

V8: Hooking up the Ignition to the Turbofan

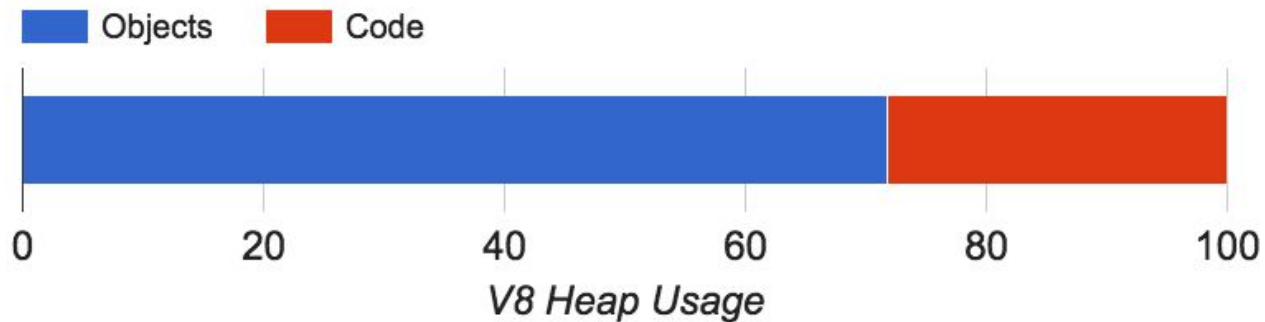
Leszek Swirski & Ross McIlroy
Google London



Ignition + Turbofan pipeline

Why a new pipeline?

- Reduce memory usage



Why a new pipeline?

- Reduce memory usage
- Reduce startup time

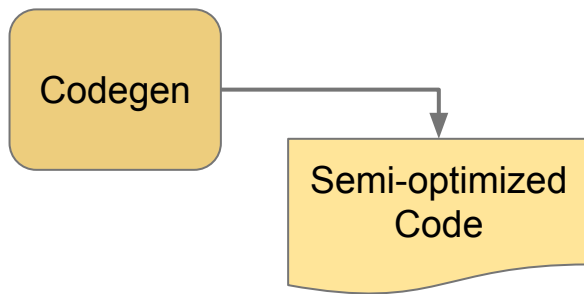


33% of time spent parsing + compiling

Why a new pipeline?

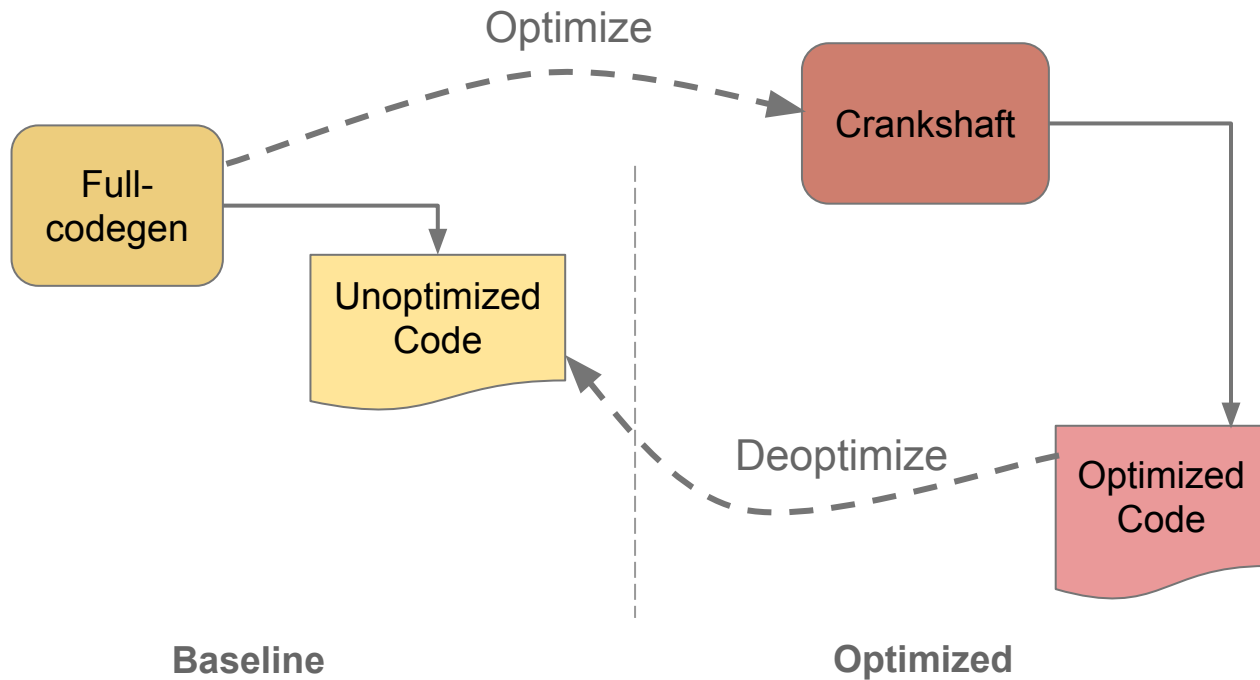
- Reduce memory usage
- Reduce startup time
- Reduce complexity

Compiler Pipeline (2008)

