Performance Profiling for V8

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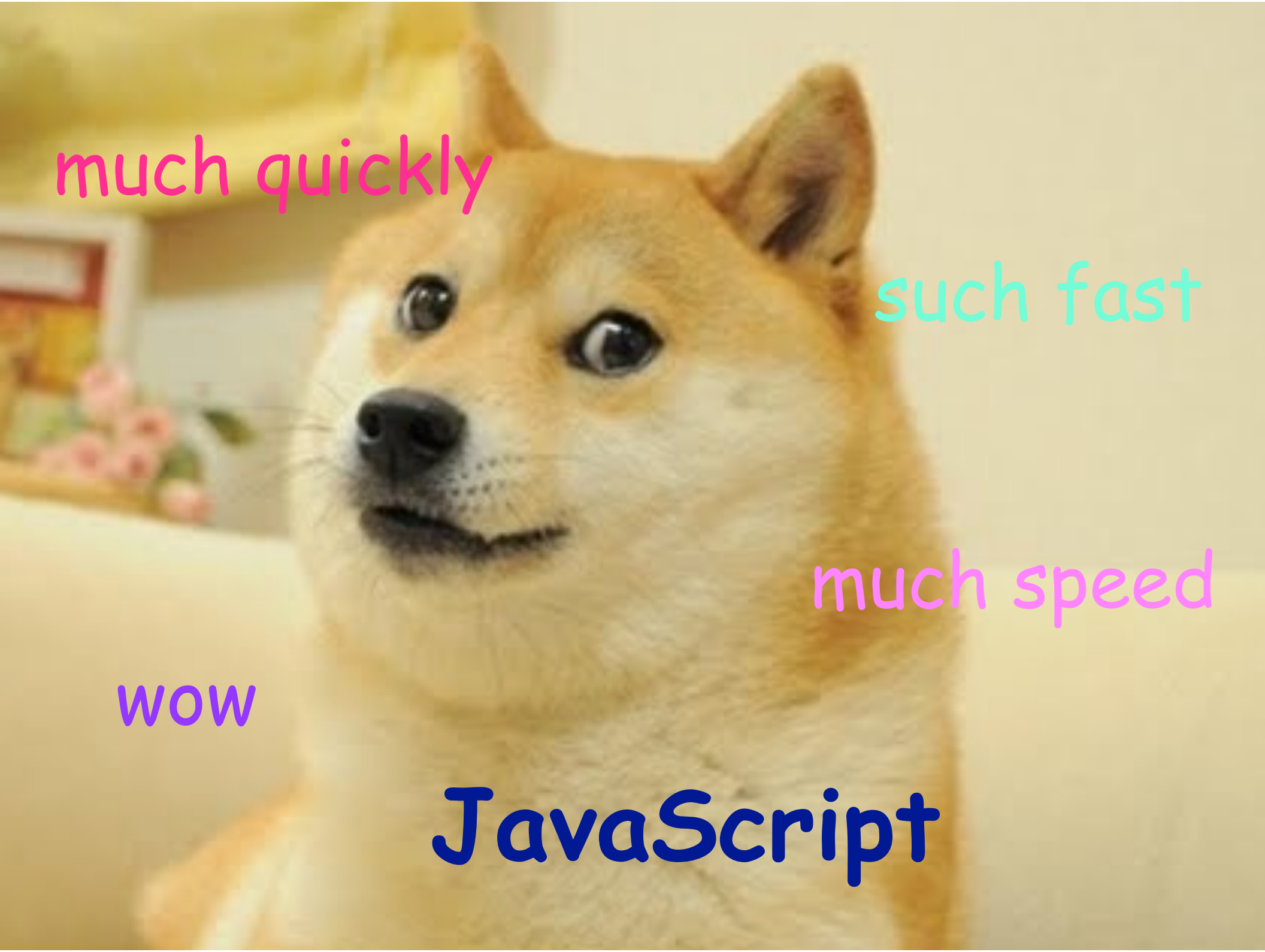
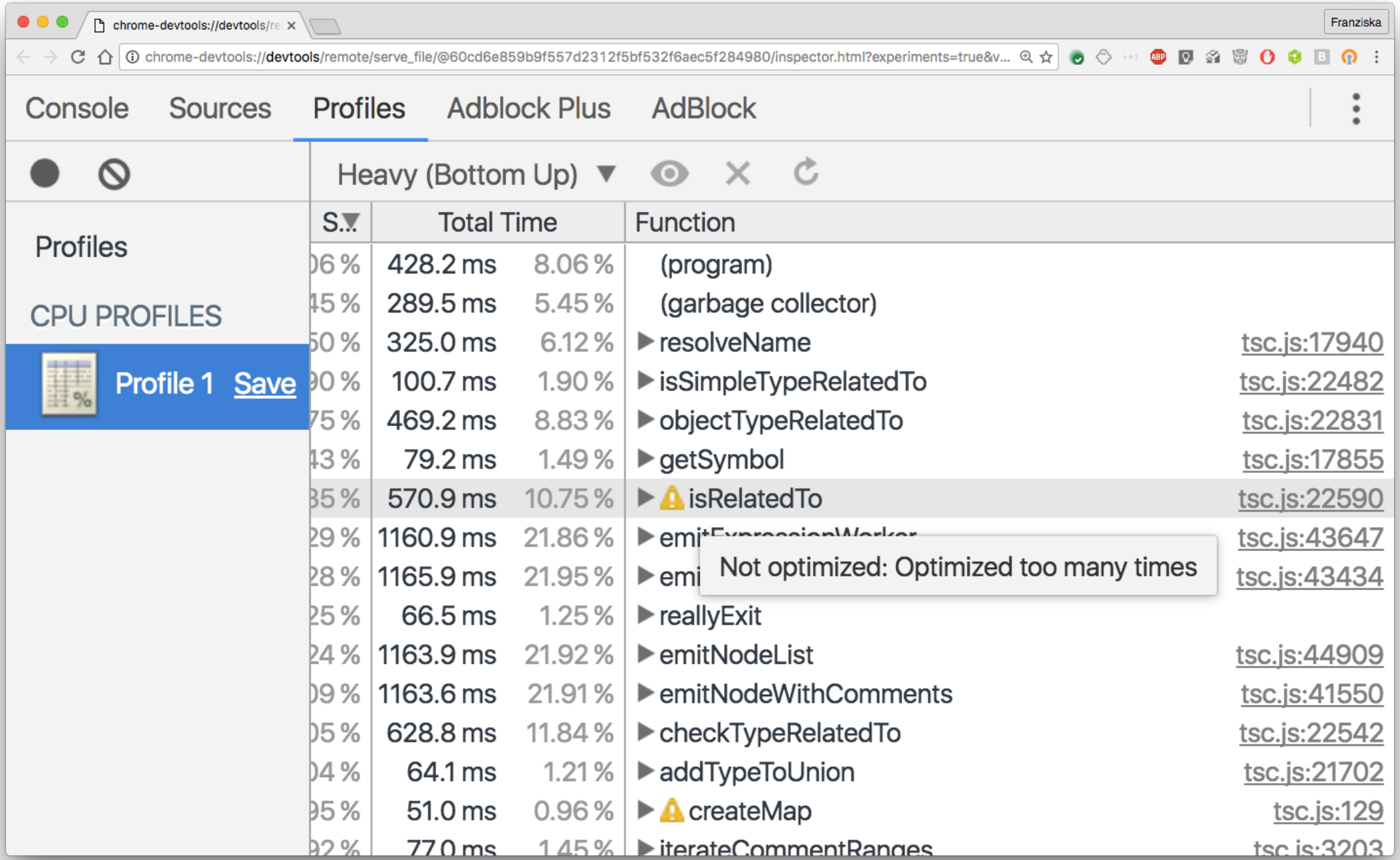

