CS169 Week 8 Section

Liang (Leon) Gong

Liang Gong, Electric Engineering & Computer Science, University of California, Berkeley.

Administrivia & Agenda

Today's Agenda:

- JavaScript
- JS Coding Practice
- JS Performance
- AJAX & Security
- Node.js

JavaScript

- Atwood's Law: any application that can be written in JavaScript, will eventually be written in JavaScript.
- No. 1 in the RedMonk PL Rankings
  - Popularity based on GitHub and StackOverflow

...

But…

- JavaScript is a terribly designed languages.
- Too many confusing features and APIs
  - You should avoid them!
- Only makes sense if you look at it from a historical perspective.

Rule: avoid using *for..in* over arrays

```
var sum = 0, value;
var array = [11, 22, 33];
for (value in array) {
    sum += value;
}
> sum ?
```


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Rule: avoid using `for..in` over arrays

```
var sum = 0, value;
var array = [11, 22, 33];
for (value in array) {
    sum += value;
}
> sum ?
```

`11 + 22 + 33 => 66`

array index
(not array value)

`0 + 1 + 2 => 3`

array index : string

`0+"0"+"1"+"2" => "0012"`

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Rule: avoid using *for..in* over arrays

```
var sum = 0, value;
var array = [11, 22, 33];
for (value in array) {
    sum += value;
}
> sum ?
```

`11 + 22 + 33 => 66`

`0 + 1 + 2 => 3`

`0+"0"+"1"+"2" => "0012"`

array index
(not array value)

array index : string

- Cross-browser issues
- Result depends on the Array prototype object

`> "0012indexOftoString..."`

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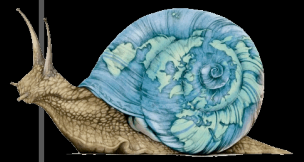
Rule: avoid using *for..in* over arrays

```
var sum = 0, value;
var array = [11, 22, 33];
for (value in array) {
    sum += value;
}
> sum ?
```



```
for (i=0; i < array.length; i++) {
    sum += array[i];
}
```

```
function addup(element, index, array) {
  sum += element;
}
array.forEach(addup);
```

```
for (elem of Array) { ... }
```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Problematic JavaScript

- Designed and Implemented in 10 days
- Not all decisions were well-thought
- Problematic language features
  - Error prone
  - Poor performance
  - Prone to security vulnerabilities
- Problematic features are still around
  - Backward compatibility
- Political fights among the browser vendors

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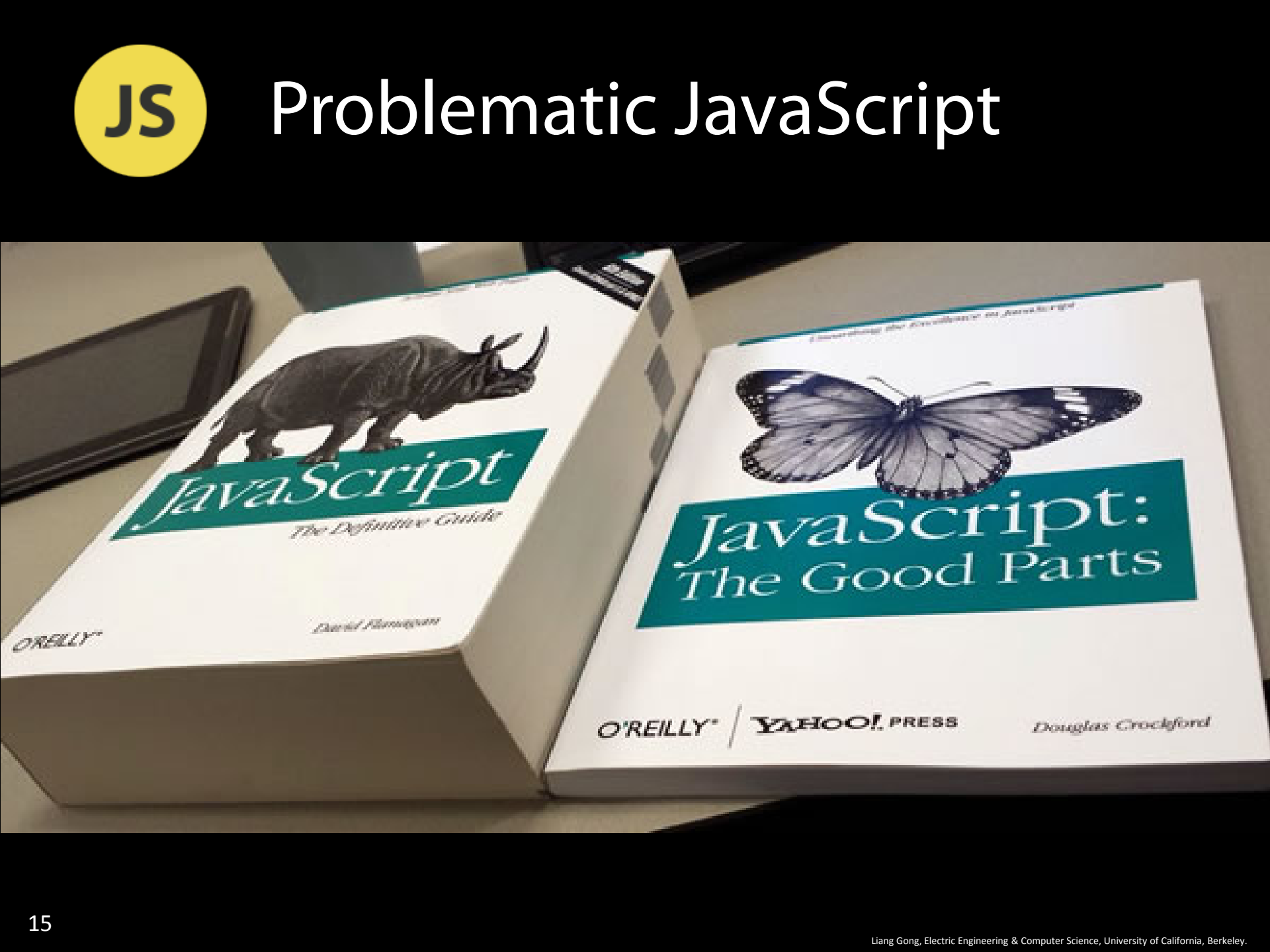
JS
Problematic JavaScript
JavaScript
The Definitive Guide
O'REILLY
David Flanagan
JavaScript:
The Good Parts
O'REILLY
YAHOO! PRESS
Douglas Crockford

Problematic JavaScript

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Exhuming the terror of JavaScript
JavaScript:
The Evil Parts
for (p=0;p<2;p++)
document.write(
eval("publisher_"+p))
Gregor Richards
Douglas Crockford

What are coding practices?

- Good coding practices
  - Informal rules
  - Improve code quality

- Better quality means:
  - Fewer correctness issues
  - Better performance
  - Better usability
  - Better maintainability
  - Fewer security loopholes
  - Fewer surprises
  - …

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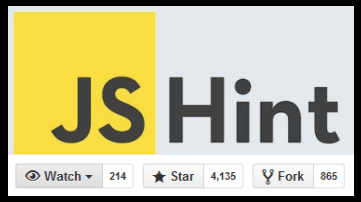
Coding Practices and Lint Tools

- Existing Lint-like checkers
  - Inspect source code
  - Rule-based checking
  - Detect common mistakes
- Limitations:
  - Approximates behavior
  - Unknown aliases
  - Lint tools favor precision over soundness
- Difficulty: Precise static program analysis



Language Misuse

Avoid setting properties of primitives, which has no effect.

```
var fact = 42;
fact.isTheAnswer = true;
console.log(fact.isTheAnswer);

> undefined
```

Uncommon Values

Avoid producing ***NaN*** (Not a Number).

```
var x = 23 - "five";

> NaN
```

ALGOT
Frame/6 wire baskets/top shelf
$64
Last year's price: $NaN

ALGOT
Frame/wire baskets/rod
$204
Last year's price: $220

ALGOT
Frame/4 wire baskets/top shelf
$44
Last year's price: $48

ALGOT
Frame/4 wire baskets/top shelf
$60
Last year's price: $NaN

ALGOT
Frame/4 wire baskets
$35
Last year's price: $39

ALGOT
Frame/4 wire baskets
$51
Last year's price: $NaN

ALGOT
Frame/4 mesh baskets/top shelf
$56
Last year's price: $60

ALGOT
Frame with rod/wire baskets
$74
Last year's price: $87

ALGOT
Frame/6 wire baskets/top shelf
$64
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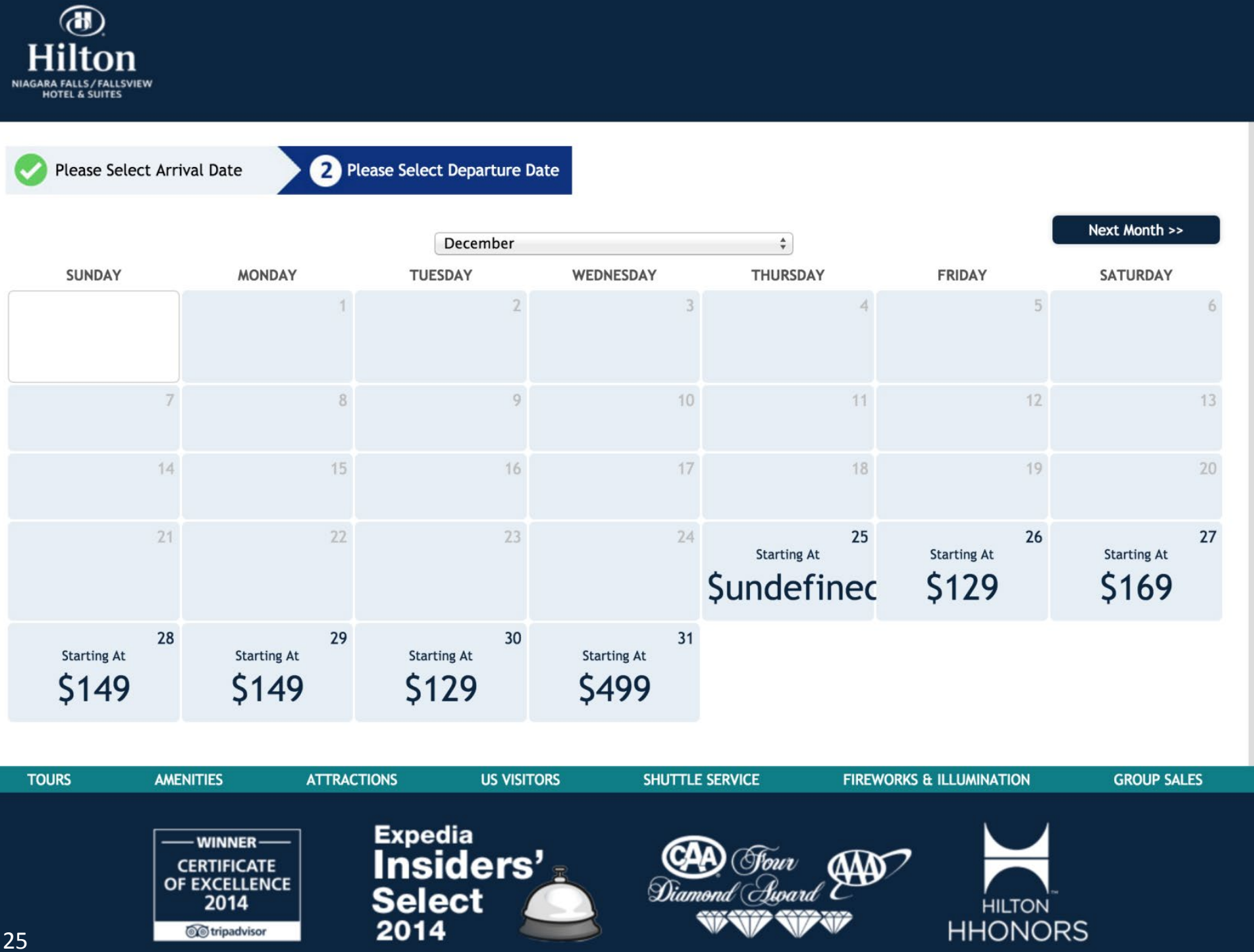
Frame with rod/wire baskets
$74
Last year's price: $87

Uncommon Values

Avoid concatenating undefined to string.

```
var value;
...
var str = "price: ";
...
var result = str + value;

> "price: undefined"
```


Hilton
NIAGARA FALLS / FALLSVIEW
HOTEL & SUITES
Please Select Arrival Date
2 Please Select Departure Date
Next Month >>
December
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
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Starting At
$undefinec
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Starting At
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Starting At
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Starting At
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$149
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$129
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Starting At
$499
TOURS
AMENITIES
ATTRACTIONS
US VISITORS
SHUTTLE SERVICE
FIREWORKS & ILLUMINATION
GROUP SALES
WINNER
CERTIFICATE OF EXCELLENCE 2014
tripadvisor
Expedia Insiders' Select 2014
CAA Four Diamond Award AAA
HILTON HHONORS

Hilton
NIAGARA FALLS / FALLSVIEW
HOTEL & SUITES

Please Select Arrival Date | 2 Please Select Departure Date

Next Month >>

December

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			3	4	5	6
7			10	11	12	13
14			17	18	19	20
21			24	25 Starting At $undefinec	26 Starting At $129	27 Starting At $169
28 Starting At $149	29 Starting At $149	30 Starting At $129	31 Starting At $499			

25 Starting At $undefinec

TOURS | AMENITIES | ATTRACTIONS | US VISITORS | SHUTTLE SERVICE | FIREWORKS & ILLUMINATION | GROUP SALES

WINNER CERTIFICATE OF EXCELLENCE 2014 tripadvisor

Expedia Insiders' Select 2014

CAA Four Diamond Award AAA

HILTON HHONORS

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API Misuse

Beware that all wrapped primitives coerce to true.

```
var b = false;
if (new Boolean(b)) {
  console.log("true");
}

> true
```

Type Related

Avoid accessing the undefined property.

```
var x; // undefined
var y = {};
y[x] = 23; // { undefined: 23 }
```

Rule: avoid setting field on primitive values

From Google Octane's Game Boy Emulator benchmark:

```
var decode64 = "";
if (dataLength > 3 && dataLength % 4 == 0) {
  while (index < dataLength) {
    decode64 += String.fromCharCode(...);
  }
  if (sixbits[3] >= 0x40) {
    decode64.length -= 1;
  }
}
```


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  }
  if (sixbits[3] >= 0x40) {
⚠   decode64.length -= 1;
  }
}
```

No effect because ***decode64*** is a primitive string.

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Rule: avoid no effect operations

⚠ `window.onbeforeunload= "Twitch.player.getPlayer().pauseVideo();"`

⚠ `window.onunload= "Twitch.player.getPlayer().pauseVideo();"`

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Rule: avoid no effect operations

⚠ `window.onbeforeunload= "Twitch.player.getPlayer().pauseVideo();"`

⚠ `window.onunload= "Twitch.player.getPlayer().pauseVideo();"`

```
window.onbeforeunload = function () {
    Twitch.player.getPlayer().pauseVideo();
}
```


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Tips: Use Contiguous Keys for Array

Use contiguous keys starting at 0 for arrays

```
var array = new Array(5000);
```

6.793s

```
var array = [];
for (var i=0;i<5000; i++) {
    array[i] = 0;
}
```

6.8s

```
for (var i=0;i<1000000000;i++) {
    array [i % 5000] = i;
}
```

```
var array = [];
array[5000-1] = 0;
```

9.163s

Tips: Use Contiguous Keys for Array

```
var array = [];
for (var i=10000;i>=0;i--){
    array[i] = i;
}
```

Tips: Use Contiguous Keys for Array

```
var array = [];
for (var i=10000;i>=0;i--){
    array[i] = i;
}
```

```
array[10000] = 10000;
array[9999] = 9999;
   ...
```

- non-contiguous array
- To save memory, JIT-engine decides to represent the array with slow data structures like hash table.

Tips: Use Contiguous Keys for Array

```
var array = [];
for (var i=10000;i>=0;i--){
    array[i] = i;
}
```

```
for (var i=0;i<=10000;i++){
    array[i] = i;
}
```

10X+ speedup!

eval is evil, do not use *eval*.