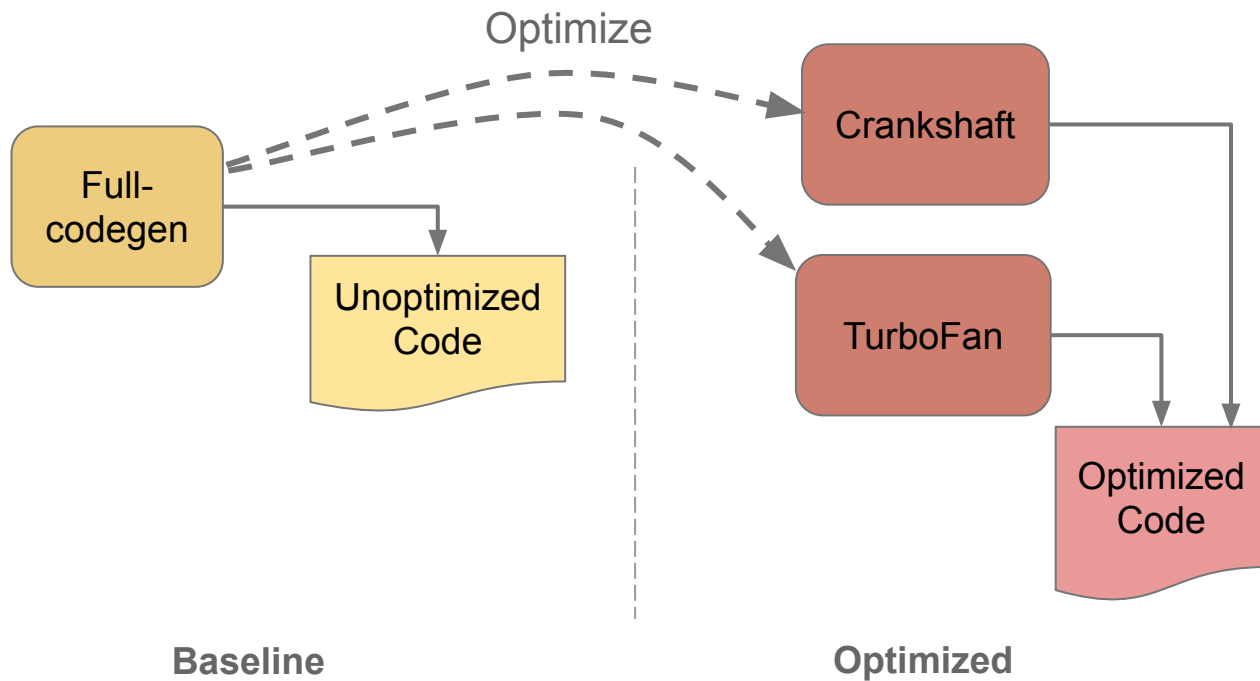


Baseline

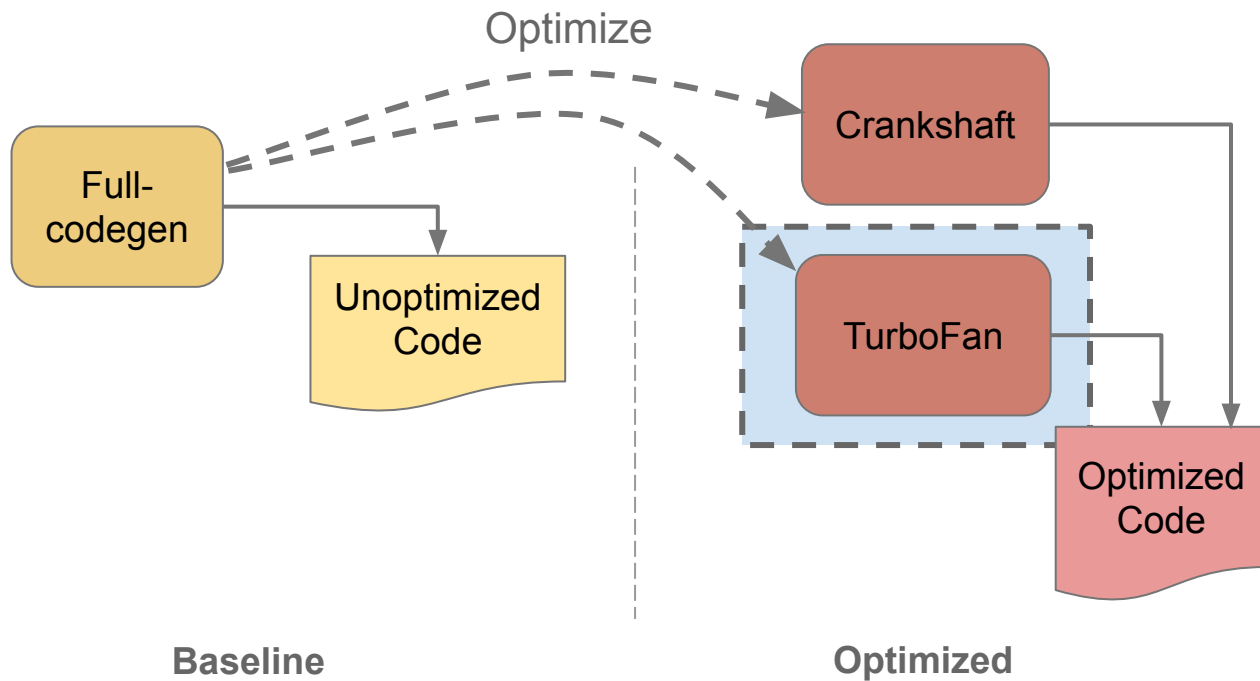
Compiler Pipeline (2010)



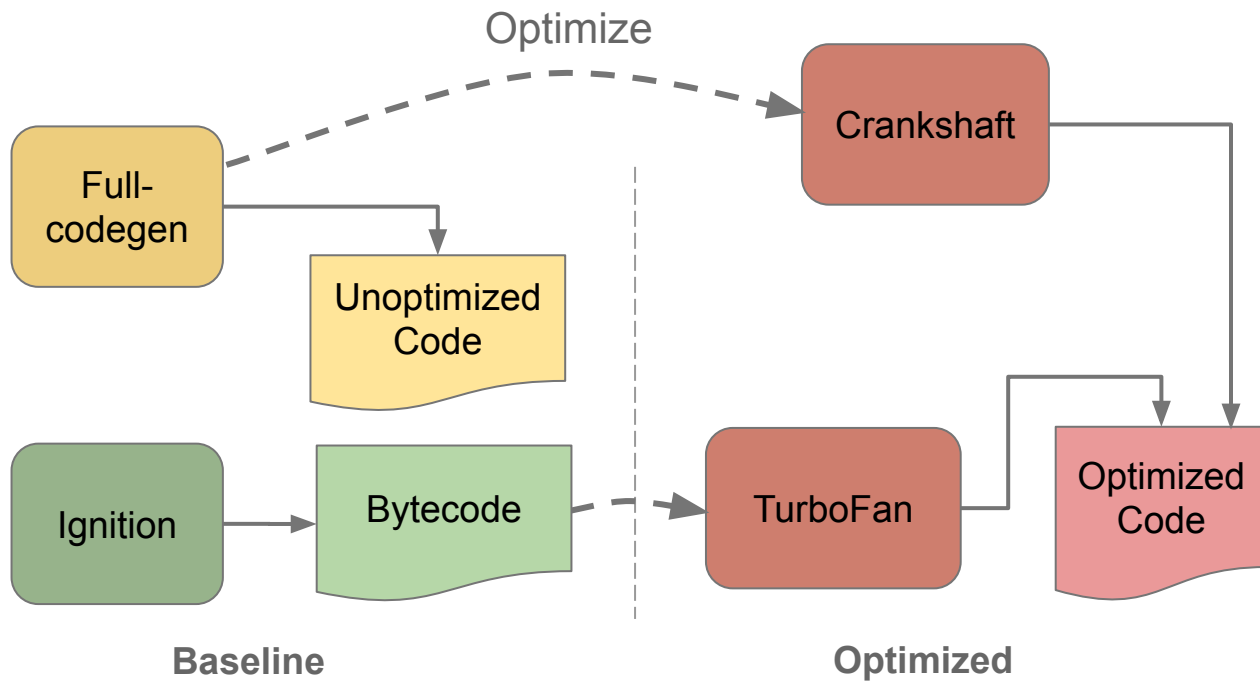
Compiler Pipeline (2015)



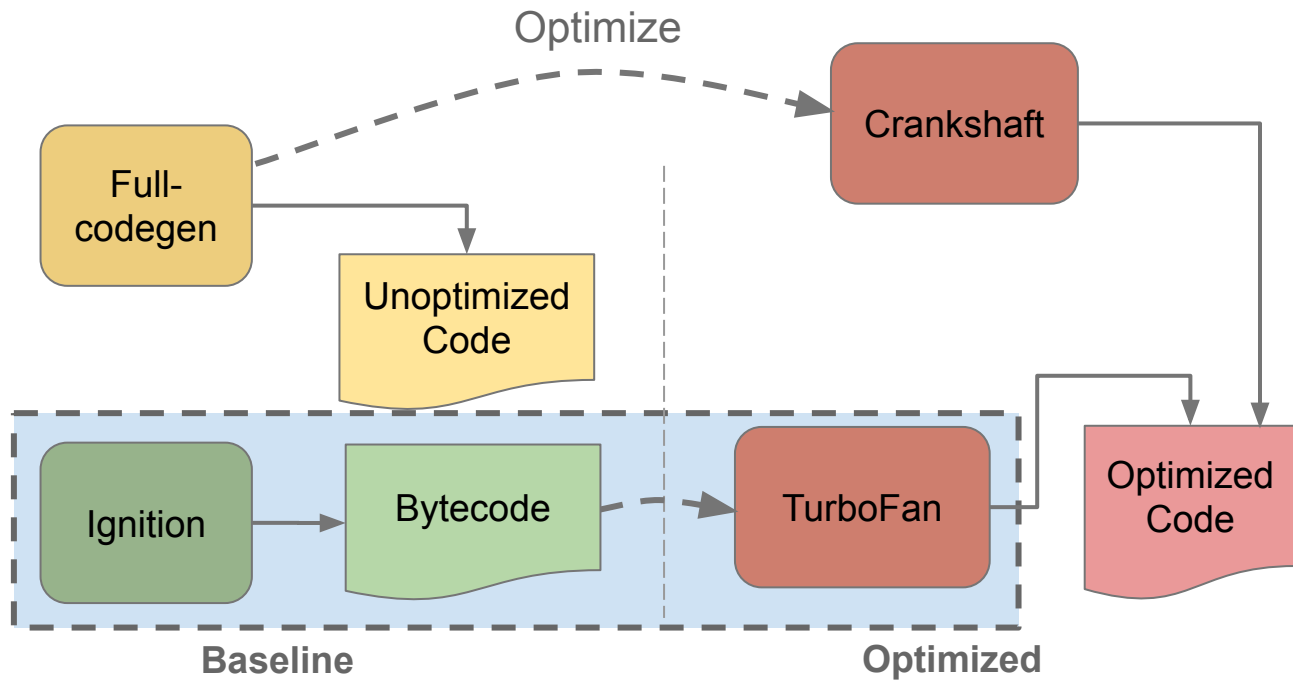
Compiler Pipeline (2015)