much quickly
such fast
much speed
wow
JavaScript

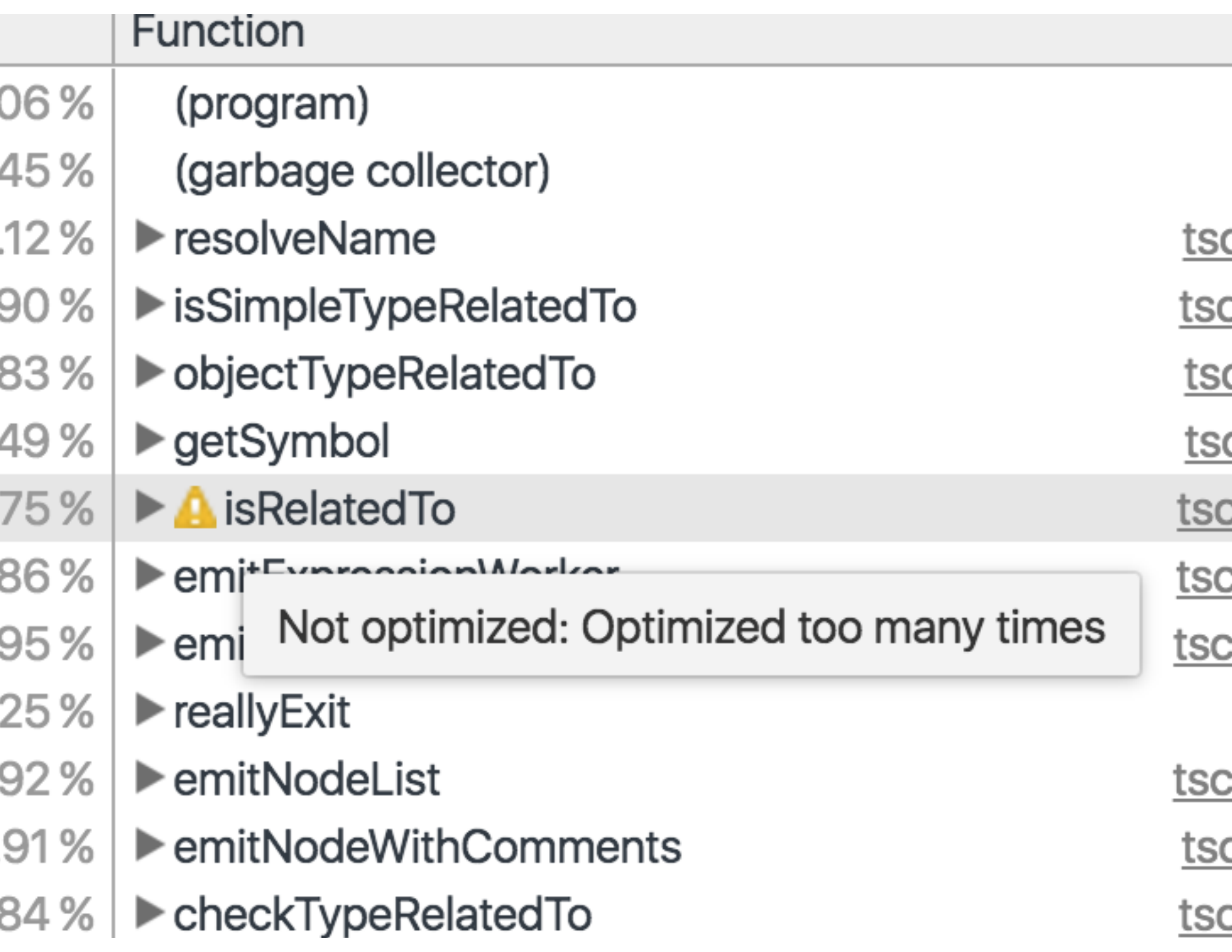
- Browser: ChakraCore, JSC, Spidermonkey, V8
- Node.js: ChakraCore, V8
- IoT: Duktape, JerryScript
- Electron: V8

Profiling V8

- Just in time (JIT) compilation
- Inline Caches (IC)
- Optimizing compiler
- Machine code

Chrome DevTools CPU Profile




Function
06 %
(program)
45 %
(garbage collector)
12 %
resolveName
90 %
isSimpleTypeRelatedTo
83 %
objectTypeRelatedTo
49 %
getSymbol
75 %
isRelatedTo
86 %
95 %
Not optimized: Optimized too many times
25 %
reallyExit
92 %
emitNodeList
91 %
emitNodeWithComments
84 %
checkTypeRelatedTo

JS is dynamically typed

- Not statically typed (Like C++, Java, Rust).

```
var obj = {
    x: 1,
    y: 1
};

delete obj.x;

obj.z = 1;
```

- Type information only available at runtime.

Just In Time (JIT) Compilation

Generate machine code during runtime, not **ahead of time** (AOT).

Property Access

```
function load(obj) {
  return obj.x;
}
```

- TypeError
- undefined
- prototype chain
- proxy
- side effects if accessor

9.1.8.1 OrdinaryGet (*O*, *P*, *Receiver*)

When the abstract operation OrdinaryGet is called with Object *O*, proper ECMAScript language value *Receiver*, the following steps are taken:

1. Assert: IsPropertyKey(*P*) is **true**.
2. Let *desc* be ? *O*.[[GetOwnProperty]](*P*).
3. If *desc* is **undefined**, then
    a. Let *parent* be ? *O*.[[GetPrototypeOf]]().
    b. If *parent* is **null**, return **undefined**.
    c. Return ? *parent*.[[Get]](*P*, *Receiver*).
4. If IsDataDescriptor(*desc*) is **true**, return *desc*.[[Value]].
5. Assert: IsAccessorDescriptor(*desc*) is **true**.
6. Let *getter* be *desc*.[[Get]].
7. If *getter* is **undefined**, return **undefined**.
8. Return ? Call(*getter*, *Receiver*).