```
var fun = eval;
...
fun("var a = 1;");
```

- Correctness Issue: `eval('a++;');`
  `var evil = eval; evil('a++;');`
- Performance Issue: *eval* is super slow
- Security Issue: code injection attack.
  `eval('a=' + userInput + ';');`

`eval` is evil, do not use `eval`.

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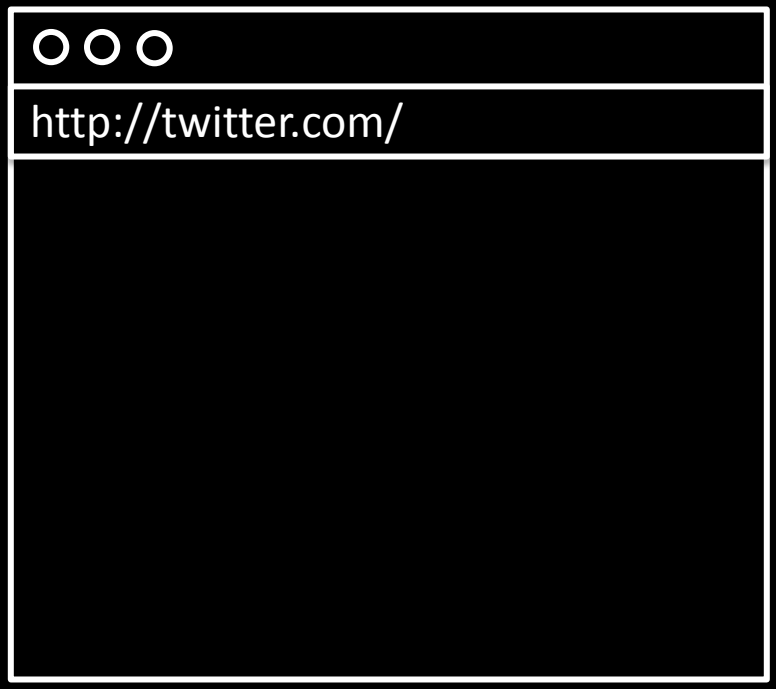
AJAX

`http://twitter.com/`

AJAX



http://twitter.com/

```
<html>
    <head>...</head>
    <body>content</body>
</html>
```

AJAX

http://twitter.com/

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AJAX

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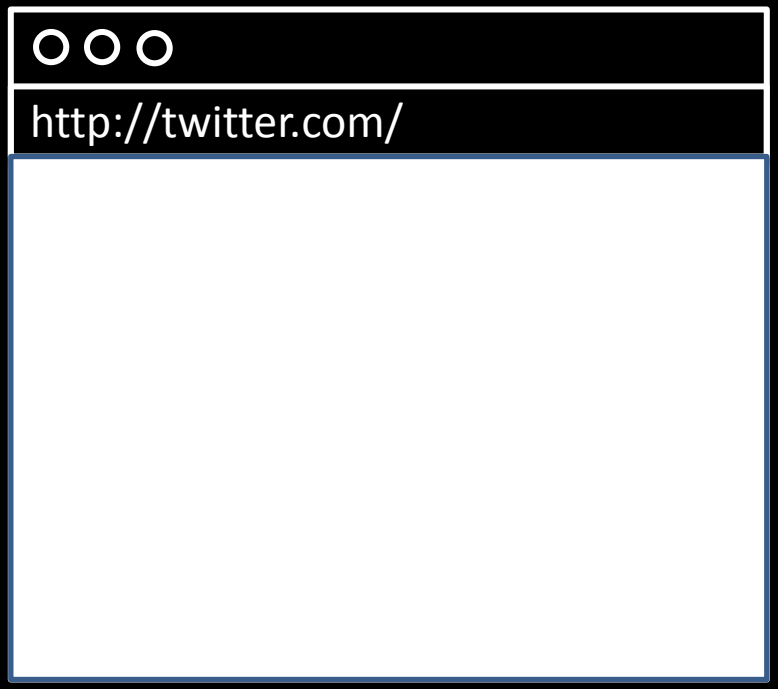
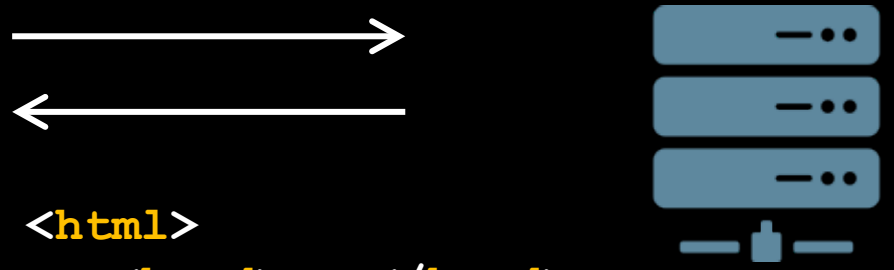


http://twitter.com/



```
<html>
    <head>...</head>
    <body>new content</body>
</html>
```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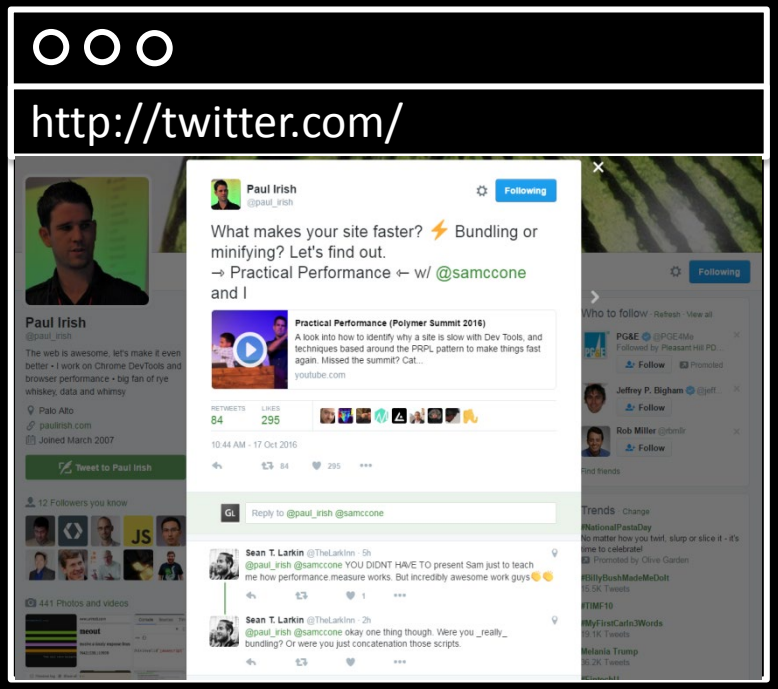
AJAX



http://twitter.com/

```
<html>
    <head>...</head>
    <body>new content</body>
</html>
```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AJAX

http://twitter.com/

```
<html>
    <head>...</head>
    <body>new content</body>
</html>
```

Redundant information has to be sent again.

Refresh the entire page → bad user experience

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AJAX

http://twitter.com/

```
[
  ["John Doe",
    "foo@gmail.com"],
  ["John Doe",
    "bar@gmail.com"]
]
```


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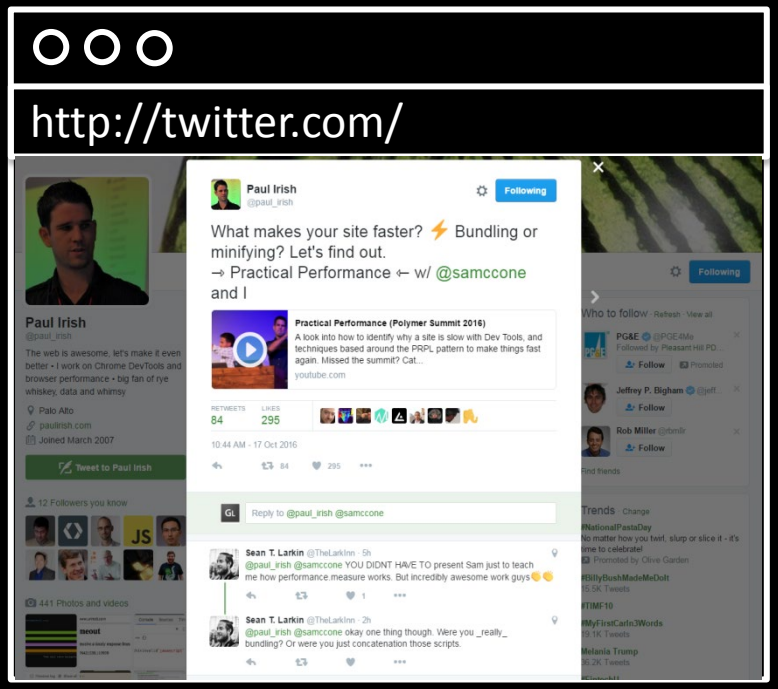
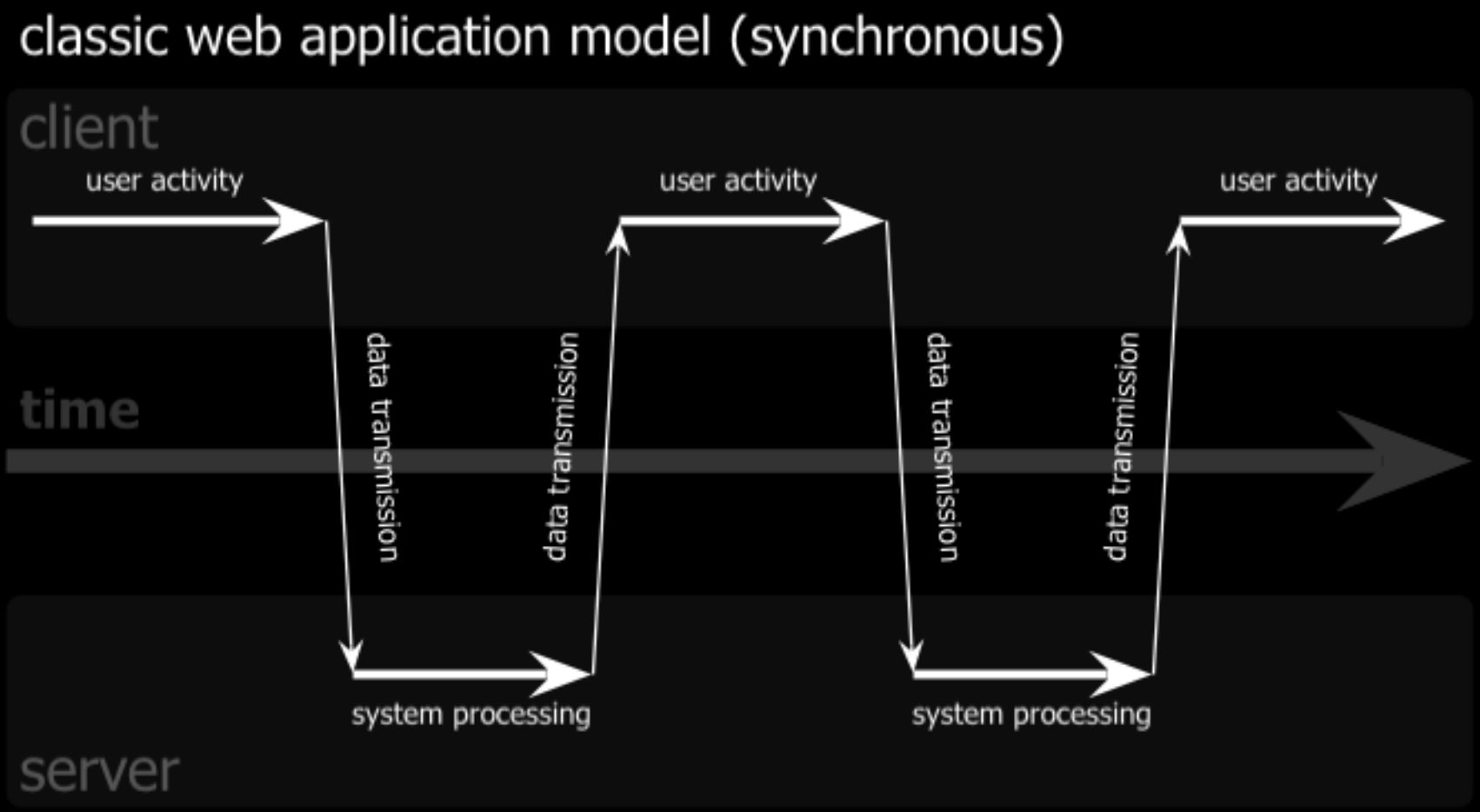
AJAX




