profiling Node.js applications

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http://pmuellr.github.io/slides/2017/01-profiling-node
http://pmuellr.github.io/slides/2017/01-profiling-node/slides.pdf
http://pmuellr.github.io/slides/ (all of Patrick's slides)

what is profiling?

- gaining insight into what your code is doing
- typically involving finding out:
  - why your code is so slow!
  - what are you doing with all that memory!

why should you profile your code?

- save money
  - run with less RAM
  - run with less CPU
- delight customers
  - your app runs faster

what kind of profiling for Node.js?

- **performance** with V8's CPU profiler
- **memory** with V8's heap snapshots

profiling performance

what does V8's CPU profiler do?

- trigger profiler on / off
- when on, at regular intervals, V8 will capture current stack trace, with time stamp, and source file / line numbers
- when turned off, profiler will aggregate the information, and produce a JSON data structure for analysis tools

understanding CPU profiling

- intro: Google Developers: Speed Up JavaScript Execution

- provides times spent executing functions:

  - **self time** - time to run the function, **not** including any functions that it called

  - **total time** - time to run the function, including any functions that it called

time-line from Chrome Dev Tools

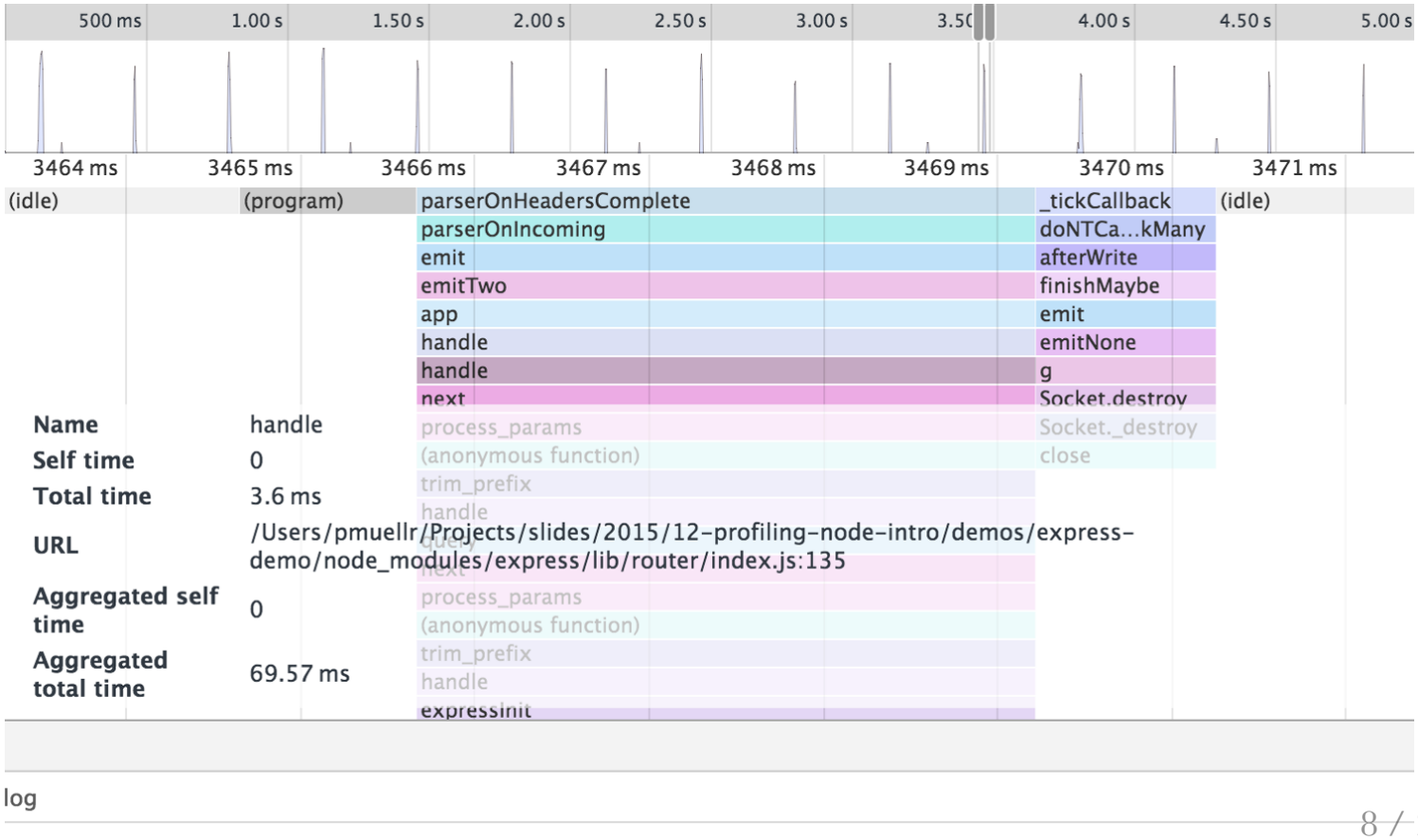
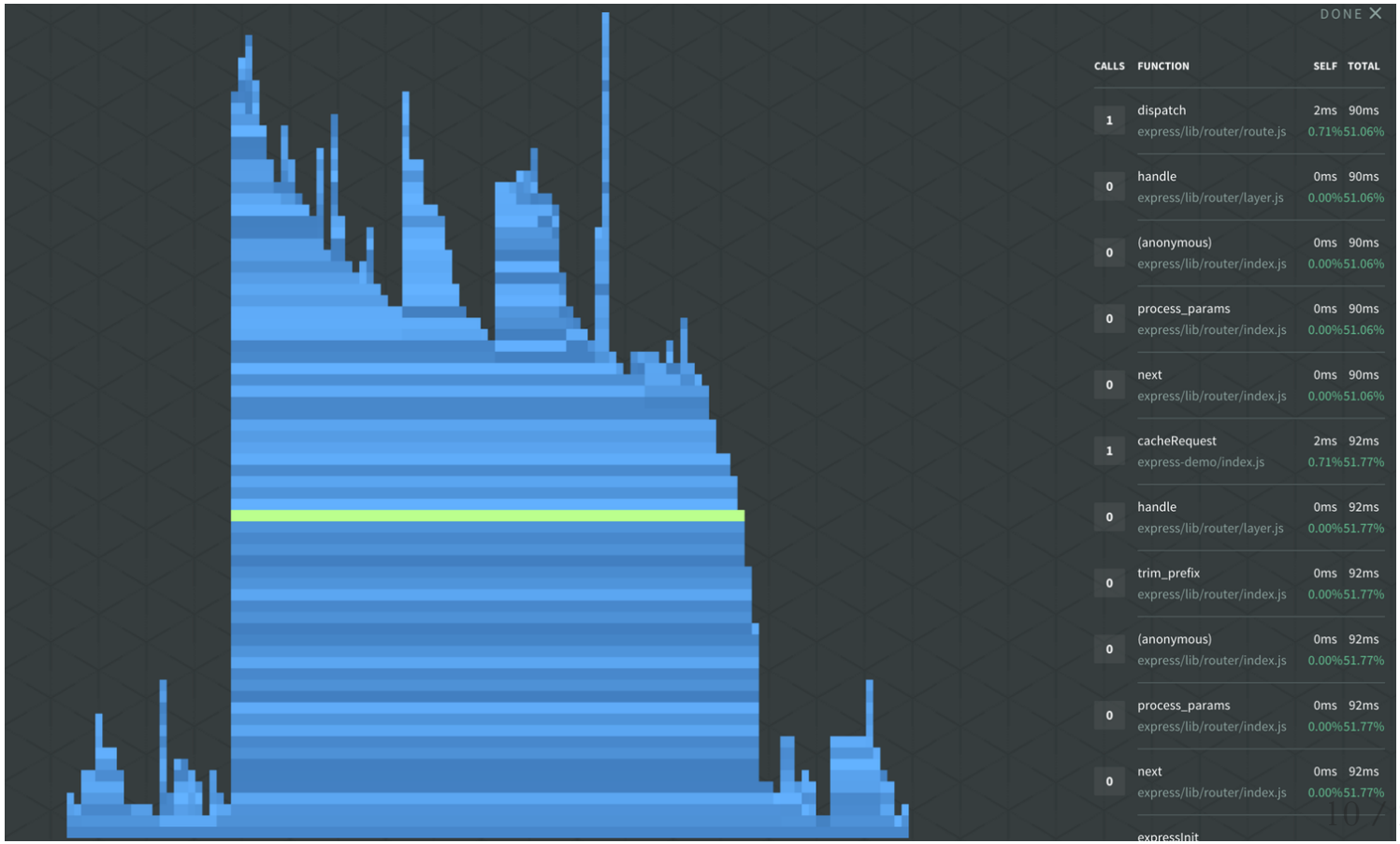