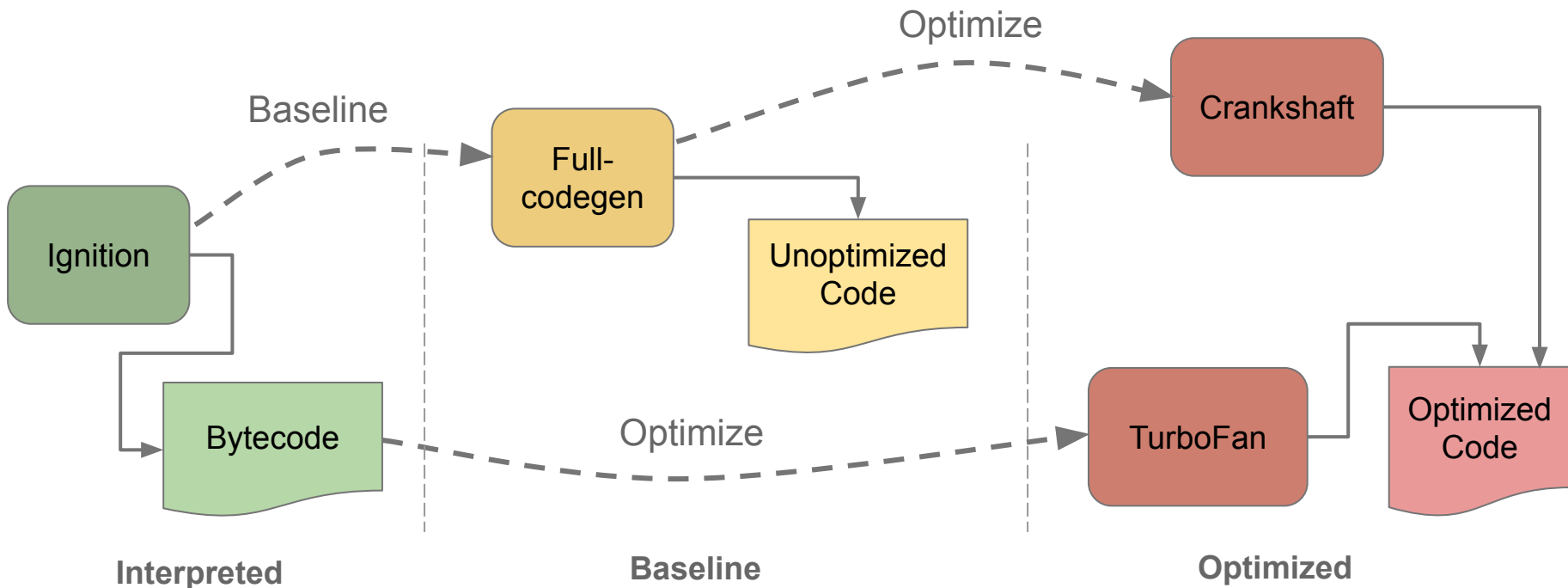
Compiler Pipeline (2016)



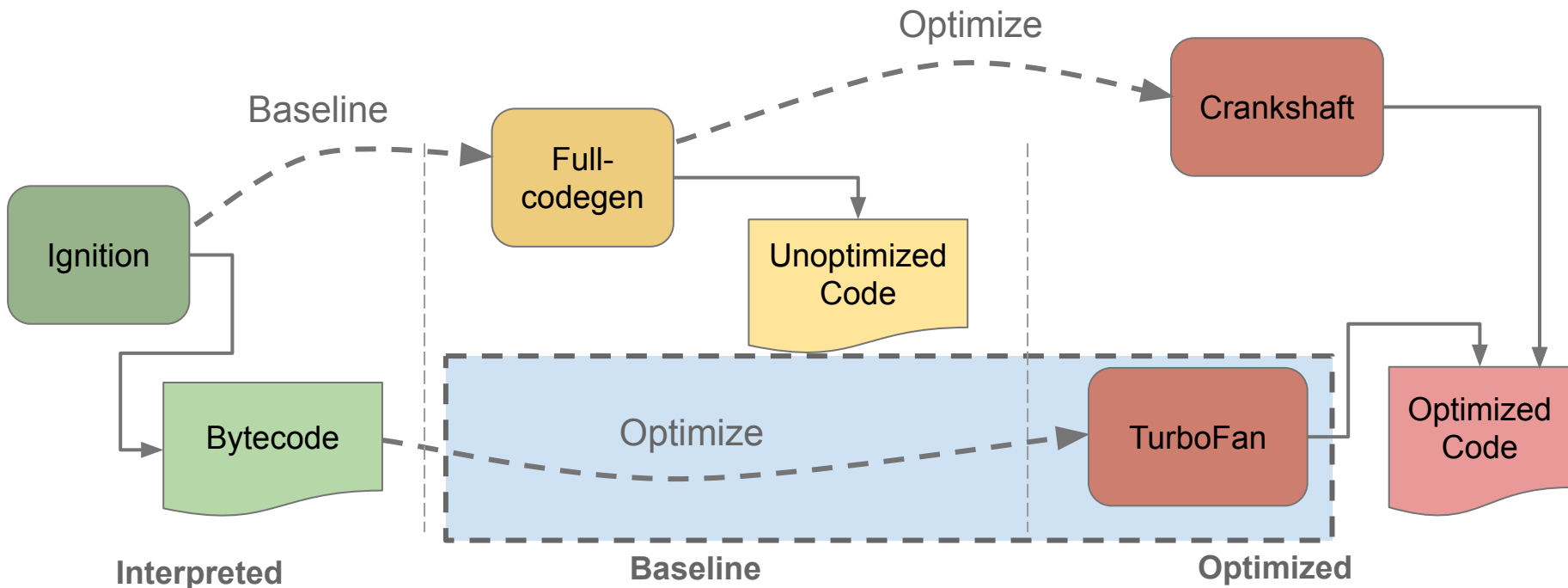
Compiler Pipeline (2016)



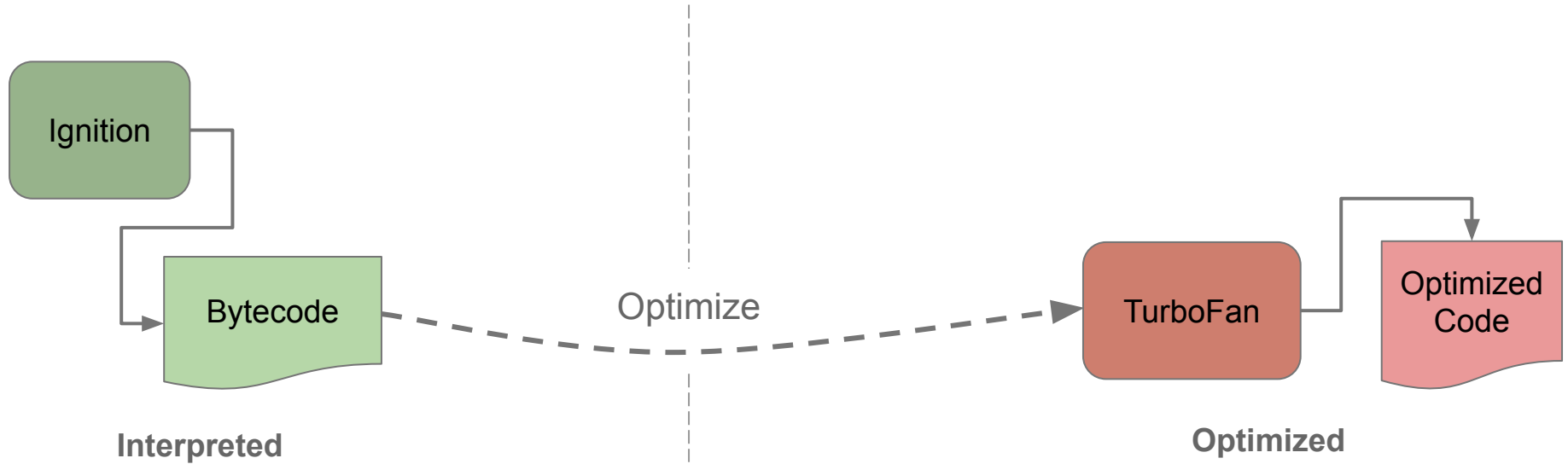
Compiler Pipeline (Svelte Devices)



Compiler Pipeline (Svelte Devices)



Compiler Pipeline (2017)