```
[
  ["John Doe",
    "foo@gmail.com"],
  ["John Doe",
    "bar@gmail.com"]
]
```

Only send the new part (in HTML, XML, or JSON).
No need to refresh the page.

AJAX



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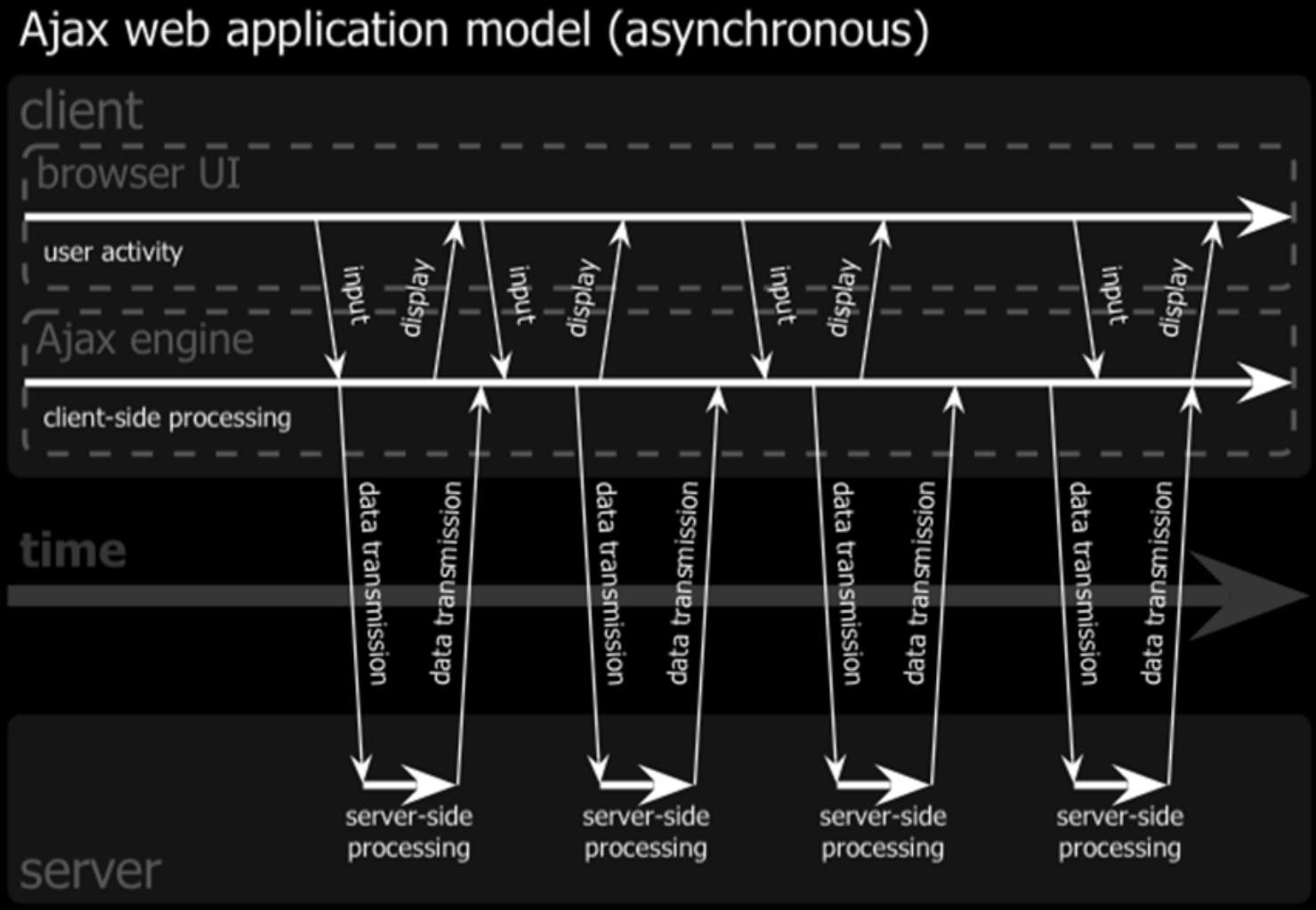

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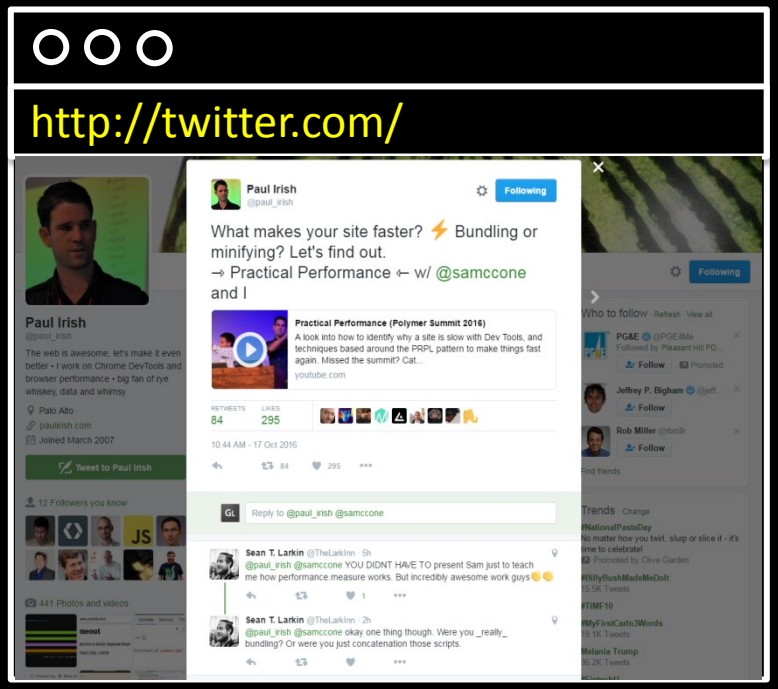
AJAX & Same Origin Policy



`http://twitter.com/`

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AJAX & Same Origin Policy

Origin: http://twitter.com/

`http://twitter.com/`

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AJAX & Same Origin Policy

Origin: http://twitter.com/

AJAX request

`http://twitter.com/`

AJAX & Same Origin Policy

Origin: http://twitter.com/

AJAX request

`http://twitter.com/`

`http://google.com/`

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AJAX & Same Origin Policy

Origin: http://twitter.com/

AJAX request

`http://twitter.com/`

`http://google.com/`

AJAX request

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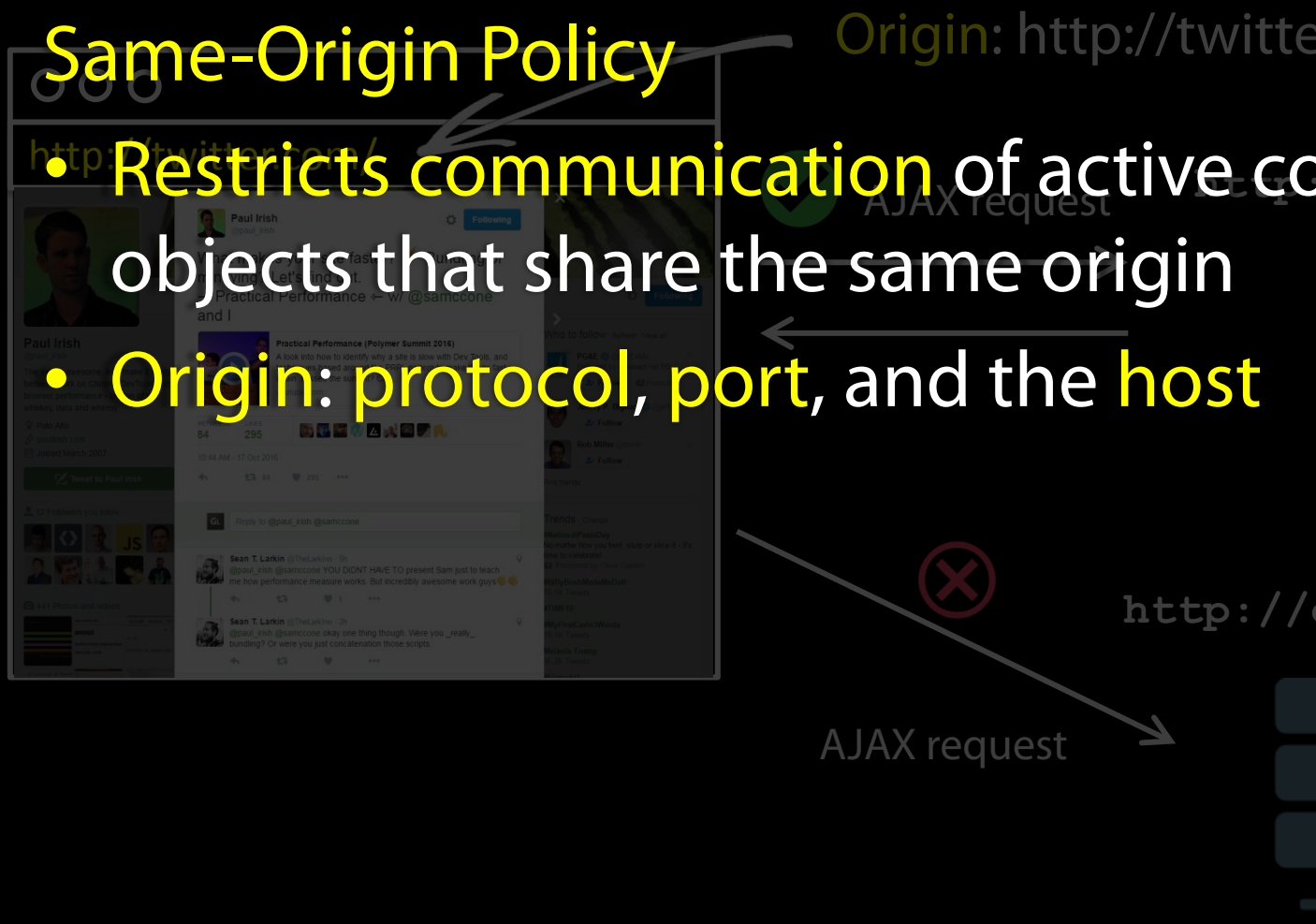
AJAX & Same Origin Policy