table from Chrome Dev Tools

Self		Total		Function	
4831.8 ms		4831.8 ms		(idle)	(program):-1
16.3 ms	9.22 %	16.3 ms	9.22 %	(program)	(program):-1
12.5 ms	7.09 %	12.5 ms	7.09 %	(garbage collector)	(program):-1
10.0 ms	5.67 %	13.8 ms	7.80 %	▶ c	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
7.5 ms	4.26 %	8.8 ms	4.96 %	▶ Lexer.next	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
6.3 ms	3.55 %	6.3 ms	3.55 %	▶ spawn	(program):-1
3.8 ms	2.13 %	3.8 ms	2.13 %	▶ now	(program):-1
3.8 ms	2.13 %	6.3 ms	3.55 %	▶ pp.eat	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
2.5 ms	1.42 %	18.8 ms	10.64 %	▶ pp.parseExprSubsc...	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
2.5 ms	1.42 %	2.5 ms	1.42 %	▶ pp.finishNode	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
2.5 ms	1.42 %	2.5 ms	1.42 %	systemStats	nsolid.js:227
2.5 ms	1.42 %	2.5 ms	1.42 %	▶ posix.dirname	path.js:528
2.5 ms	1.42 %	30.0 ms	17.02 %	▶ parse	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
2.5 ms	1.42 %	95.0 ms	53.90 %	▶ app	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
2.5 ms	1.42 %	8.8 ms	4.96 %	▶ OutgoingMessage.end	_http_outgoing.js:513
2.5 ms	1.42 %	2.5 ms	1.42 %	▶ ServerResponse.writeHead	_http_server.js:159
2.5 ms	1.42 %	3.8 ms	2.13 %	▶ Agent.addRequest	_http_agent.js:109
2.5 ms	1.42 %	87.5 ms	49.65 %	▶ render	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
2.5 ms	1.42 %	2.5 ms	1.42 %	▶ slice	buffer.js:609
2.5 ms	1.42 %	108.8 ms	61.70 %	▶ emit	events.js:116
1.3 ms	0.71 %	91.3 ms	51.77 %	▶ cacheRequest	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
1.3 ms	0.71 %	1.3 ms	0.71 %	▶ posix.join	path.js:474
1.3 ms	0.71 %	1.3 ms	0.71 %	▶ pp.readString	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
1.3 ms	0.71 %	7.5 ms	4.26 %	▶ base.NewExpressio...	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
1.3 ms	0.71 %	1.3 ms	0.71 %	▶ _tokentype.types.b...	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
1.3 ms	0.71 %	11.3 ms	6.38 %	▶ pp.parseExprList	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos
1.3 ms	0.71 %	5.0 ms	2.84 %	▶ pp.parseIdent	/Users/pmuellr/Projects/slides/2015/12-profiling-node-intro/demos