Bytecode to graph

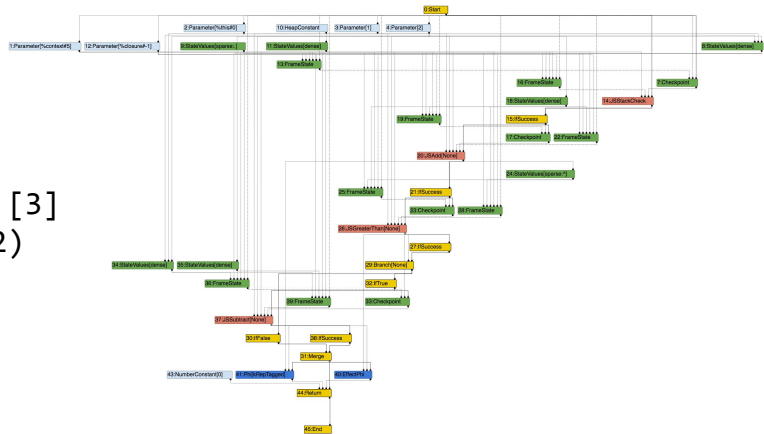
Ignition to Turbofan

```
function f(a, b) {  
    var result = a + b;  
    if (a > b) {  
        result = a - b;  
    }  
    return result;  
}
```

```

0 : 7d          StackCheck
1 : 1c 02       Ldar a1
3 : 28 03 02    Add a0, [2]
6 : 1d fa       Star r0
8 : 1c 02       Ldar a1
10 : 4f 03 03   TestGreaterThanOr a0, [3]
13 : 74 09      JumpIfFalse [9] (@22)
15 : 1c 02       Ldar a1
17 : 29 03 04   Sub a0, [4]
20 : 1d fa       Star r0
22 : 1c fa       Ldar r0
24 : 81         Return

```



Text

Bytecode (Ignition)

Sea-of-nodes graph (Turbofan)

Executing bytecode

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
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10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09    JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

Parameters

0x00000004	0x00000010
a0	a1

Registers

r0

Accumulator

--

Executing bytecode

0 : 7d	StackCheck
1 : 1c 02	Ldar a1
3 : 28 03 02	Add a0, [2]
6 : 1d fa	Star r0
8 : 1c 02	Ldar a1
10 : 4f 03 03	TestGreaterThan a0, [3]
13 : 74 09	JumpIfFalse [9] (@22)
15 : 1c 02	Ldar a1
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24 : 81	Return

Parameters

0x00000004	0x00000010
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Executing bytecode

0	:	7d		StackCheck
1	:	1c 02		Ldar a1
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24	:	81		Return

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```

Parameters

0x00000004	0x00000010
a0	a1

Registers

r0

Accumulator

0x00000014

Executing bytecode

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6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
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15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

Parameters

0x00000004	0x00000010
a0	a1

Registers

0x00000014
r0

Accumulator

0x00000014

Executing bytecode

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
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Accumulator

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Executing bytecode

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Parameters

0x00000004	0x00000010
a0	a1

Registers

0x00000014
r0

Accumulator

0x00000000

Executing bytecode

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0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
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Parameters

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a0	a1

Registers

0x00000014
r0

Accumulator

0x00000000

Executing bytecode

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0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
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8 : 1c 02    Ldar a1
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a0	a1

Registers

0x00000014
r0

Accumulator

0x00000014

Executing bytecode

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0 : 7d      StackCheck
1 : 1c 02    Ldar a1
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13 : 74 09    JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
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20 : 1d fa    Star r0
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Parameters

0x00000004	0x00000010
a0	a1

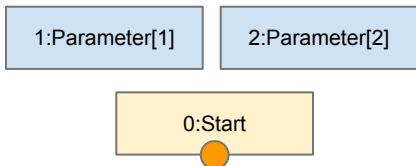
Registers

0x00000014
r0

Accumulator

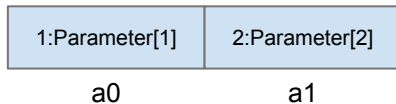
0x00000014

Building a graph

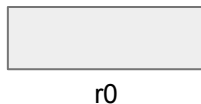


```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
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22 : 1c fa    Ldar r0
24 : 81      Return
```

Parameters



Registers



Accumulator



Building a graph

0 : 7d StackCheck		
1	: 1c 02	Ldar a1
3	: 28 03 02	Add a0, [2]
6	: 1d fa	Star r0
8	: 1c 02	Ldar a1
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17	: 29 03 04	Sub a0, [4]
20	: 1d fa	Star r0
22	: 1c fa	Ldar r0
24	: 81	Return

Parameters

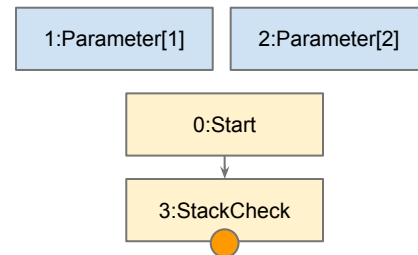
1:Parameter[1]	2:Parameter[2]
a0	a1

Registers

r0

Accumulator

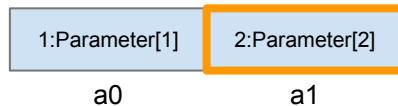
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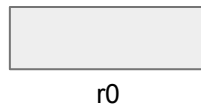
Building a graph

0	:	7d		StackCheck
1	:	1c 02		Ldar a1
3	:	28 03 02		Add a0, [2]
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17	:	29 03 04		Sub a0, [4]
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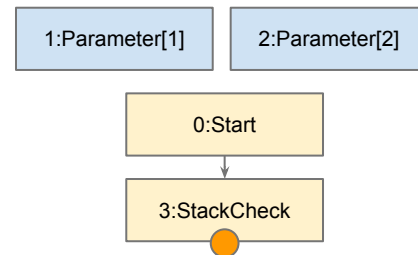
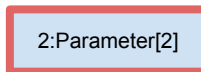
Parameters



Registers



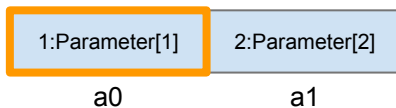
Accumulator



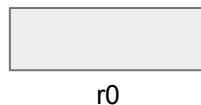
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0	: 7d	StackCheck
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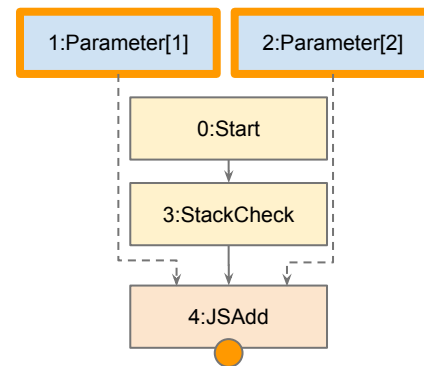
Parameters



Registers



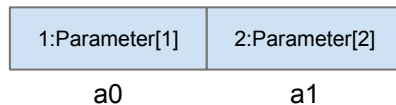
Accumulator



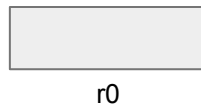
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3	:	28 03 02		Add a0, [2]
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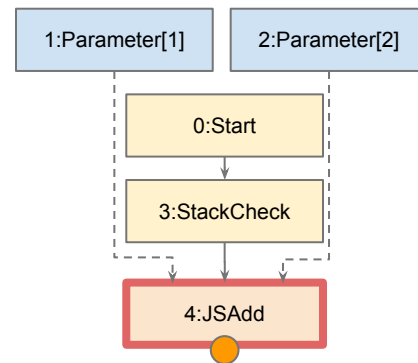
Parameters



Registers



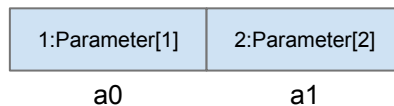
Accumulator



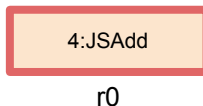
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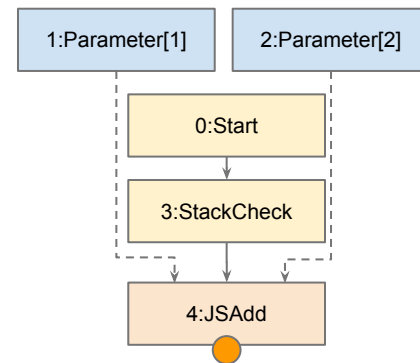
Parameters



Registers



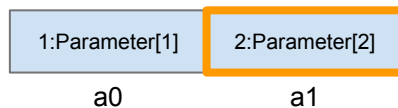
Accumulator



Building a graph

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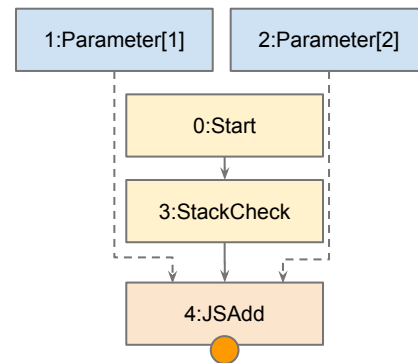
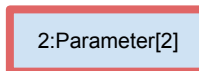
Parameters