Same-Origin Policy

- Restricts communication of active content to objects that share the same origin
- Origin: protocol, port, and the host



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An Attack Scenario

`http://attacker.org/`

An Attack Scenario

`http://attacker.org/`

`http://email.com/`

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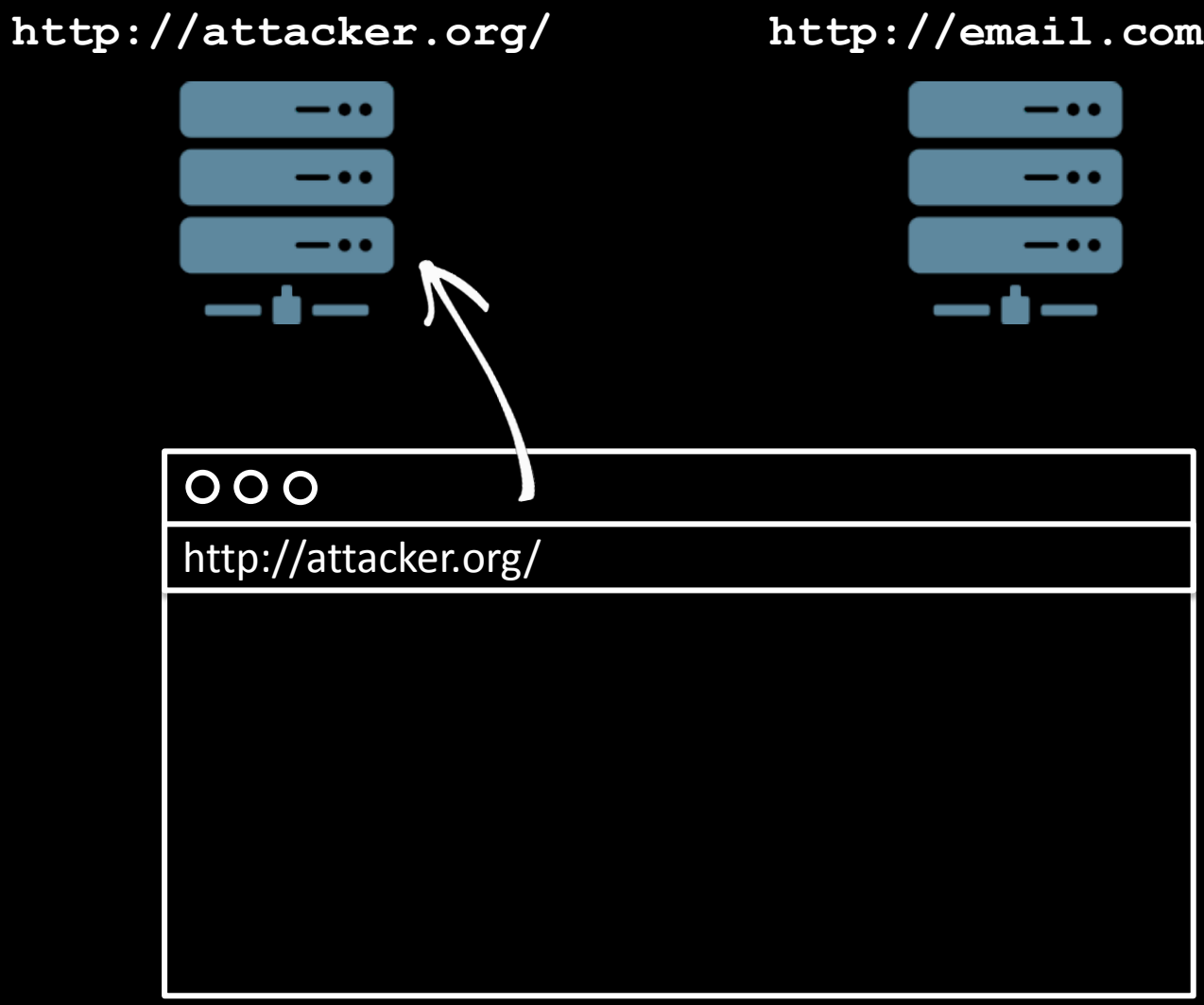

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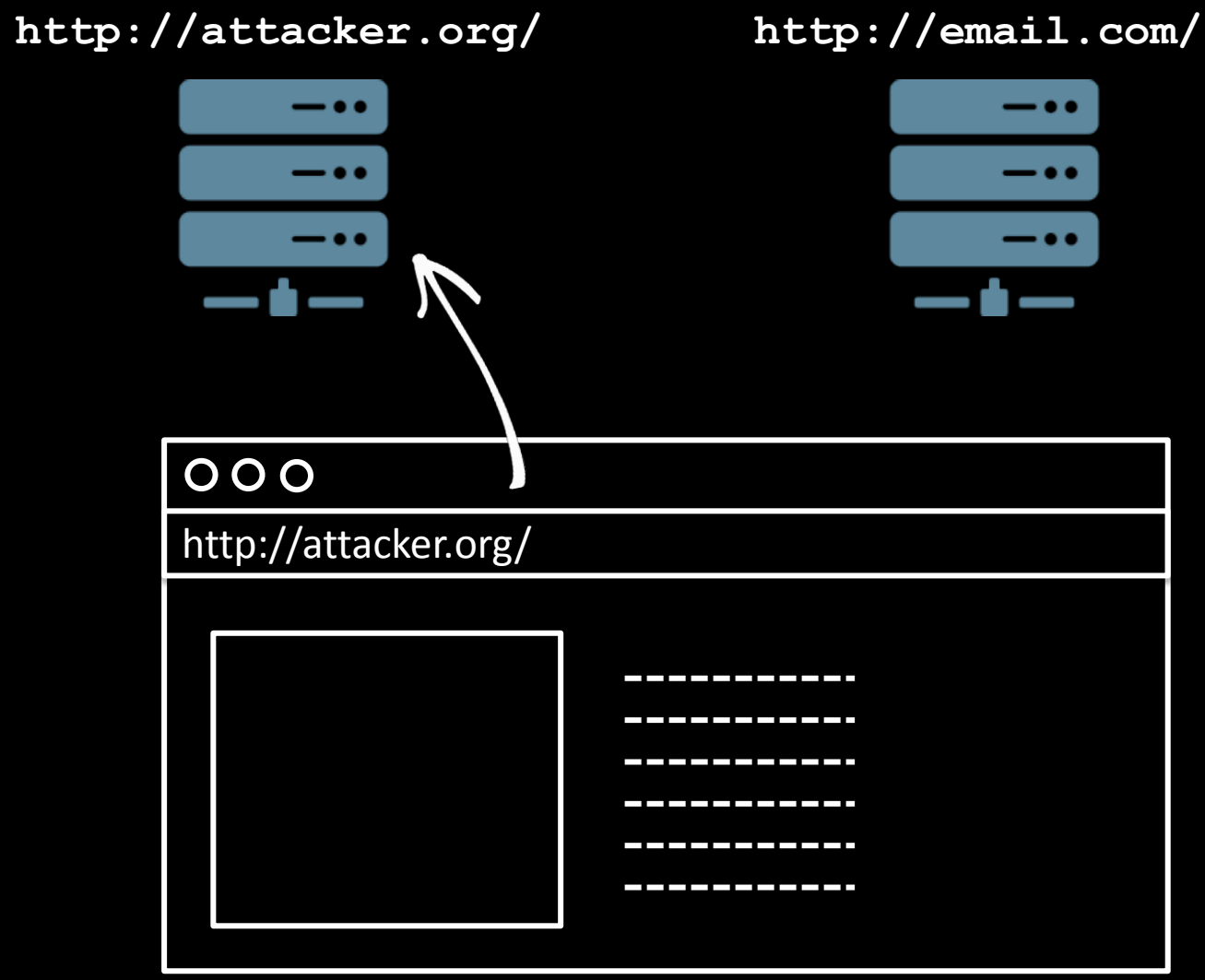
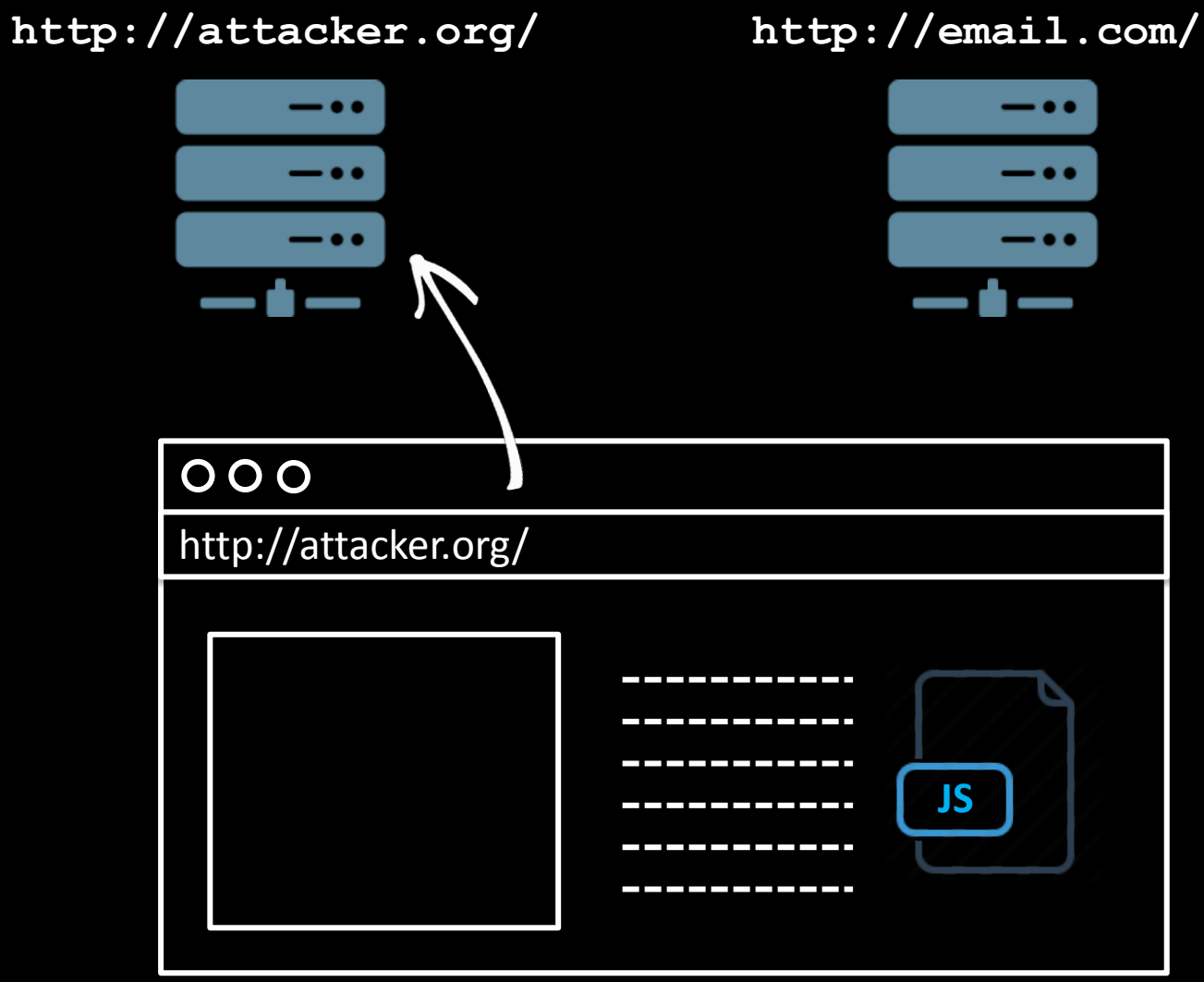
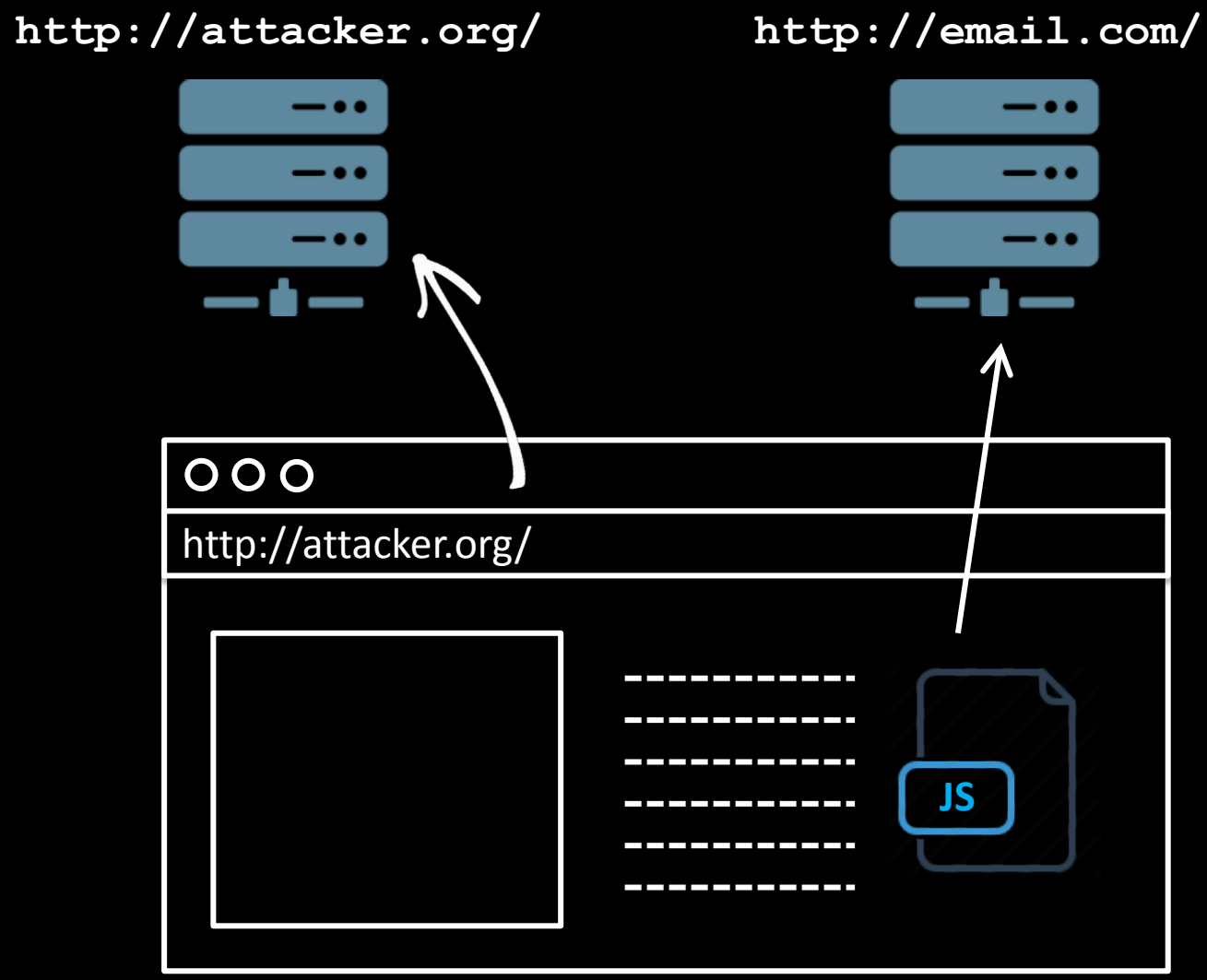


An Attack Scenario



An Attack Scenario



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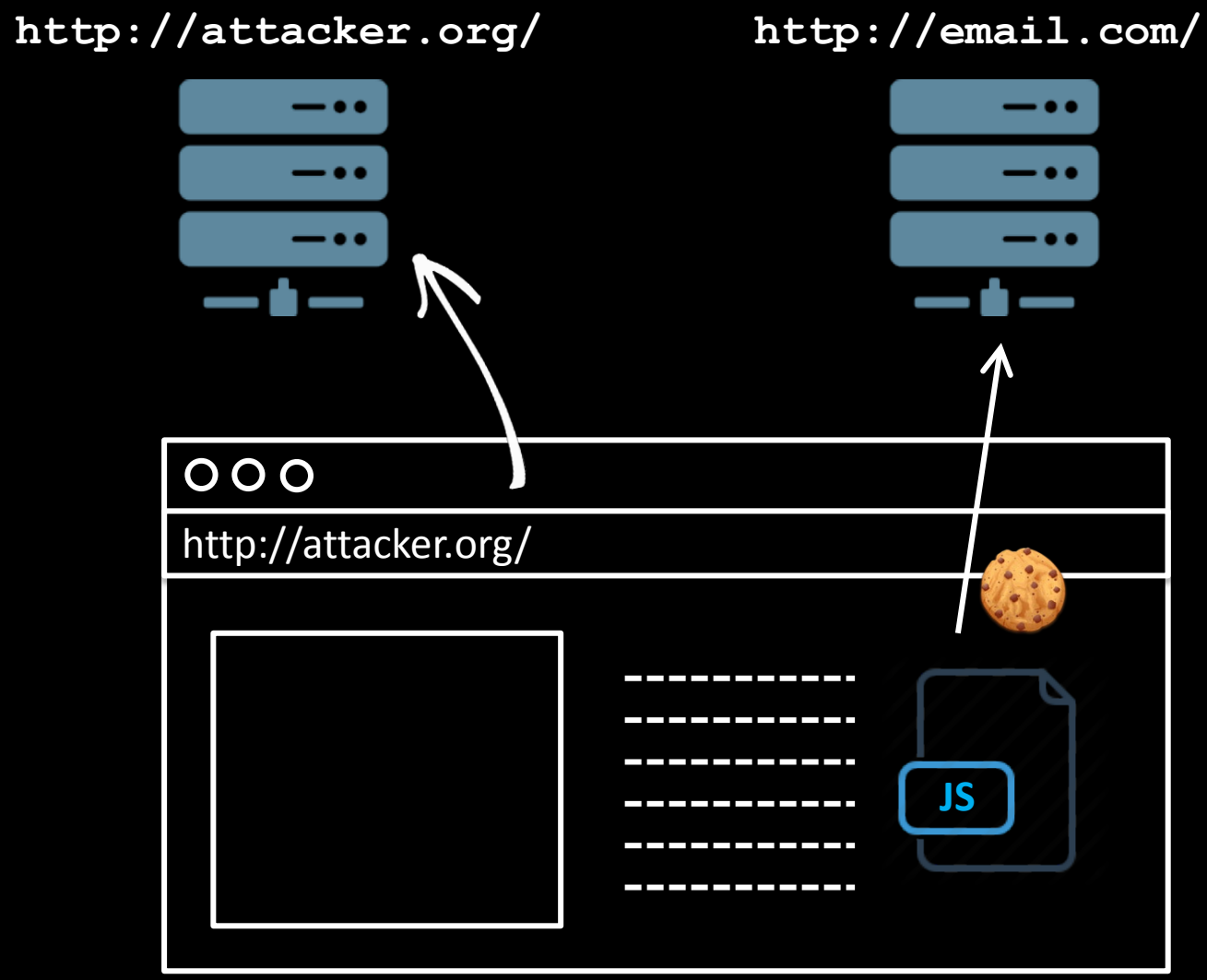

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http://attacker.org/ http://email.com/

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JSON Hijacking (2006)

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`http://gmail.com/`

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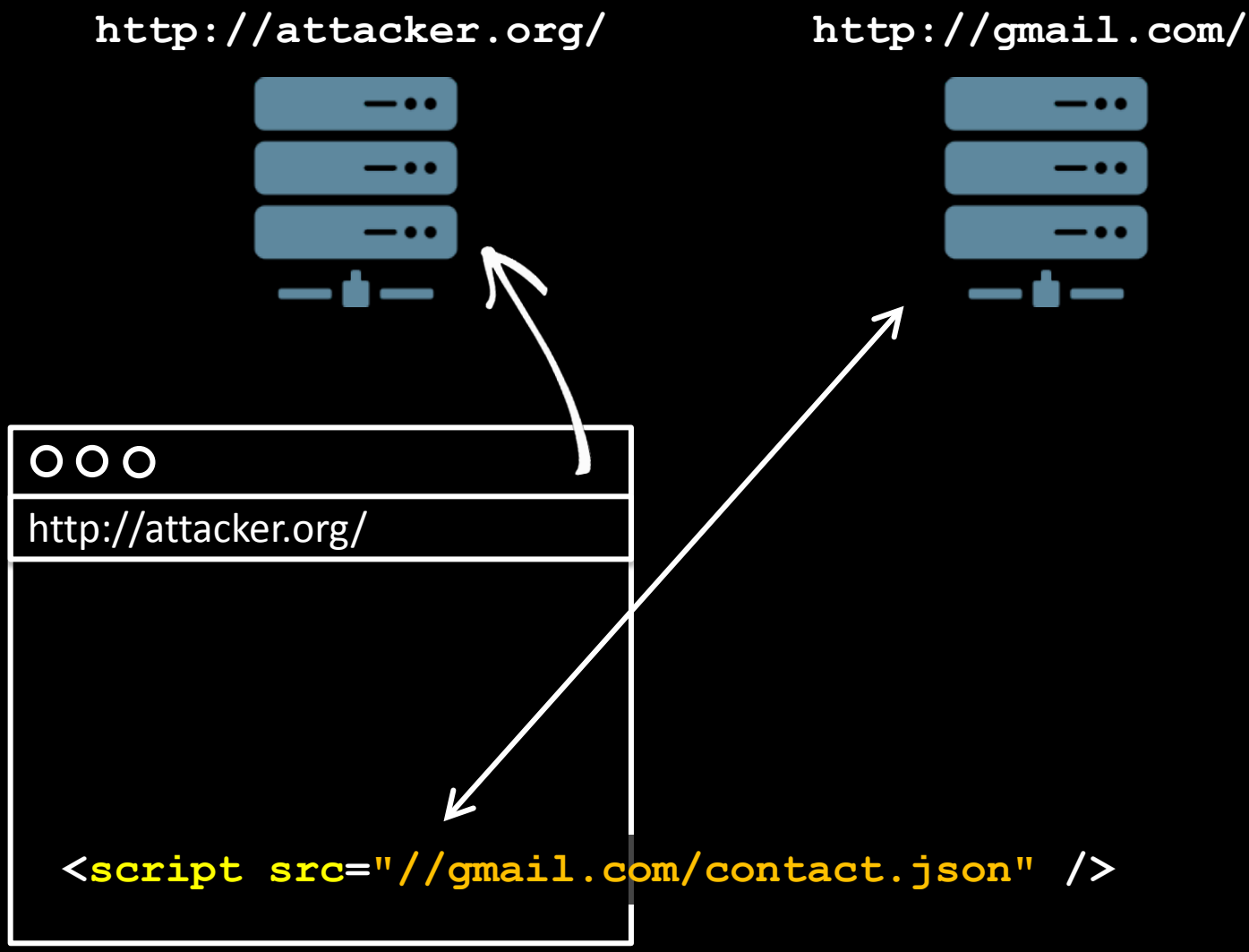

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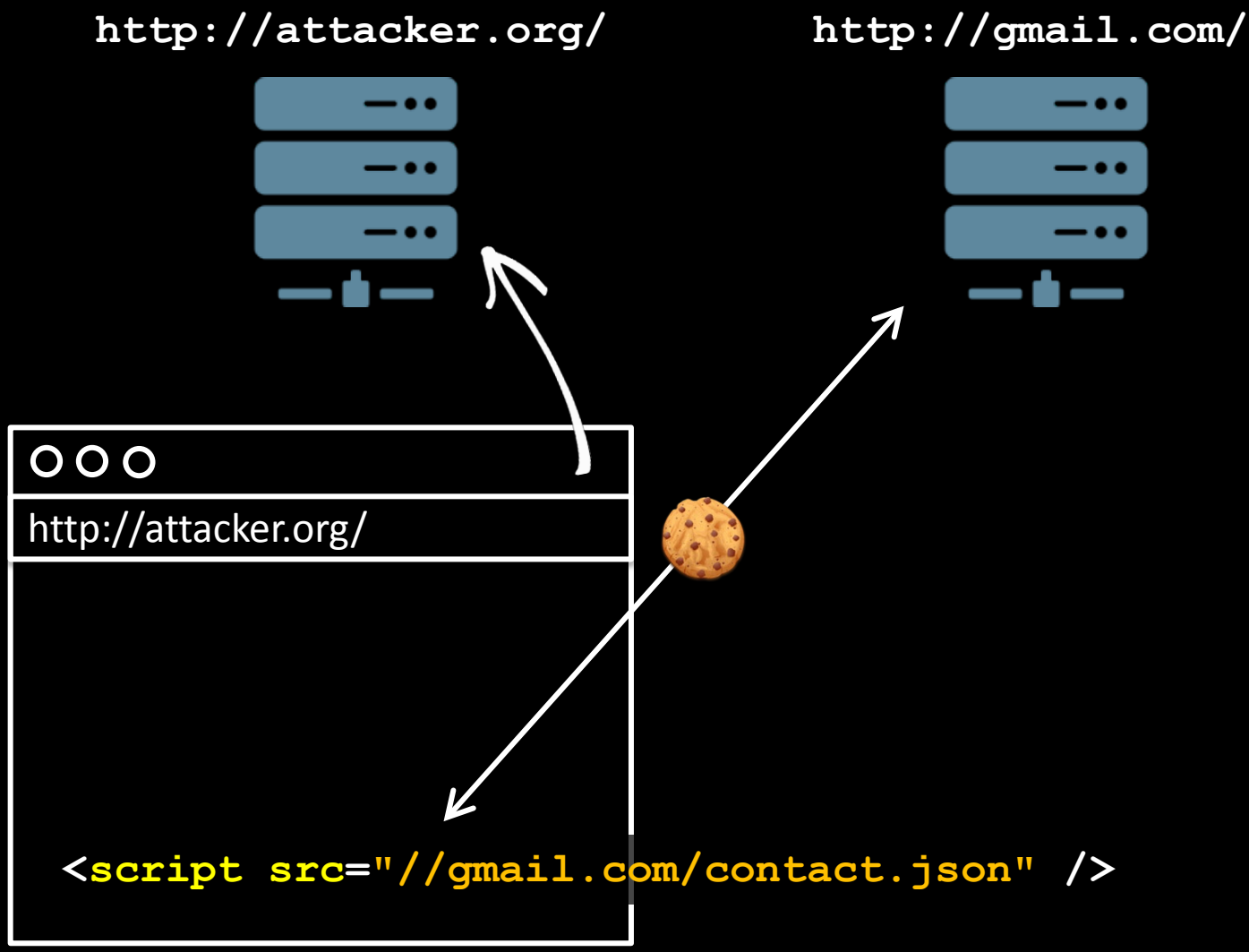

