High Performance JavaScript

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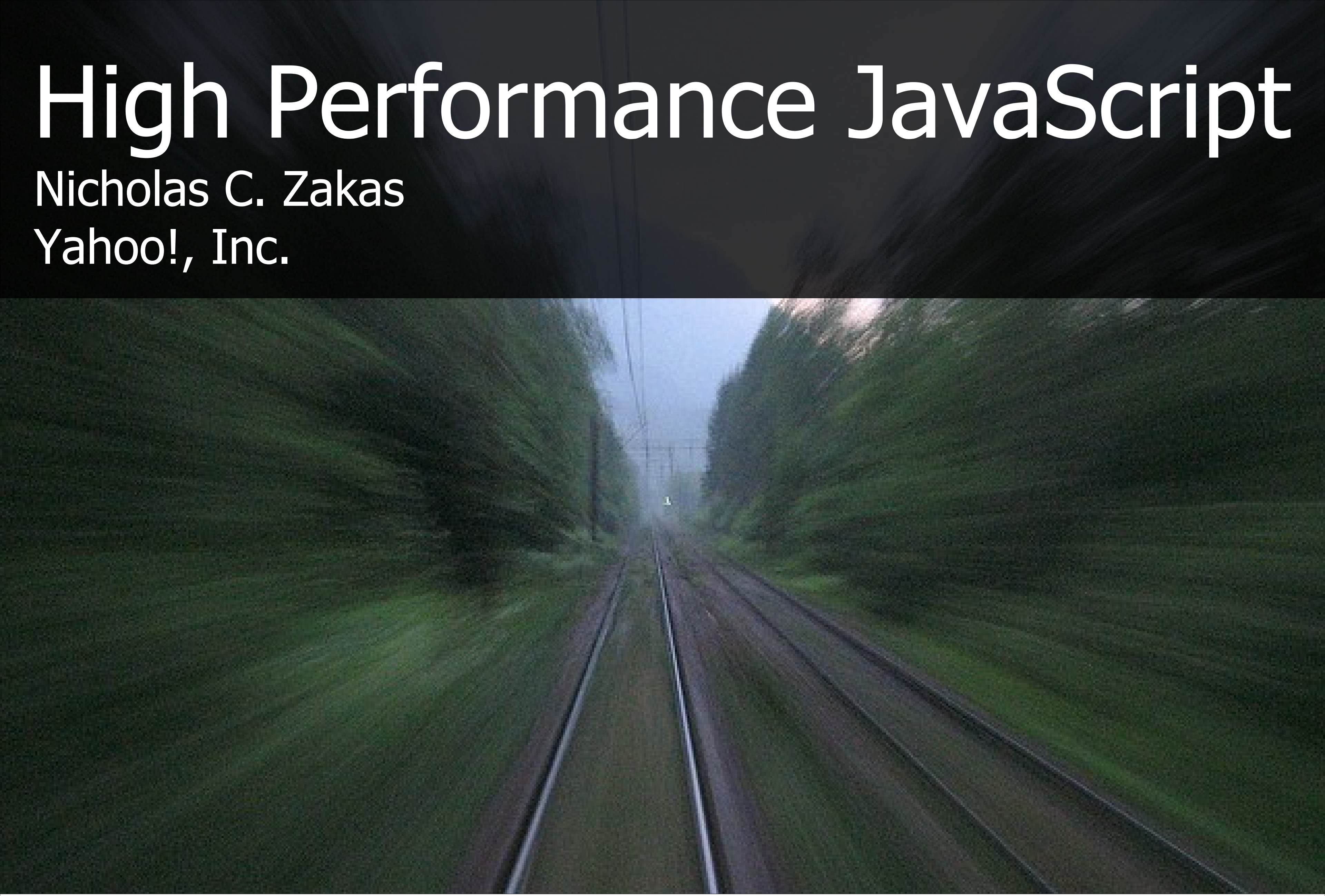

fronteers
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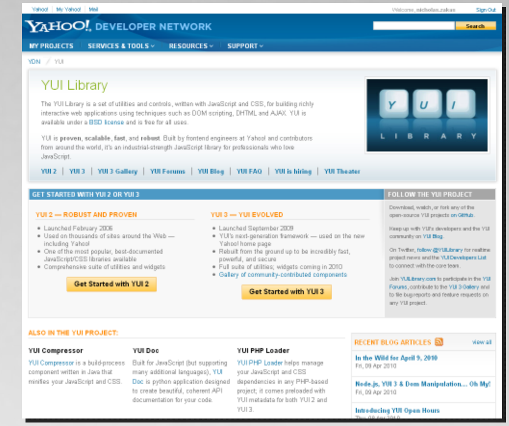
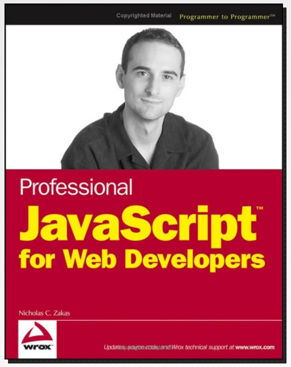
October 9, 2010

Who's this guy?

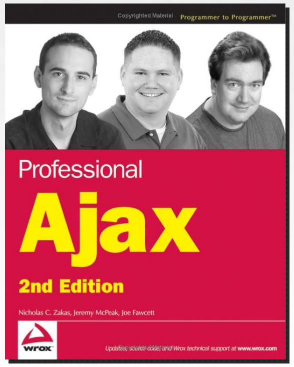
Principal Front End Engineer



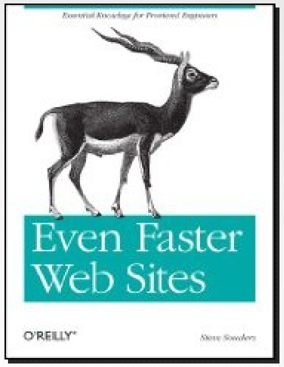
Contributor,
Creator of YUI Test



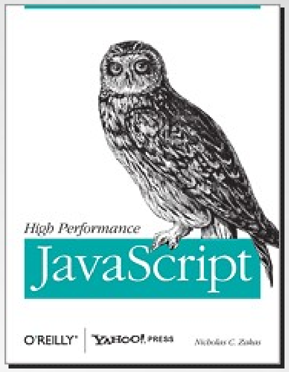
Author



Lead Author



Contributor



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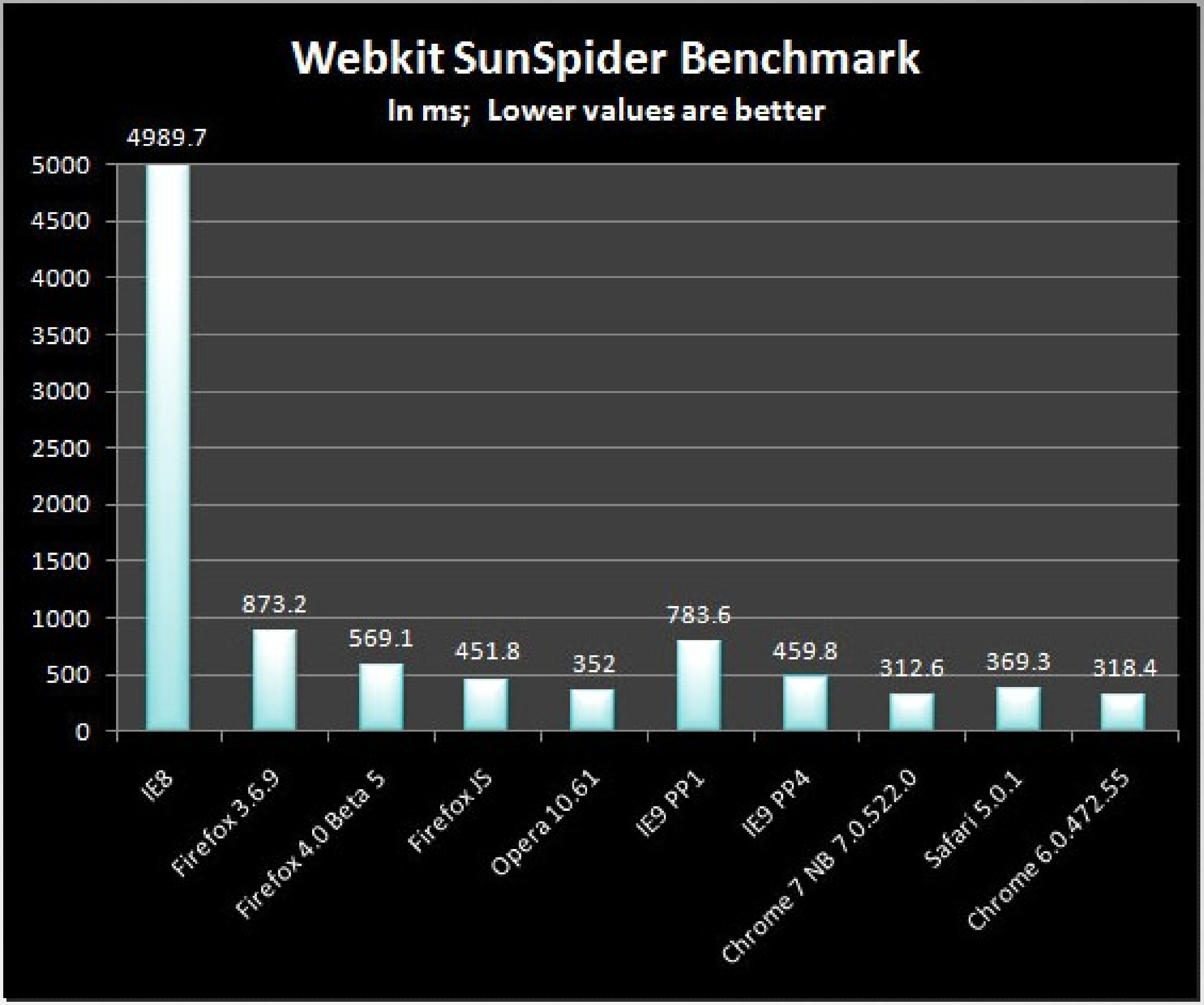
(Complaints: @codepo8)

Does JavaScript performance matter?

After all, all browsers now have optimizing JavaScript engines

Tracemonkey/ JaegarMonkey (3.5+)	V8 (all)	Squirrelfish (4+)	Chakra (9+)	Karakan (10.5+)



So our scripts are getting really, really fast

Old computers ran slow applications

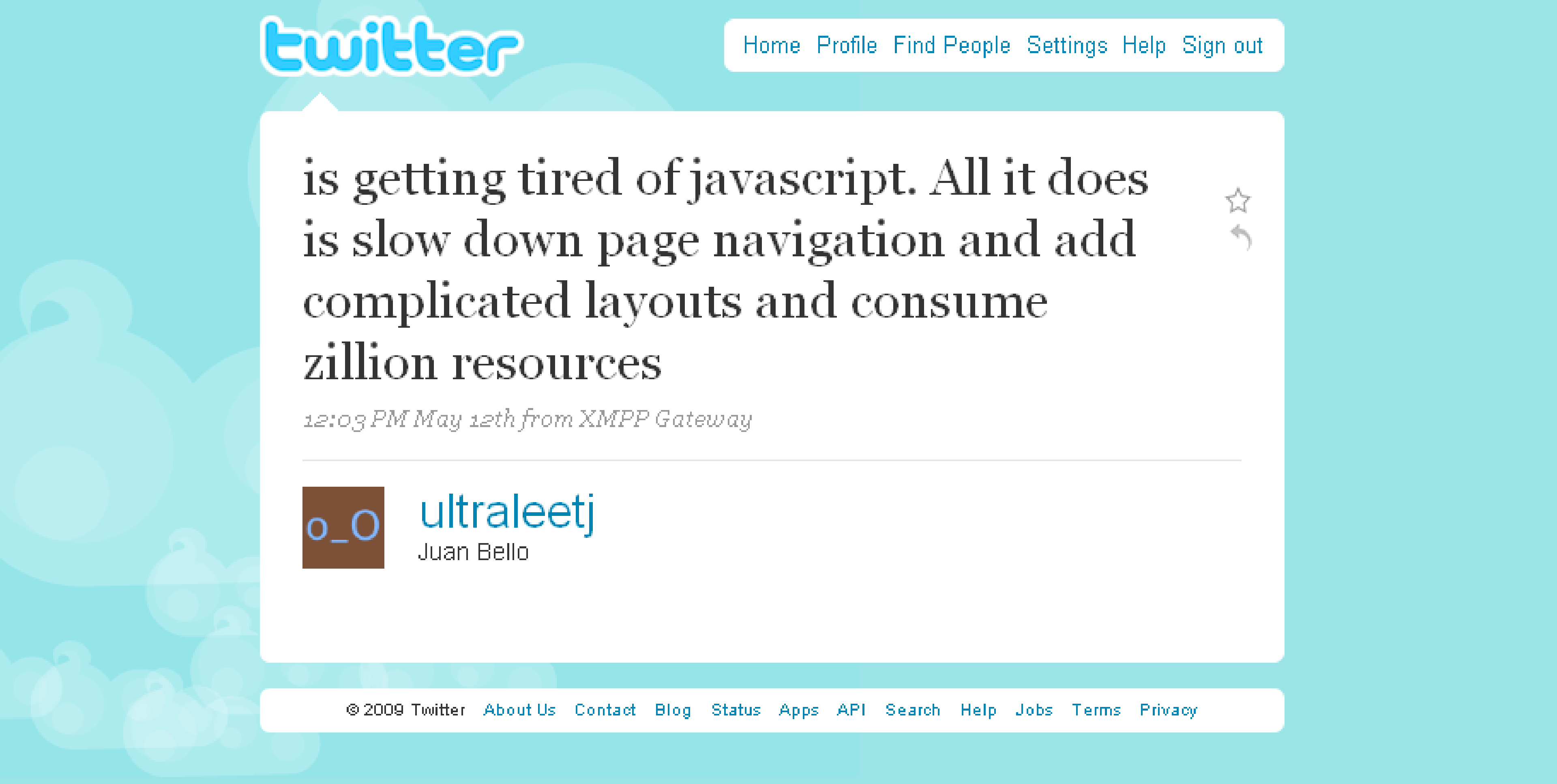
Small amounts of CPU power and memory

New computers are generally faster but slow applications still exist

More CPU + more memory = less disciplined application development

It's still possible to write slow JavaScript on the new, faster JavaScript engines

JavaScript performance
directly
affects user experience


twitter
Home Profile Find People Settings Help Sign out

is getting tired of javascript. All it does is slow down page navigation and add complicated layouts and consume zillion resources

12:03 PM May 12th from XMPP Gateway

o_O ultraleetj
Juan Bello

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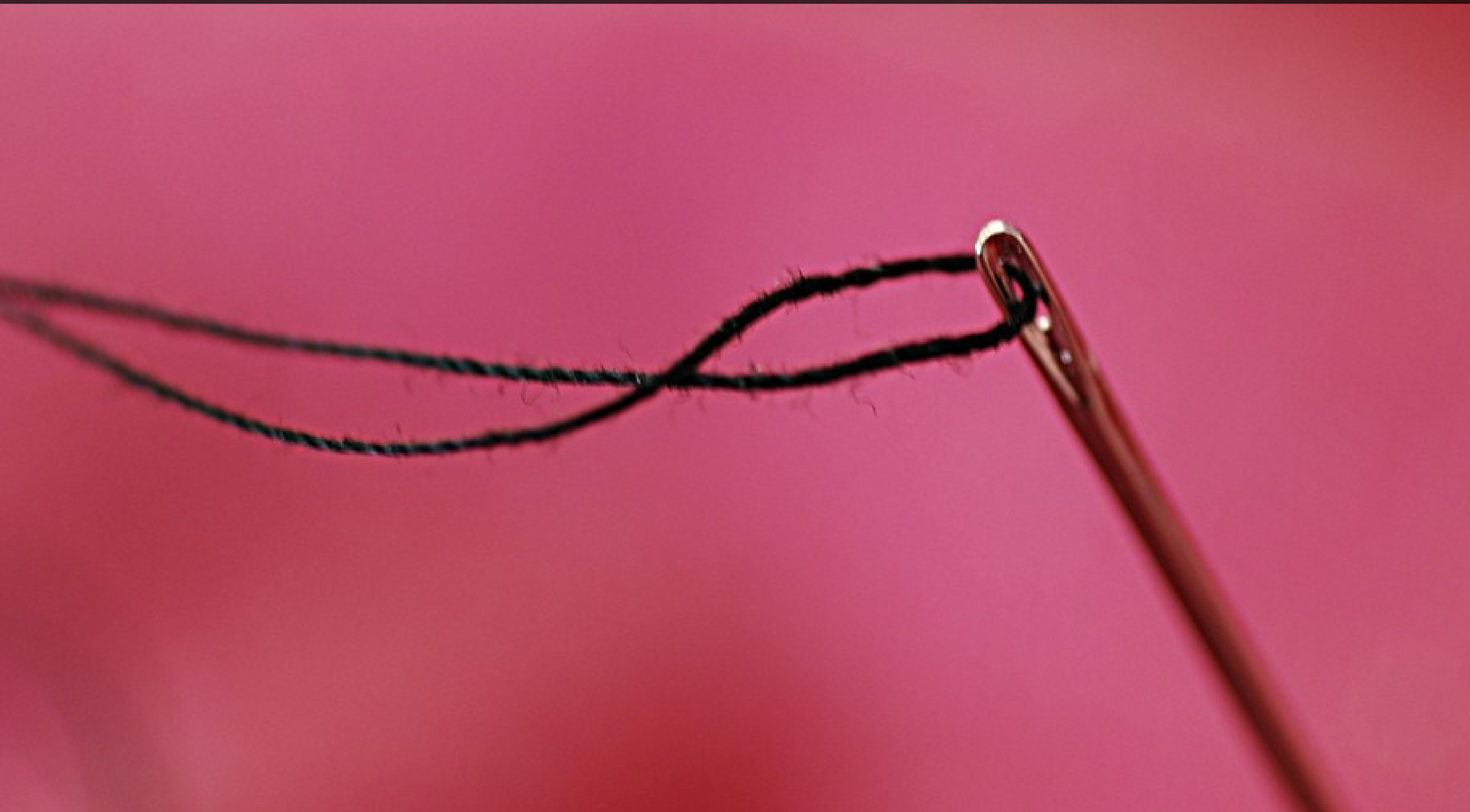
Where to start?