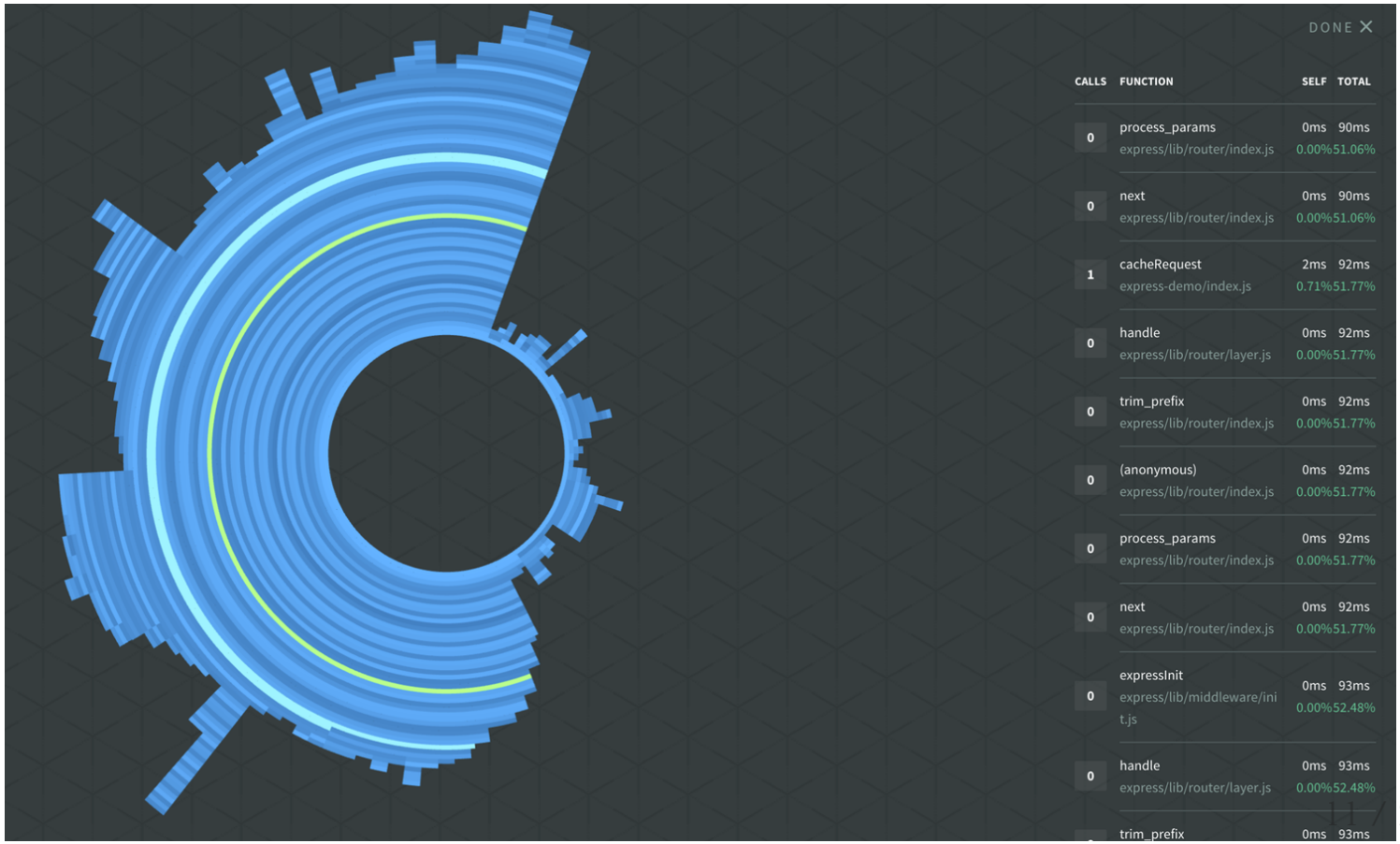
`profiling performance` `profiling Node.js applications`

flame graph from N|Solid



profiling performance profiling Node.js applications

sunburst from N | Solid



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profiling memory

what are V8 heap snapshots?