Registers



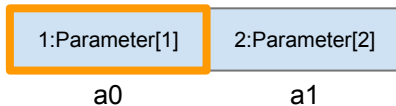
Accumulator



Building a graph

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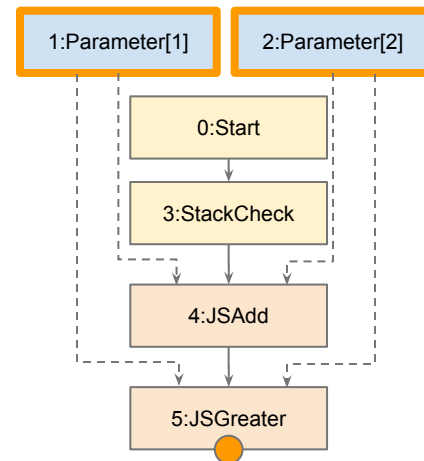
Parameters



Registers



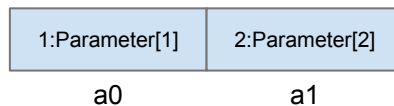
Accumulator



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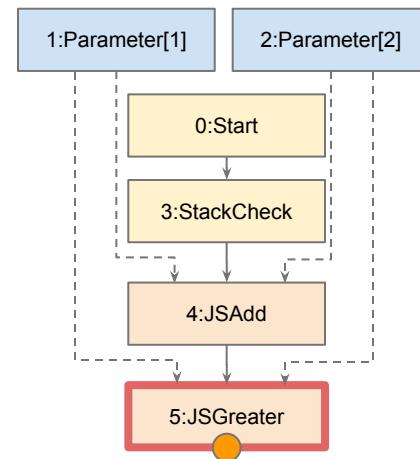
Parameters



Registers



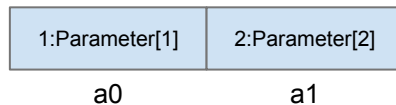
Accumulator



Building a graph

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0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
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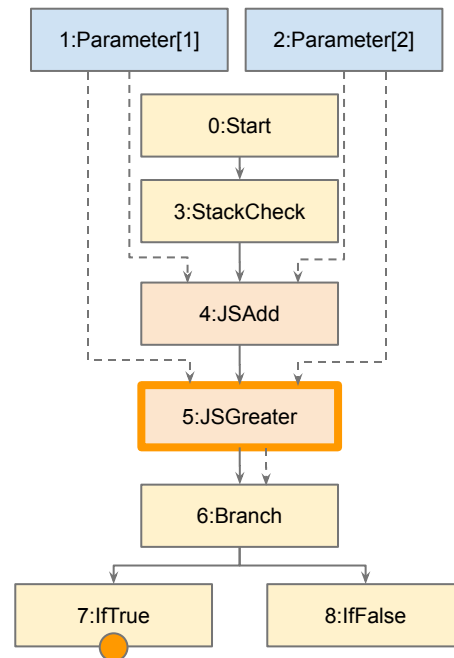
Parameters



Registers



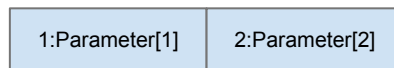
Accumulator



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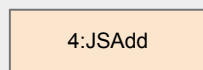
Parameters



a0

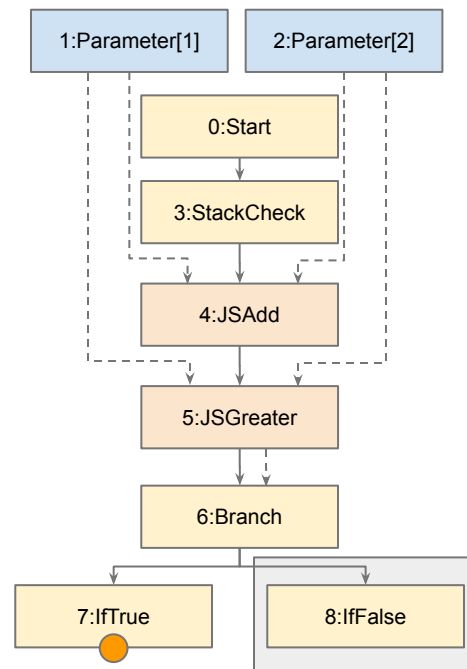
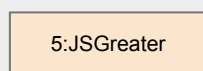
a1

Registers



r0

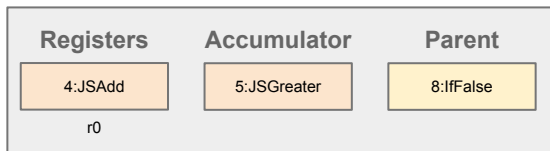
Accumulator



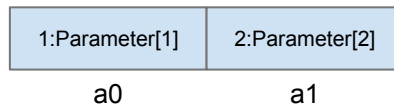
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

22:



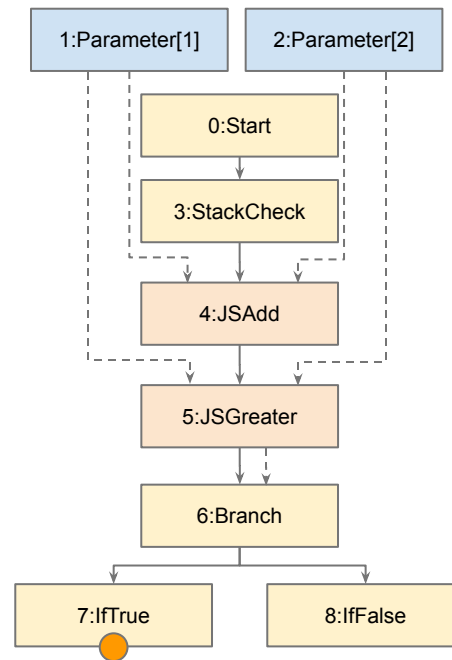
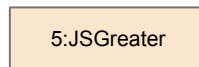
Parameters



Registers



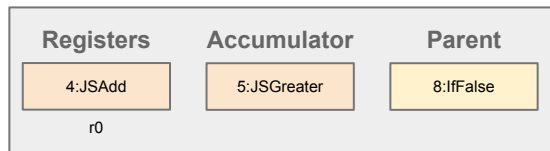
Accumulator



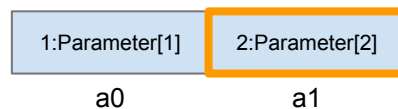
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02   Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

22:



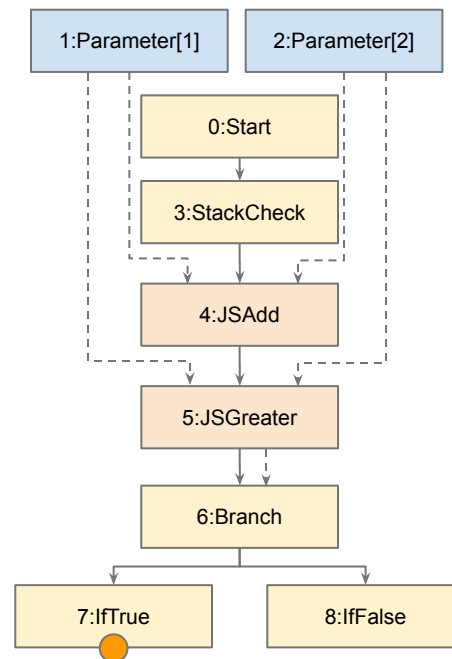
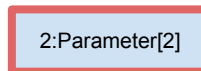
Parameters



Registers



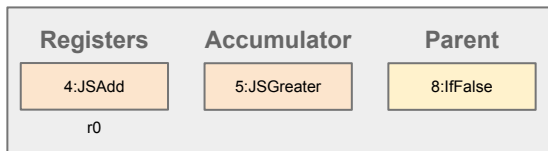
Accumulator



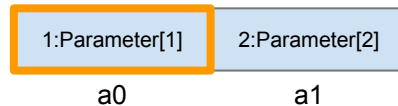
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

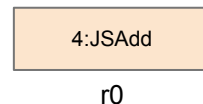
22:



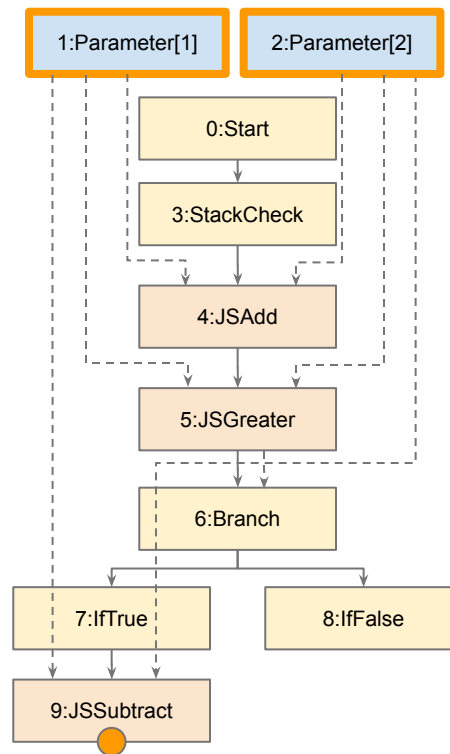
Parameters



Registers



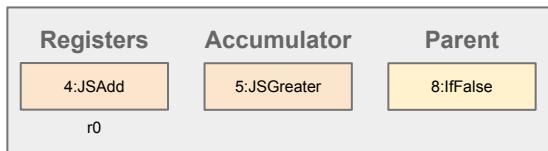
Accumulator



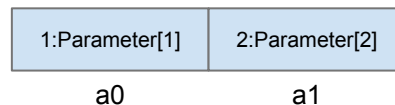
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09    JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