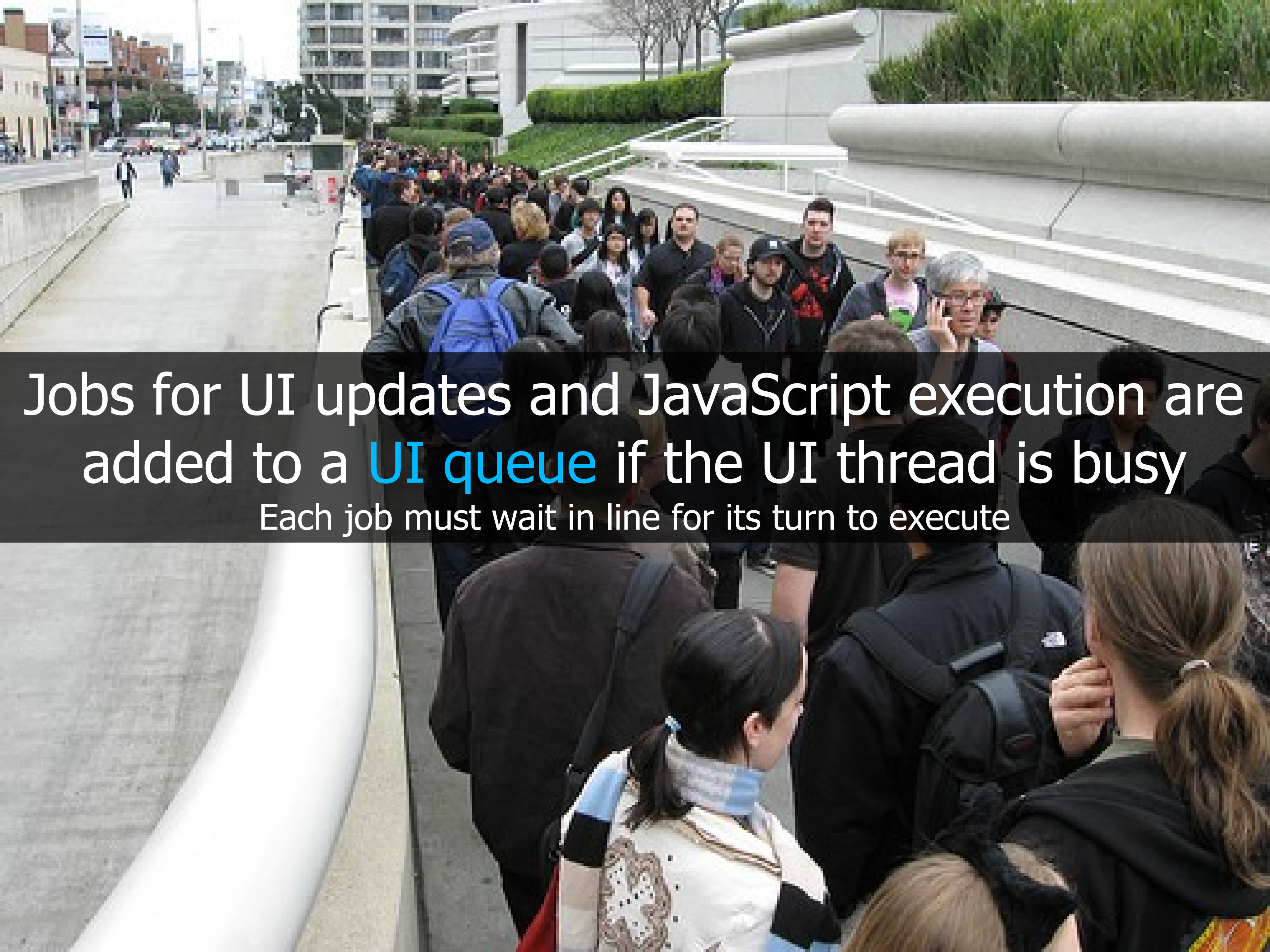
The UI Thread

The brains of the operation

The browser UI thread is responsible for both UI updates and JavaScript execution

Only one can happen at a time





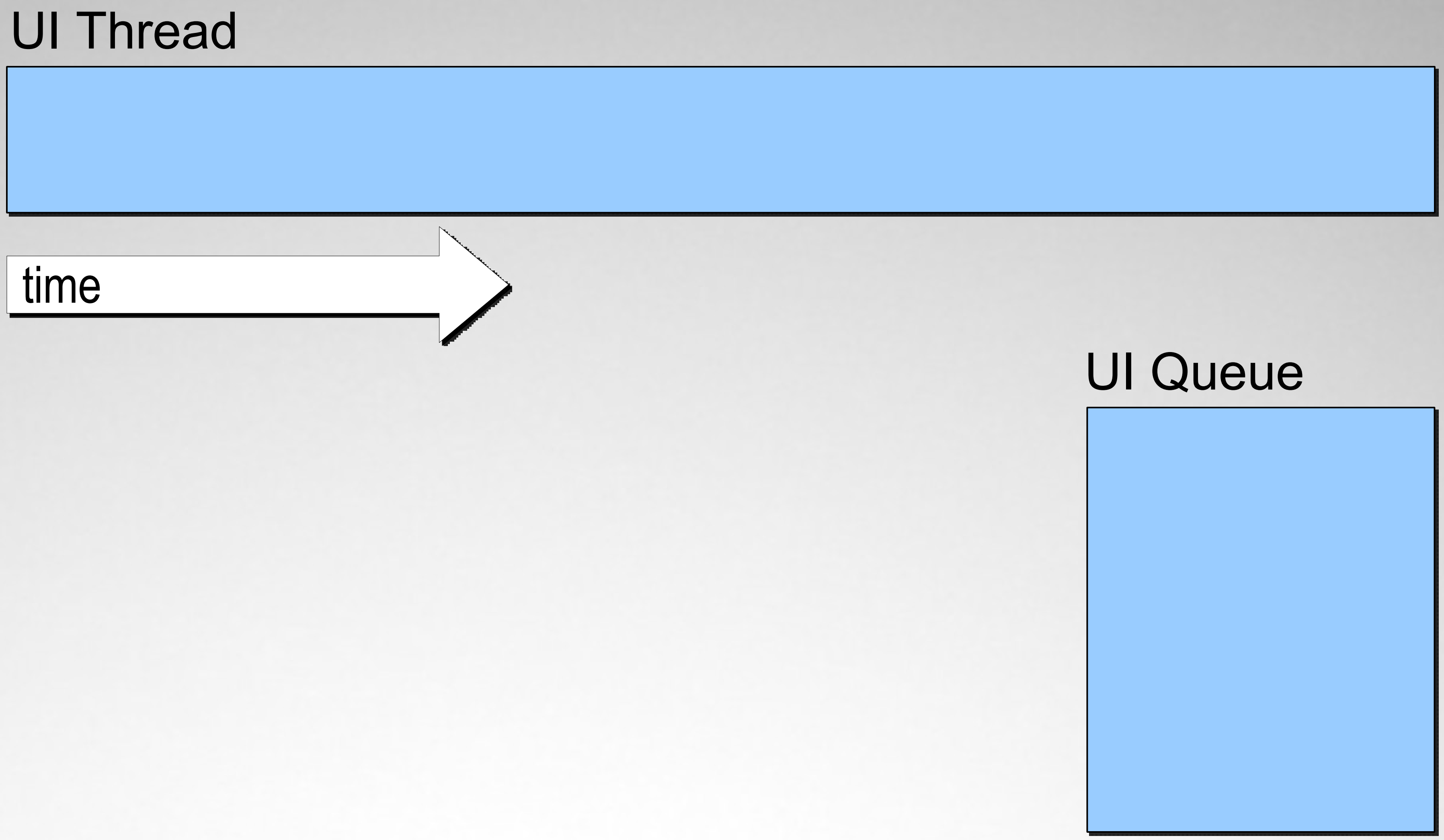
Jobs for UI updates and JavaScript execution are added to a UI queue if the UI thread is busy

Each job must wait in line for its turn to execute

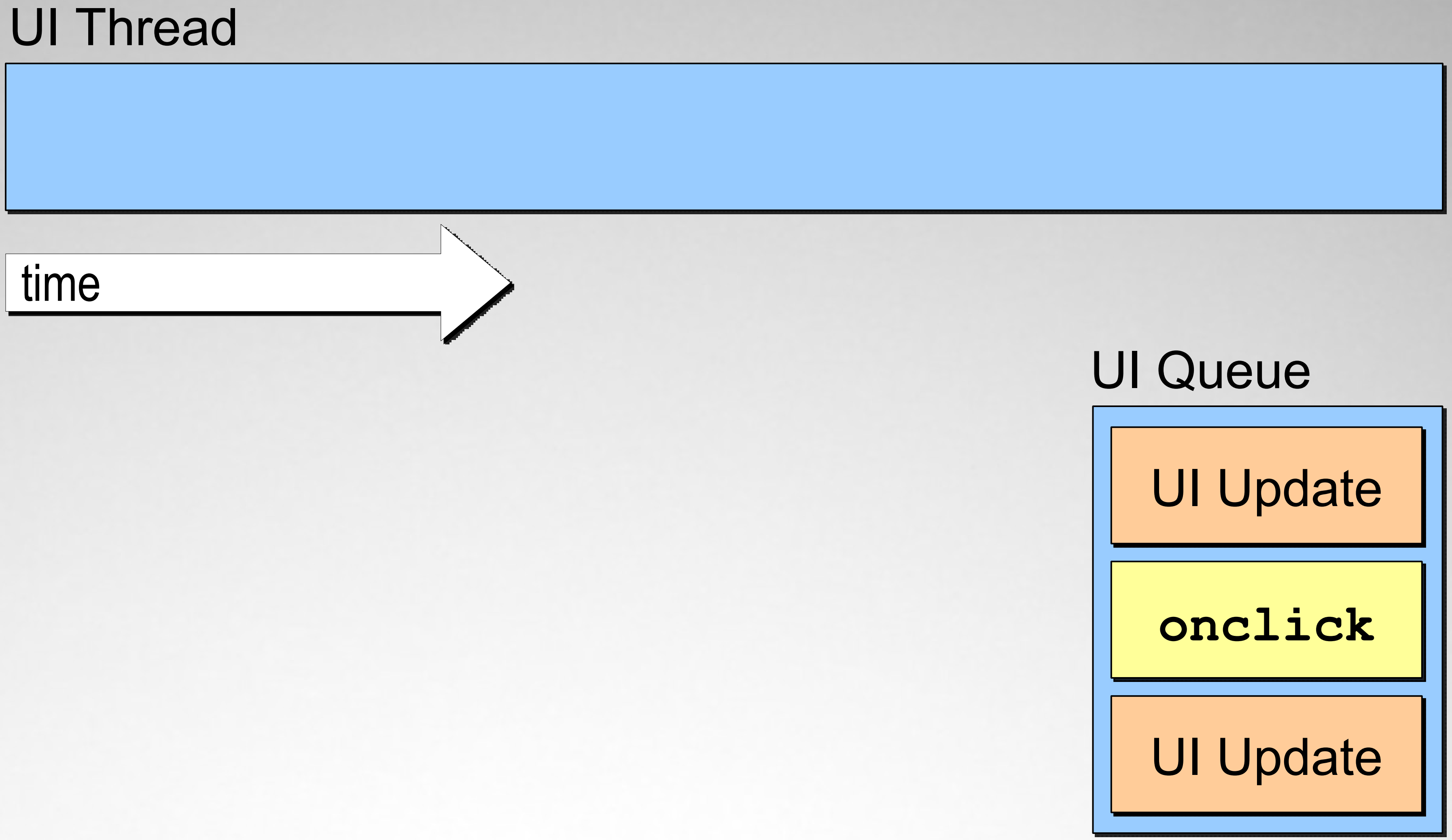
```
<button id="btn" style="font-size: 30px; padding: 0.5em
     1em">Click Me</button>

<script type="text/javascript">
window.onload = function(){
   document.getElementById("btn").onclick = function(){
       //do something
   };
};
</script>
```

Demo!

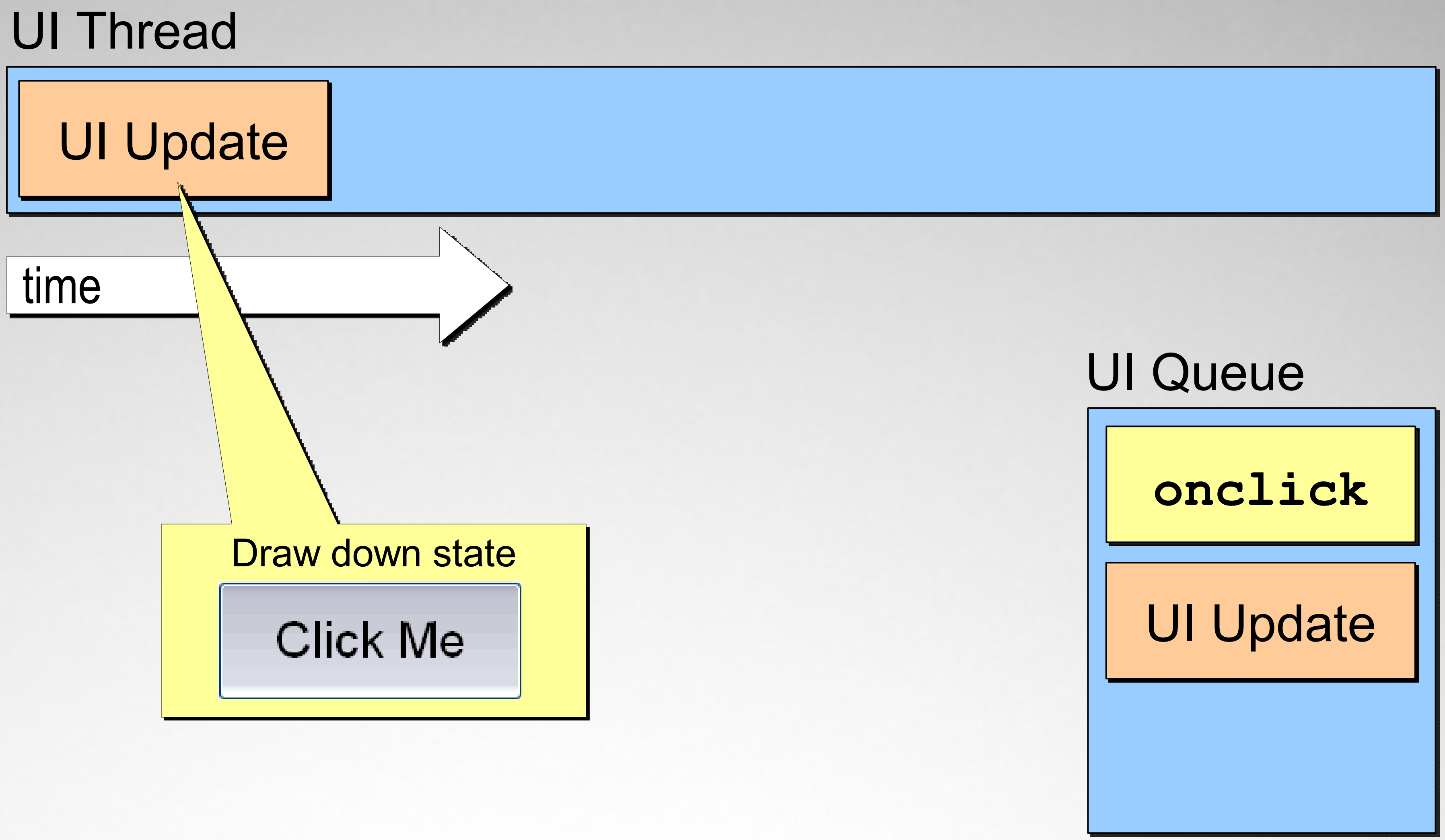
Before Click



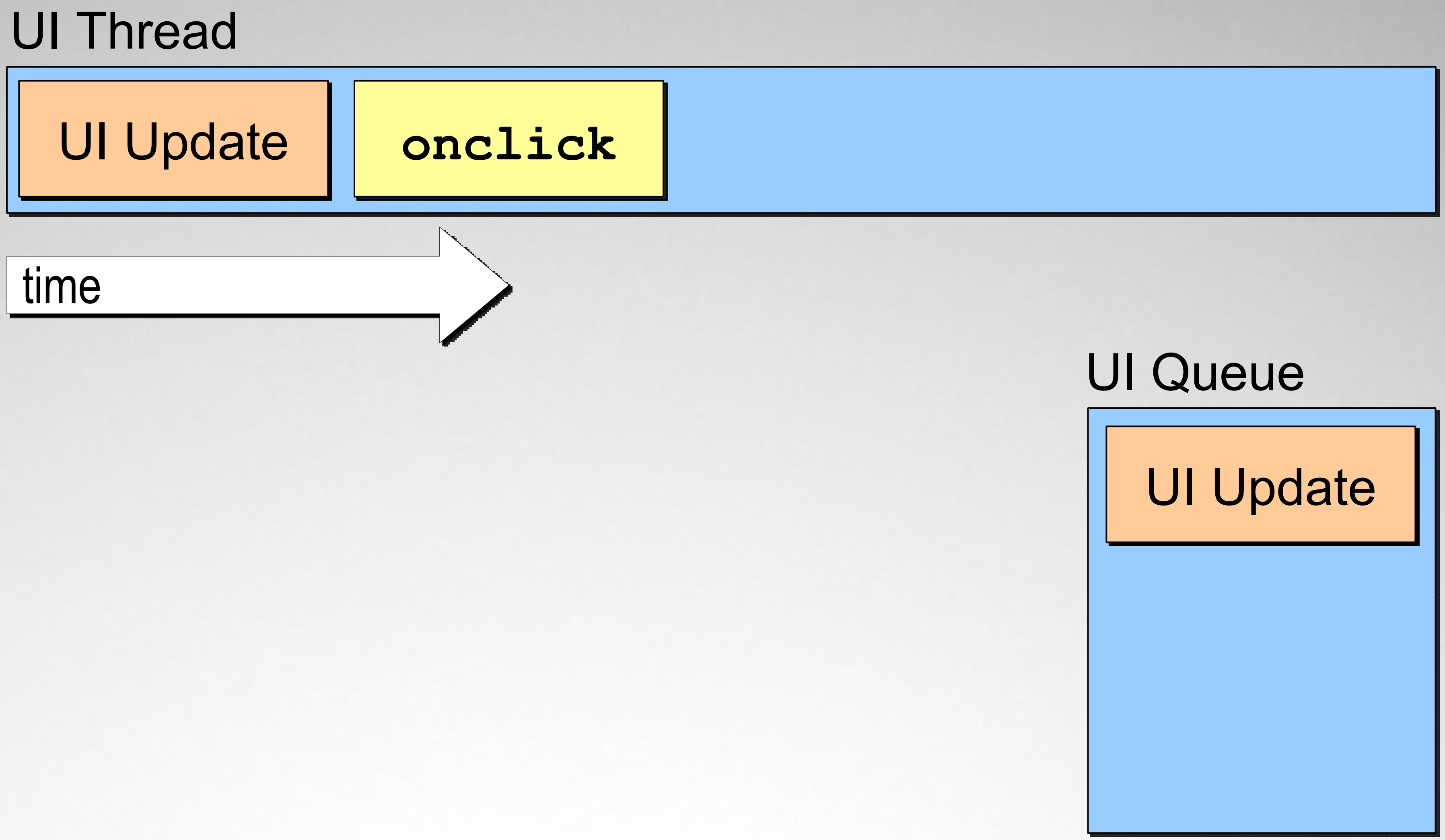
When Clicked



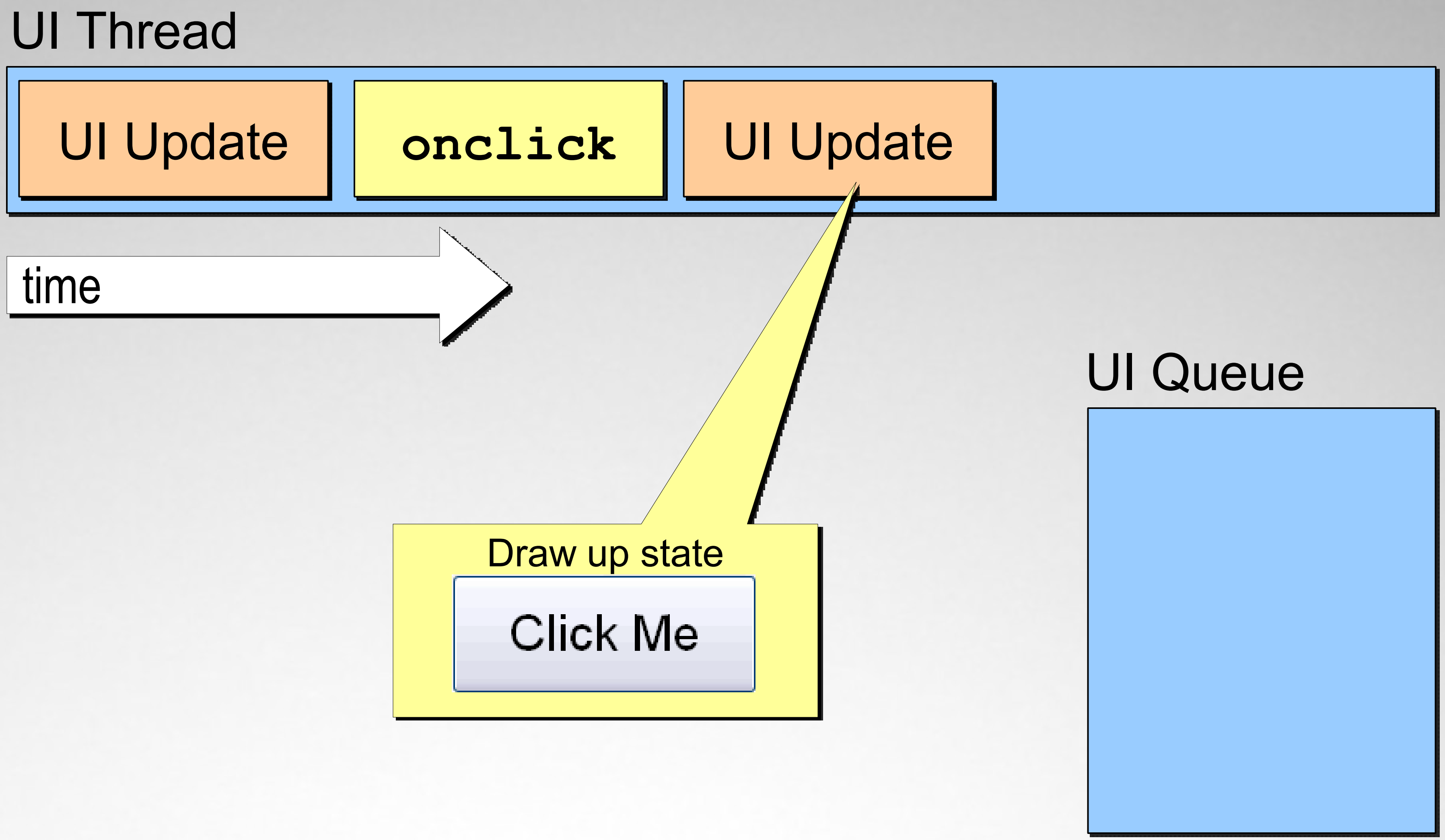
When Clicked



When Clicked



When Clicked



No UI updates while JavaScript is executing

Demo!