EcmaScript specification

`obj.x`

```
function load(obj) {
    return obj.x;
}
```

Cache

{x: int} → offset 1

```
load({x: 5});

load({x: 17});
```

→

9.1.8.1 Ordinary[illegible]Get (*O*, *P*, *Receiver*) #

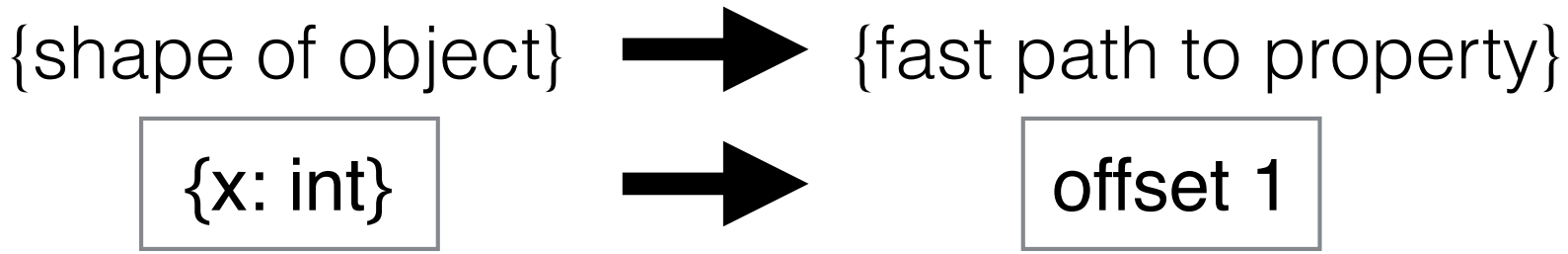
When the abstract operation OrdinaryGet is called with Object *O*, property key *P*, and ECMAScript language value *Receiver*, the following steps are taken:

1. Assert: IsProperty[illegible](*P*) is **true**.
2. Let *desc* be ? *O*.[[GetO[illegible]Property]](*P*).
3. If *desc* is **undefined**, then
    a. Let *parent* be ? *O*.[[GetPro[illegible]peOf]]().
    b. If *parent* is **null**, return **undefi[illegible]**.
    c. Return ? *parent*.[[Get]](*P*, *Receiver*).
4. If IsDataDescriptor(*desc*) is **true**, return *desc*.[[[illegible]lue]].
5. Assert: IsAccessorDescriptor(*desc*) is **true**.
6. Let *getter* be *desc*.[[Get]].
7. If *getter* is **undefined**, return **undefined**.
8. Return ? Call(*getter*, *Receiver*).

Inline Cache (IC)

```
function load(obj) {
    if(cond) {
        return obj.x;
    } else {
        return obj.x + 1;
    }
}
```

Shape of object = map = hidden class



Optimizing compiler

- Modern engines have optimizing compilers
- Basic compiler runs first and collects information, “hot functions” are then compiled by optimizing compiler

Optimization + IC

=

Speed

Optimized Machine Code

```
function load(obj) {
    return obj.x;
}
```

```
$ d8 --allow-natives-syntax –trace-opt –print-opt-code –code-comments load-opt.js
 [compiling method 0x9508e1f30c1 <JS Function load (SharedFunctionInfo 0xc3433e59a11)> using Crankshaft]
[optimizing 0x9508e1f30c1 <JS Function load (SharedFunctionInfo 0xc3433e59a11)> - took 5.019, 0.103,
0.089 ms]
```

```
                ;;; <@12,#7> context
32f7a584c2a     10  488b45f8        REX.W movq rax,[rbp-0x8]
                ;;; <@13,#7> gap
32f7a584c2e     14  488945e8        REX.W movq [rbp-0x18],rax
                ;;; <@16,#11> -------------------- B2 --------------------
                ;;; <@17,#11> gap
32f7a584c32     18  488bf0          REX.W movq rsi,rax
                ;;; <@18,#13> stack-check
32f7a584c35     21  493ba5100c0000  REX.W cmpq rsp,[r13+0xc10]
32f7a584c3c     28  7305            jnc 35  (0x132f7a584c43)
32f7a584c3e     30  e8bdd5f4ff      call StackCheck  (0x132f7a4d2200)    ;; code: BUILTIN
                ;;; <@20,#13> lazy-bailout
                ;;; <@21,#13> gap
32f7a584c43     35  488b4510        REX.W movq rax,[rbp+0x10]
                ;;; <@22,#15> check-non-smi
32f7a584c47     39  a801            test al,0x1
32f7a584c49     41  0f8427000000    jz 86  (0x132f7a584c76)
                ;;; <@24,#16> check-maps
32f7a584c4f     47  49baf9afa8795f080000 REX.W movq r10,0x85f79a8aff9    ;; object: 0x85f79a8a
32f7a584c59     57  4c3950ff        REX.W cmpq [rax-0x1],r10
32f7a584c5d     61  0f8518000000    jnz 91  (0x132f7a584c7b)
                ;;; <@26,#17> load-named-field
32f7a584c63     67  8b401b          movl rax,[rax+0x1b]
                ;;; <@28,#21> smi-tag
32f7a584c66     70  8bd8            movl rbx,rax
32f7a584c68     72  48c1e320        REX.W shlq rbx, 32
                ;;; <@29,#21> gap
32f7a584c6c     76  488bc3          REX.W movq rax,rbx
                ;;; <@30,#19> return
32f7a584c6f     79  488be5          REX.W movq rsp,rbp
-------- Jump table --------------------
  call 0x3a9097b8400a      ;; deoptimization bailout 1
  call 0x3a9097b84014      ;; deoptimization bailout 2
le.
```