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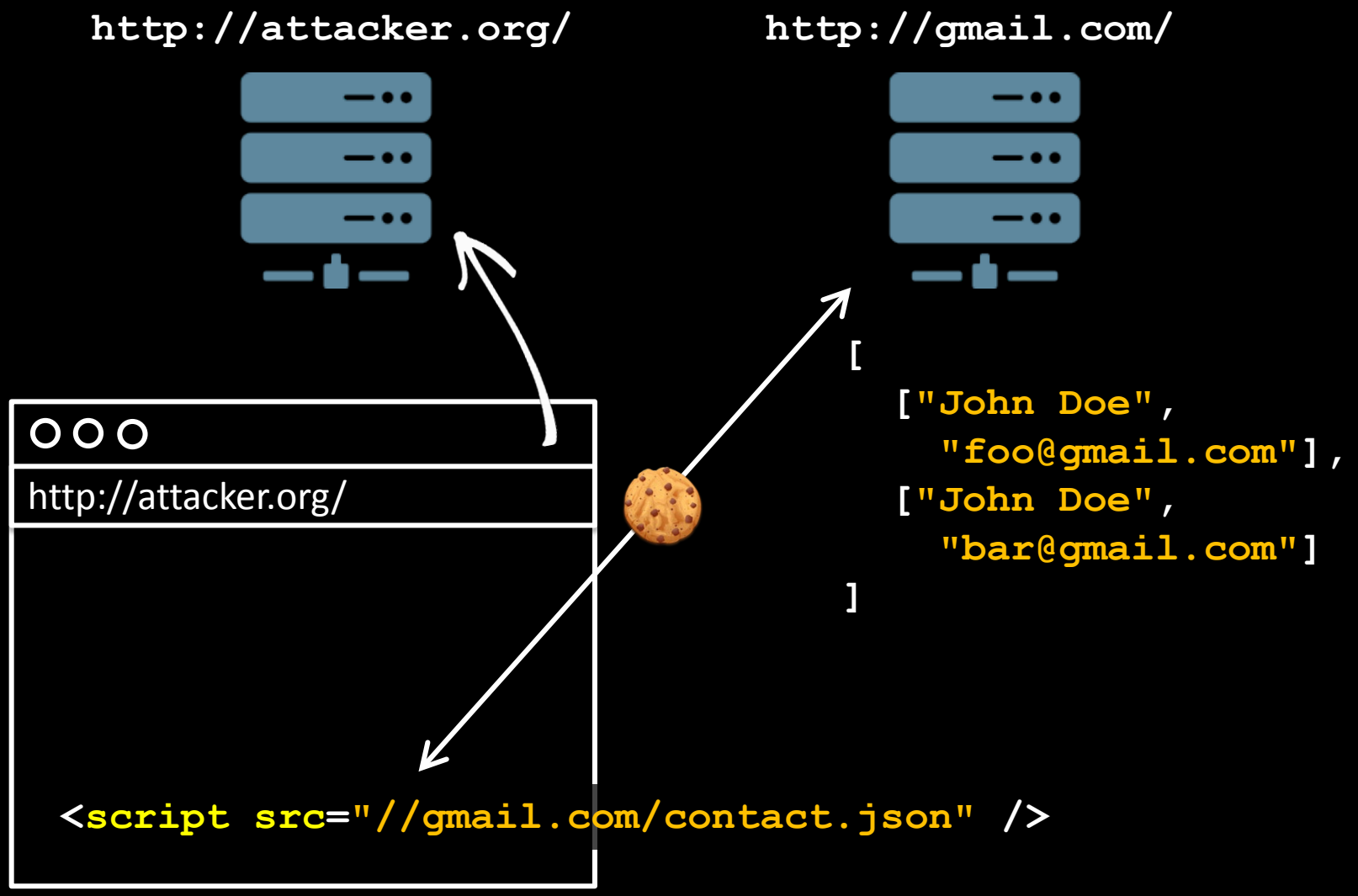

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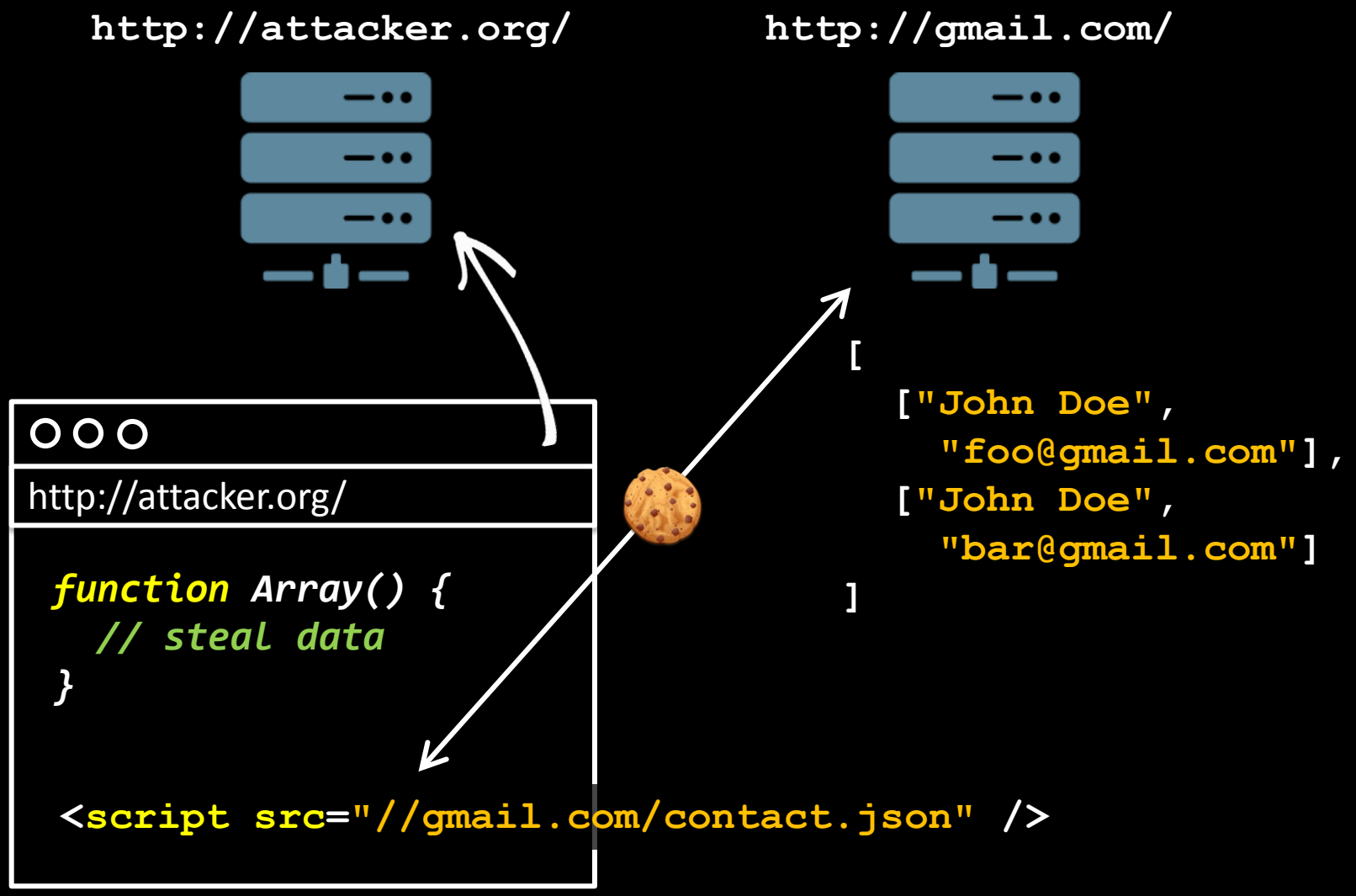
JSON Hijacking (2006)



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Cross-Site Script Inclusion (XSSI)

`http://attacker.org/`

`http://vuln.com/`

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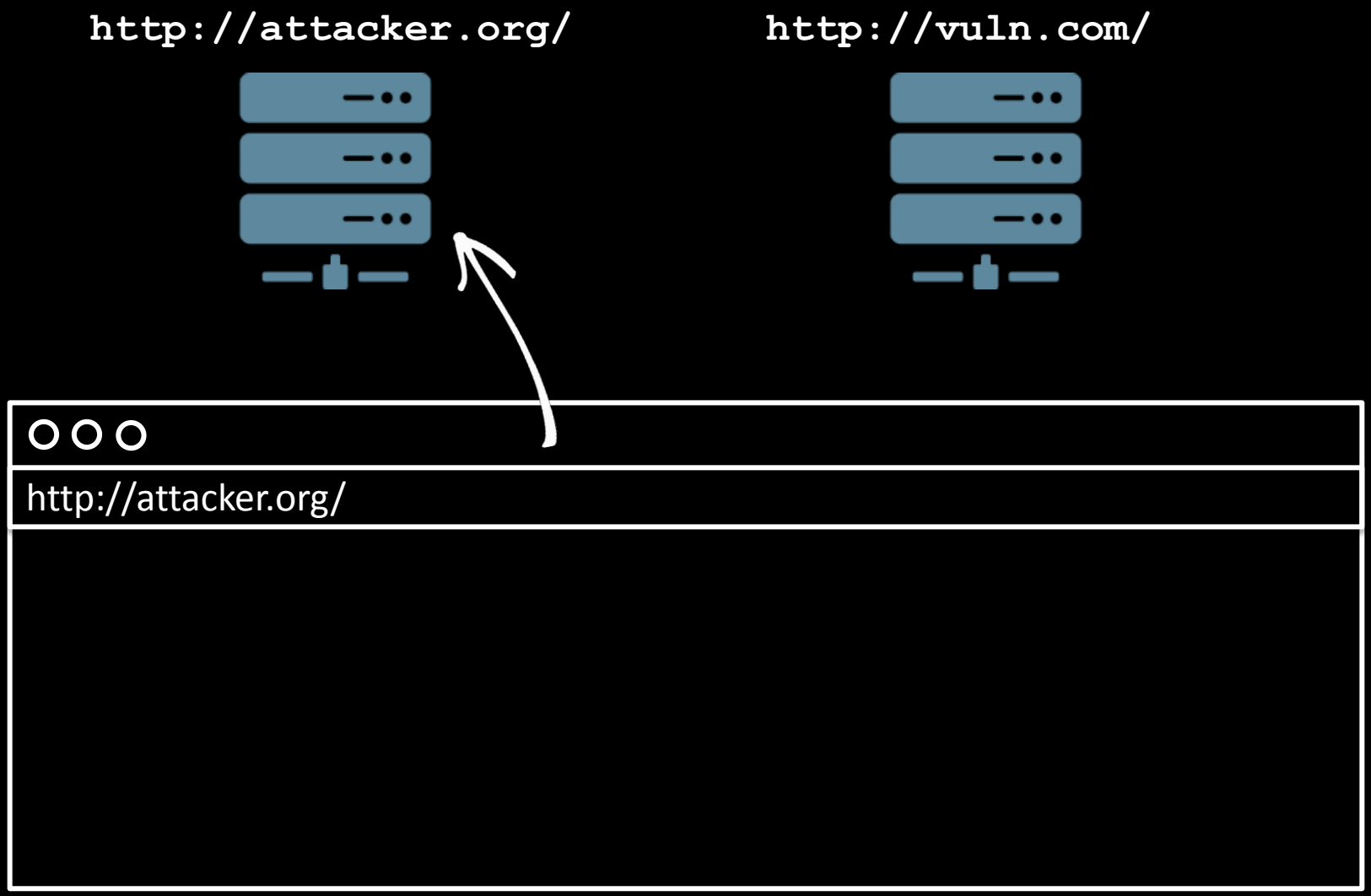

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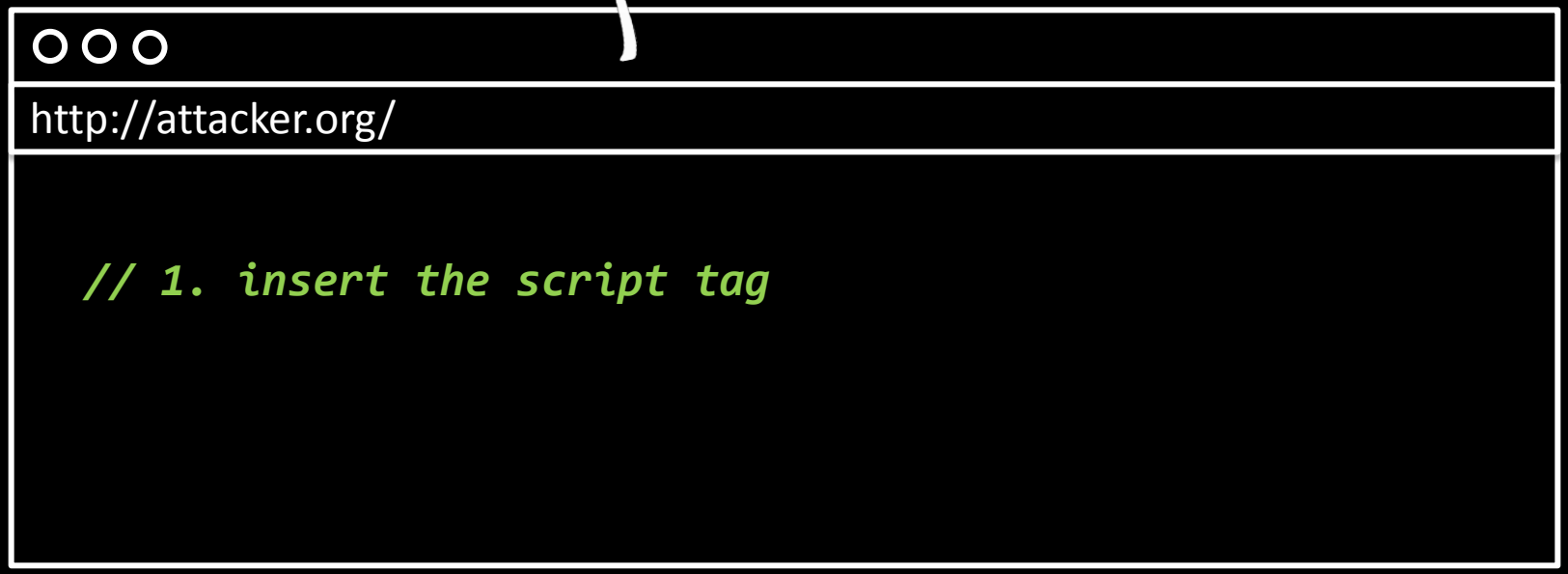

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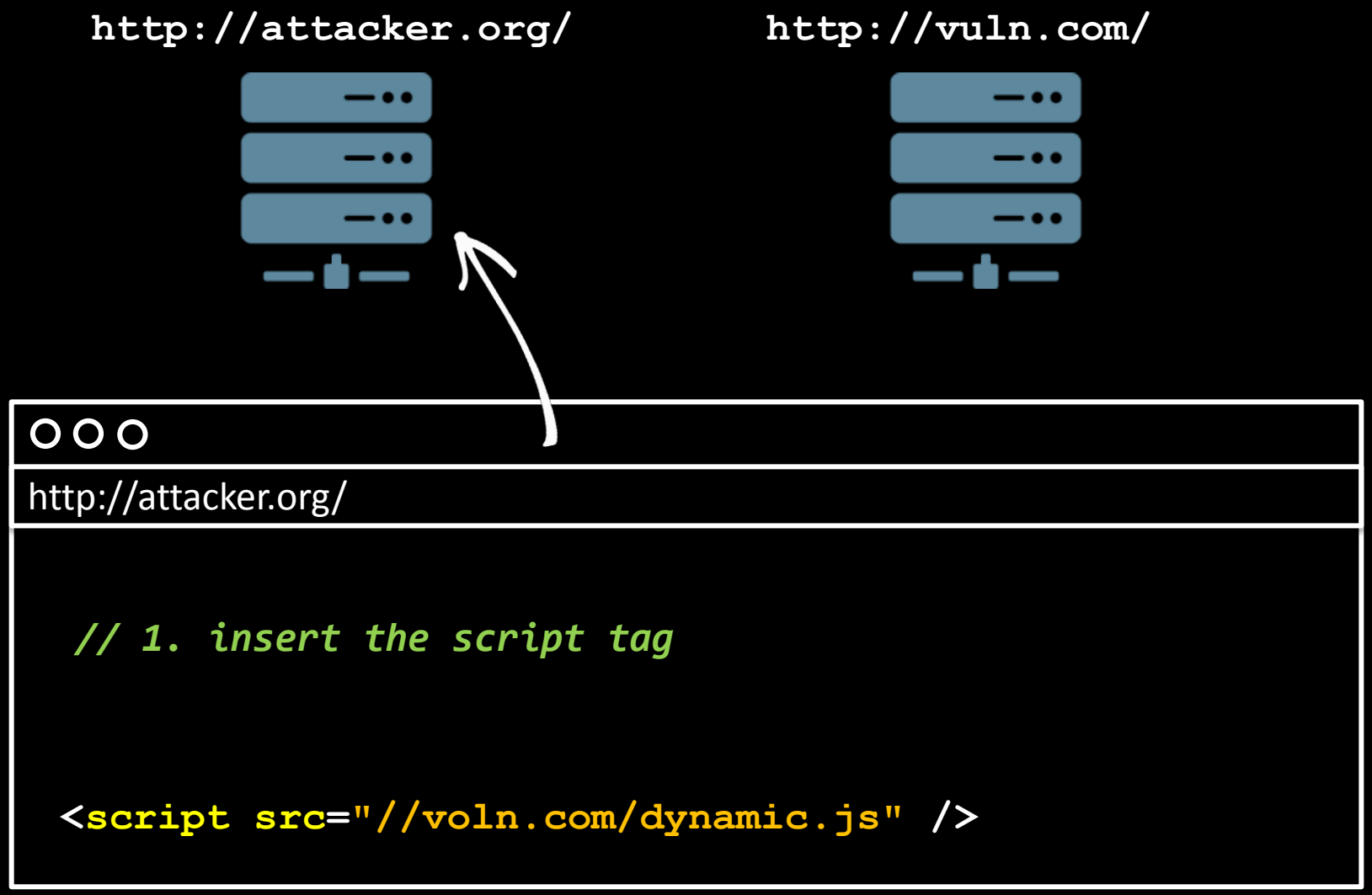

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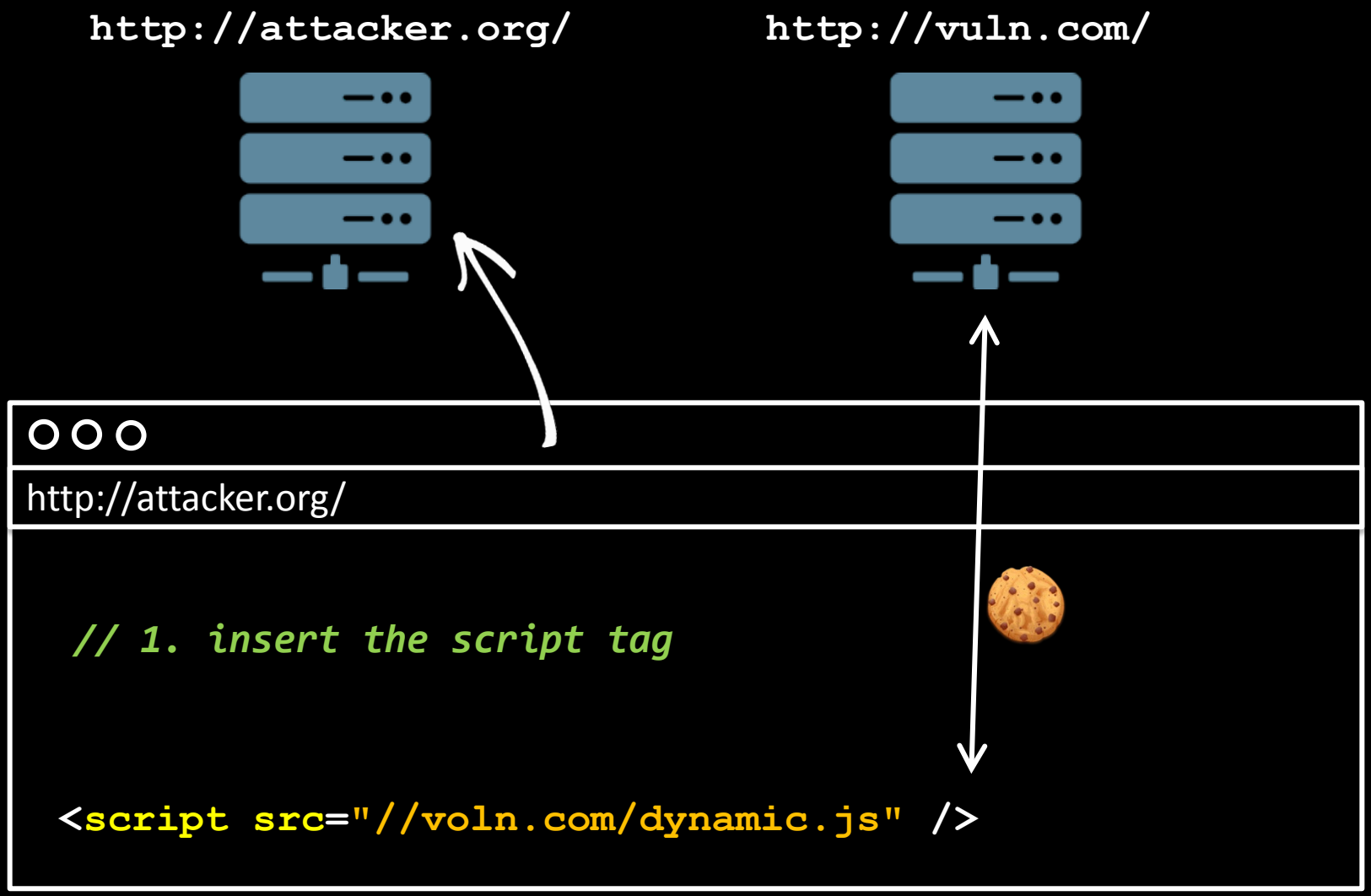

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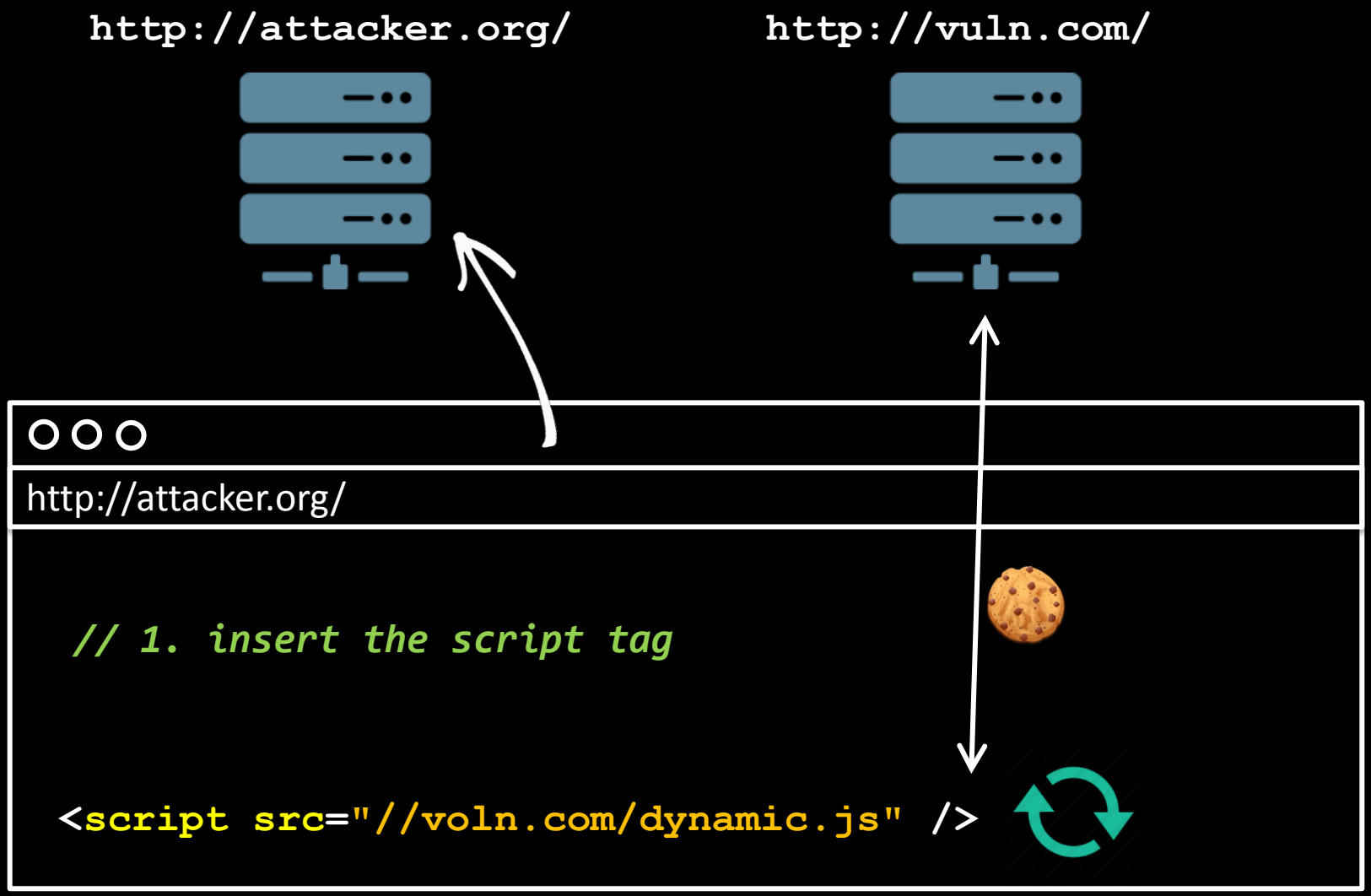

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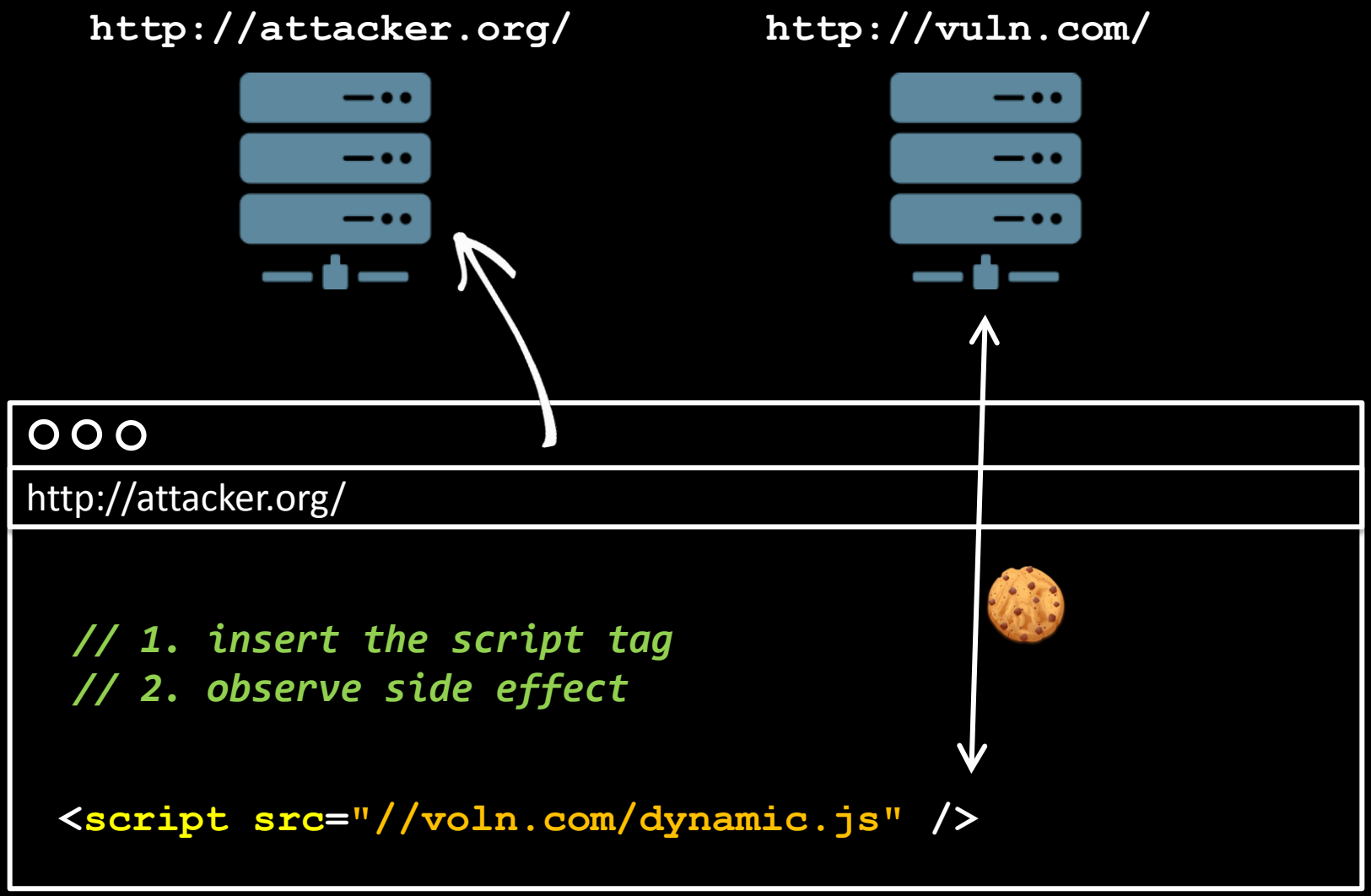

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RQ: Can such data be leaked in a similar way?

Leaking data stored in global variables:

dynamic.js