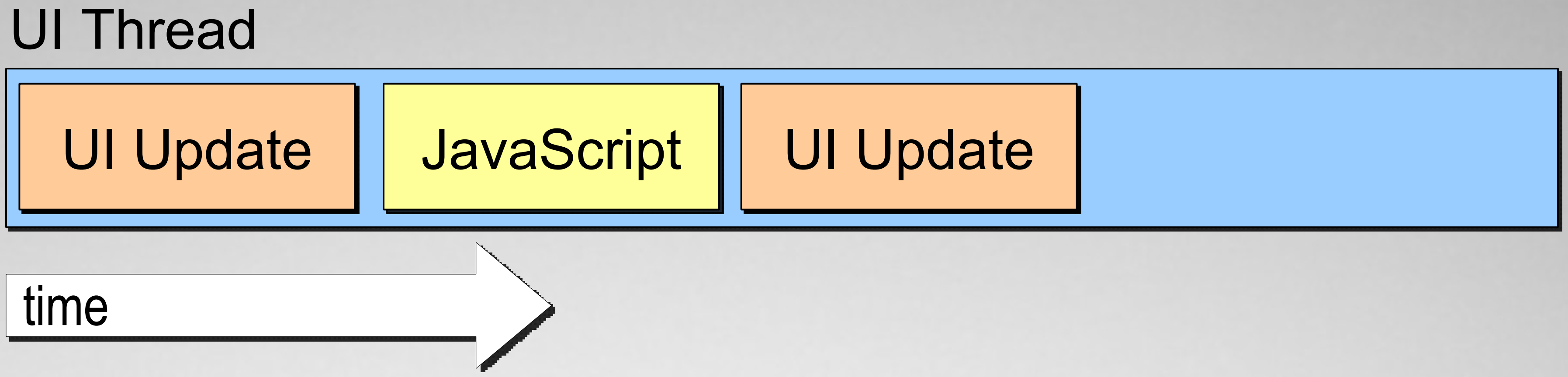
JavaScript May Cause UI Update

```
<button id="btn" style="font-size: 30px; padding: 0.5em
    1em">Click Me</button>

<script type="text/javascript">
window.onload = function(){
   document.getElementById("btn").onclick = function(){
       var div = document.createElement("div");
       div.className = "tip";
       div.innerHTML = "You clicked me!";
       document.body.appendChild(div);
   };
};
</script>
```

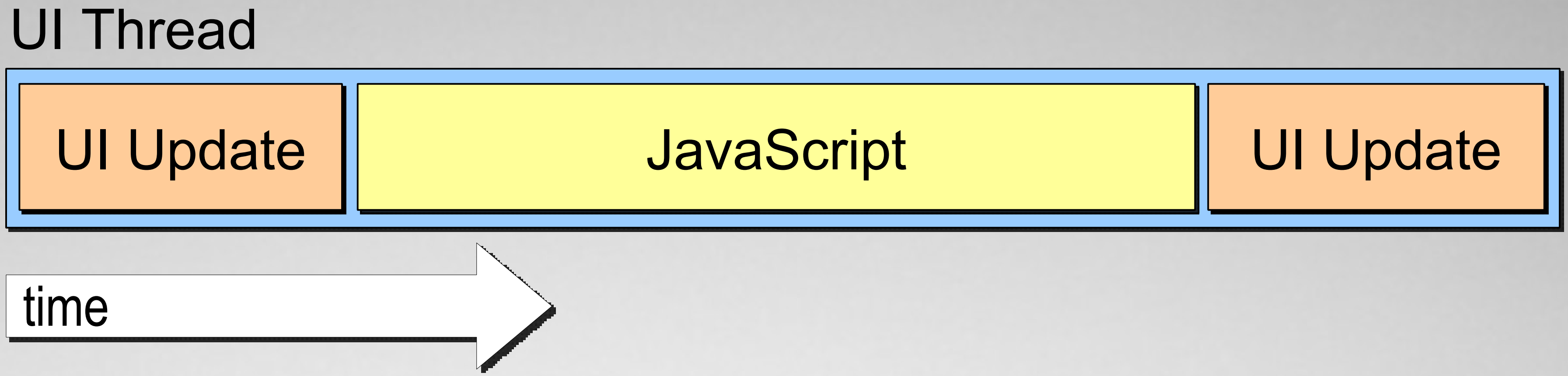
A UI update must use the latest info available

Long-running JavaScript
=
Unresponsive UI

Responsive UI



Unresponsive UI

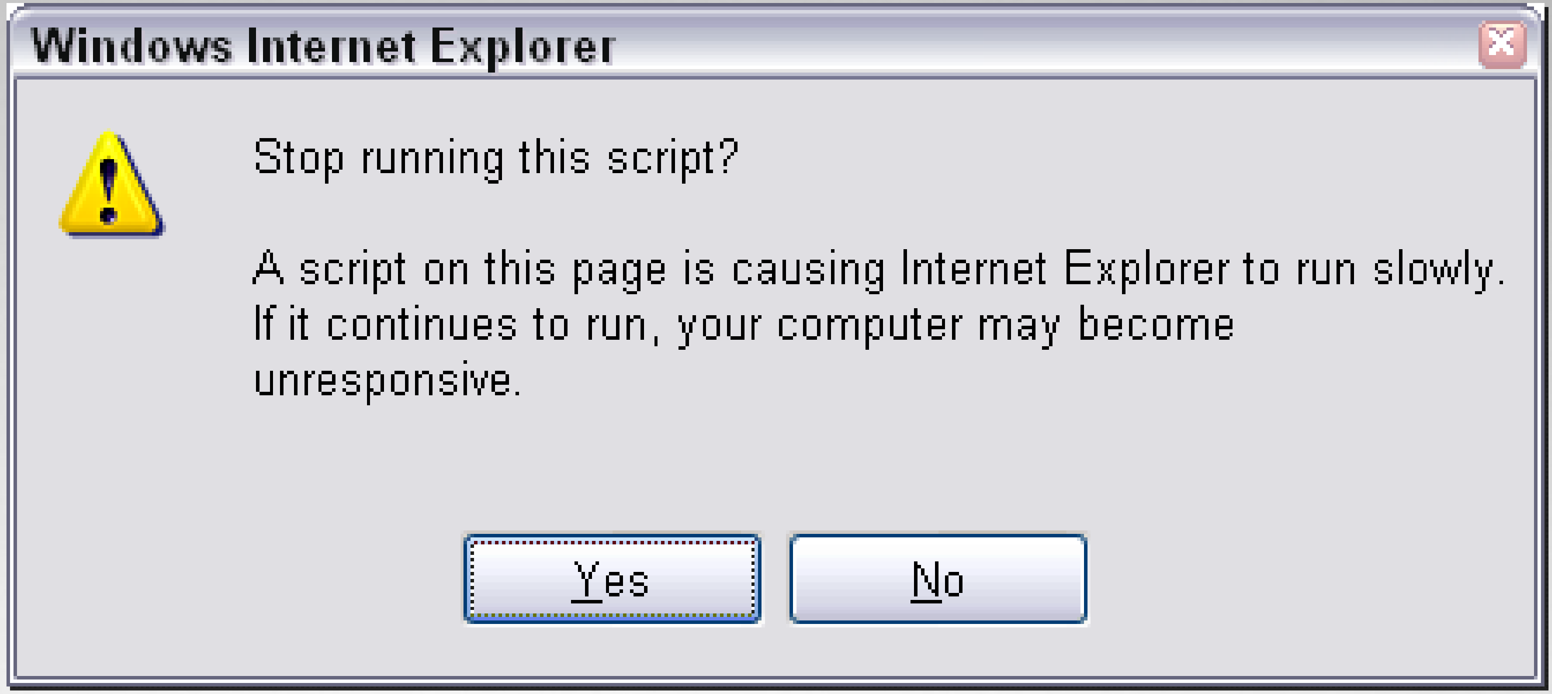


The longer JavaScript runs, the worse the user experience

The runaway script timer prevents JavaScript from running for too long

Each browser imposes its own limit (except Opera)

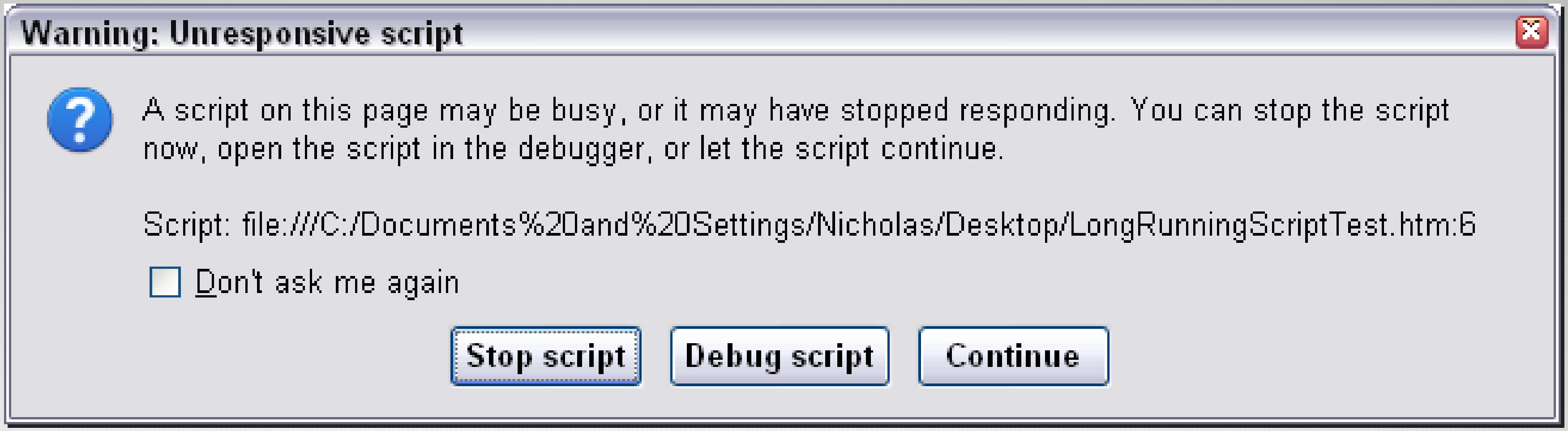
Internet Explorer



Stop running this script?

A script on this page is causing Internet Explorer to run slowly. If it continues to run, your computer may become unresponsive.

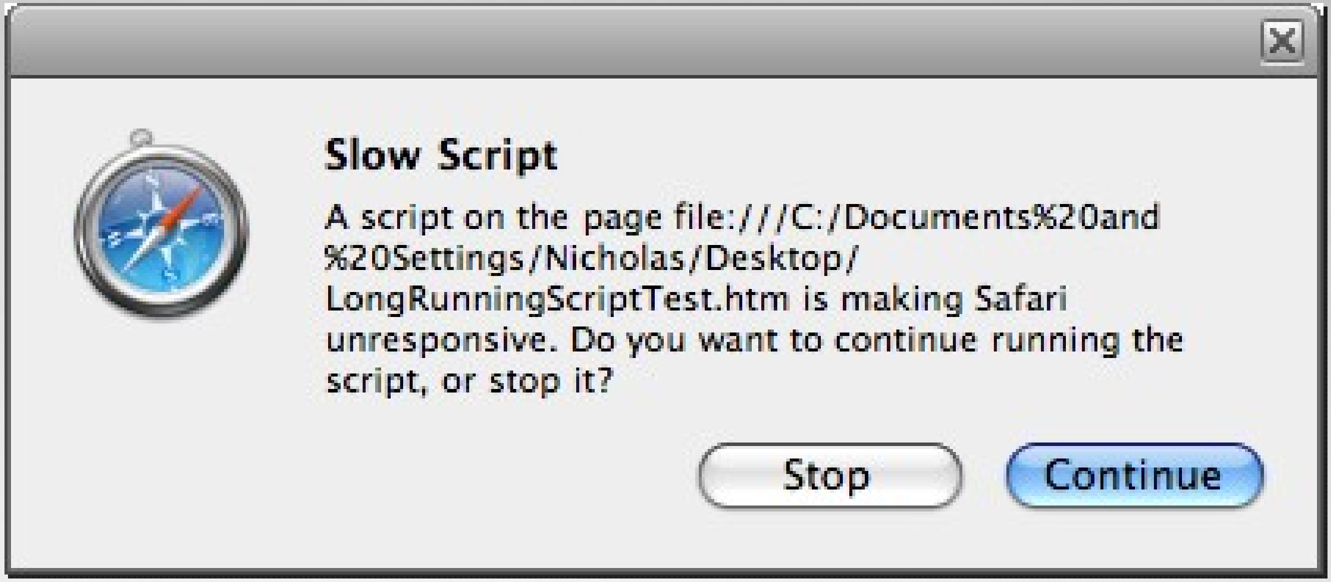
Firefox


Warning: Unresponsive script

A script on this page may be busy, or it may have stopped responding. You can stop the script now, open the script in the debugger, or let the script continue.

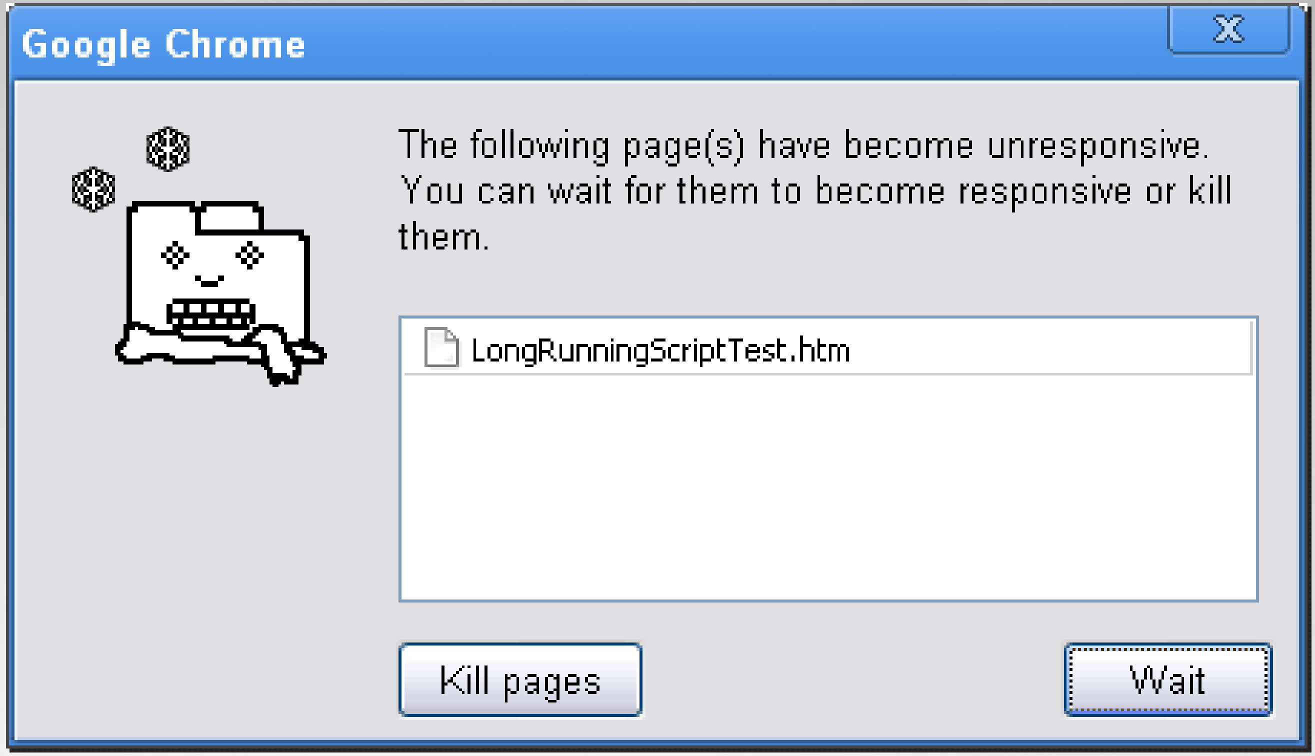
Script: file:///C:/Documents%20and%20Settings/Nicholas/Desktop/LongRunningScriptTest.htm:6

Safari


Slow Script

A script on the page file:///C:/Documents%20and%20Settings/Nicholas/Desktop/LongRunningScriptTest.htm is making Safari unresponsive. Do you want to continue running the script, or stop it?

Chrome



Google Chrome

The following page(s) have become unresponsive. You can wait for them to become responsive or kill them.

LongRunningScriptTest.htm

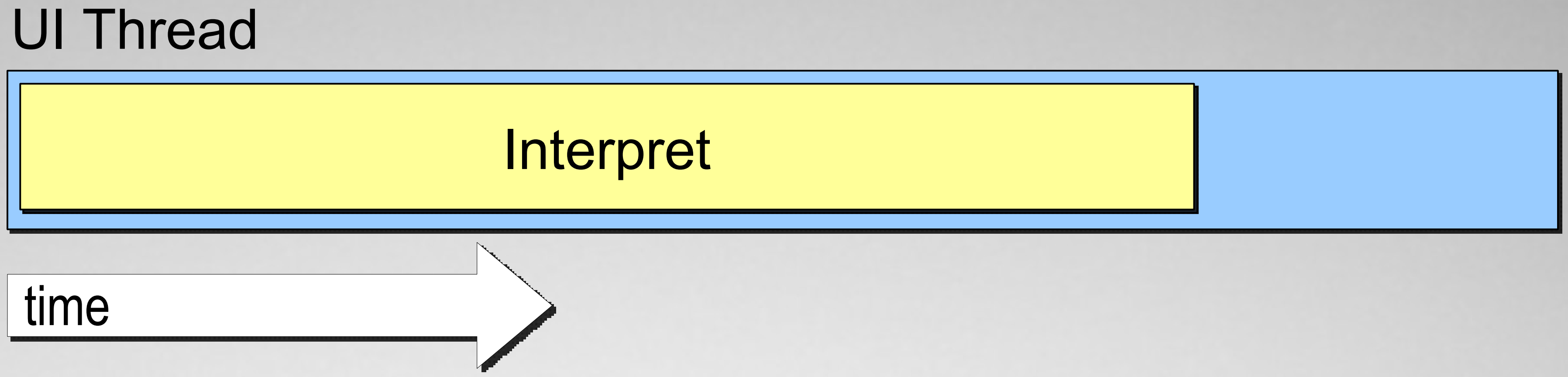
http://www.flickr.com/photos/wordridden/426920261/

Runaway Script Timer Limits

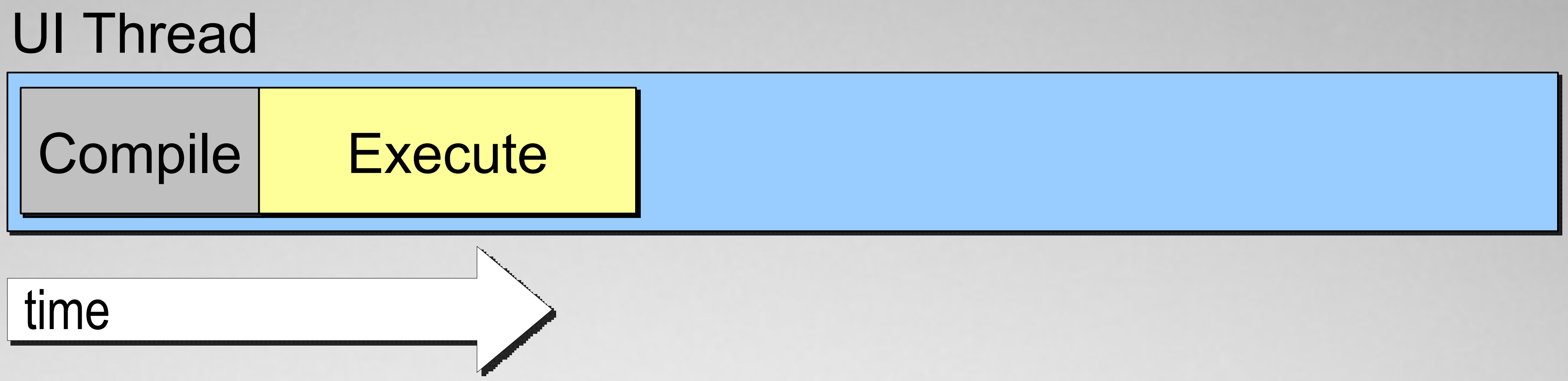
- Internet Explorer: 5 million statements
- Firefox: 10 seconds
- Safari: 5 seconds
- Chrome: Unknown, hooks into normal crash control mechanism
- Opera: none

Does JIT compiling help?