IC States

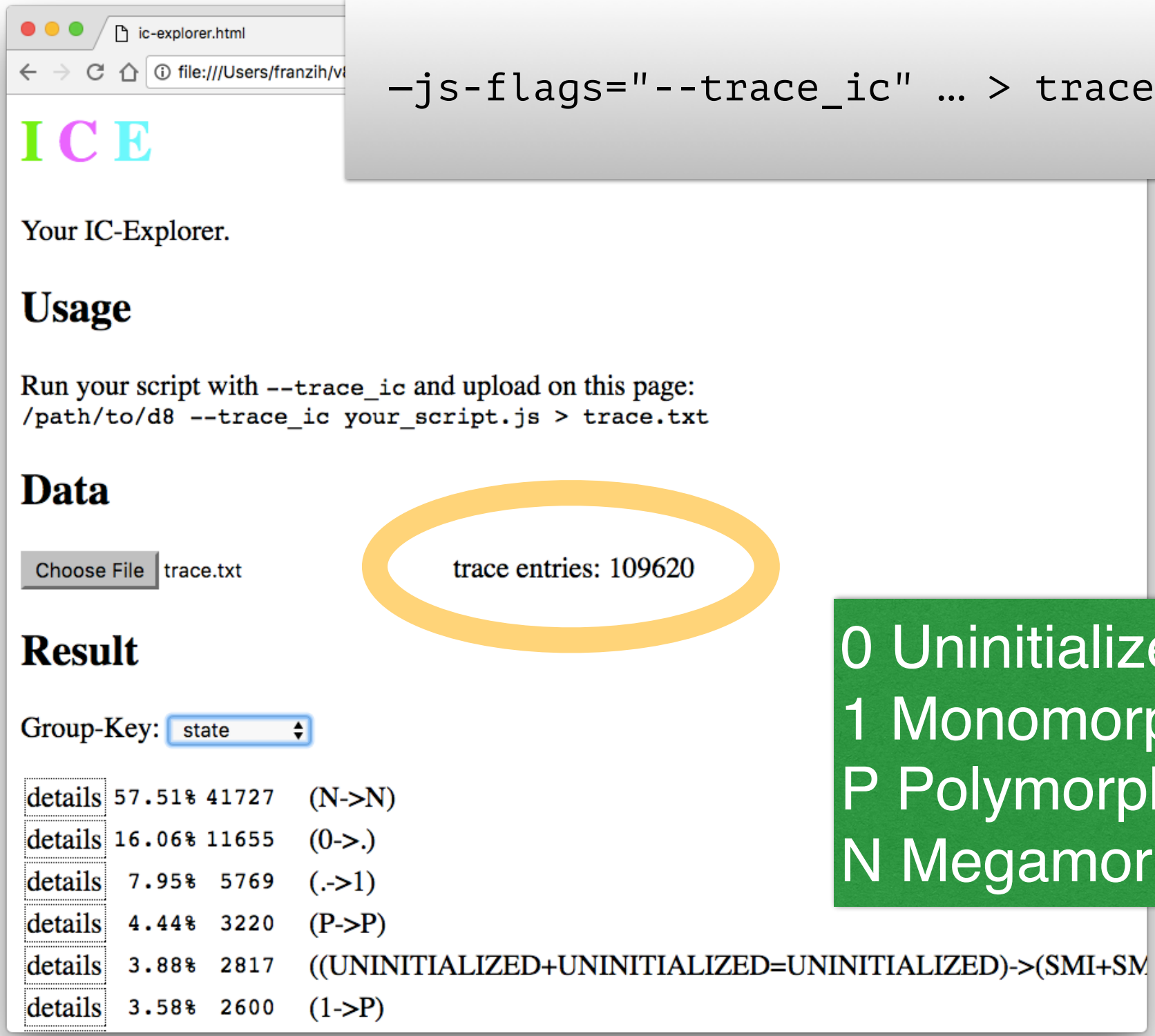
- Uninitialized
- Monomorphic: 1 map
- Polymorphic: 2-4 map
- Megamorphic: more than 4 map

```
                ;;; <@12,#7> context
32f7a584c2a     10  488b45f8        REX.W movq rax,[rbp-0x8]
                ;;; <@13,#7> gap
32f7a584c2e     14  488945e8        REX.W movq [rbp-0x18],rax
                ;;; <@16,#11> -------------------- B2 --------------------
                ;;; <@17,#11> gap
32f7a584c32     18  488bf0          REX.W movq rsi,rax
                ;;; <@18,#13> stack-check
32f7a584c35     21  493ba5100c0000  REX.W cmpq rsp,[r13+0xc10]
32f7a584c3c     28  7305            jnc 35  (0x132f7a584c43)
32f7a584c3e     30  e8bdd5f4ff      call StackCheck  (0x132f7a4d2200)    ;; code: BUILTIN
                ;;; <@20,#13> lazy-bailout
                ;;; <@21,#13> gap
32f7a584c43     35  488b4510        REX.W movq rax,[rbp+0x10]
                ;;; <@22,#15> check-non-smi
32f7a584c47     39  a801            test al,0x1
32f7a584c49     41  0f8427000000    jz 86  (0x132f7a584c76)
                ;;; <@24,#16> check-maps
32f7a584c4f     47  49baf9afa8795f080000 REX.W movq r10,0x8                5f79a8a
32f7a584c59     57  4c3950ff        REX.W cmpq [rax-0x1],r10
32f7a584c5d     61  0f8518000000    jnz 91  (0x132f7a584c7b)
                ;;; <@26,#17> load-named-field
32f7a584c63     67  8b401b          movl rax,[rax+0x1b]
                ;;; <@28,#21> smi-tag
32f7a584c66     70  8bd8            movl rbx,rax
32f7a584c68     72  48c1e320        REX.W shlq rbx, 32
                ;;; <@29,#21> gap
32f7a584c6c     76  488bc3          REX.W movq rax,rbx
                ;;; <@30,#19> return
32f7a584c6f     79  488be5          REX.W movq rsp,rbp
32f7a584c72     82  5d              pop rbp
32f7a584c73     83  c21000          ret 0x10
                ;;; -------------------- Jump table --------------------
32f7a584c76     86  e88ff3d7ff      call 0x132f7a30400a     ;; deoptimization bailout 1
32f7a584c7b     91  e894f3d7ff      call 0x132f7a304014     ;; deoptimization bailout 2
                ;;; Safepoint table.
```

–js-flags="–print-opt-code –code-comments”