```
// local variable at top level
var first_name = "John";

// variable missing the "var" keyword
last_name = "Doe";

// global variable
window.user_email = "john@doe.com";
```

evil.js

```
console.log(first_name);
console.log(last_name);
Console.log(user_email);
```


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RQ: Can such data be leaked in a similar way?

Leaking data via global functions:

dynamic.js

```
function example() {
  var email = "john@doe.com";
  window.MyLibrary.doSomething(email);
}
```

evil.js

```
window.MyLibrary = {};
window.MyLibrary.doSomething = function(email) {
  console.log(email);
}
```


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RQ: Can such data be leaked in a similar way?

Leaking data via built-in APIs:

dynamic.js

```
function example() {
  var email = "john@doe.com";
  JSON.stringify(email);
}
```

evil.js

```
JSON.stringify = function (data) {
  sendToAttackerBackend(data);
}
```


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RQ: Can such data be leaked in a similar way?

Other APIs:

```
ArrayBuffer, Map, Set, WeakMap, WeakSet
decudeURI, decudeURIComponent,
encodeURI, encodeURIComponent,
escape, unescape
...
```

```
JSON.stringify = function (data) {                    evil.js
  sendToAttackerBackend(data);
}
```

Prototypical Inheritance

// object1 → Object.prototype → null

```
var object1 = {a: 1};
```

// object2 → object1 → Object.prototype → null

```
var object2 = Object.create(object1);

console.log(object2.a)
> 1
```

RQ: Can such data be leaked in a similar way?

Leaking data via the ***this*** reference:

dynamic.js

```
(function () {
  var secret_values = ["john@doe.com", "top secret"];
  secret_values.forEach(function (secret) {
    // do something secret here
  })
})();
```

evil.js