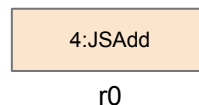
22:



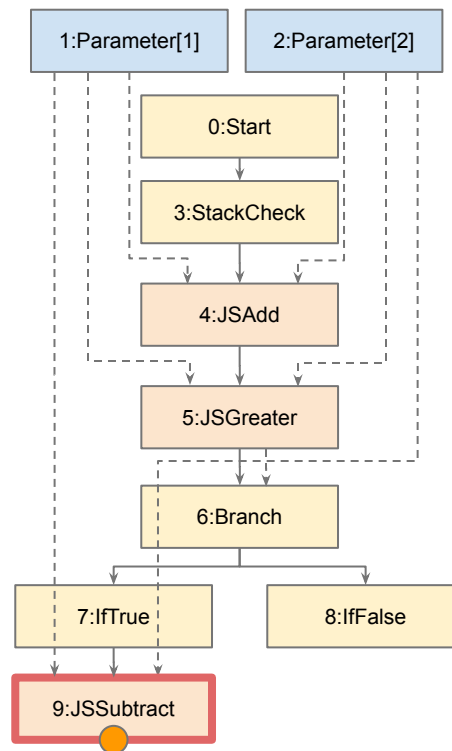
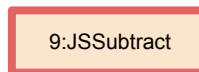
Parameters



Registers



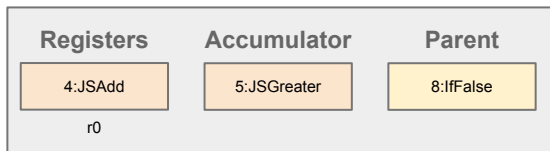
Accumulator



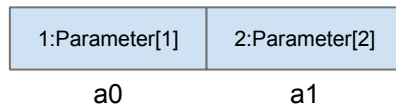
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

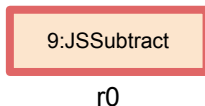
22:



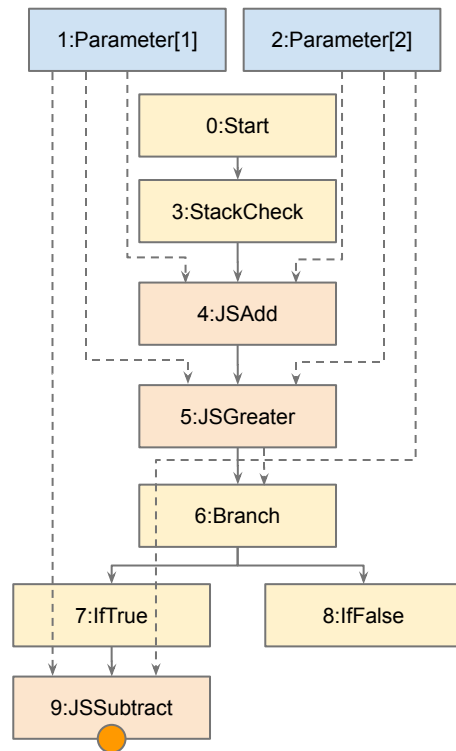
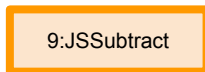
Parameters



Registers



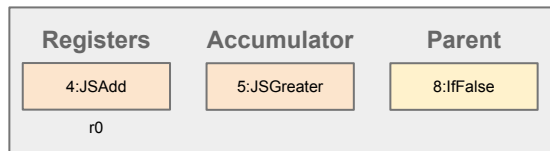
Accumulator



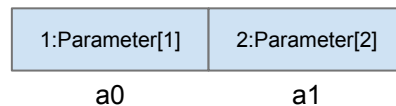
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

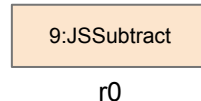
22:



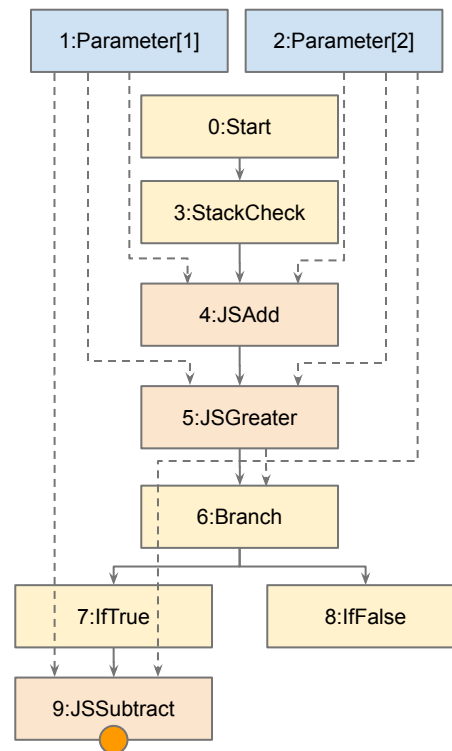
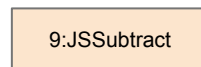
Parameters