- JSON file describing every reachable JavaScript object in the application; taking a snapshot always starts with a garbage collection
- JSON files are ... large; figure 2x heap memory allocated by Node.js

understanding heap snapshots

- intro: Google Developers: Viewing Heap Snapshots
- object sizes/counts, grouped by constructor
  - **shallow size** - the size of memory held by an object itself
  - **retained size** - the size of memory that can be freed once an object is deleted

heapmap from Chrome Dev Tools

Constructor	Distance	Objects Count ▼		Shallow Size		Retained Size	
▶ ReadableState	6	8 266	2%	1 587 072	4%	1 851 584	4%
▶ (concatenated string)	4	6 780	1%	271 200	1%	310 768	1%
▶ WritableState	6	4 134	1%	793 808	2%	1 324 416	3%
▼ TagRequest	10	4 133	1%	99 192	0%	99 376	0%
▶ TagRequest @4987	11			24	0%	24	0%
▶ TagRequest @4989	10			24	0%	208	0%
▶ TagRequest @5053	11			24	0%	24	0%
▶ TagRequest @5101	11			24	0%	24	0%
▶ TagRequest @5149	11			24	0%	24	0%
▶ TagRequest @5197	11			24	0%	24	0%
▶ TagRequest @7635	11			24	0%	24	0%
▶ TagRequest @7683	11			24	0%	24	0%
▶ TagRequest @9239	11			24	0%	24	0%

Retainers

Object	Distance ▲	Shallow Size		Retained Size	
▼ __tag in IncomingMessage @4975	10	240	0%	6 320	0%
▼ [19] in Array @166833	9	32	0%	25 882 456	58%
▼ Requests in system / Context @71747	8	80	0%	25 882 768	58%
▼ context in function pingServer() @71753	7	72	0%	1 584	0%
▼ _repeat in Timeout @166413	6	144	0%	1 728	0%
▼ _idlePrev in Timer @1105	5	32	0%	224	0%
▼ [333] in @66753	4	56	0%	208	0%
▼ lists in system / Context @37847	3	224	0%	960	0%
▼ context in function () @5879	2	72	0%	72	0%
▶ clearInterval in @583	1	48	0%	4 968	0%
▶ value in system / PropertyCell @37929	3	32	0%	32	0%
▶ clearInterval in @66411	4	56	0%	56	0%
▶ 22 in (map descriptors)[] @65155	6	272	0%	272	0%
▶ context in function () @5865	2	72	0%	72	0%
▶ context in function () @5845	2	72	0%	72	0%

what kind of output can you get?

- large JSON file - could be 100's of MB; figure 2x allocated heap
- can "diff" snapshots to help identify leaks
- can drill into or out from references in Chrome Dev Tools; references / referenced by

using the tools

profiling tools

- node --inspect
- NodeSource N|Solid
  - generates CPU profiles and heap snapshots that can be further analyzed by CDT (and the UI for **`node --inspect`**)

demo app

expecting faster response time - **what's slowing down this app?**

this app seems to be leaking memory - **what objects are leaking?**

- source for the express-demo
- see the instructions in demos/README.md

demo time!

profiling tips

profiling performance

- look for **width** in trace visualizations; height only shows stack trace which may not have any perf consequences
- for N|Solid, "script" profiling a web server: start profile, run load tester, stop profile
- use node/v8 option **`--no-use-inlining`** to turn off function inlining; stack traces may make more sense (but no inlining!)

profiling memory

- easiest way to find a memory leak:
  - take a heap snapshot; run load tester; take another heap snapshot; diff in Chrome Dev Tools
- 'tag' objects you think might be leaking w/easy to find class:

```
req.__tag = new TagRequest()
```

profiling Node.js applications

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