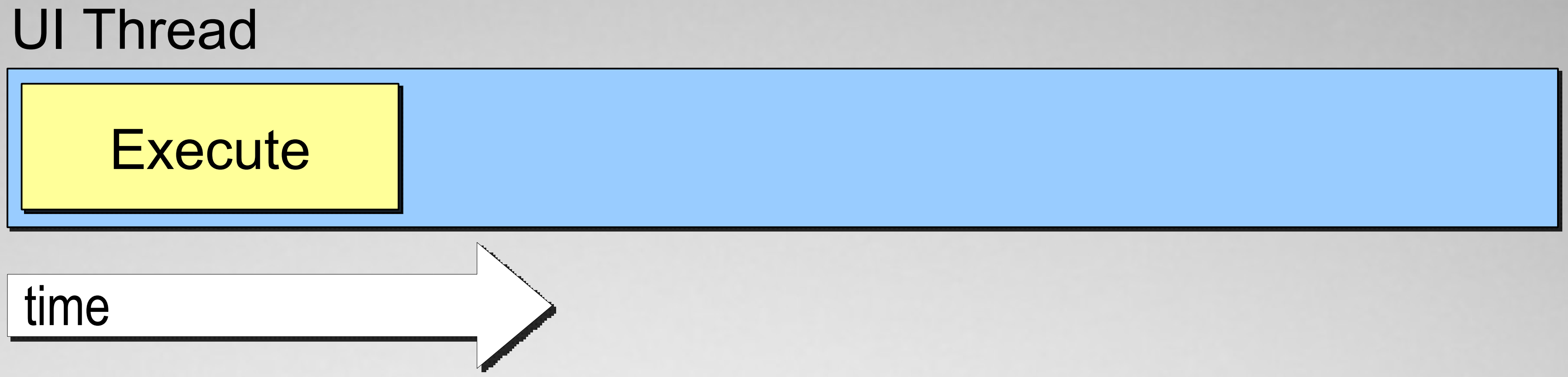
Interpreted JavaScript



JITed JavaScript (1st Run)



JITed JavaScript (After 1st Run)



How Long Is Too Long?

“0.1 second [100ms] is about the limit for having the user feel that the system is reacting instantaneously, meaning that no special feedback is necessary except to display the result.”

- Jakob Nielsen

Demo!

Translation:

No single JavaScript job should execute for more than 100ms to ensure a responsive UI

Recommendation:

Limit JavaScript execution to no more than 50ms

measured on IE6 :)

Doing so makes your program awesome

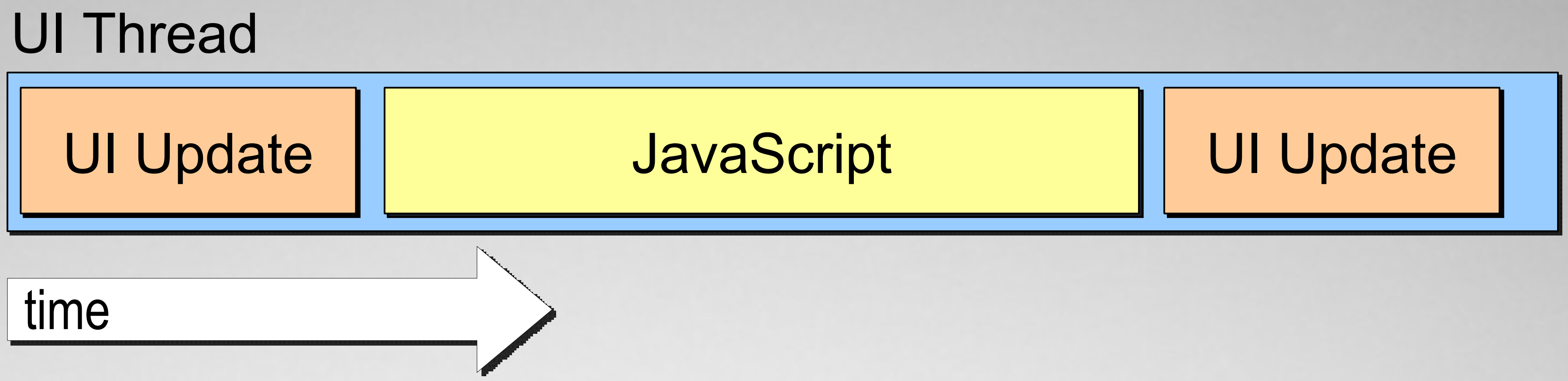
Loadtime Techniques

Don't let JavaScript interfere with page load performance

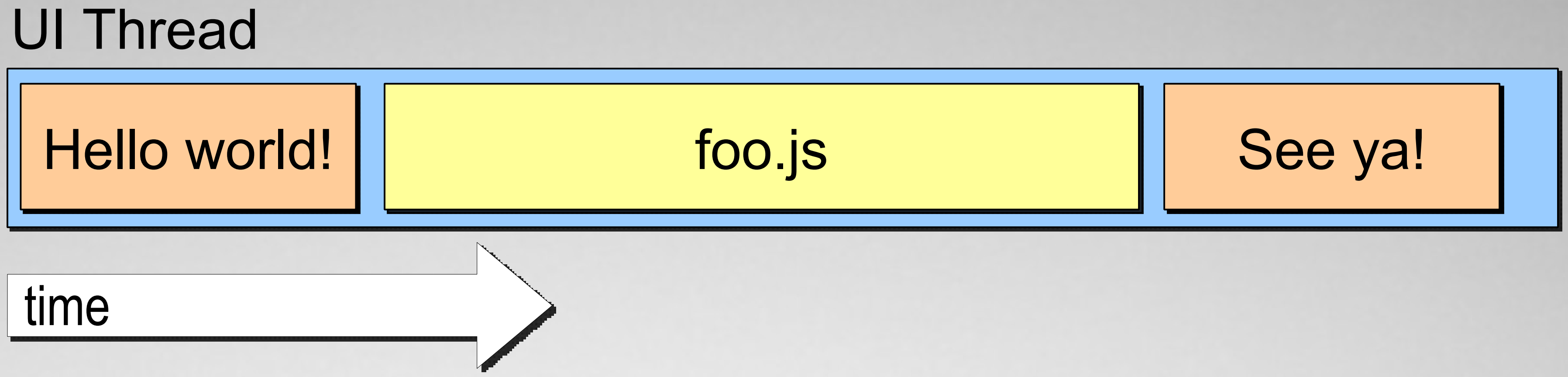
During page load, JavaScript takes more time on the UI thread

```html
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <script src="foo.js"></script>
    <p>See ya!</p>
</body>
</html>
```

Result

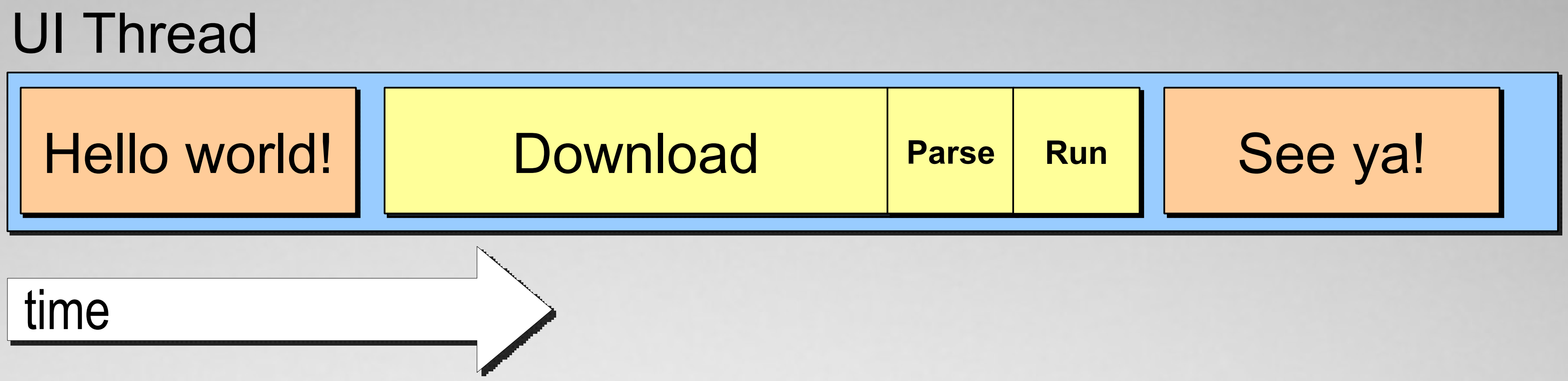


Result



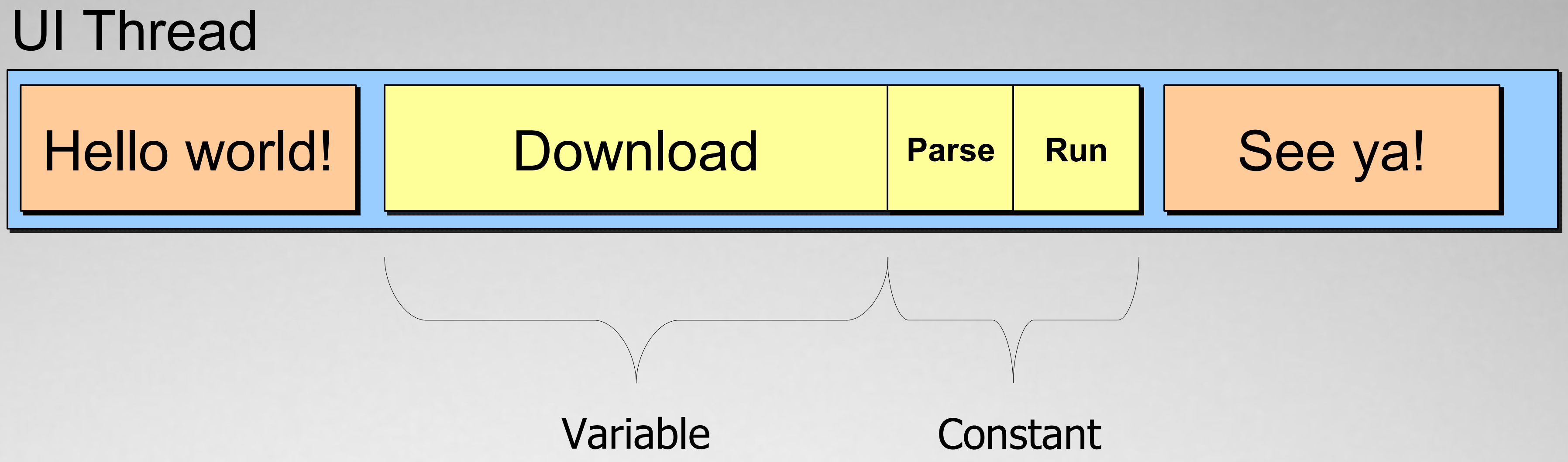
Demo!

Result



The UI thread needs to wait for the script to download, parse, and run before continuing

Result



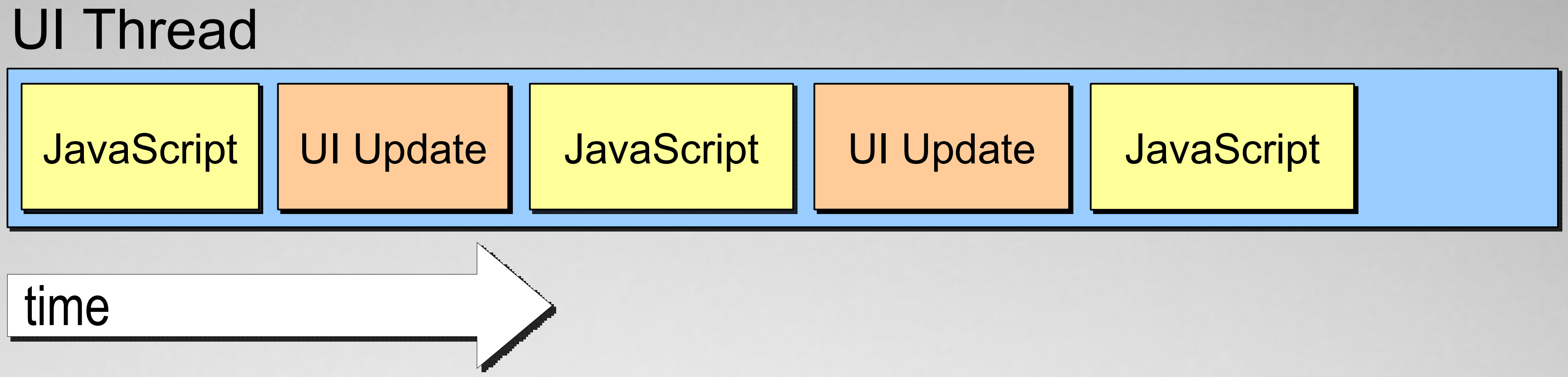
Download time takes the longest and is variable

Translation:

The page doesn't render while JavaScript is downloading, parsing, or executing during page load

```html
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <script src="foo.js"></script>
    <p>Hello world!</p>
    <script src="bar.js"></script>
    <p>See ya!</p>
    <script src="baz.js"></script>
    <p>Uh oh!</p>
</body>
</html>
```

Result



The more scripts to download in between UI updates, the longer the page takes to render

Technique #1: Put scripts at the bottom

Best Practices for Speeding Up Your Web Site

The Exceptional Performance team has identified a number of best practices for making web pages fast. The list includes 35 best practices divided into 7 categories.

Put Scripts at the Bottom

tag: javascript

The problem caused by scripts is that they block parallel downloads. The HTTP/1.1 specification suggests that browsers download no more than two components in parallel per hostname. If you serve your images from multiple hostnames, you can get more than two downloads to occur in parallel. While a script is downloading, however, the browser won't start any other downloads, even on different hostnames.

In some situations it's not easy to move scripts to the bottom. If, for example, the script uses `document.write` to insert part of the page's content, it can't be moved lower in the page. There might also be scoping issues. In many cases, there are ways to workaround these situations.

An alternative suggestion that often comes up is to use deferred scripts. The `DEFER` attribute indicates that the script does not contain document.write, and is a clue to browsers that they can continue rendering. Unfortunately, Firefox doesn't support the `DEFER` attribute. In Internet Explorer, the script may be deferred, but not as much as desired. If a script can be deferred, it can also be moved to the bottom of the page. That will make your web pages load faster.

top | discuss this rule

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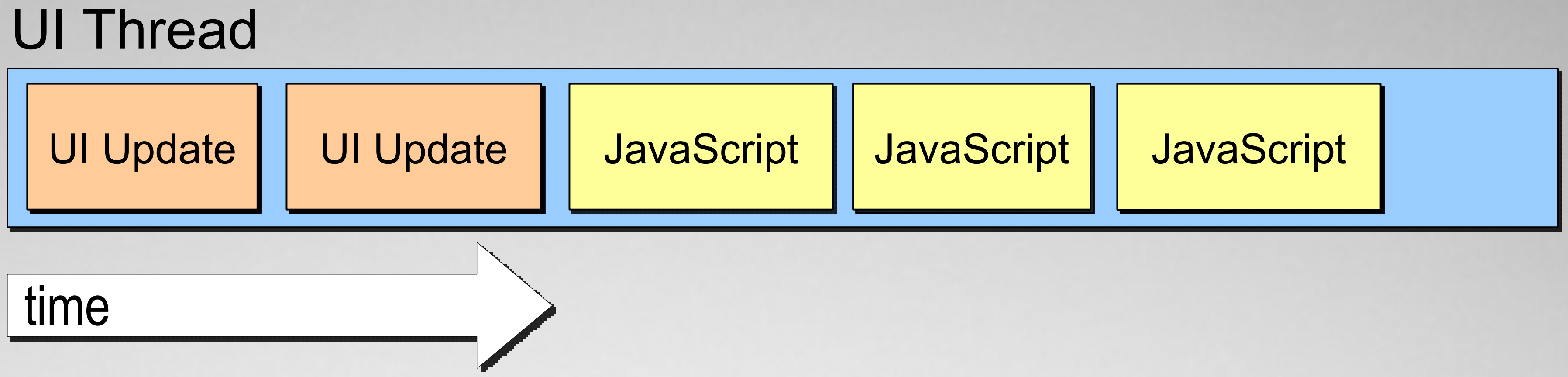
```
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <p>See ya!</p>
    <script src="foo.js"></script>
</body>
</html>
```

Put Scripts at Bottom

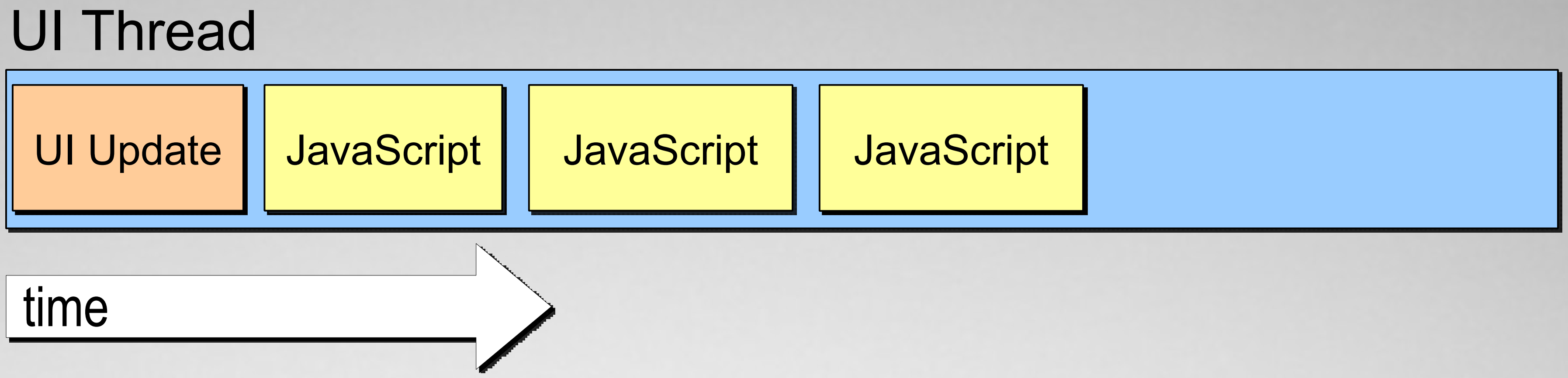


Demo!

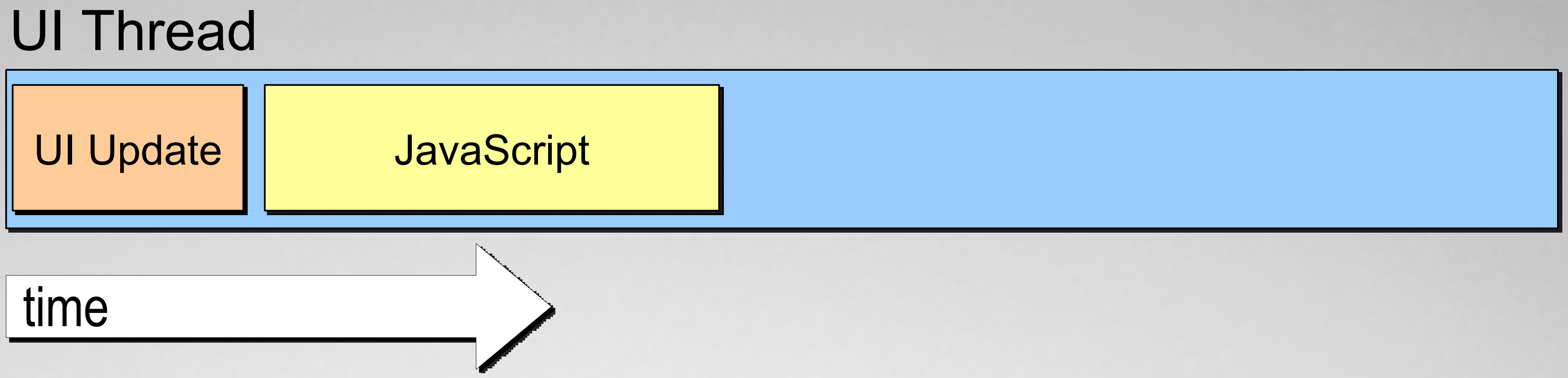
Even if there are multiple scripts, the page renders quickly

Technique #2: Combine JavaScript files

```html
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <p>See ya!</p>
    <script src="foo.js"></script>
    <script src="bar.js"></script>
    <script src="baz.js"></script>
</body>
</html>
```



Each script has overhead of downloading



Combining all of the files limits the network overhead and gets scripts onto the page faster

```html
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <p>See ya!</p>
    <script src="foo-and-bar-and-baz.js"></script>
</body>
</html>
```

Technique #3: Load scripts dynamically

Basic Technique

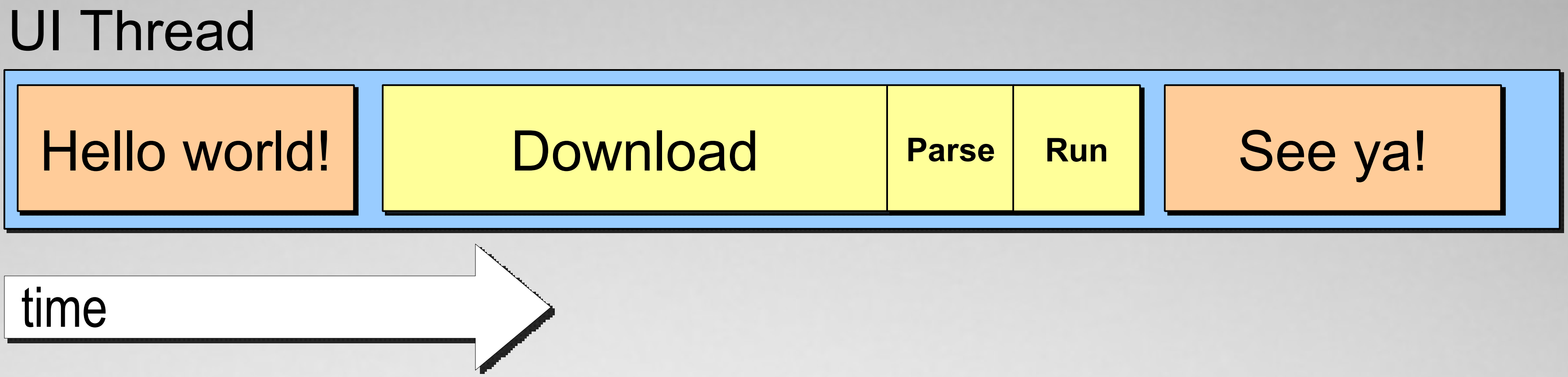
```
var script = document.createElement("script"),
    body;
script.type = "text/javascript";
script.src = "foo.js";
body.appendChild(script, body.firstChild);
```