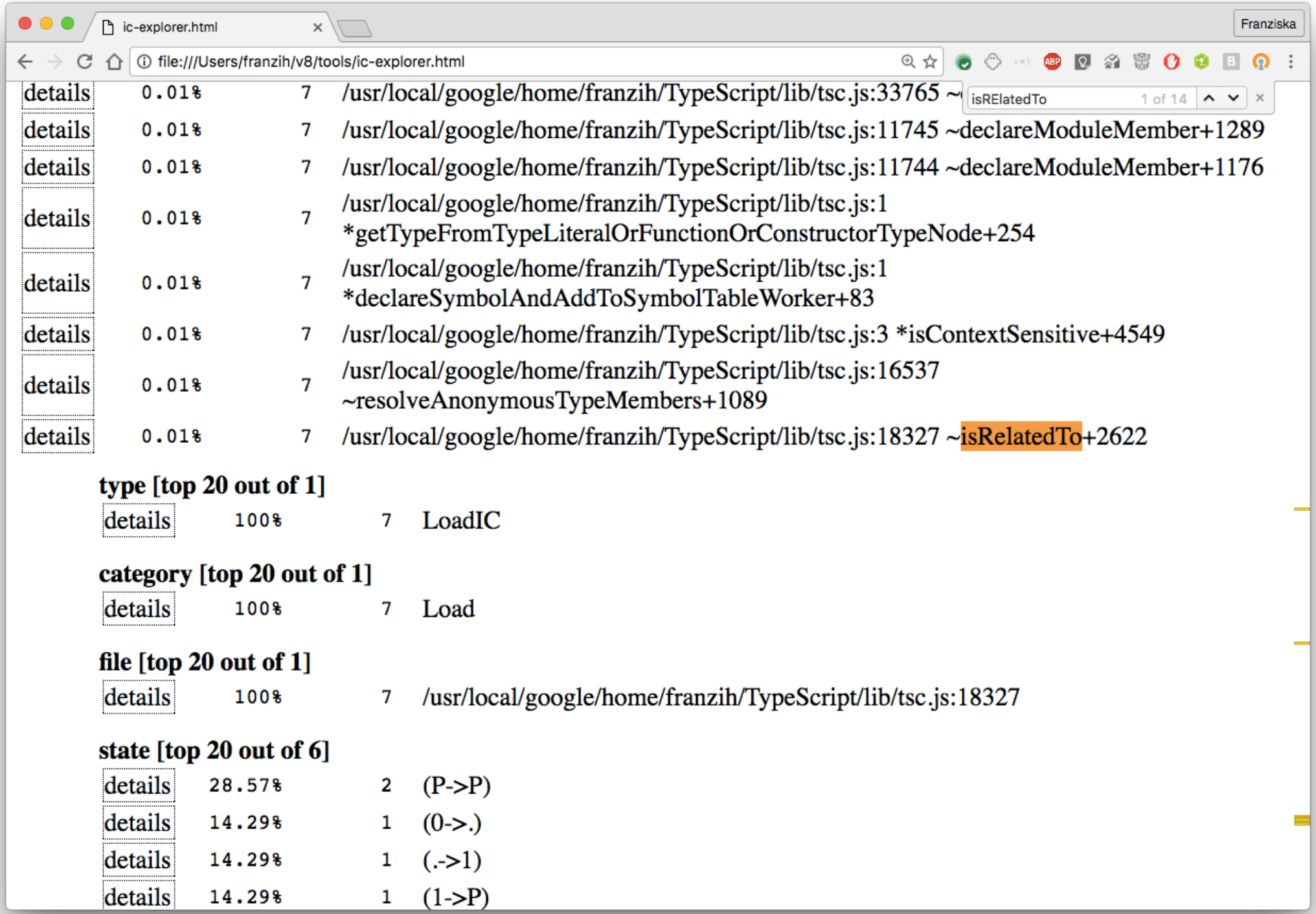
```
--- Optimized code ---
optimization_id = 0
source_position = 15
kind = OPTIMIZED_FUNCTION
name = load
stack_slots = 5
compiler = crankshaft
Instructions (size = 163)
0x2c845eb04d80     0  55              push rbp
0x2c845eb04d81     1  4889e5          REX.W movq rbp,rsp
0x2c845eb04d84     4  56              push rsi
0x2c845eb04d85     5  57              push rdi
0x2c845eb04d86     6  4883ec08        REX.W subq rsp,0x8
0x2c845eb04d8a    10  488b45f8        REX.W movq rax,[rbp-0x8]
0x2c845eb04d8e    14  488945e8        REX.W movq [rbp-0x18],rax
0x2c845eb04d92    18  488bf0          REX.W movq rsi,rax
0x2c845eb04d95    21  493ba5100c0000  REX.W cmpq rsp,[r13+0xc10]
0x2c845eb04d9c    28  7305            jnc 35  (0x2c845eb04da3)
0x2c845eb04d9e    30  e85dd4f4ff      call StackCheck  (0x2c845ea52200)    ;; code: BUILTIN
0x2c845eb04da3    35  488b4510        REX.W movq rax,[rbp+0x10]
0x2c845eb04da7    39  a801            test al,0x1
0x2c845eb04da9    41  0f8457000000    jz 134  (0x2c845eb04e06)
0x2c845eb04daf    47  49baf9af8034610e0000 REX.W movq r10,0xe613480aff9   ;; object: 0x
0x2c845eb04db9    57  4c3950ff        REX.W cmpq [rax-0x1],r10
0x2c845eb04dbd    61  7434            jz 115  (0x2c845eb04df3)
0x2c845eb04dbf    63  49ba01b18034610e0000 REX.W movq r10,0xe613480b101   ;; objec
0x2c845eb04dc9    73  4c3950ff        REX.W cmpq [rax-0x1],r10
0x2c845eb04dcd    77  7424            jz 115  (0x2c845eb04df3)
0x2c845eb04dcf    79  49ba59b18034610e0000 REX.W movq r10,0xe613480b159   ;; object
0x2c845eb04dd9    89  4c3950ff        REX.W cmpq [rax-0x1],r10
0x2c845eb04ddd    93  7414            jz 115  (0x2c845eb04df3)
0x2c845eb04ddf    95  49bab1b18034610e0000 REX.W movq r10,0xe613480b1b1   ;; object: 0xe613480
0x2c845eb04de9   105  4c3950ff        REX.W cmpq [rax-0x1],r10
0x2c845eb04ded   109  0f8518000000    jnz 139  (0x2c845eb04e0b)
0x2c845eb04df3   115  8b401b          movl rax,[rax+0x1b]
0x2c845eb04df6   118  8bd8            movl rbx,rax
0x2c845eb04df8   120  48c1e320        REX.W shlq rbx, 32
0x2c845eb04dfc   124  488bc3          REX.W movq rax,rbx
0x2c845eb04dff   127  488be5          REX.W movq rbp,rsp
0x2c845eb04e02   130  5d              pop rbp
0x2c845eb04e03   131  c21000          ret 0x10
0x2c845eb04e06   134  e8fff3ffff      call 0x2c845eb04e0a  ; deoptimization bailout 1
0x2c845eb04e0b   139  e804f2ffff      call 0x2c845eb04014  ; deoptimization bailout 2

Source positions:
 pc offset  position
```