Registers



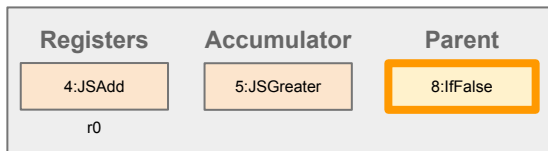
Accumulator



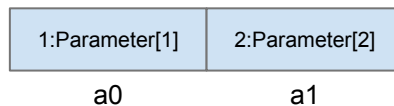
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10: 4f 03 03 TestGreaterThan a0, [3]
13: 74 09    JumpIfFalse [9] (@22)
15: 1c 02    Ldar a1
17: 29 03 04 Sub a0, [4]
20: 1d fa    Star r0
22: 1c fa    Ldar r0
24: 81      Return
```

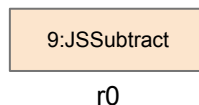
22:



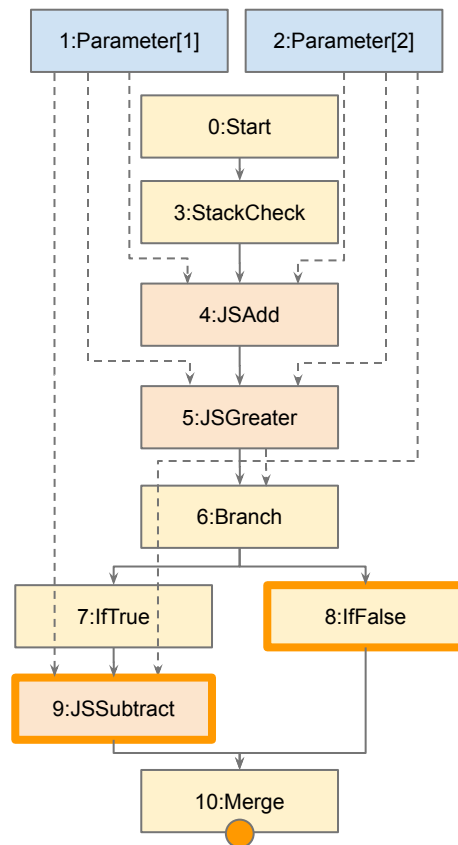
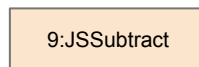
Parameters



Registers



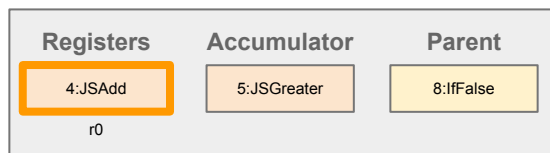
Accumulator



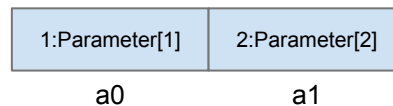
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

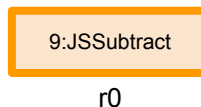
22:



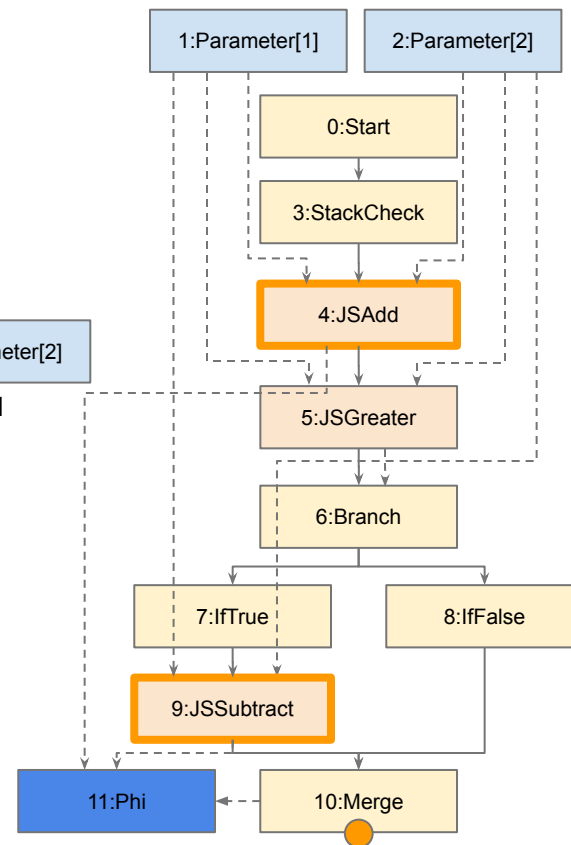
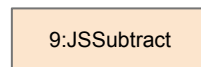
Parameters



Registers



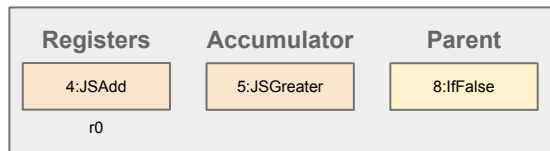
Accumulator



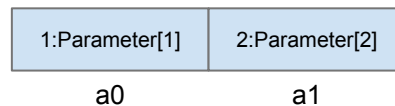
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

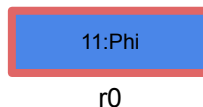
22:



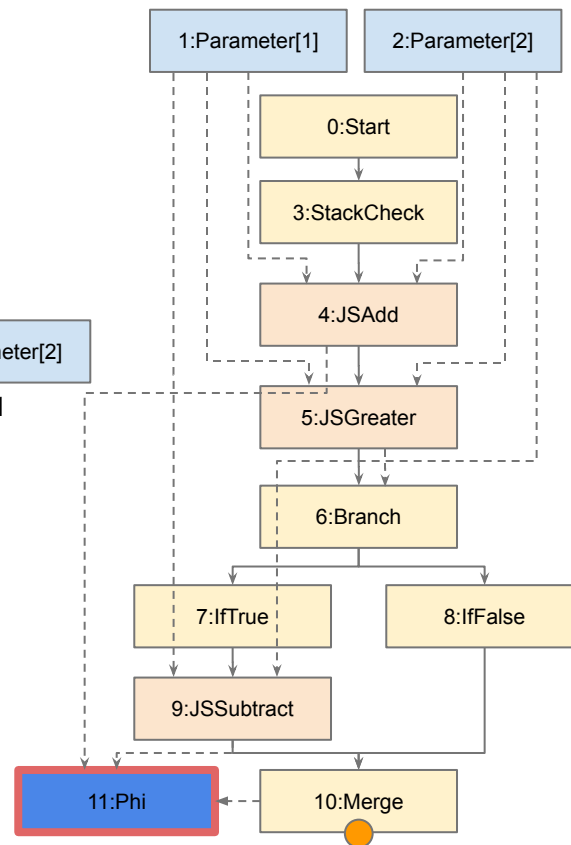
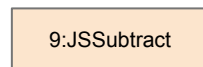
Parameters



Registers



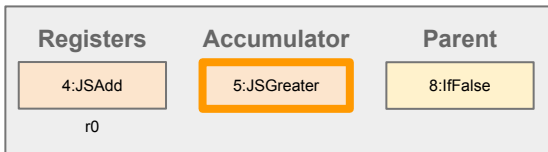
Accumulator



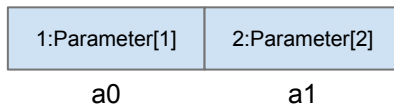
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

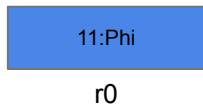
22:



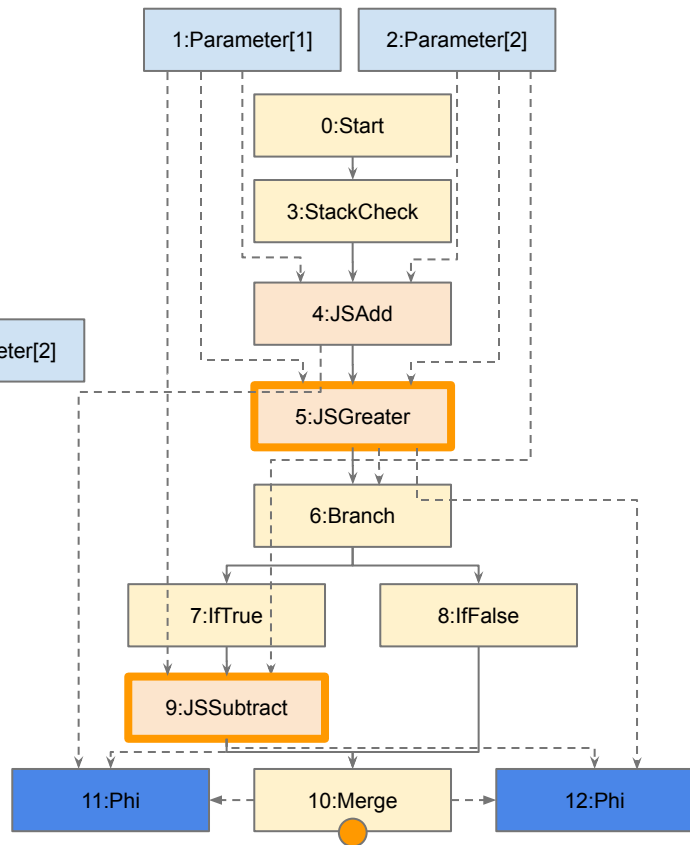
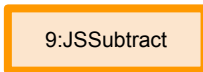
Parameters



Registers



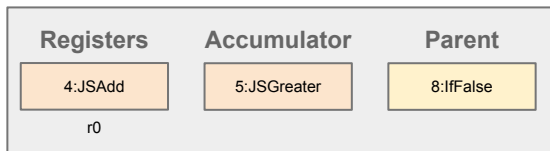
Accumulator



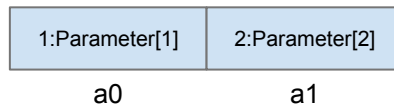
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

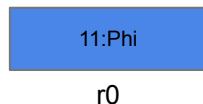
22:



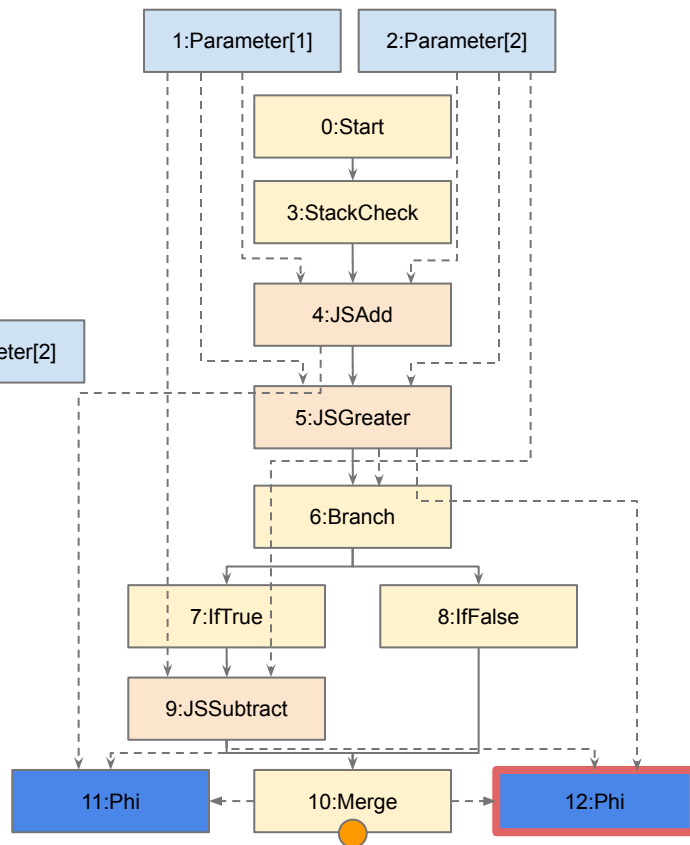
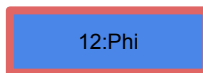
Parameters



Registers