Dynamically loaded scripts are non-blocking

Downloads no longer block the UI thread

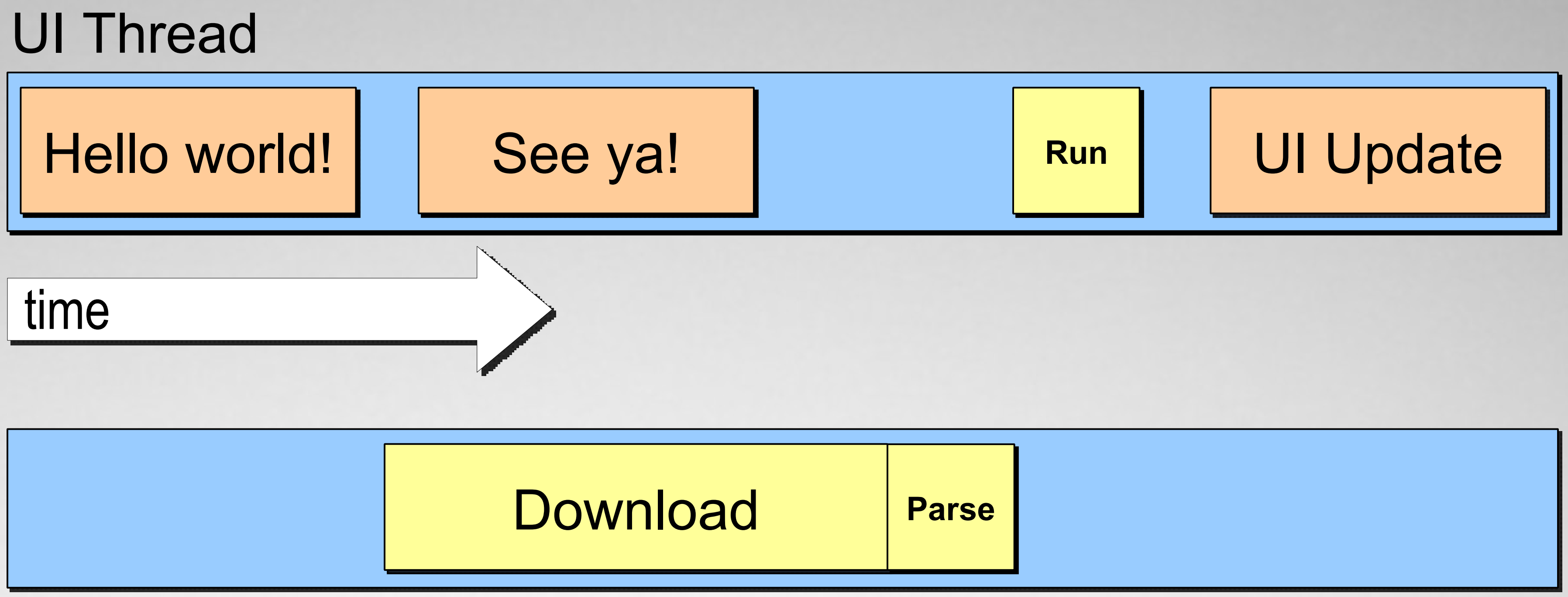
```html
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <script src="foo.js"></script>
    <p>See ya!</p>
</body>
</html>
```

Using HTML <script>



```
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <script>
    var script = document.createElement("script"),
        body = document.body;
    script.type = "text/javascript";
    script.src = "foo.js";
    body.insertBefore(script, body.firstChild);
    </script>
    <p>See ya!</p><!-- more content -->
</body>
</html>
```

Using Dynamic Scripts



Only code execution happens on the UI thread, which means less blocking of UI updates

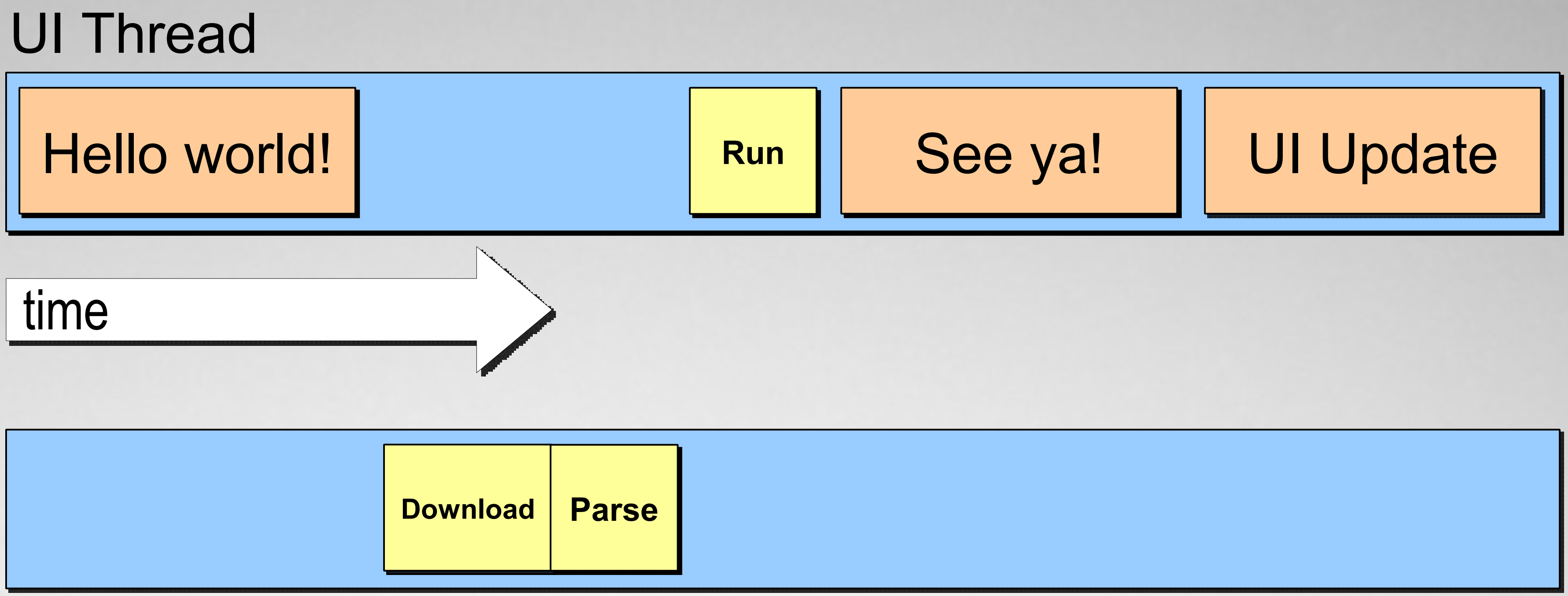
```
function loadScript(url, callback){

   var script = document.createElement("script"),
       body = document.body;
   script.type = "text/javascript";

   if (script.readyState){  //IE <= 8
       script.onreadystatechange = function(){
           if (script.readyState == "loaded" ||
                   script.readyState == "complete"){
               script.onreadystatechange = null;
               callback();
           }
       };
   } else {  //Others
       script.onload = function(){
           callback();
       };
   }

   script.src = url;
   body.insertBefore(script, body.firstChild);

}
```

Usage

```
loadScript("foo.js", function(){
    alert("Loaded!");
});
```

Timing Note:
Script execution begins immediately after download and parse – timing of execution is not guaranteed

Using Dynamic Scripts

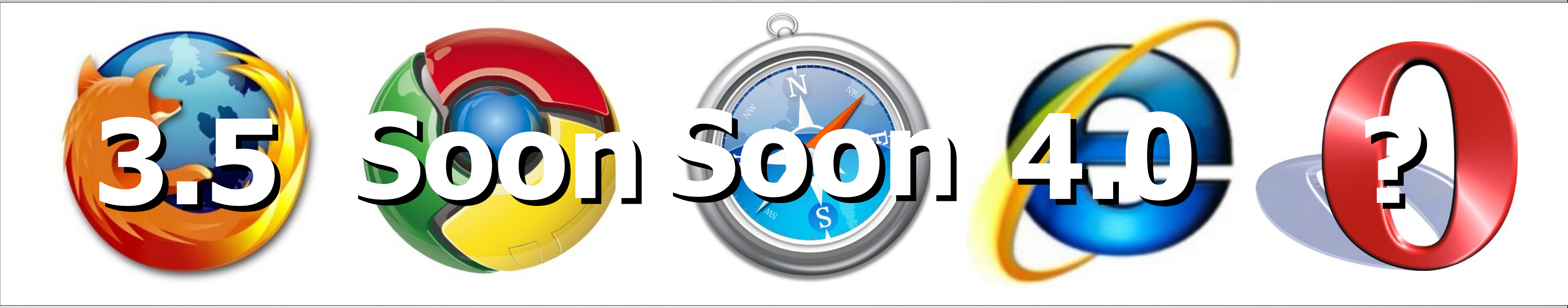


Depending on time to download and script size, execution may happen before next UI update

Technique #4: Defer scripts

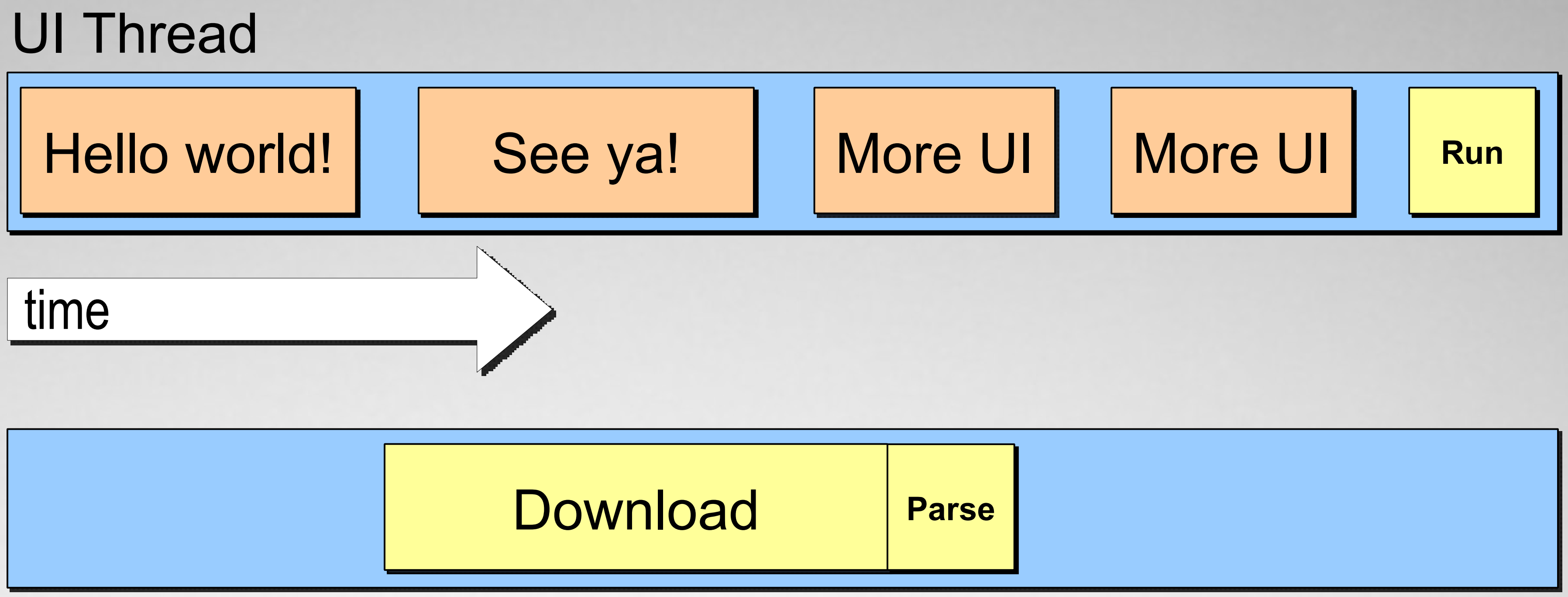
```
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <script defer src="foo.js"></script>
    <p>See ya!</p>
    <!-- even more markup -->
</body>
</html>
```

Support for <script defer>



Deferred scripts begin to download immediately, but don't execute until all UI updates complete (DOMContentLoaded)

Using <script defer>



Similar to dynamic script nodes, but with a guarantee that execution will happen last

Timing Note:

Although scripts always execute after UI updates complete, the order of multiple <script defer> scripts is not guaranteed across browsers

Technique #5: Asynchronous scripts

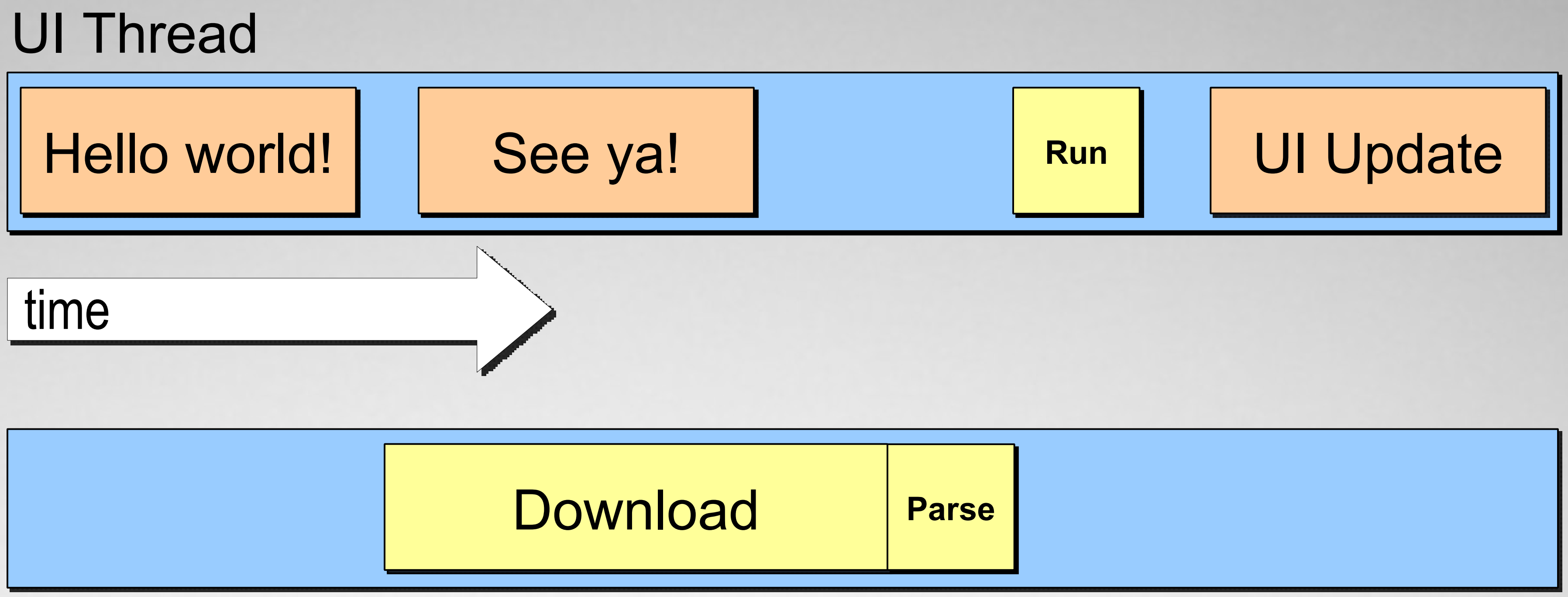
```html
<!doctype html>
<html>
<head>
    <title>Example</title>
</head>
<body>
    <p>Hello world!</p>
    <script async src="foo.js"></script>
    <p>See ya!</p>
    <!-- even more markup -->
</body>
</html>
```

Support for <script async>

3.6 Soon Soon ? ?

Asynchronous scripts behave a lot like dynamic scripts

Using <script async>



Download begins immediately and execution is slotted in at first available spot

Note:

Order of execution is explicitly not preserved for asynchronous scripts

Runtime Techniques

Ways to ensure JavaScript doesn't run away

```
function processArray(items, process, callback){
    for (var i=0,len=items.length; i < len; i++){
        process(items[i]);
    }
    callback();
}
```

Technique #1: Timers

JavaScript Timers

- Created using setTimeout()
- Schedules a new JavaScript execution job for some time in the future
- When the delay is up, the job is added to the UI queue
  - Note: This does not guarantee execution after the delay, just that the job is added to the UI queue and will be executed when appropriate

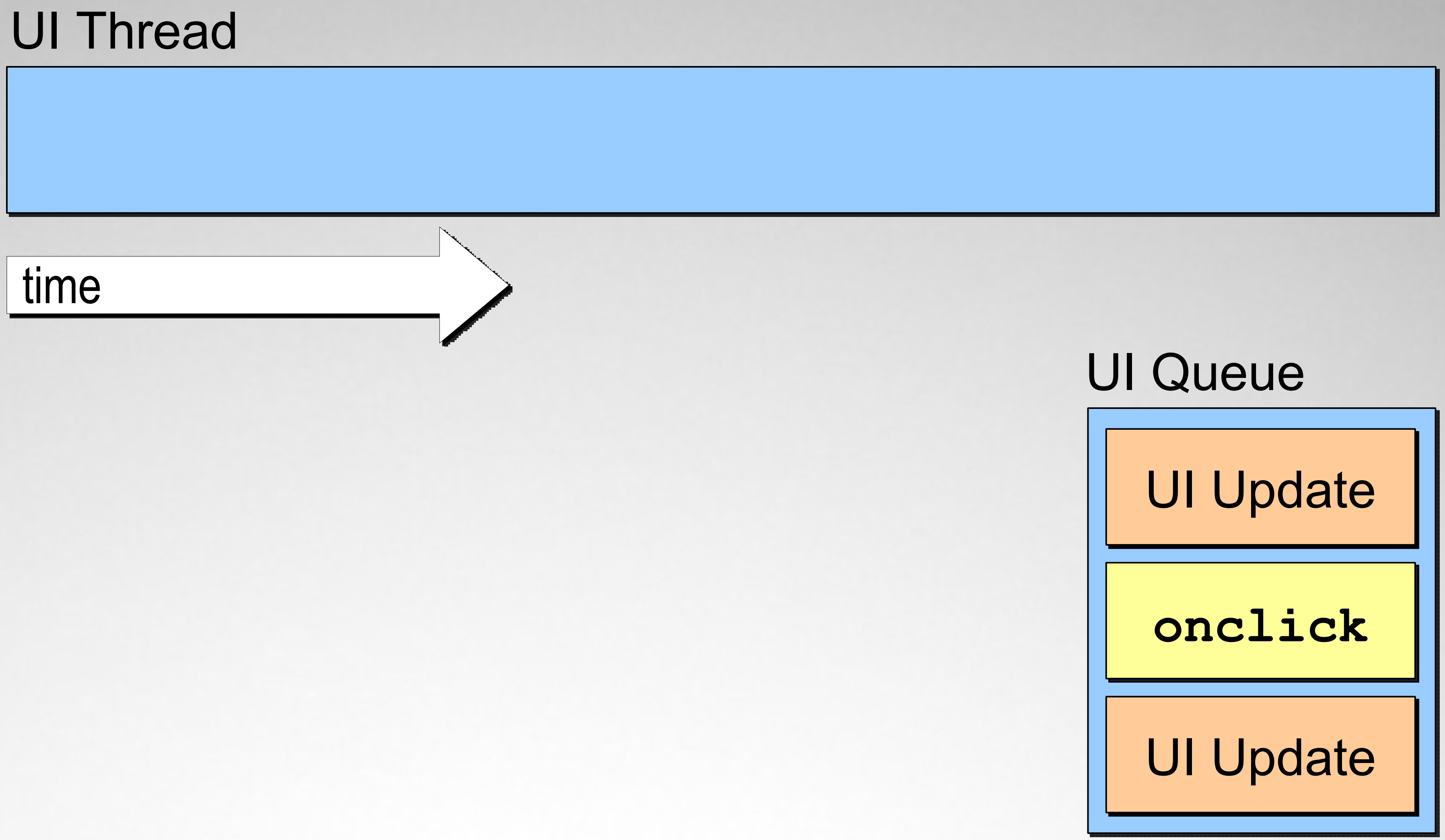
JavaScript Timers

- For complex processing, split up into timed functionality
- Use timers to delay some processing for later

