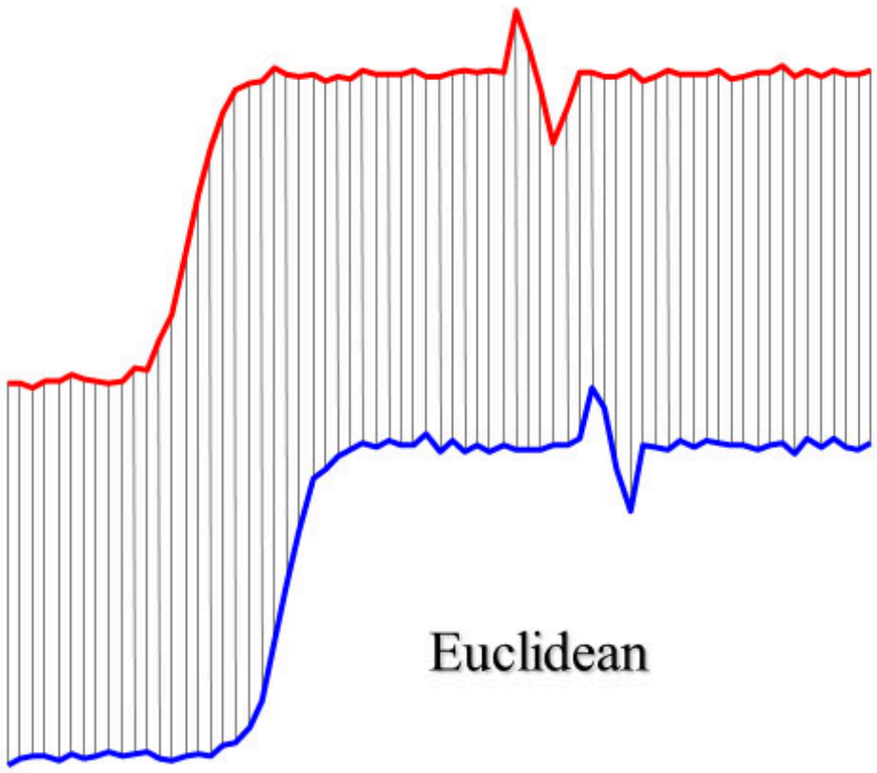
& Inter-keystroke Timing

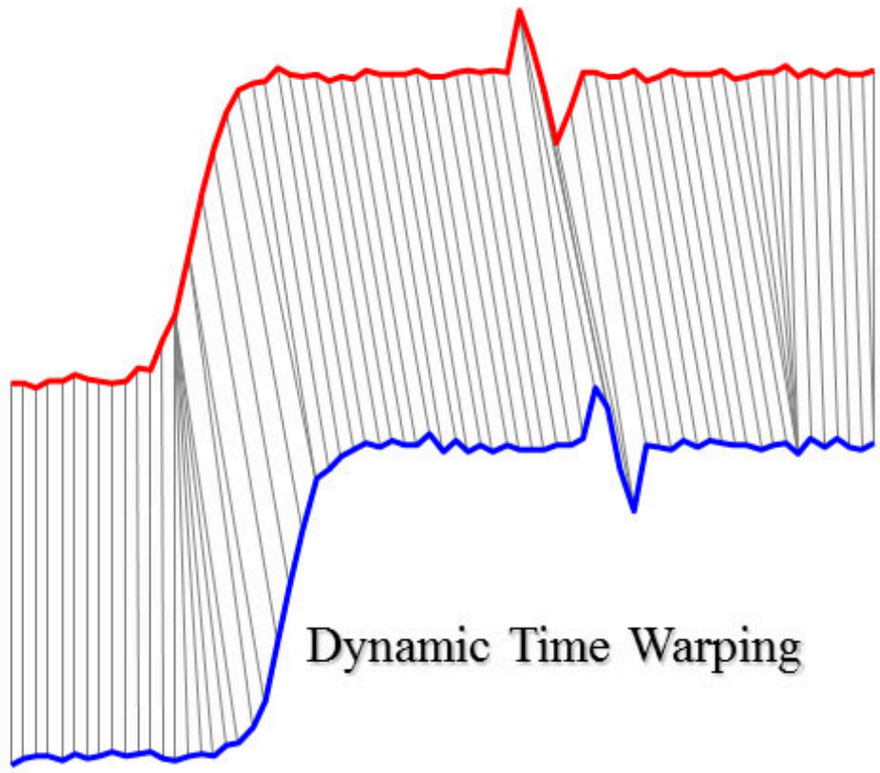
Web Page Identification



Monitor the EventLoop while page loading

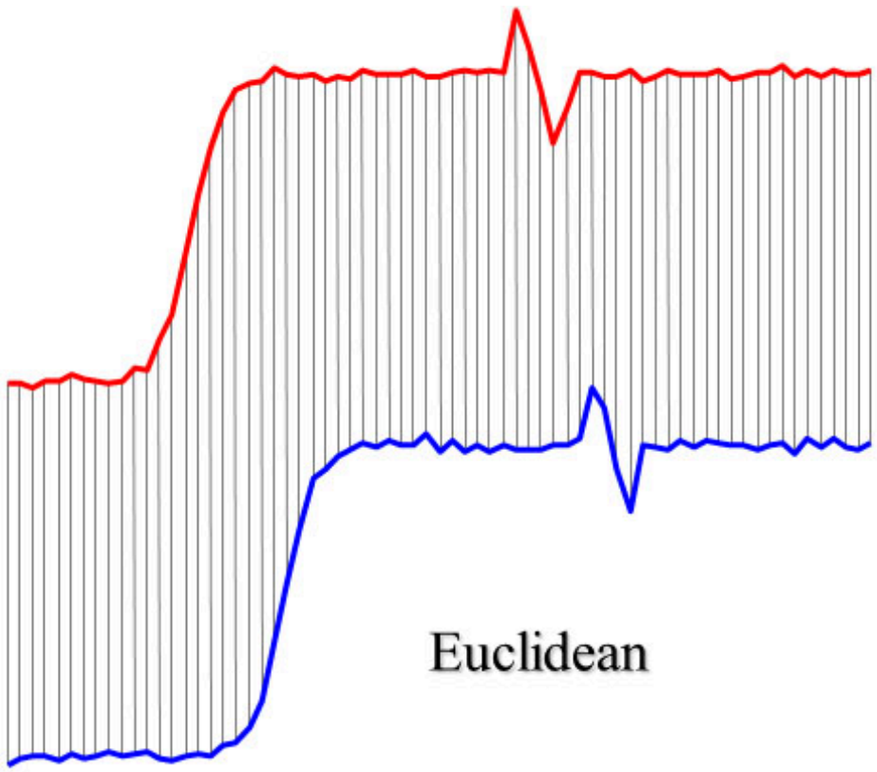
Dynamic Time Warping

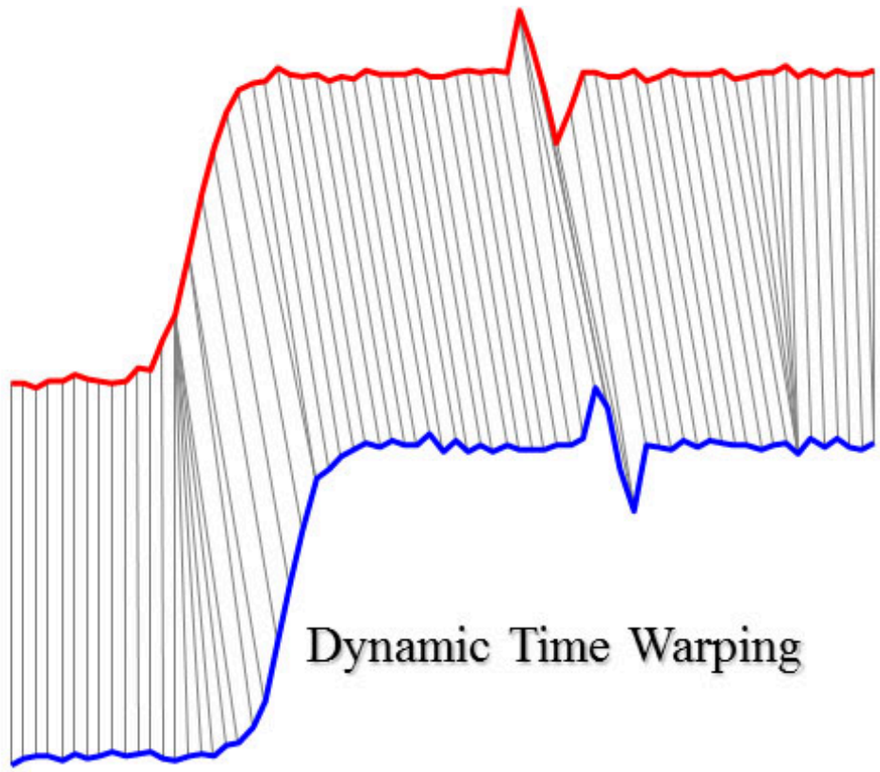




DTW is resistant to delays in the occurrence of events

Dynamic Time Warping

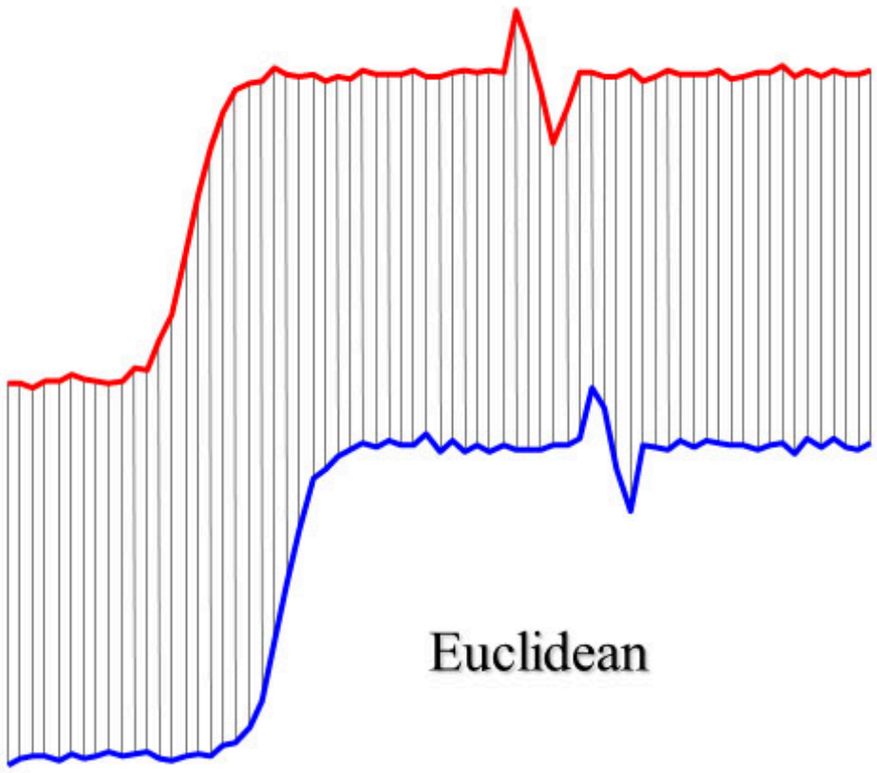


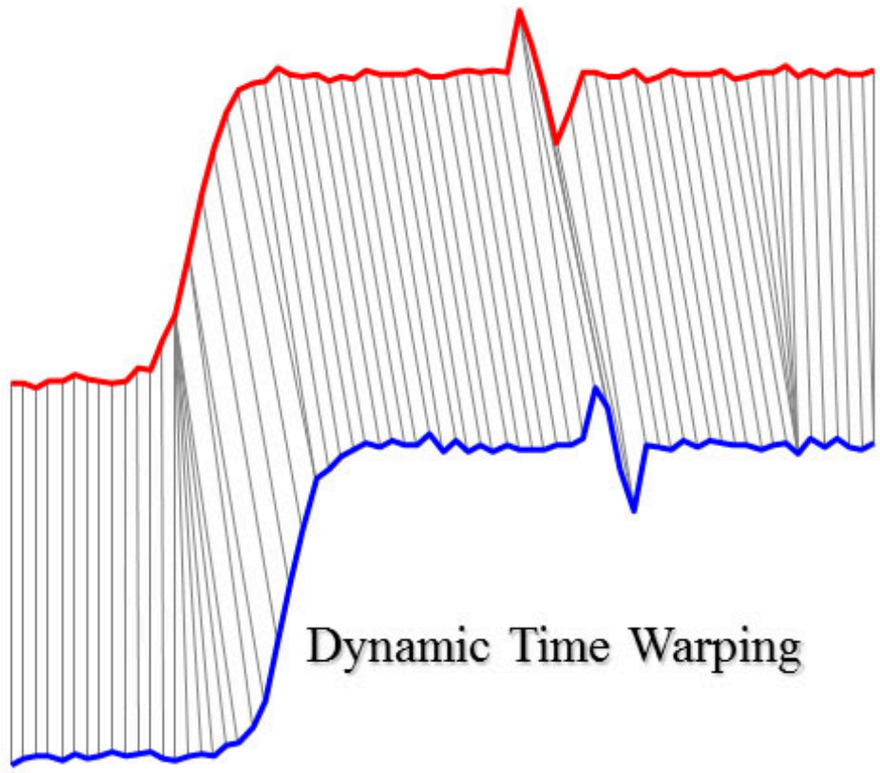