```
Array.prototype.forEach = function(callback) {
  console.log(this); // this points to the array
}
```


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RQ: Can such data be leaked in a similar way?

Other APIs:

String.prototype.concat
String.prototype.substring
String.prototype.toString
String.prototype.replace
Array.prototype.join
Array.prototype.map
Array.prototype.forEach
...

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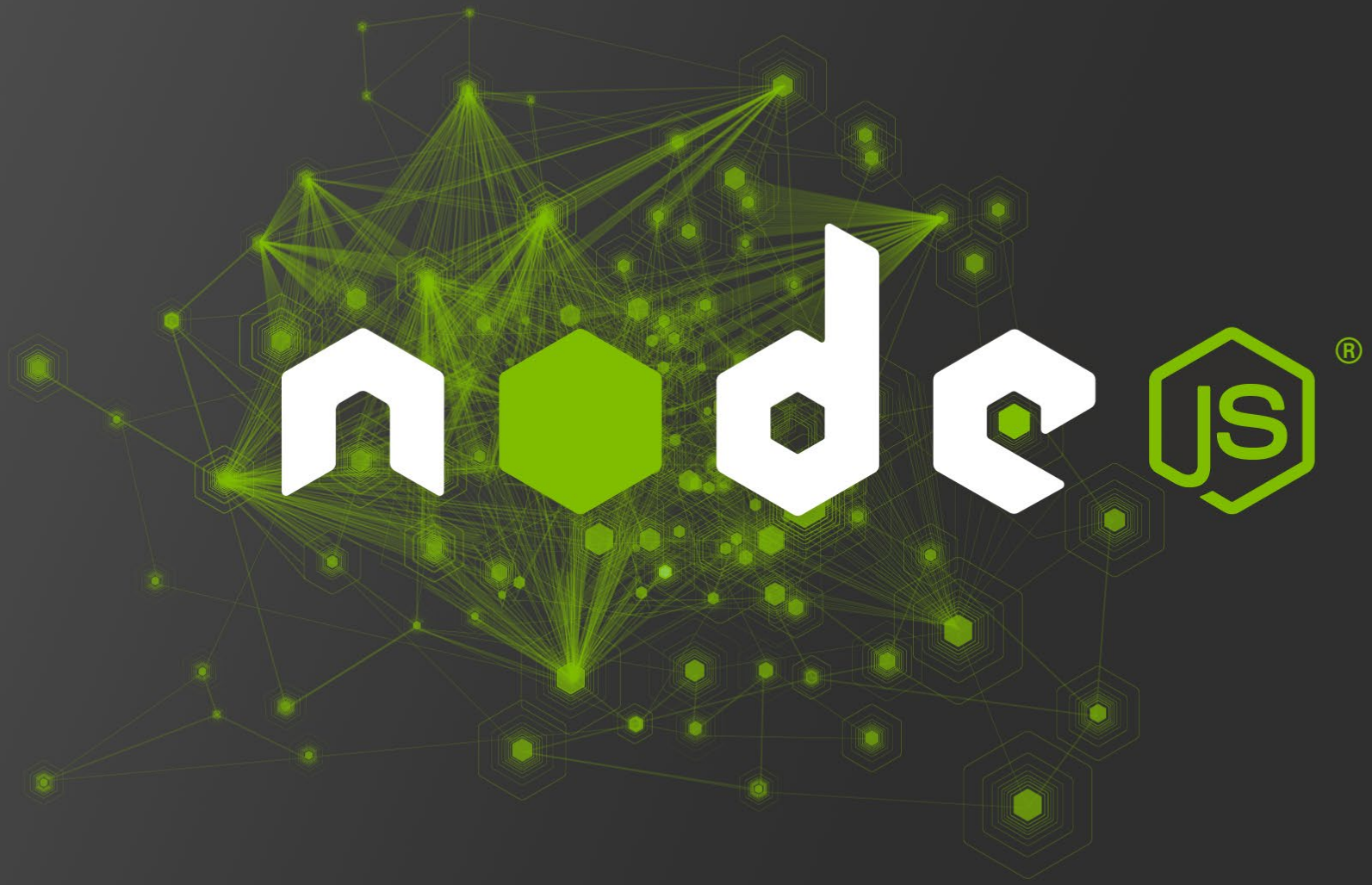

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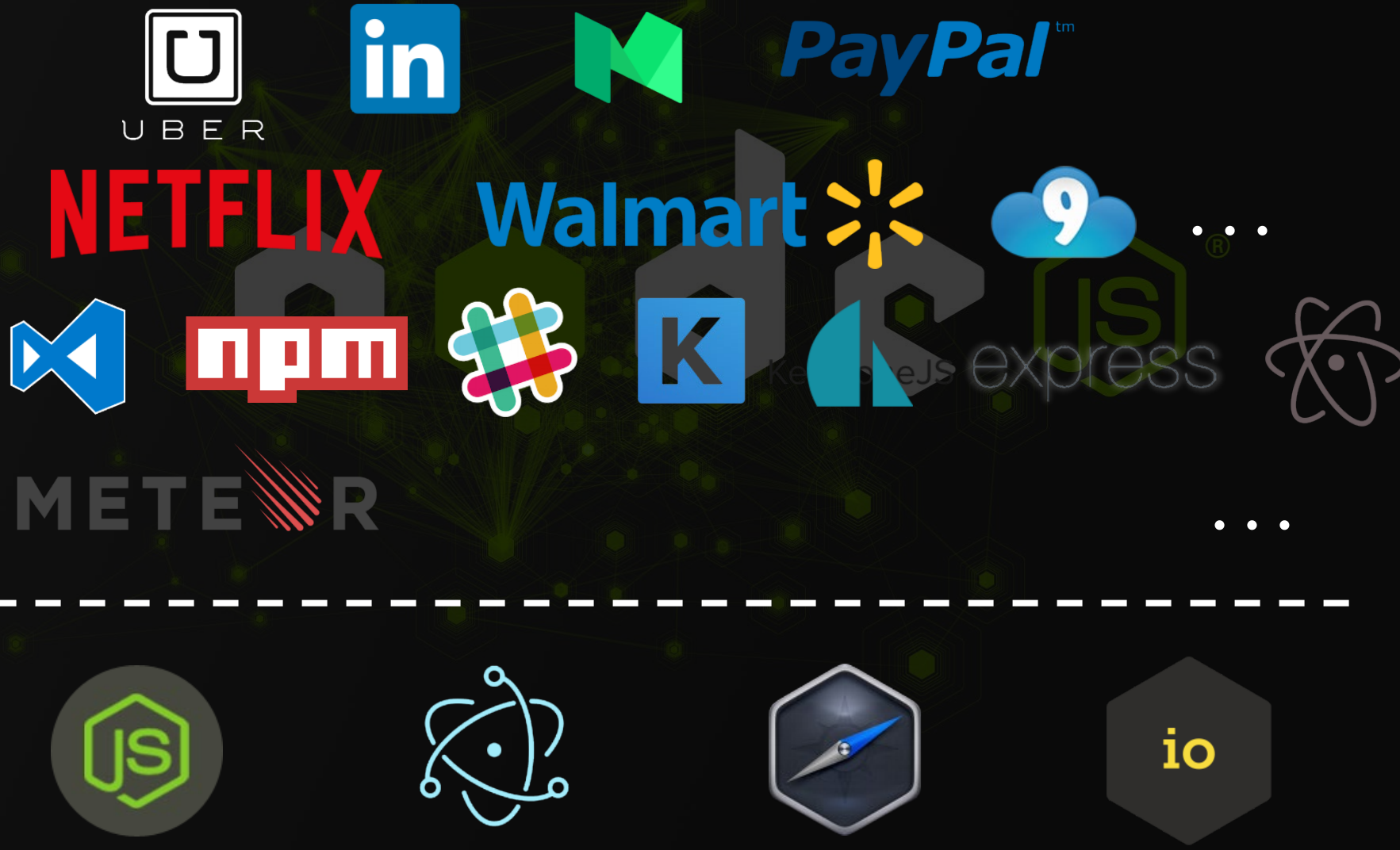
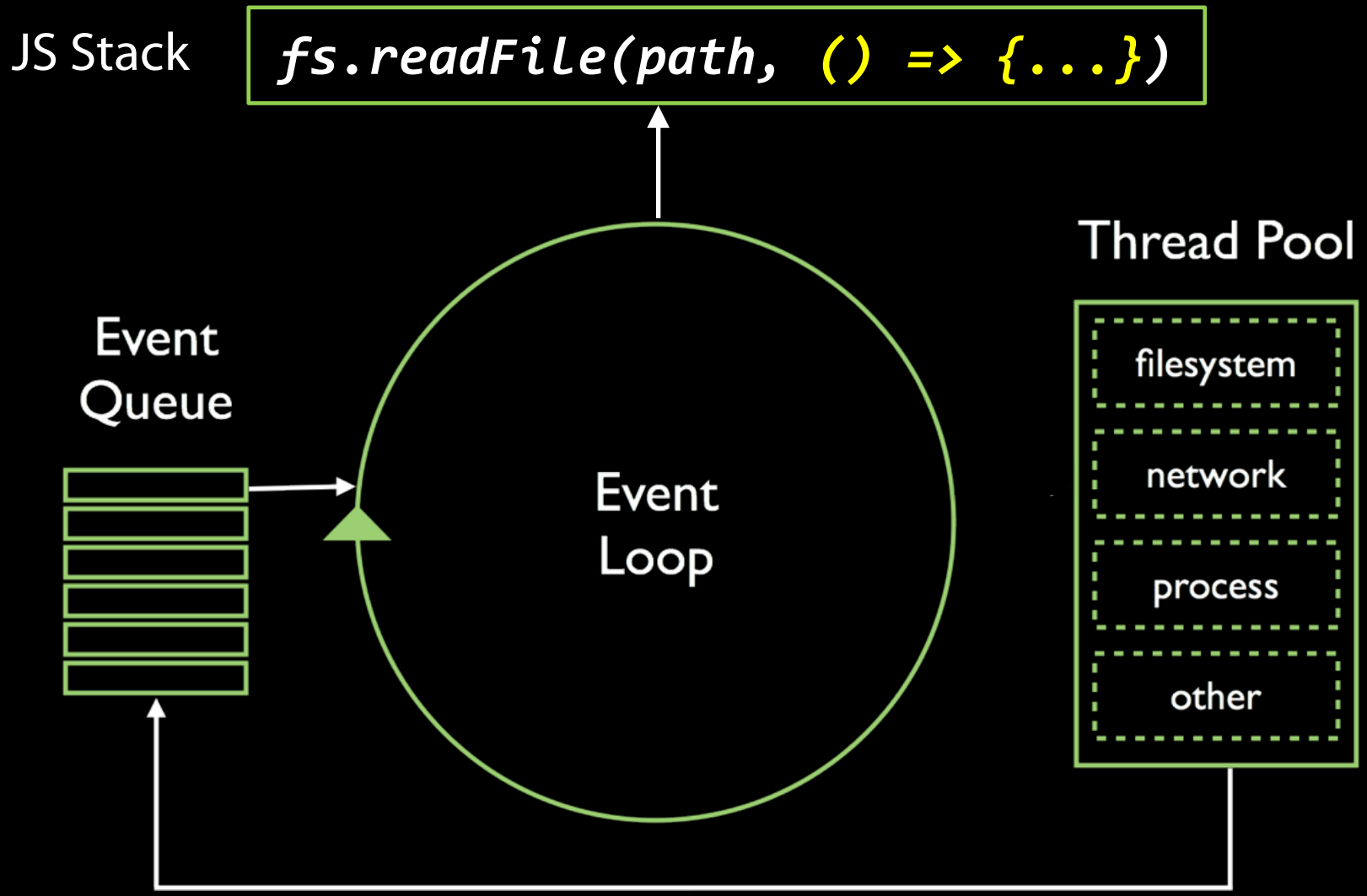
Motivation: Node.js is Rising



Async I/Os: Blessing and Curse

- Node.js: server-side JS runtime, single threaded, async programming model
- Asynchronous API: permits other processing to continue before the transmission has finished.
  - ✓ No time wasted on waiting blocking I/Os
  - ✓ Fast for I/O heavy tasks
  - ✗ Callback hell
  - ✗ Problematic for debugging

Event Loop and Callback



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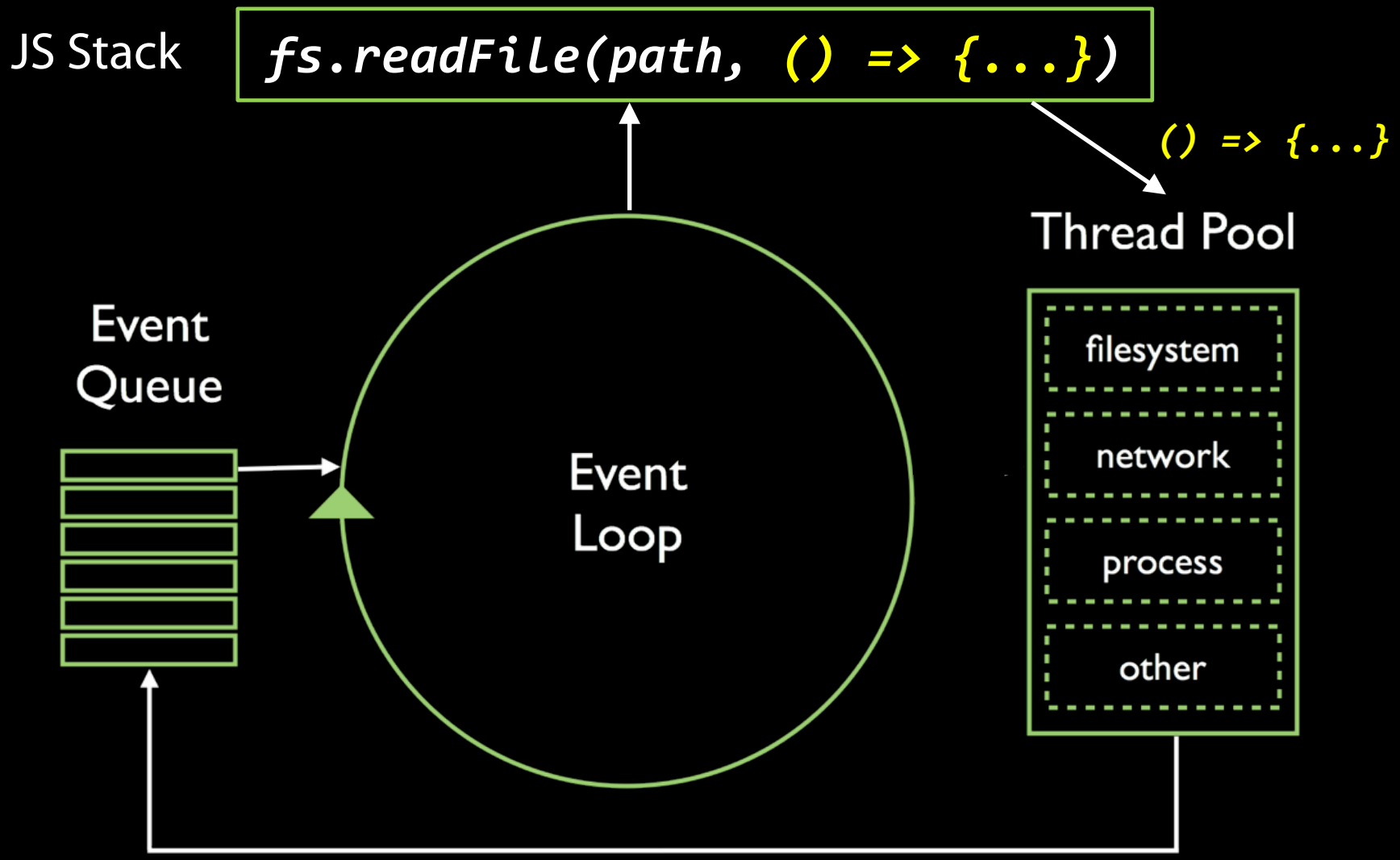