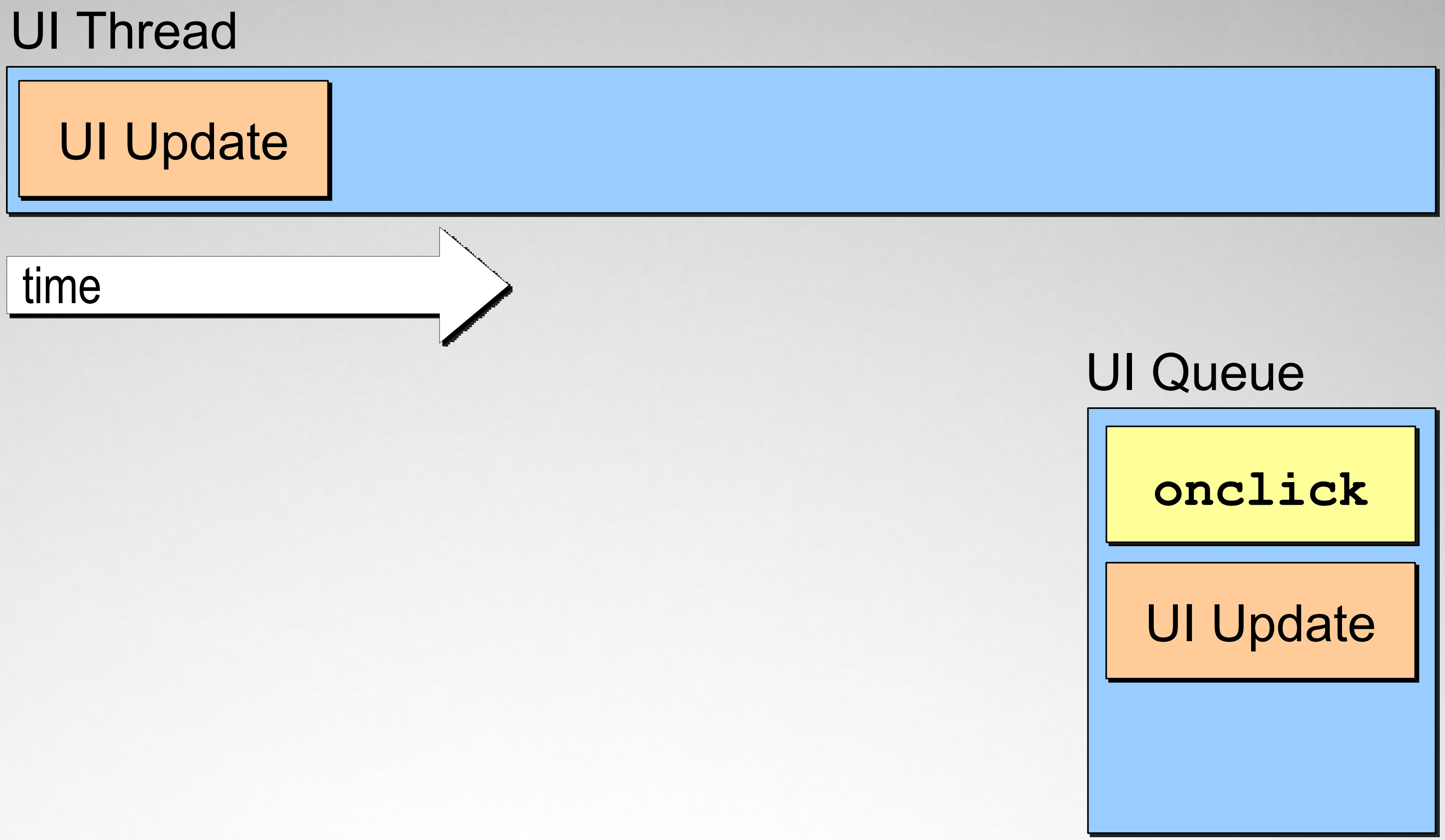
```
function timedProcessArray(items, process, callback){
    //create a clone of the original
     var todo = items.concat();
    setTimeout(function(){
        var start = +new Date();
        do {
            process(todo.shift());
        } while (todo.length > 0 &&
              (+new Date() - start < 50));
        if (todo.length > 0){
            setTimeout(arguments.callee, 25);
        } else {
            callback(items);
        }
    }, 25);
}
```

Demo(s)!