4 maps in IC



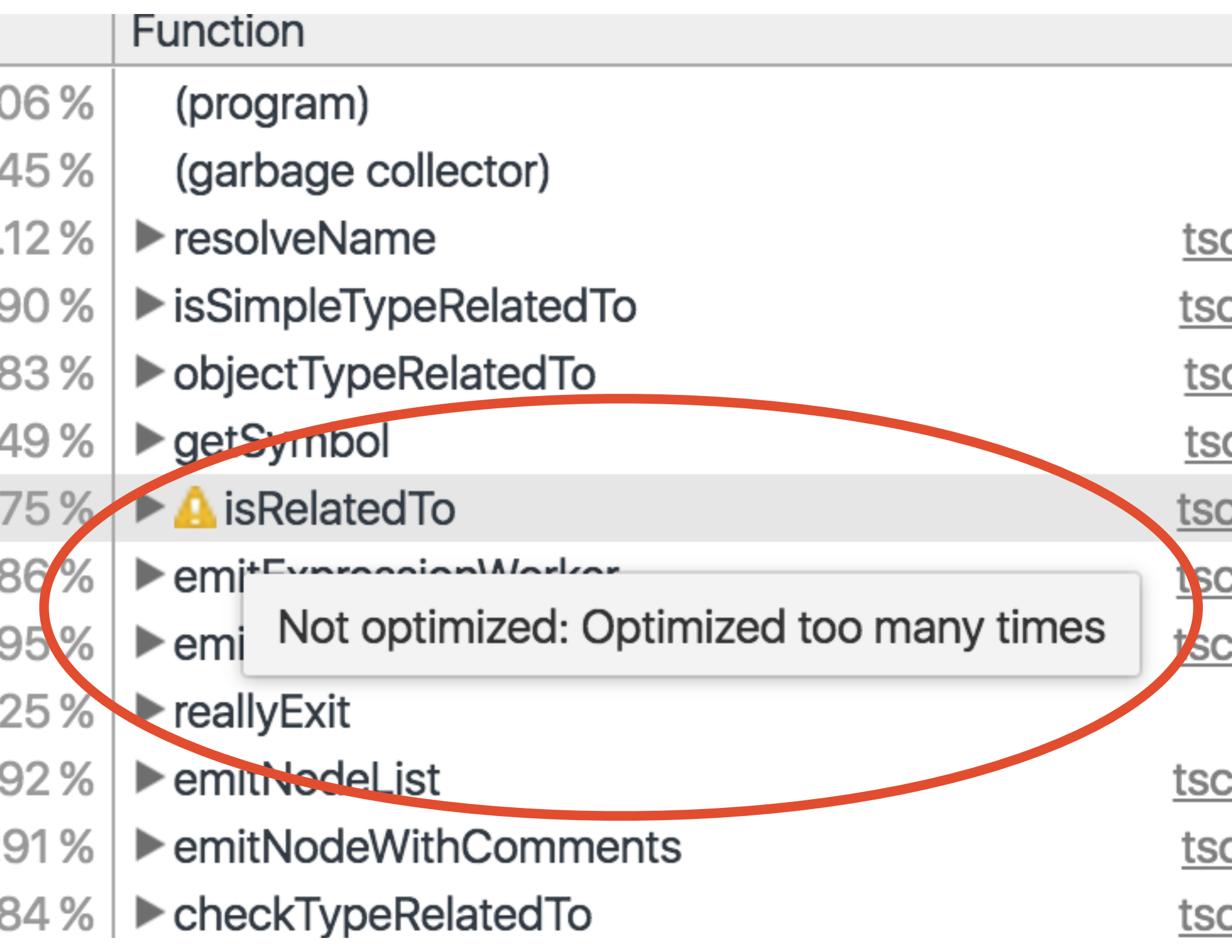

```
–js-flags="--trace_ic" … > trace.txt
```

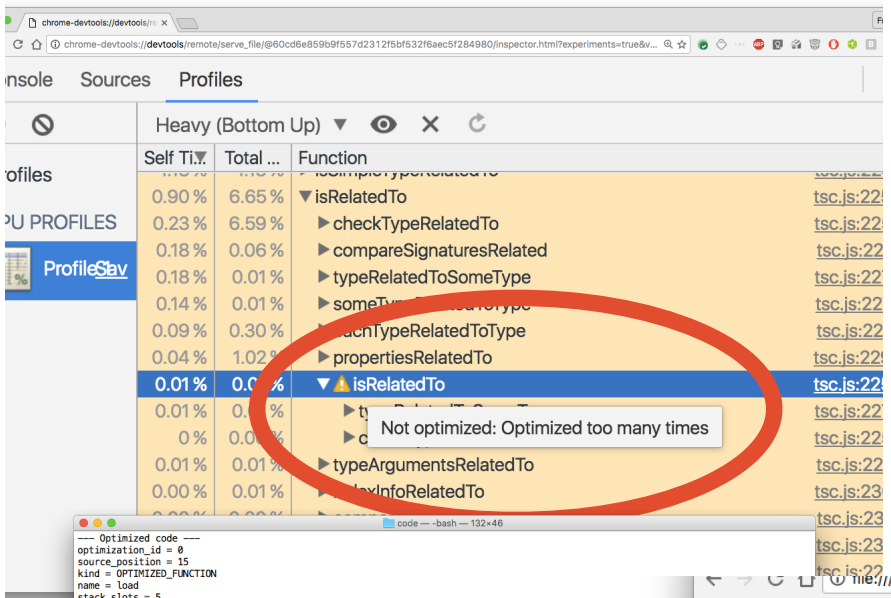
0 Uninitialized
1 Monomorphic
P Polymorphic
N Megamorphic

