Theseus: Understanding Asynchronous Code

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The Problem:
asynchronous control flow is convoluted

JavaScript relies on callback functions for events (UI, network, etc.), blocking I/O operations, and control structures like loops. They are error-prone and many libraries exist to help structure them.

Callbacks turn questions about whether a point in the code has been executed into reachability questions that are difficult to answer with ordinary call graphs and most debugging tools.

My Approach:
visualize program behavior within the editor

Show information about a program's run-time behavior within the code using syntax highlighting and widgets in the margin. These provide information scent and can answer questions before the user thinks to ask them.

Update information in real-time, making the code part of the program's interface.

Extend the call graph with links for asynchronous event chains.
Reveal caller/callee relationships in the program's log.

0 clicks:
reachability coloring + call counts

```
0 calls   mouseClicked({ button: 1 }, function () {
38          $('body').append('first click recorded!');
39        });
40
1 call    keyPressed({ key: 32 }, function () {
42          $('body').append('keystroke recorded!');
43        });
44
0 calls   mouseClicked({ button: 1 }, function () {
46          $('body').append('second click recorded!');
47        });
48        </script>
```

Code that has never been executed is colored gray. Call counts are shown next to every function definition.

Users tend to leave the editor open on one side of the screen and watch code light up as they interact with their application.

Download Theseus today!

1 click:
retroactive log

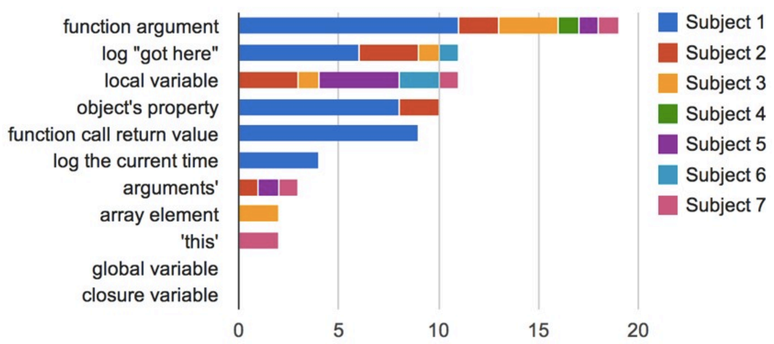
```
5 calls   function reverse(str) {
5             return str.split("").reverse().join("");
6         }
```

Log

reverse (index.html:4)	2:30:46.827	str = "Tom"	return value = "moT"	Backtrace →
reverse (index.html:4)	2:30:46.827	str = "Rob"	return value = "boR"	Backtrace →
reverse (index.html:4)	2:30:46.828	str = null	exception = ▶ TypeError: Cannot read property 'split' of null	
reverse (index.html:4)	2:30:46.828	str = "foo"	return value = "oof"	Backtrace →
reverse (index.html:4)	2:30:46.828	str = "bar"	return value = "rab"	Backtrace →

Click a function's call count to retroactively log the arguments, return value, and any thrown exceptions of every invocation of that function.

Statistics from a lab study about the types of values people print and inspect (without Theseus) suggest that inferring the values to print based on context may be sufficient in most cases:



2 clicks:
asynchronous call tree

```
4 calls   function fetch(id, callback) {
37            var stream = new Stream(id);
38            var allData = '';
39
12 calls      stream.on('data', function (data) {
41              allData += data;
42            });
43
2 calls       stream.on('end', function () {
45              callback(null, allData);
46            });
47
2 calls       stream.on('error', function (err) {
49              callback(err);
50            });
51
52            return stream;
53        }
```

Log

fetch (index7.html:36)	2:03:44.794	id = 1	callback = ▶ Function	return value = ▶ [object Object]	Backtrace →
('error' handler) (index7.html:48)	ASYNC 2:03:45.070	err = "stream error"	this = ▶ [object Object]		Backtrace →
fetch (index7.html:36)	2:03:44.796	id = 2	callback = ▶ Function	return value = ▶ [object Object]	Backtrace →
fetch (index7.html:36)	2:03:44.797	id = 3	callback = ▶ Function	return value = ▶ [object Object]	Backtrace →
('error' handler) (index7.html:48)	ASYNC 2:03:45.094	err = "stream error"	this = ▶ [object Object]		Backtrace →
fetch (index7.html:36)	2:03:44.797	id = 4	callback = ▶ Function	return value = ▶ [object Object]	Backtrace →

Invocations with a caller/callee relationship are shown nested in a call tree. Event chains are shown the same way and flagged with 'async'.

This combination of console and call tree untangles the control flow of complex asynchronous code, visualizing control- and data-flow together.