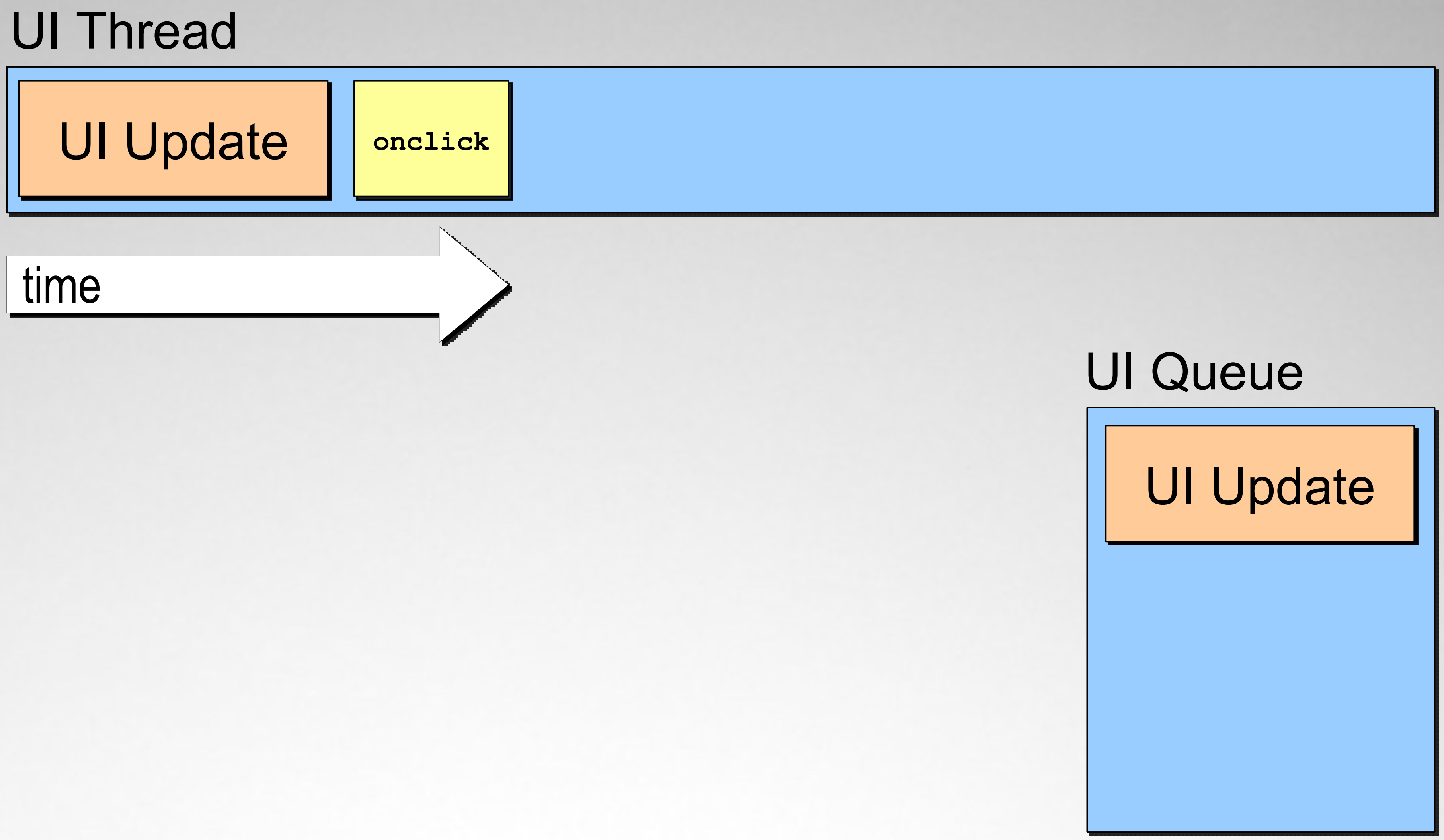
When Clicked



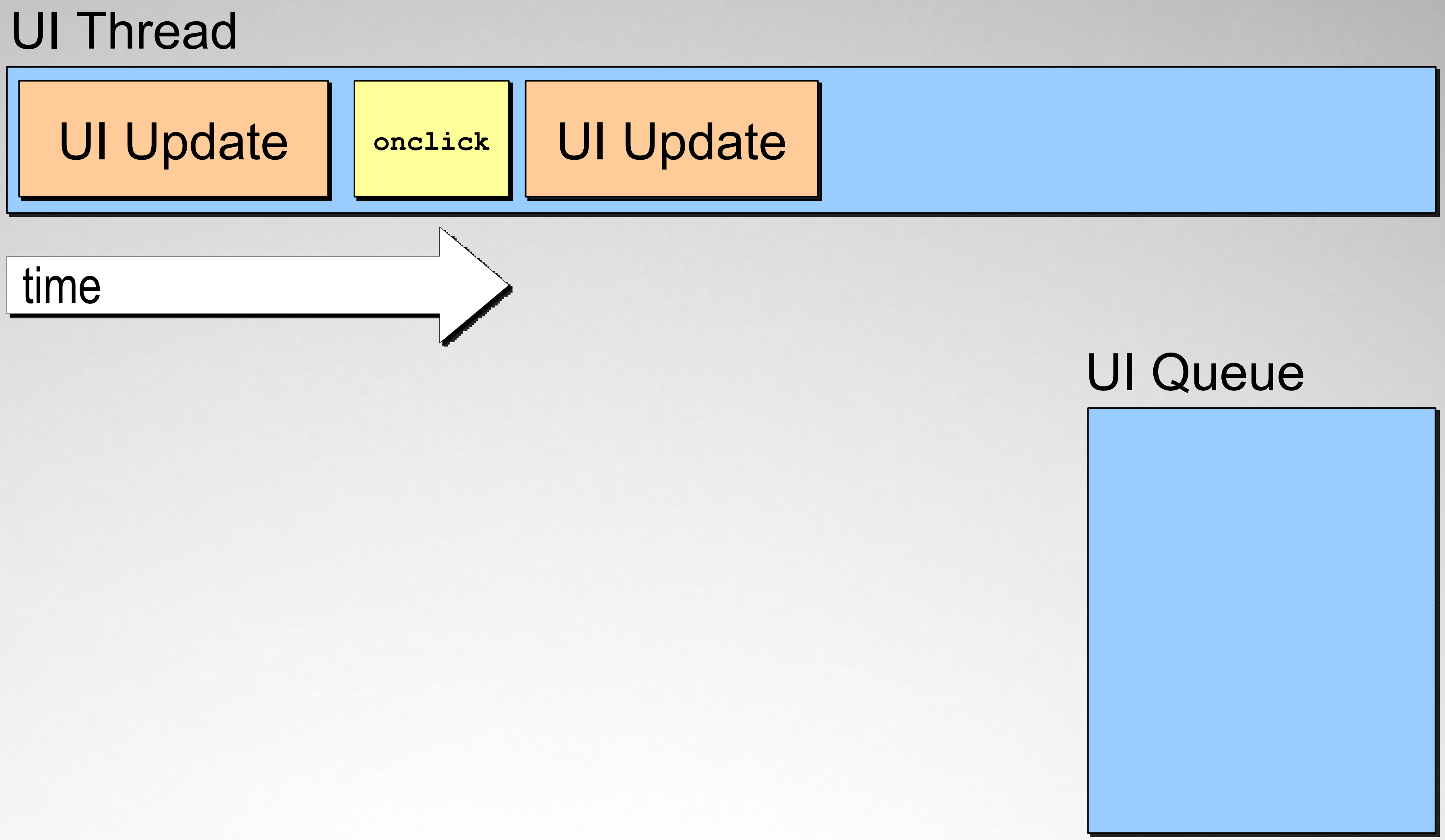
When Clicked



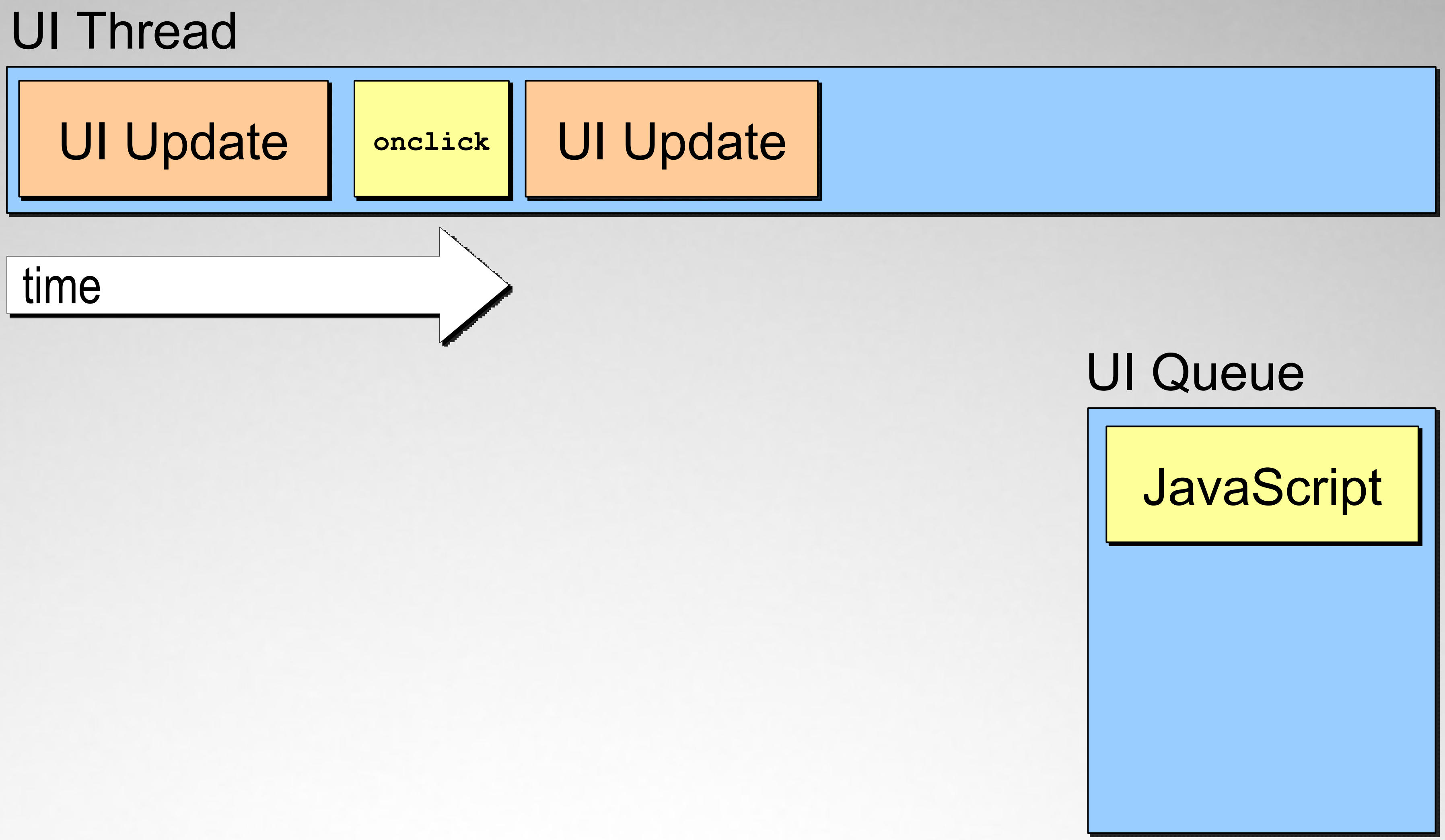
When Clicked



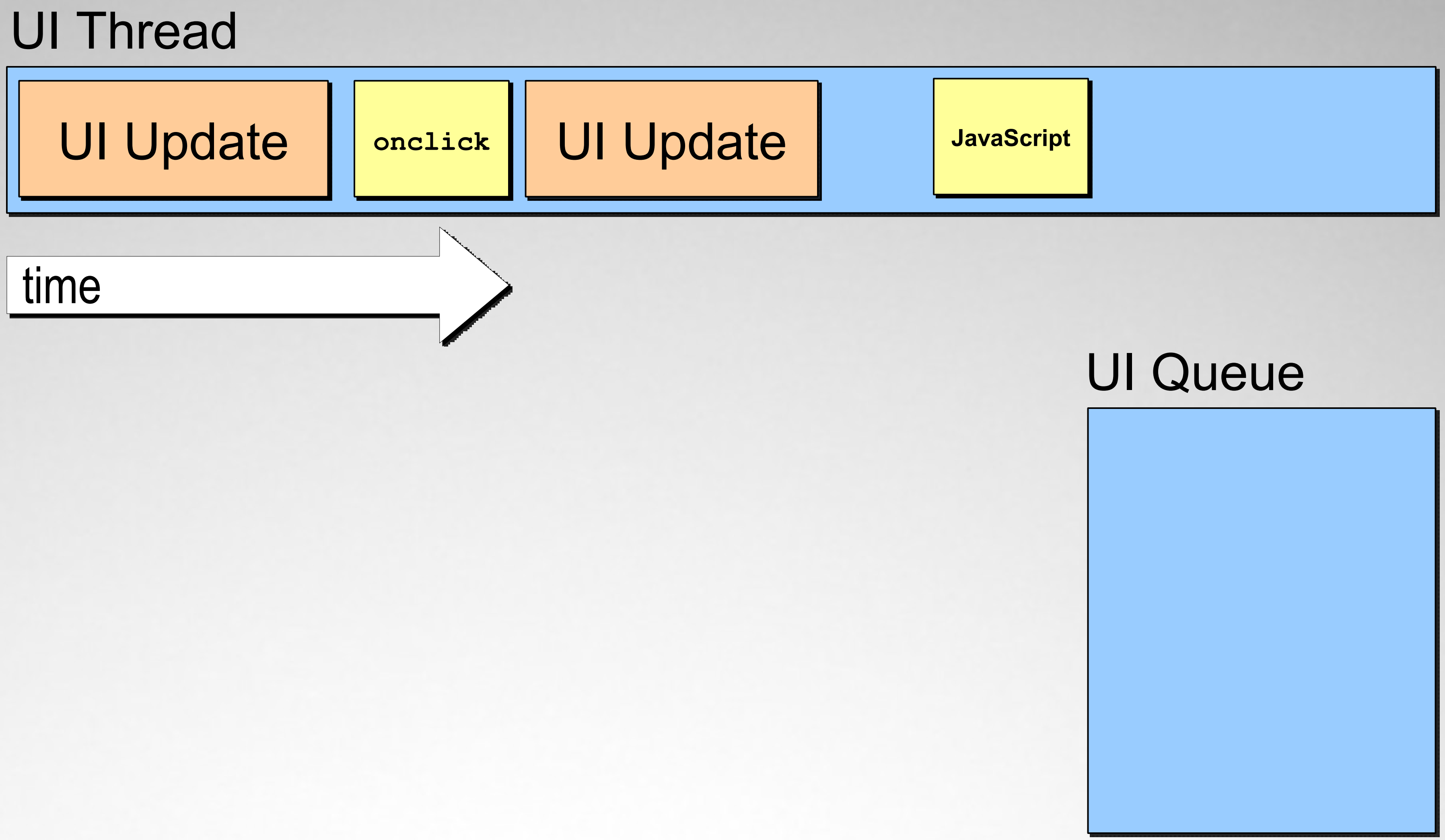
When Clicked



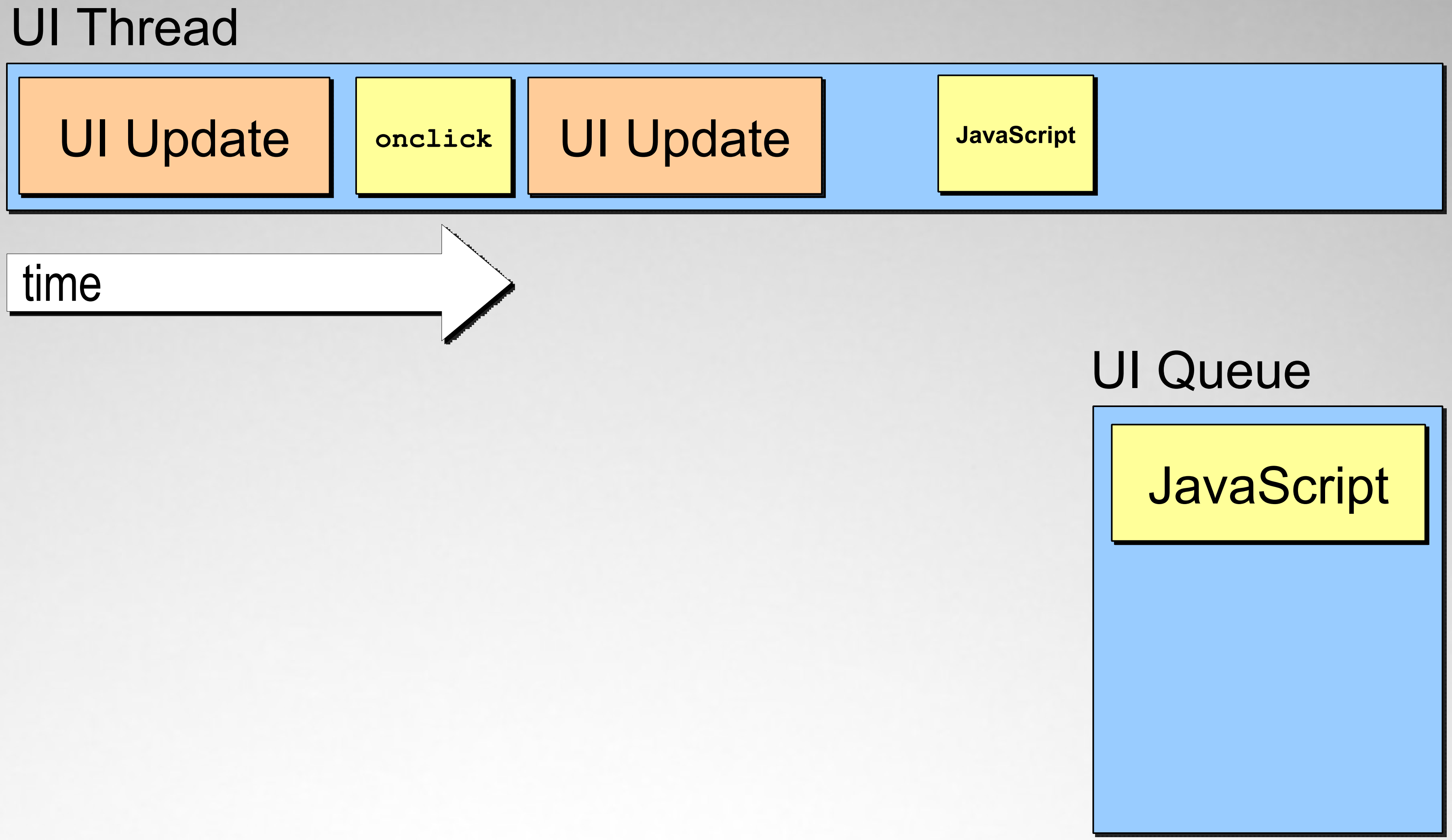
After 25ms


UI Thread
UI Update
onclick
UI Update
time
UI Queue
JavaScript

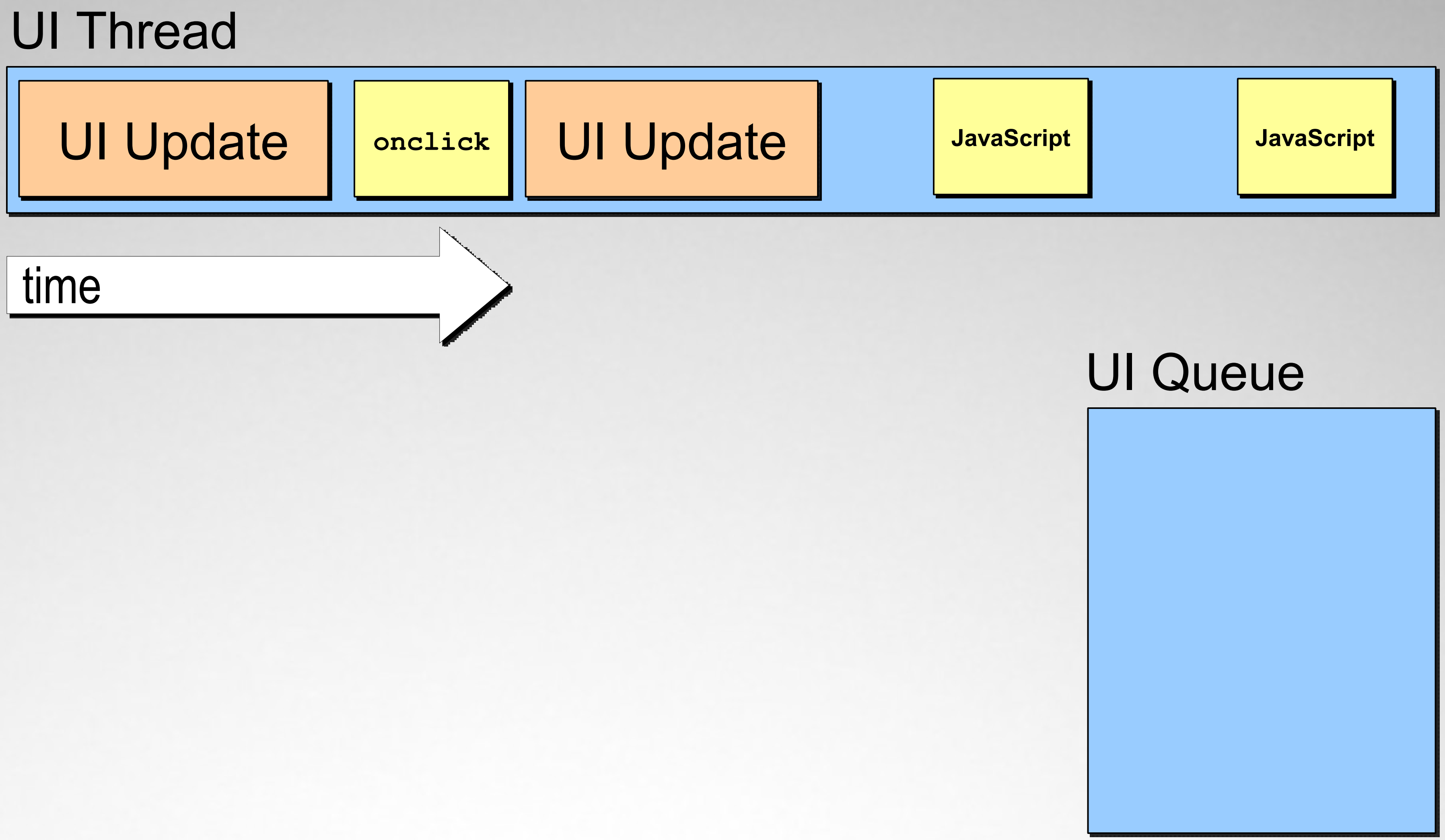
After 25ms


UI Thread
UI Update
onclick
UI Update
JavaScript
time
UI Queue

After Another 25ms



After Another 25ms



Technique #2: Web Workers

Call For Comments

Web Workers

Draft Recommendation — 3 April 2010

You can take part in this work. Join the working group's discussion list.
Web designers! We have a FAQ, a forum, and a help mailing list for you!

This version:

http://whatwg.org/ww

Version history:

Twitter messages (non-editorial changes only): http://twitter.com/WHATWG
Commit-Watchers mailing list: http://lists.whatwg.org/listinfo.cgi/commit-watchers-whatwg.org
Interactive Web interface: http://html5.org/tools/web-workers-tracker
Subversion interface: http://svn.whatwg.org/webworkers/

Issues:

To send feedback: whatwg@whatwg.org
To view and vote on feedback: http://www.whatwg.org/issues/

Editor:

Ian Hickson, Google, ian@hixie.ch

Call For Comments

Abstract

This specification defines an API that allows Web application authors to spawn background workers running scripts in parallel to their main page. This allows for thread-like operation with message-passing as the coordination mechanism.

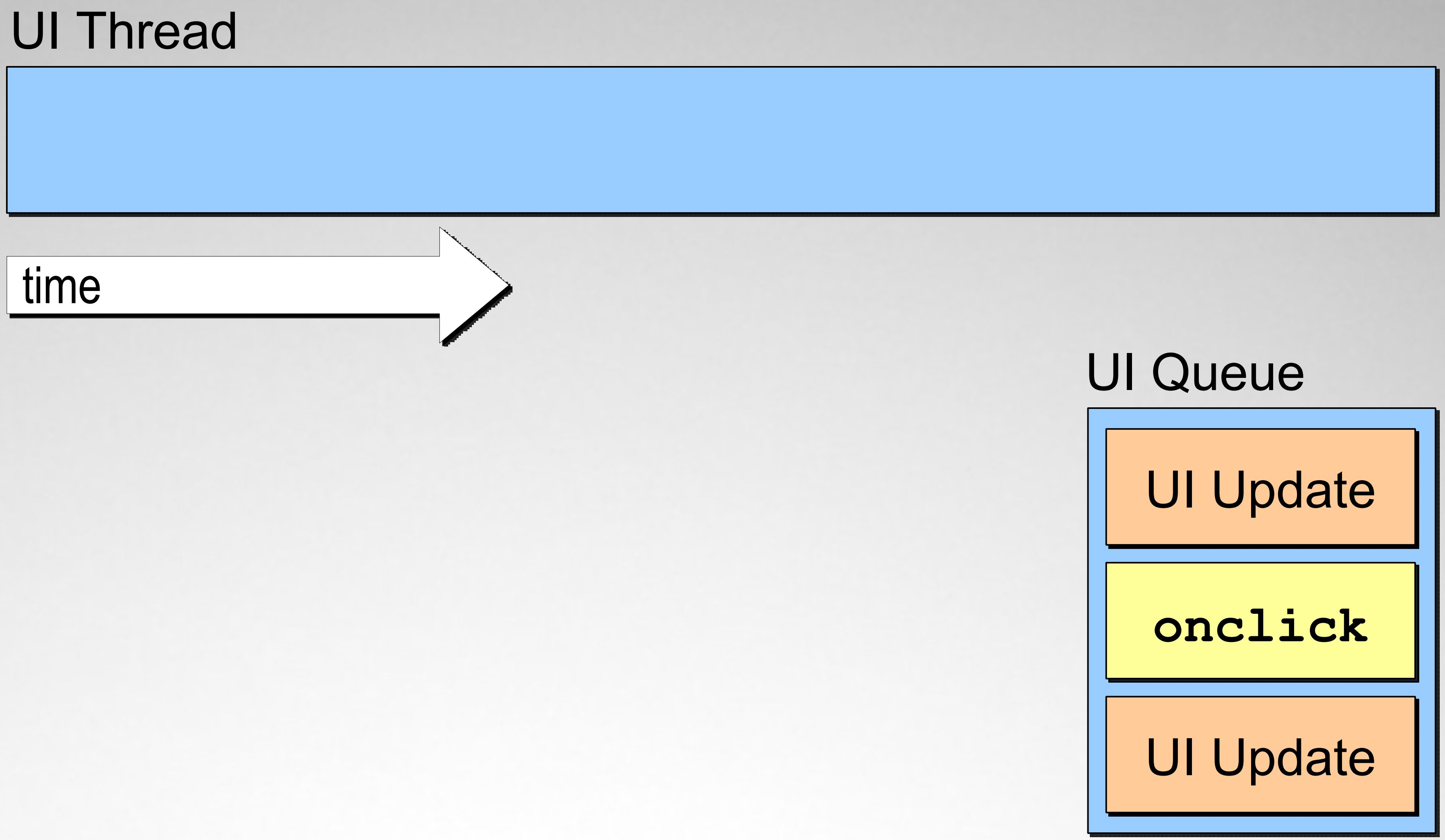
Web Workers

- Asynchronous JavaScript execution
- Execution happens in a separate process
  - Not on the UI thread = no UI delays
- Data-driven API
  - Data is serialized when sending data into or out of Worker
  - No access to DOM, BOM
  - Completely separate execution environment

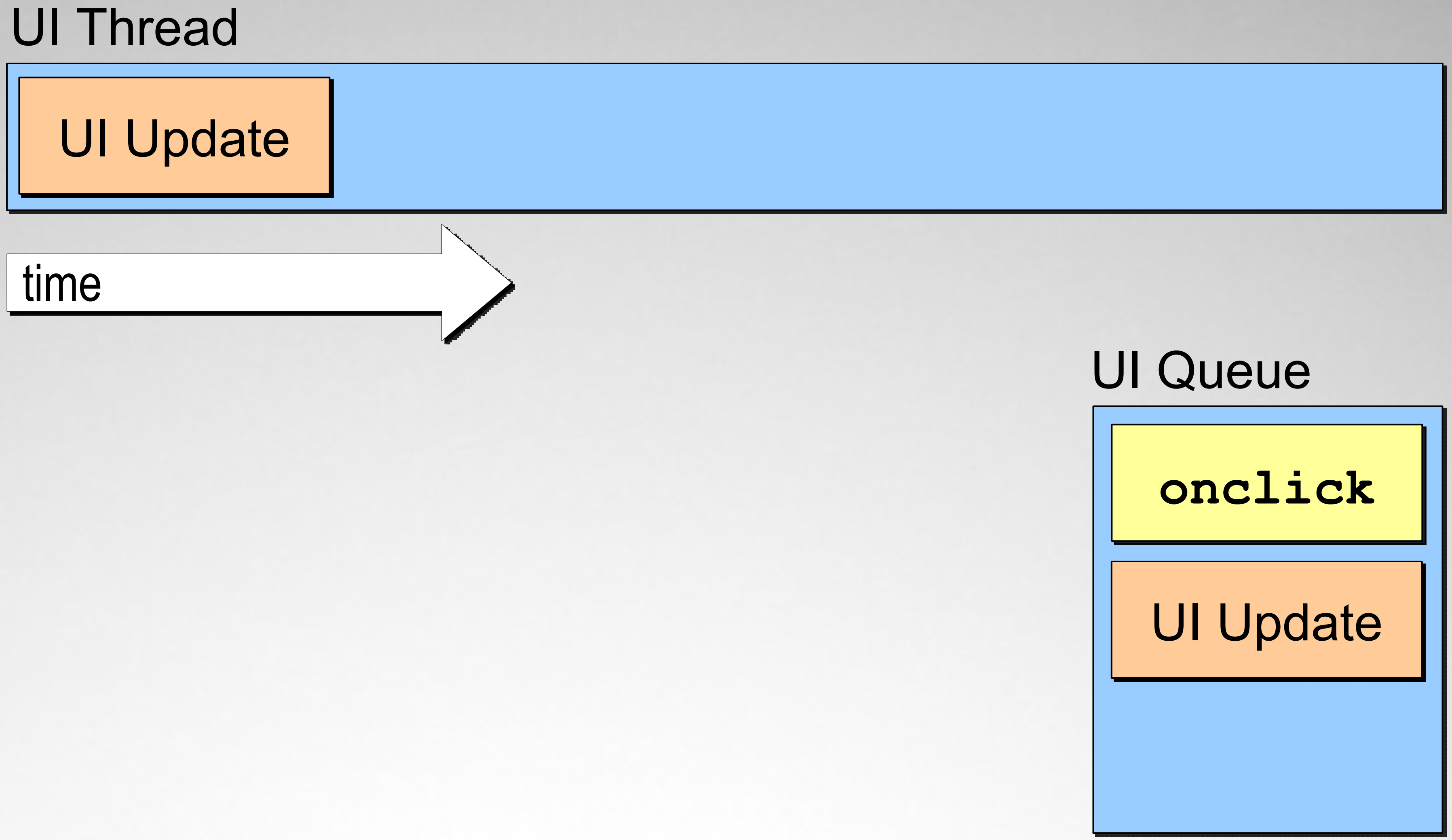
```
//in page
var worker = new Worker("process.js");
worker.onmessage = function(event){
    useData(event.data);
};
worker.postMessage(values);


//in process.js
self.onmessage = function(event){
    var items = event.data;
    for (var i=0,len=items.length; i < len; i++){
        process(items[i]);
    }
    self.postMessage(items);
};
```

Demo!

When Clicked



When Clicked



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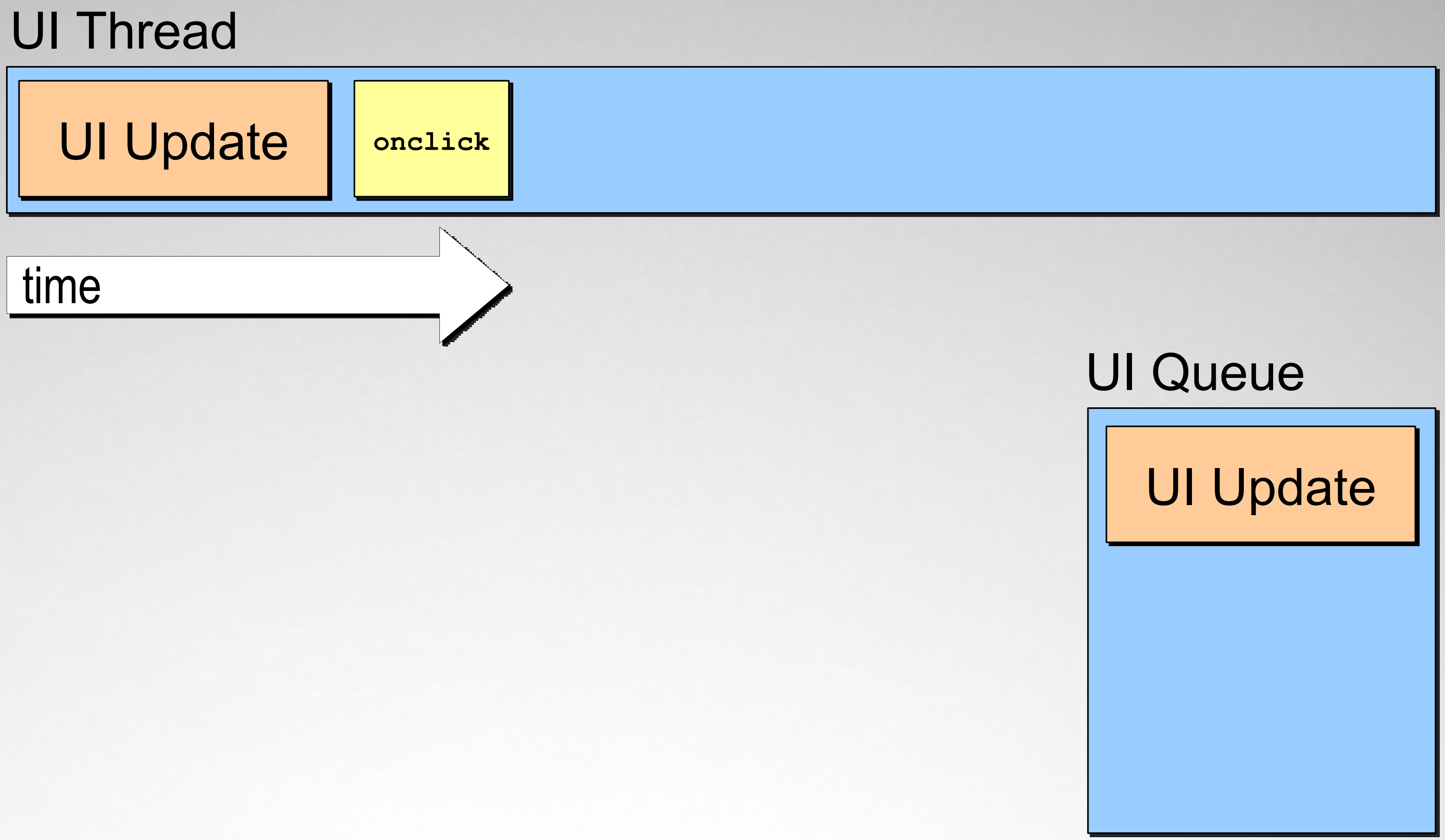