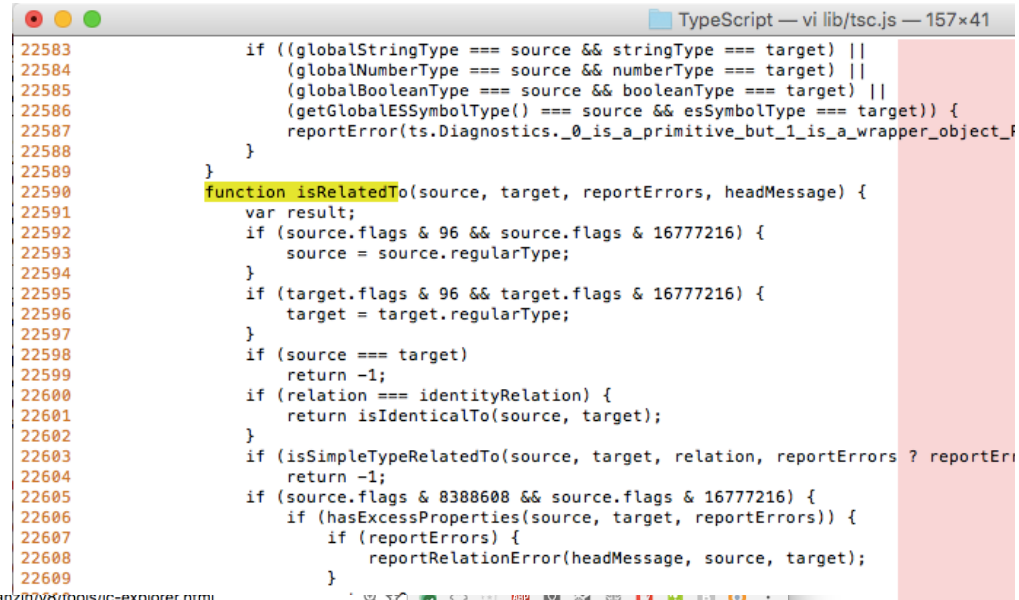

ic-explorer.html
Franziska
file:///Users/franzih/v8/tools/ic-explorer.html
isRElatedTo 1 of 14
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:33765 ~
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:11745 ~declareModuleMember+1289
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:11744 ~declareModuleMember+1176
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:1 *getTypeFromTypeLiteralOrFunctionOrConstructorTypeNode+254
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:1 *declareSymbolAndAddToSymbolTableWorker+83
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:3 *isContextSensitive+4549
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:16537 ~resolveAnonymousTypeMembers+1089
details 0.01% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:18327 ~isRelatedTo+2622
type [top 20 out of 1]
details 100% 7 LoadIC
category [top 20 out of 1]
details 100% 7 Load
file [top 20 out of 1]
details 100% 7 /usr/local/google/home/franzih/TypeScript/lib/tsc.js:18327
state [top 20 out of 6]
details 28.57% 2 (P->P)
details 14.29% 1 (0->.)
details 14.29% 1 (.->1)
details 14.29% 1 (1->P)

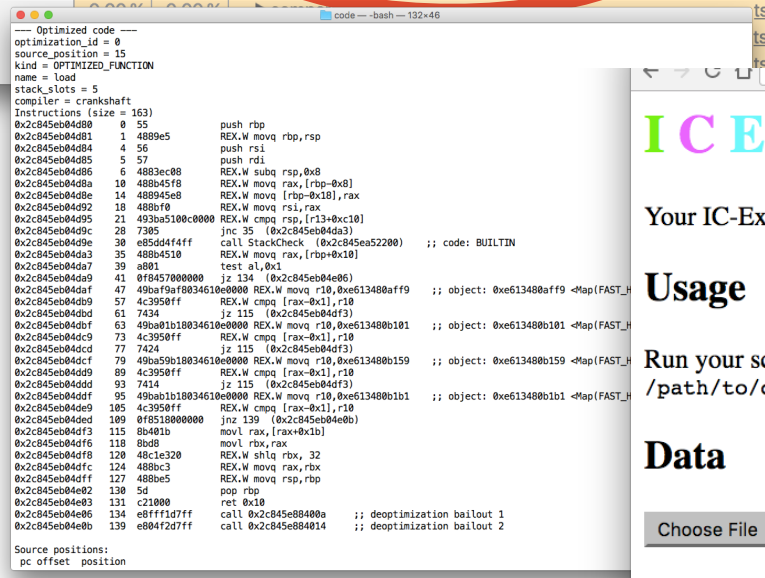
--trace-opt –trace-deopt

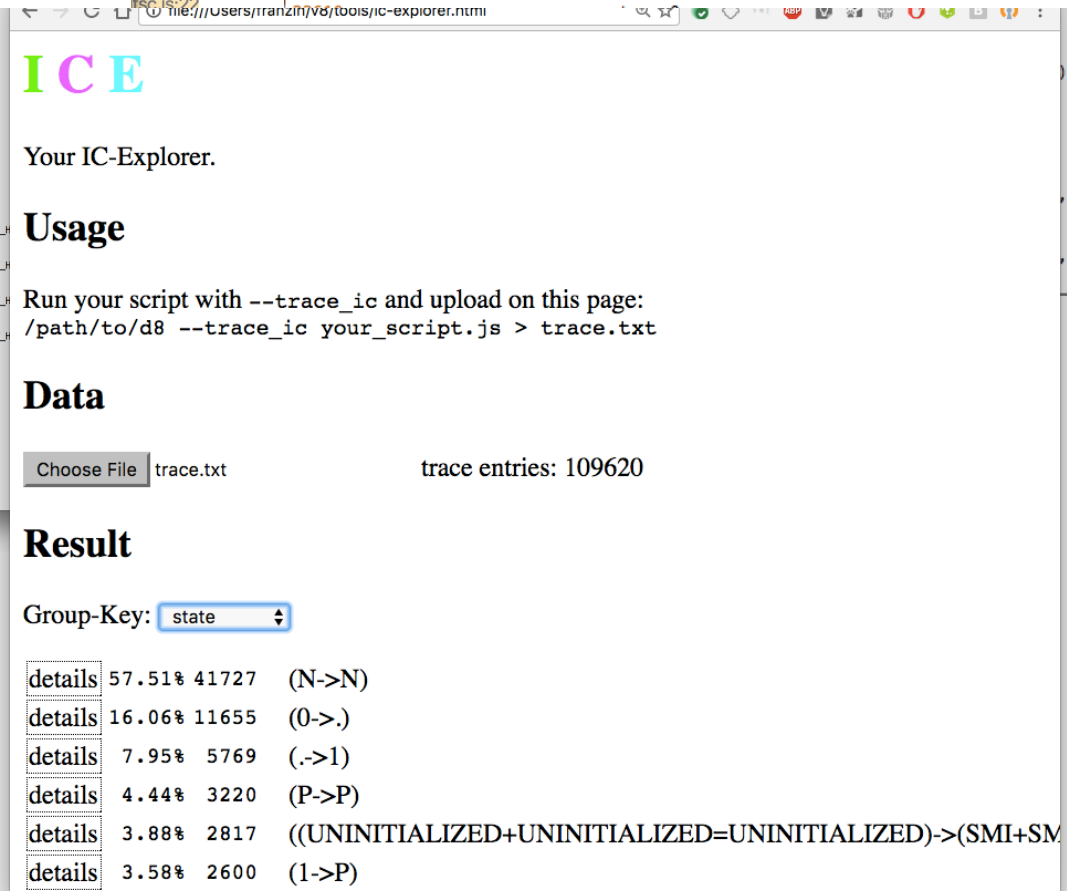
```
$ node --trace-opt –trace-deopt load-opt.js
[compiling method 0x1b9f780f3139 <JS Function
load (SharedFunctionInfo 0x3697a6859ad1)> using
Crankshaft]
[optimizing 0x1b9f780f3139 <JS Function load
(SharedFunctionInfo 0x3697a6859ad1)> - took
0.910, 0.052, 0.058 ms]
[evicting entry from optimizing code map (notify
deoptimized) for 0x3697a6859ad1
<SharedFunctionInfo load>]
```