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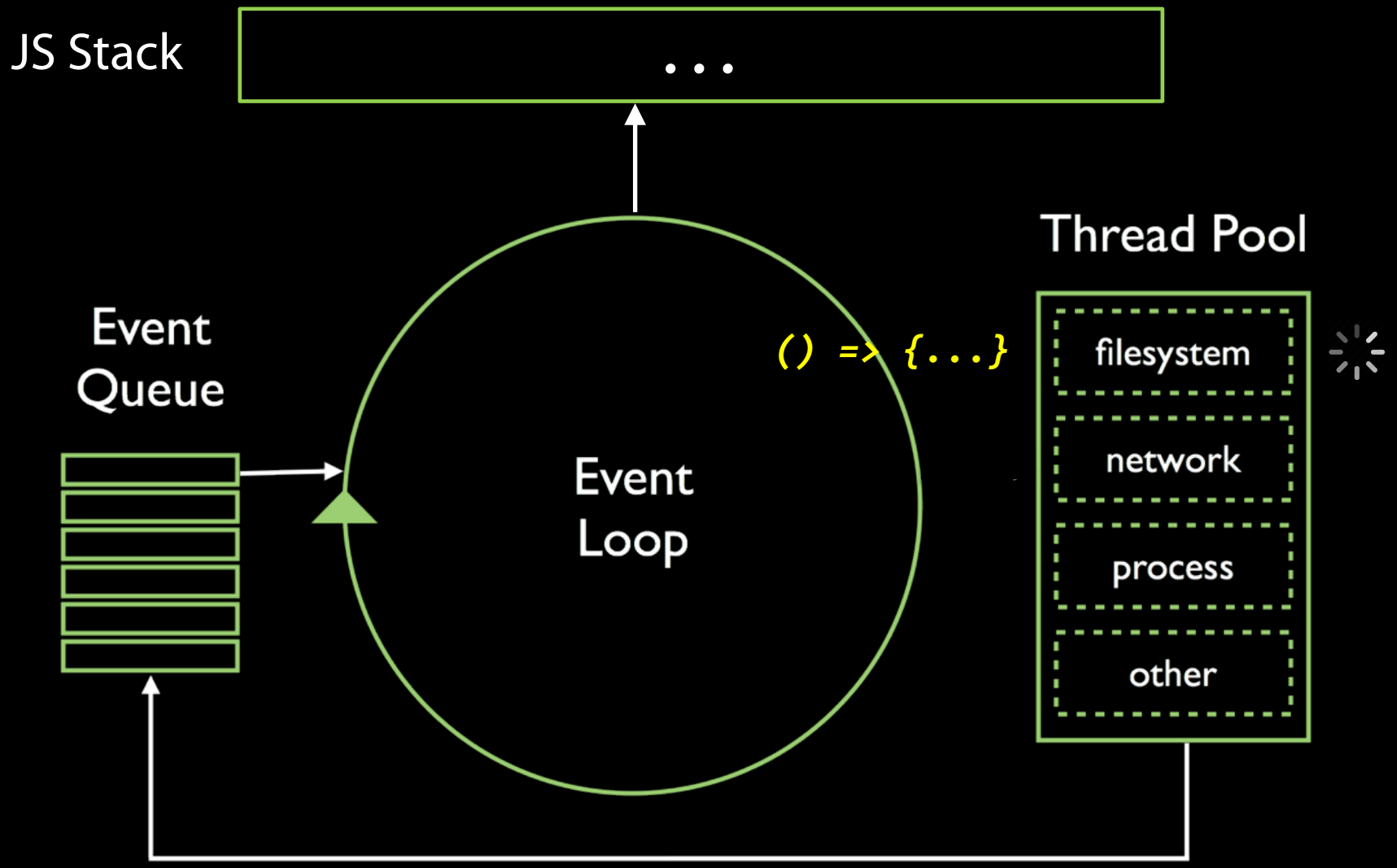

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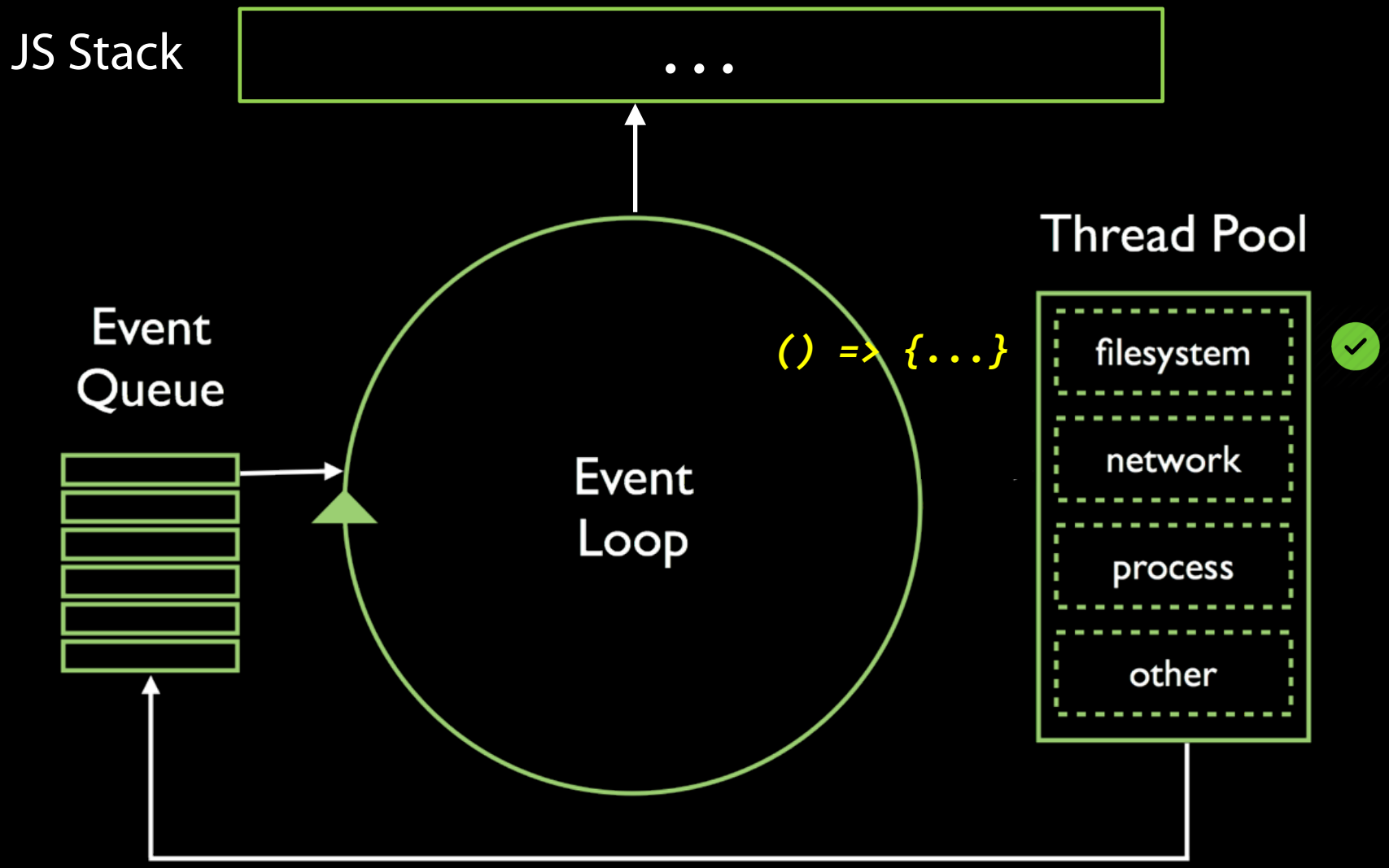

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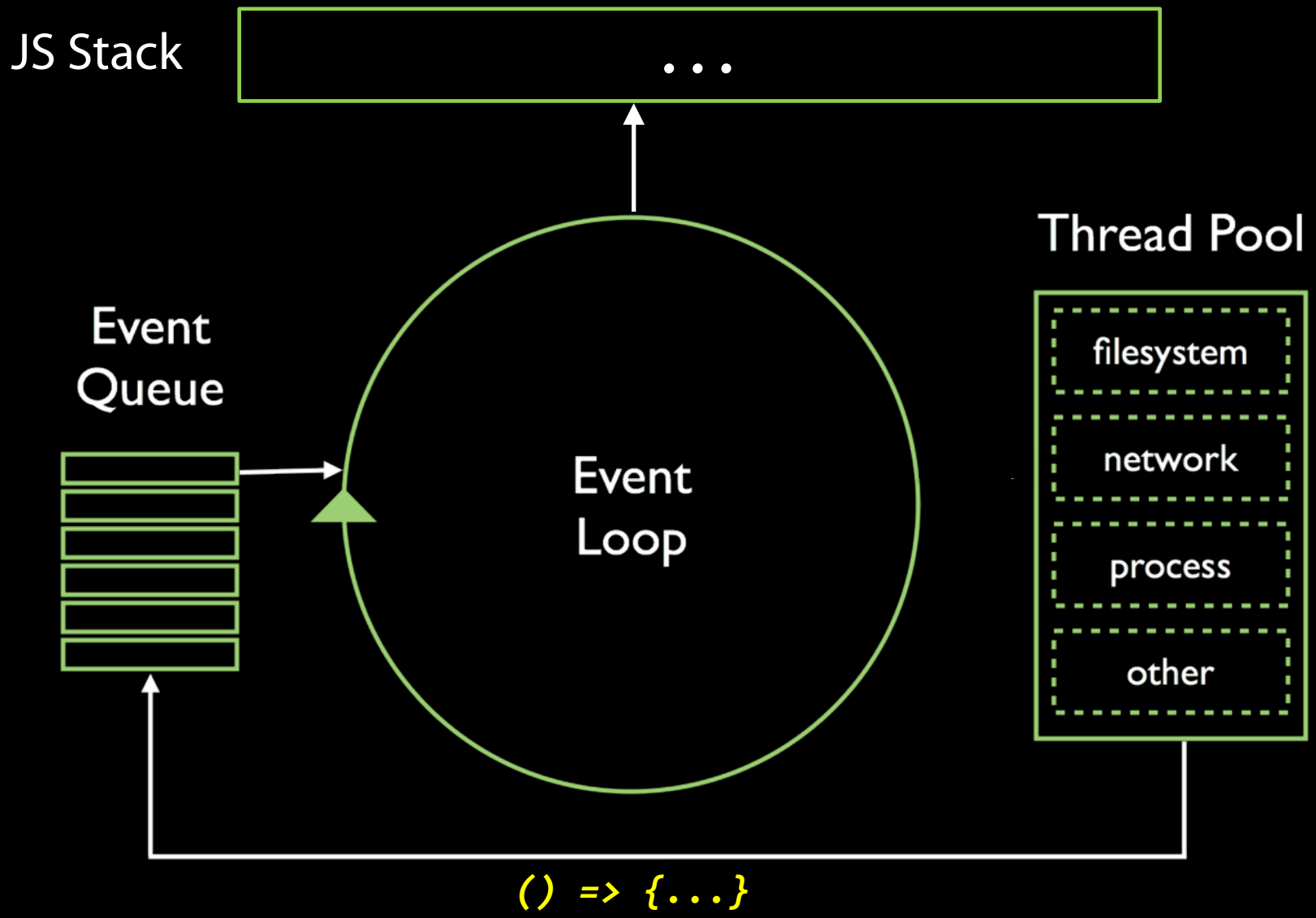

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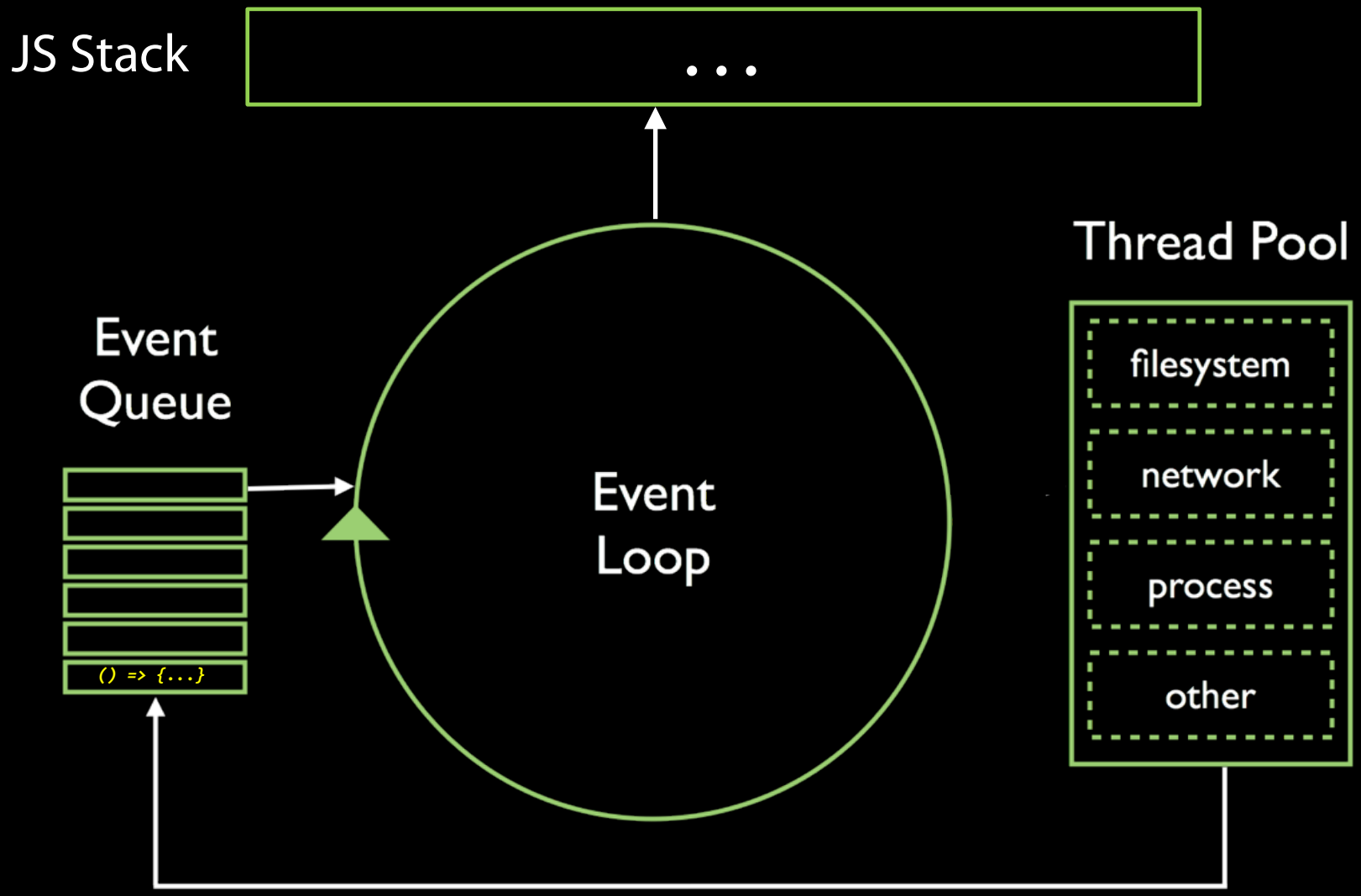

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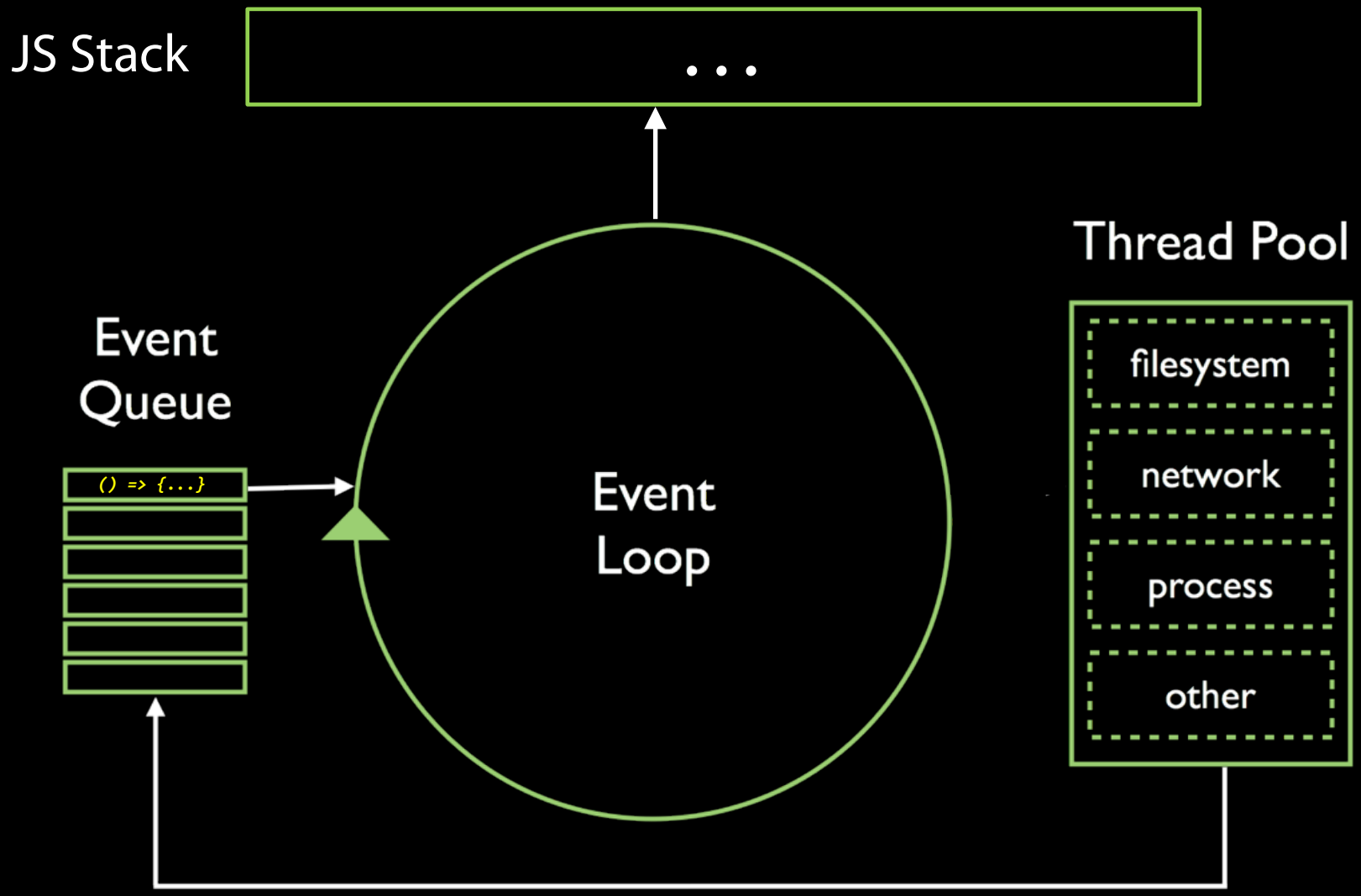

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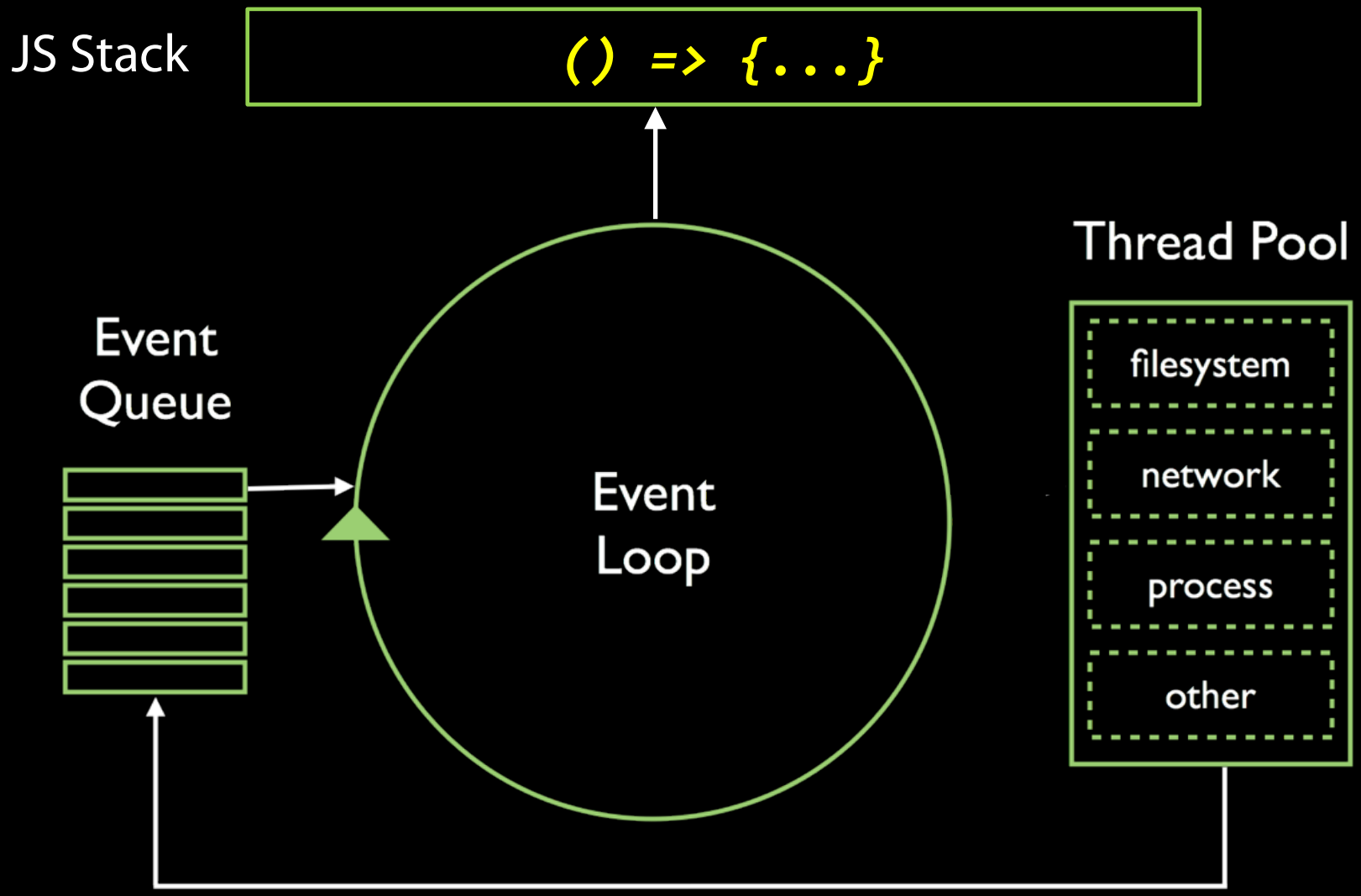

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Trouble for Debugging

```
1 var fs = require('fs');
2 function callback(err, data) {
3       if (err) throw new Error();
4 }
5 function main() {
6       fs.readFile('file1.txt', callback);
7       fs.readFile('file2.txt', callback);
8 }
9 main();
```

```
> if (err) throw new Error();
>                ^
> Error
>     at <dir>\example.js:3:17
>     at fs.js:207:20
>     at Object.oncomplete (fs.js:107:15)
```