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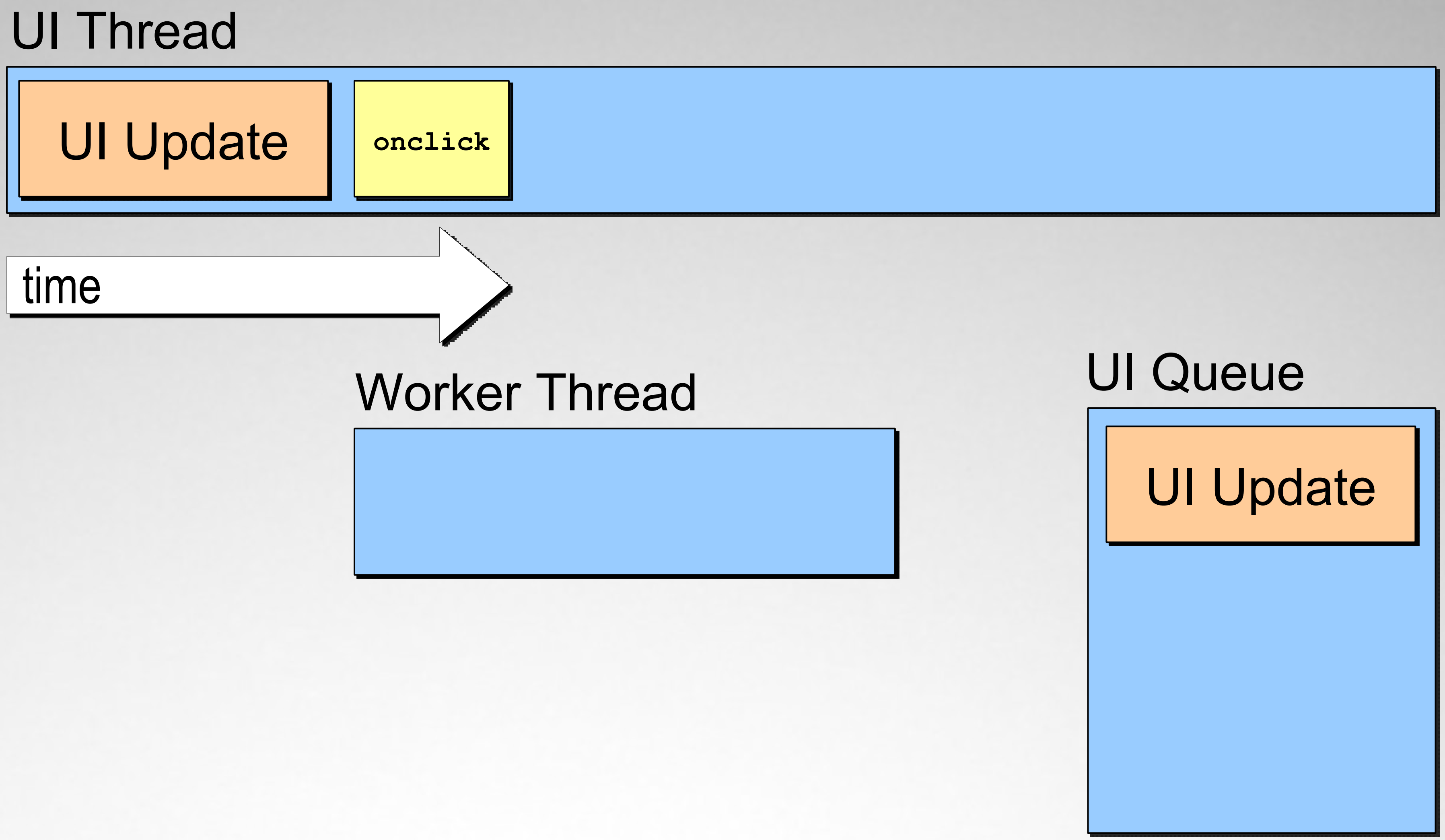

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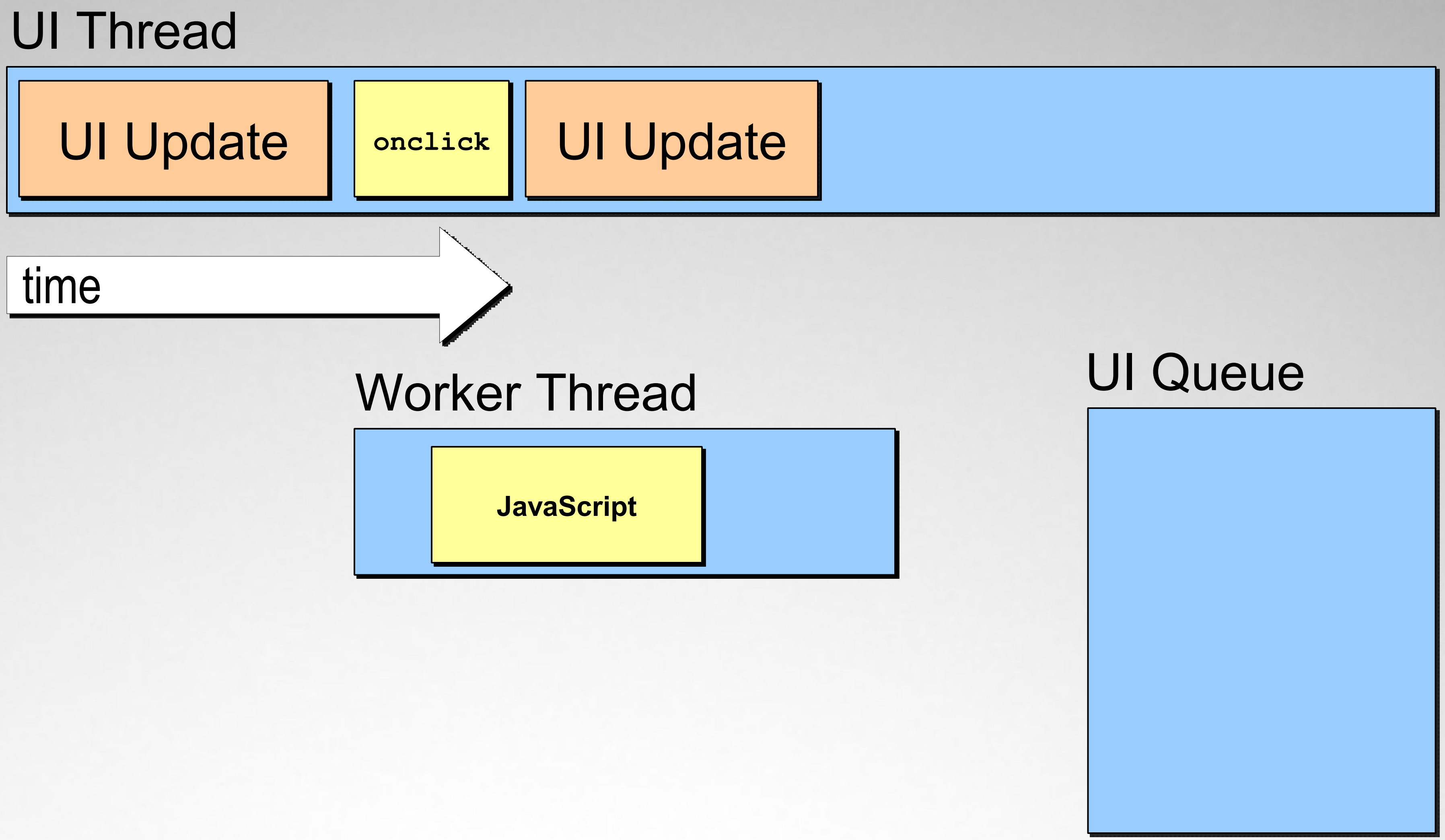
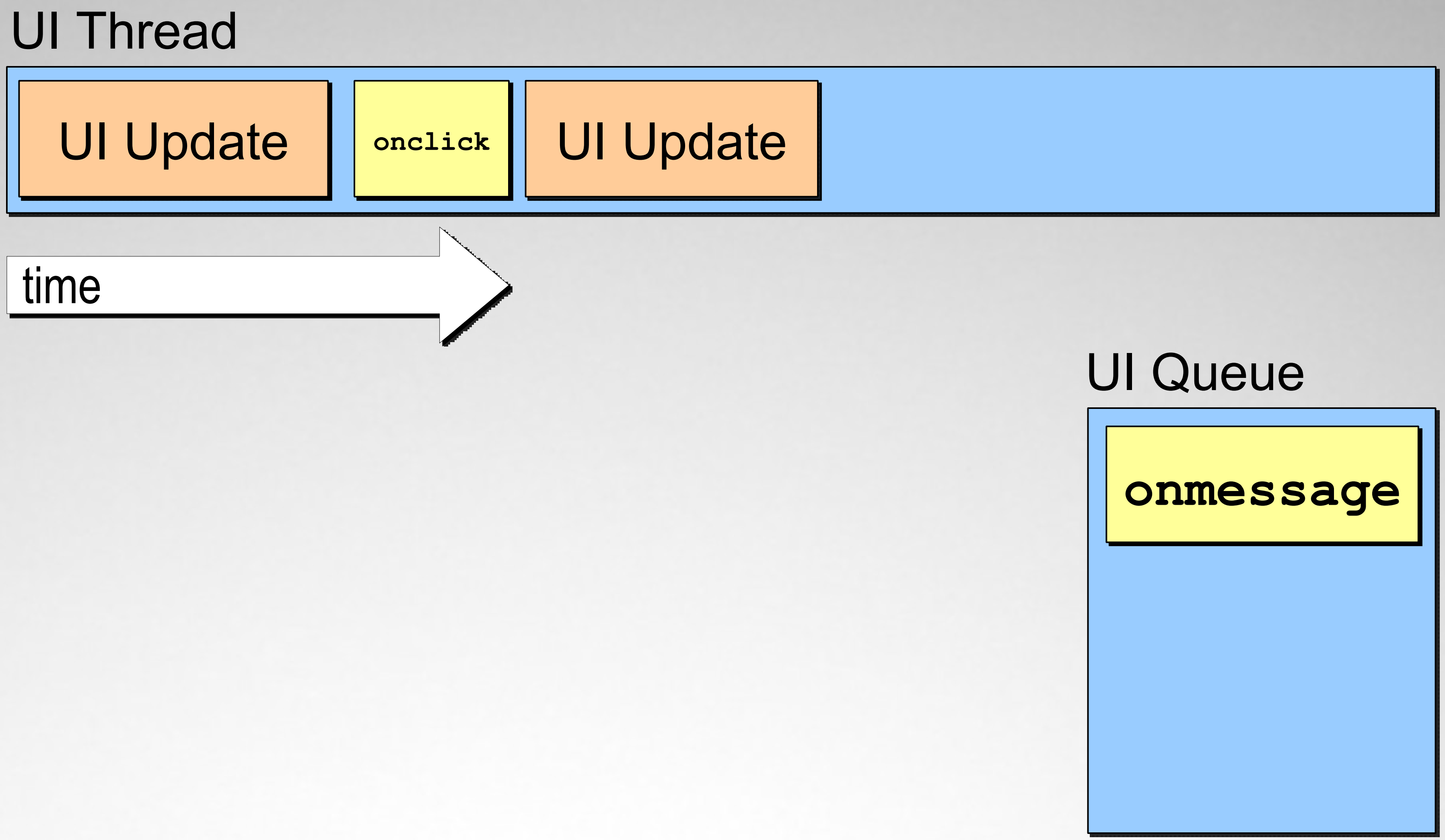
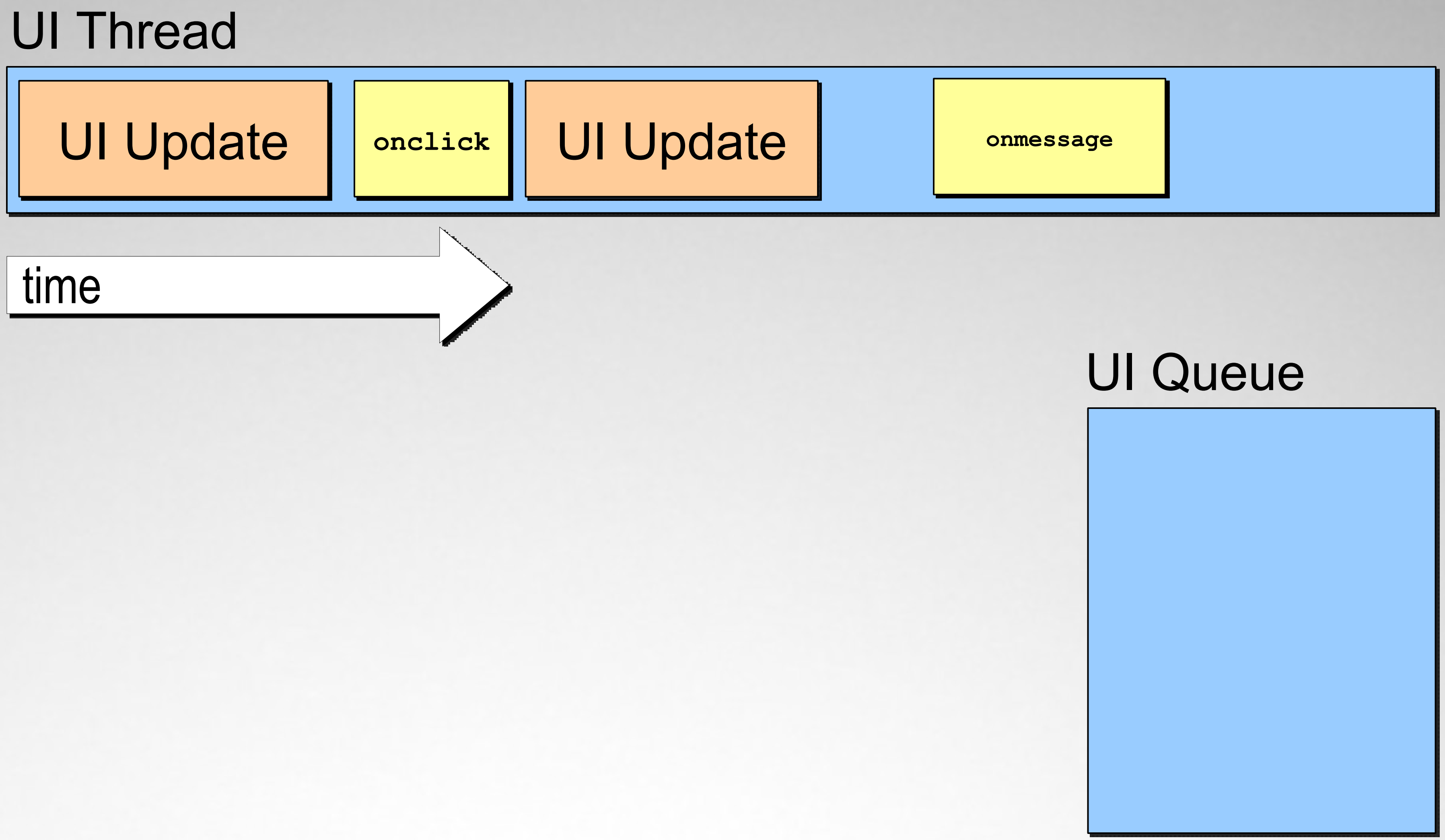


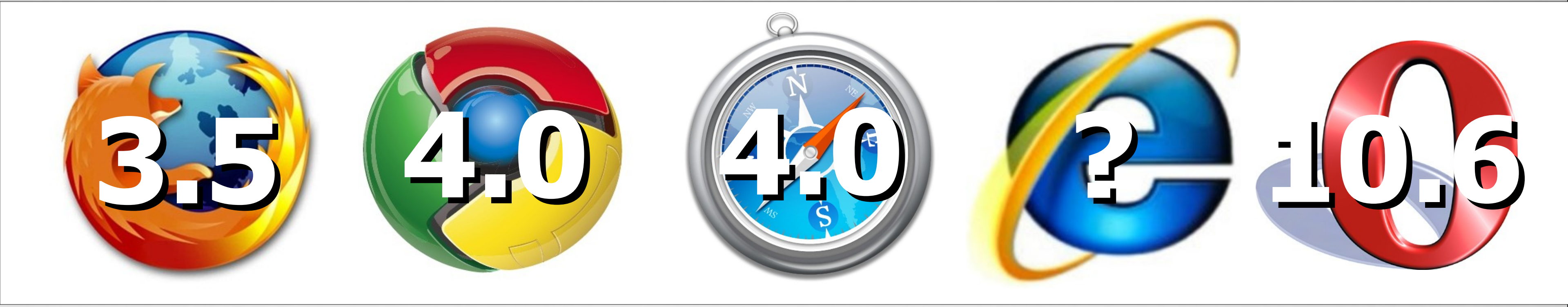
Worker Thread Complete



Worker Thread Complete



Support for Web Workers

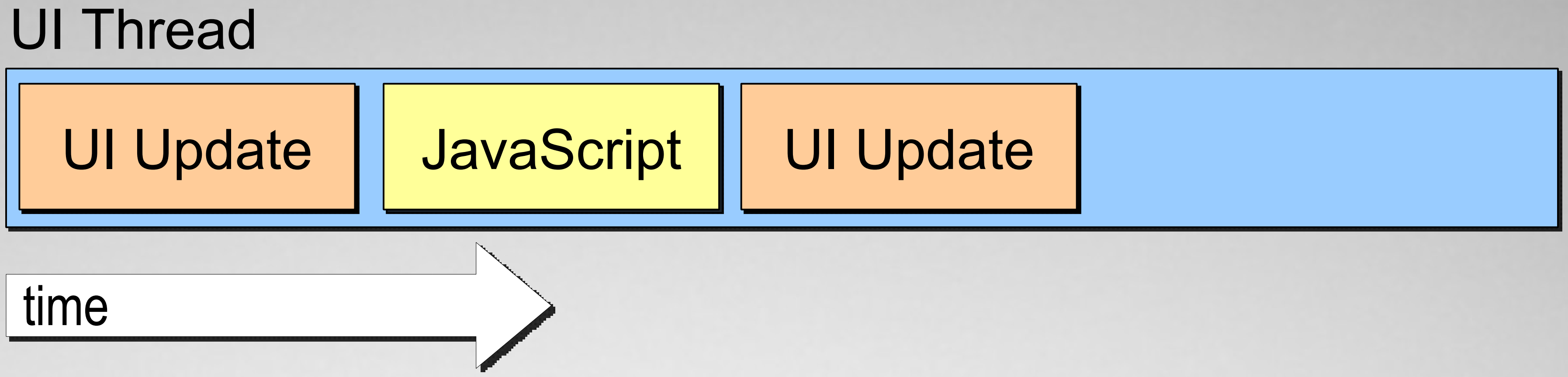


Recap

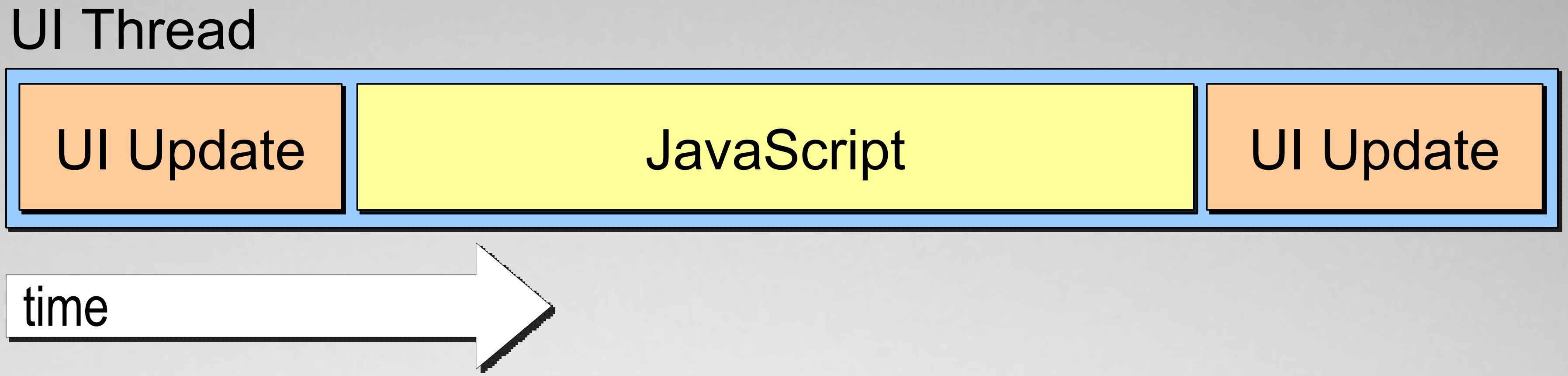
The browser UI thread is responsible for both UI updates and JavaScript execution

Only one can happen at a time

Responsive UI



Unresponsive UI



Avoid Slow Loading JavaScript

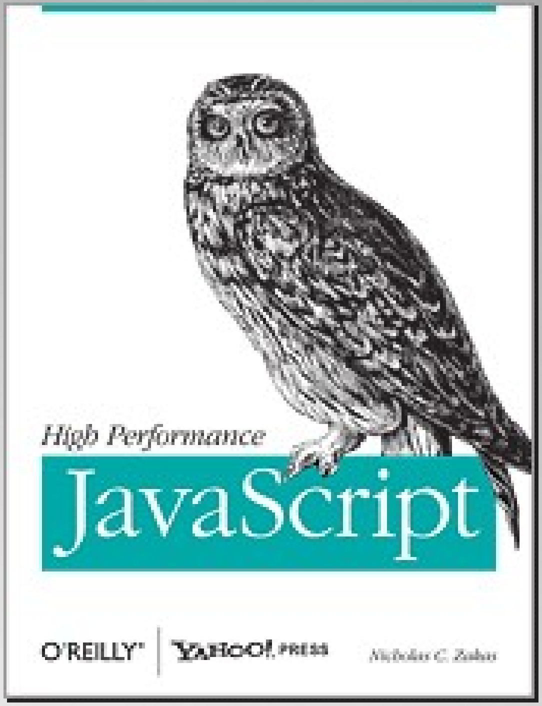
- Put scripts at the bottom
- Concatenate scripts into as few files as possible
- Choose the right way to load your scripts
  - Dynamically created scripts
  - Deferred scripts
  - Asynchronous scripts

Avoid Slow JavaScript

- Don't allow JavaScript to execute for more than 50ms
- Break up long JavaScript processes using:
  - Timers
  - Web Workers

The End

Etcetera



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Questions?

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