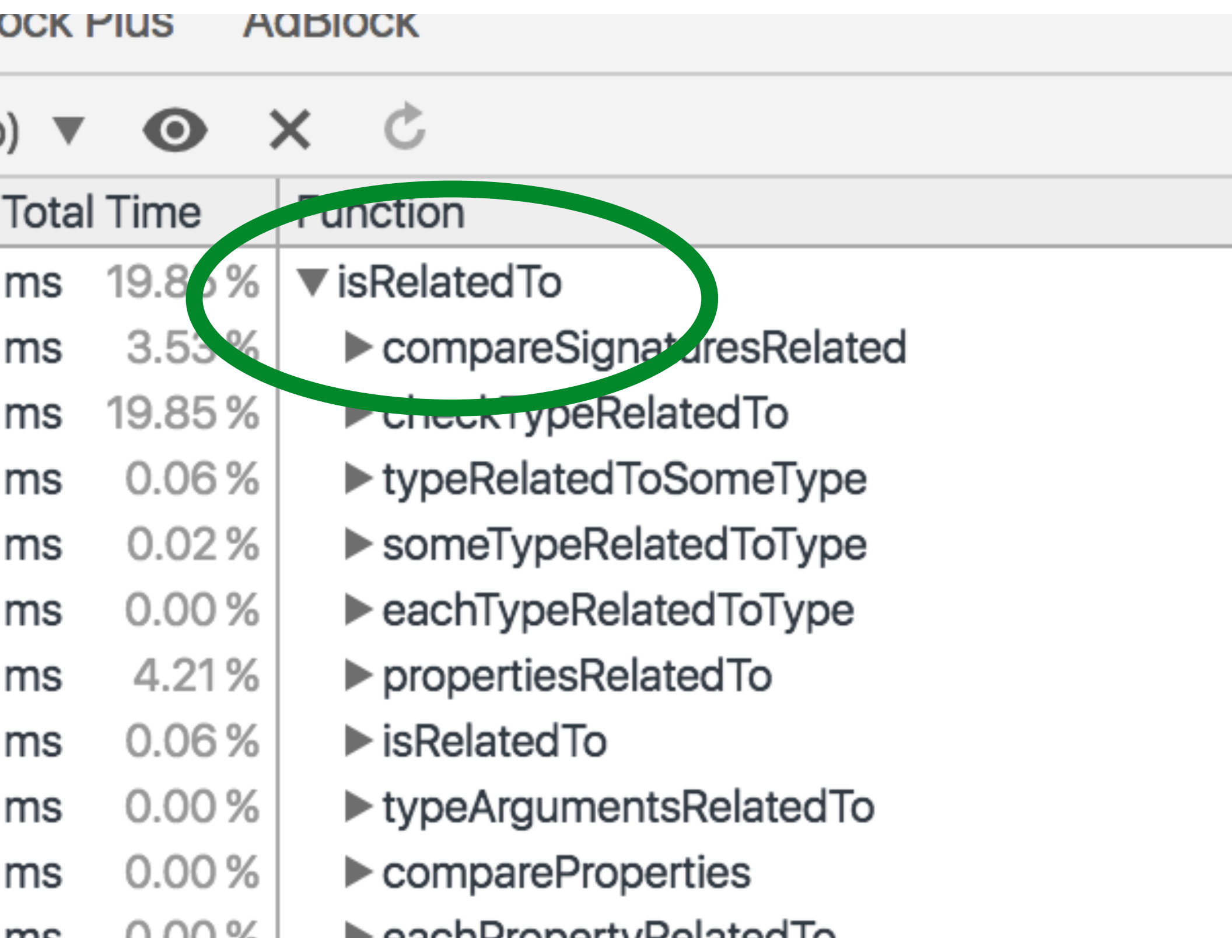

Function
06 %
(program)
45 %
(garbage collector)
12 %
resolveName
90 %
isSimpleTypeRelatedTo
83 %
objectTypeRelatedTo
49 %
getSymbol
75 %
isRelatedTo
86 %
95 %
25 %
reallyExit
92 %
emitNodeList
91 %
emitNodeWithComments
84 %
checkTypeRelatedTo
Not optimized: Optimized too many times


Sources
Profiles
Heavy (Bottom Up)
Self Ti...
Total ...
Function
isRelatedTo
checkTypeRelatedTo
compareSignaturesRelated
typeRelatedToSomeType
propertiesRelatedTo
typeArgumentsRelatedTo
Not optimized: Optimized too many times


TypeScript — vi lib/tsc.js — 157×41
function isRelatedTo(source, target, reportErrors, headMessage) {
var result;
if (source.flags & 96 && source.flags & 16777216) {
source = source.regularType;
}
if (target.flags & 96 && target.flags & 16777216) {
target = target.regularType;
}
if (source === target)
return -1;
if (relation === identityRelation) {
return isIdenticalTo(source, target);
}
if (isSimpleTypeRelatedTo(source, target, relation, reportErrors ? reportErr
return -1;
if (source.flags & 8388608 && source.flags & 16777216) {
if (hasExcessProperties(source, target, reportErrors)) {
if (reportErrors) {
reportRelationError(headMessage, source, target);


code — -bash — 132×46
--- Optimized code ---
optimization_id = 0
source_position = 15
kind = OPTIMIZED_FUNCTION
name = load
stack_slots = 5
compiler = crankshaft
Instructions (size = 163)
Source positions:
pc offset position


I C E
Your IC-Explorer.
Usage
Run your script with --trace_ic and upload on this page:
/path/to/d8 --trace_ic your_script.js > trace.txt
Data
Choose File
trace.txt
trace entries: 109620
Result
Group-Key:
state
details 57.51% 41727 (N->N)
details 16.06% 11655 (0->.)
details 7.95% 5769 (.->1)
details 4.44% 3220 (P->P)
details 3.88% 2817 ((UNINITIALIZED+UNINITIALIZED=UNINITIALIZED)->(SMI+SM
details 3.58% 2600 (1->P)


ock Plus
AdBlock
Total Time
Function
ms 19.85 %
isRelatedTo
ms 3.53 %
compareSignaturesRelated
ms 19.85 %
checkTypeRelatedTo
ms 0.06 %
typeRelatedToSomeType
ms 0.02 %
someTypeRelatedToType
ms 0.00 %
eachTypeRelatedToType
ms 4.21 %
propertiesRelatedTo
ms 0.06 %
isRelatedTo
ms 0.00 %
typeArgumentsRelatedTo
ms 0.00 %
compareProperties

Be careful with optimizations!

- Don’t “optimize” unless you must
- Measure first

Be careful with optimizations!

- V8 internals change
- Different in other engines

- `$ chrome --js-flags="--trace-opt"`
  - `–trace-opt –trace-deopt`
  - `–print-opt-code`
  - `–trace-ic`
- `$ node –trace-ic …`
- `$ d8 (V8 shell)`
- IC Explorer v8/tools/ic-explorer.html

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