DTW is resistant to delays in the occurrence of events

2-4 seconds of measuring

Dynamic Time Warping





DTW is resistant to delays in the occurrence of events

2-4 seconds of measuring

One trace for training

Web Page Identification

500 pages x 30 traces x 3 machines x 2 event loops

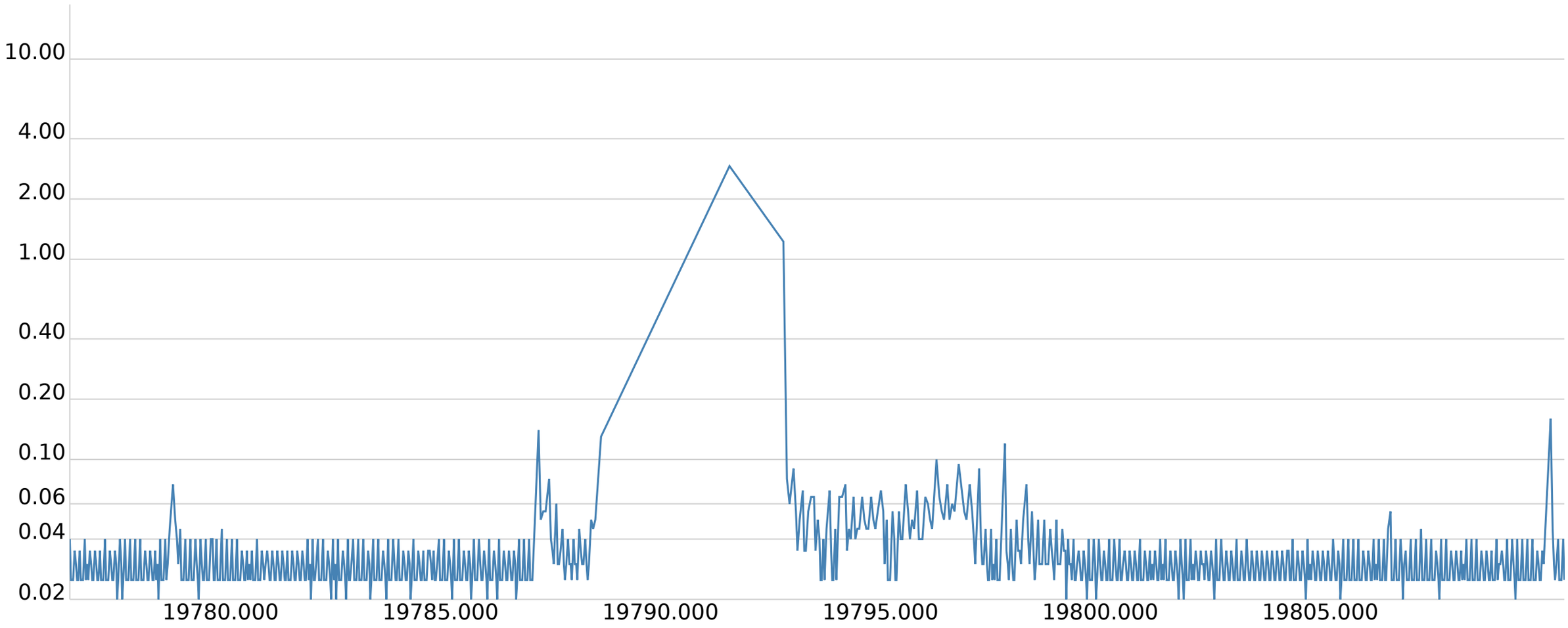
Renderer's main thread: **75%** (Linux desktop)

Host's I/O thread: **23%** (Macbook Pro)

(recognition rates below 5% across machines)

R-library and datasets:
https://github.com/cgvwzq/rlang-loophole

Inter-keystroke Timing



We obtain the password length and time between consecutive pressed keys

Inter-keystroke Timing

10.000 passwords

90% accuracy

precision: σ = 6.1 ms

Inter-keystroke Timing

10.000 passwords

90% accuracy

precision: σ = 6.1 ms

More precision than network based attacks.

Less noise than in micro-architectural attacks.

No privileges. No training.

Countermeasures

- Reduce clock resolution
- Site Isolation Project
- CPU throttling
- Rate limiting

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- ~~Reduce clock resolution~~
- Site Isolation Project
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Conclusions

- Shared event loops in Chrome are vulnerable to timing side-channels
- We systematically study how this channel can be used for different attacks
- Fundamental design issues that need to be addressed

Thank you! :)

Questions?