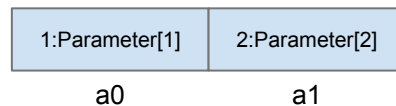
Accumulator



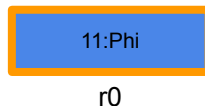
Building a graph

0	: 7d	StackCheck
1	: 1c 02	Ldar a1
3	: 28 03 02	Add a0, [2]
6	: 1d fa	Star r0
8	: 1c 02	Ldar a1
10	: 4f 03 03	TestGreaterThan a0, [3]
13	: 74 09	JumpIfFalse [9] (@22)
15	: 1c 02	Ldar a1
17	: 29 03 04	Sub a0, [4]
20	: 1d fa	Star r0
22	: 1c fa	Ldar r0
24	: 81	Return

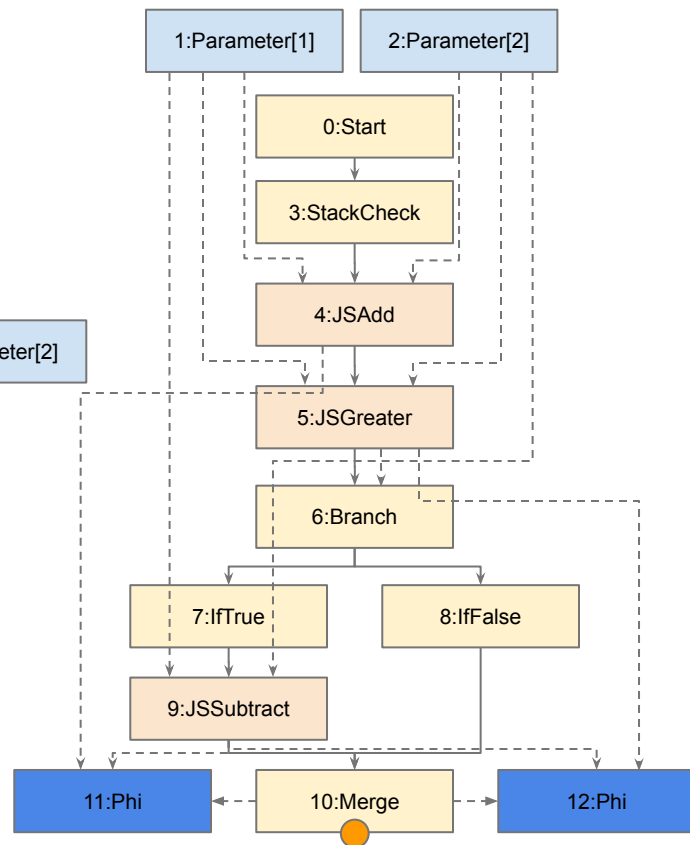
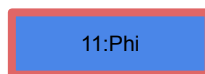
Parameters



Registers



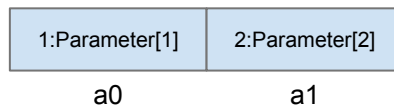
Accumulator



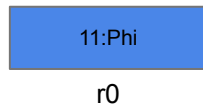
Building a graph

0 : 7d	StackCheck
1 : 1c 02	Ldar a1
3 : 28 03 02	Add a0, [2]
6 : 1d fa	Star r0
8 : 1c 02	Ldar a1
10 : 4f 03 03	TestGreaterThan a0, [3]
13 : 74 09	JumpIfFalse [9] (@22)
15 : 1c 02	Ldar a1
17 : 29 03 04	Sub a0, [4]
20 : 1d fa	Star r0
22 : 1c fa	Ldar r0
24 : 81	Return

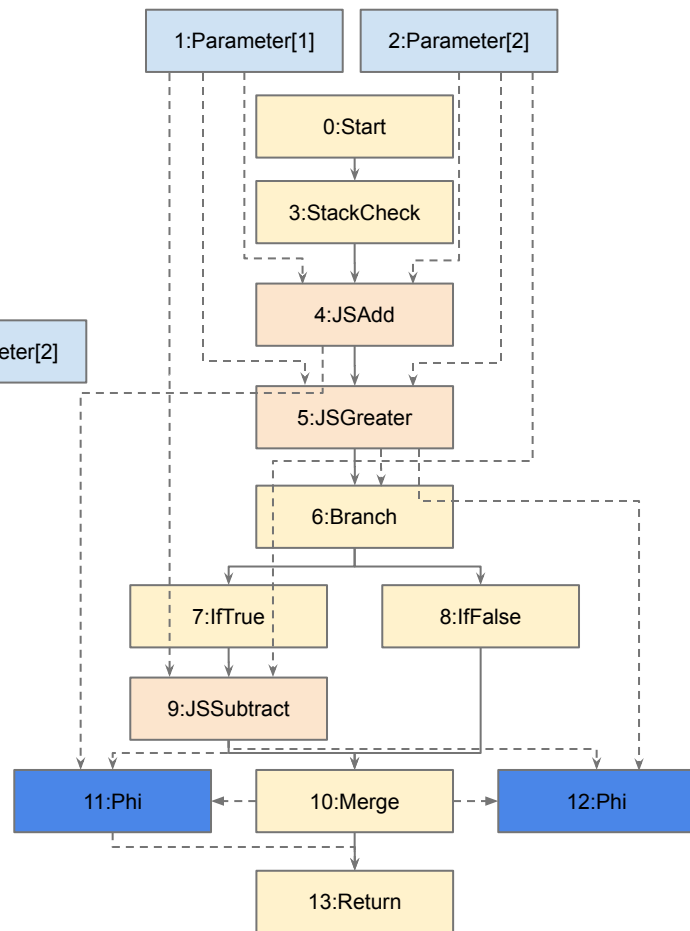
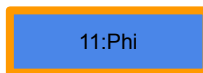
Parameters



Registers



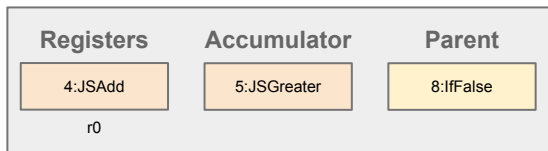
Accumulator



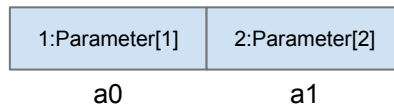
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09    JumpIfFalse [9] (@22)
15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

22:



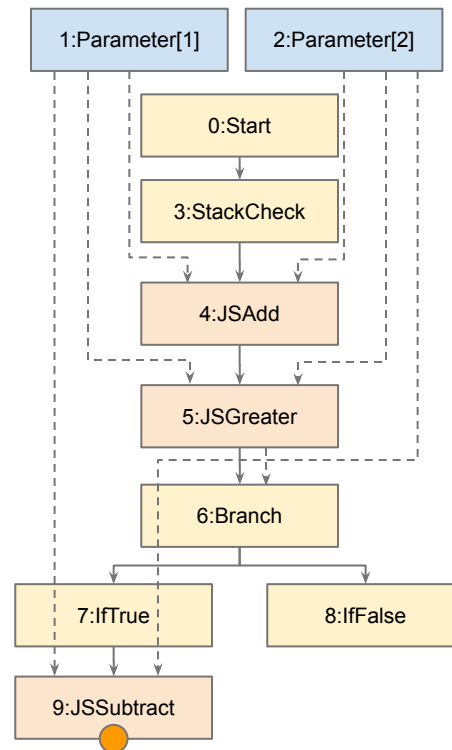
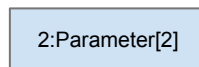
Parameters



Registers



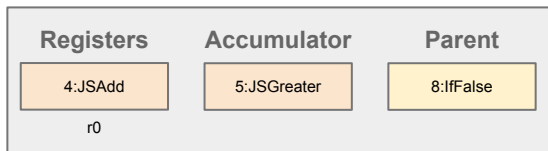
Accumulator



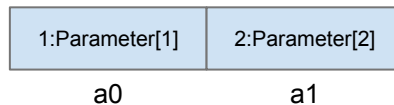
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02   Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa   Star r0
8 : 1c 02   Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02   Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa   Star r0
22 : 1c fa   Ldar r0
24 : 81      Return
```

22:



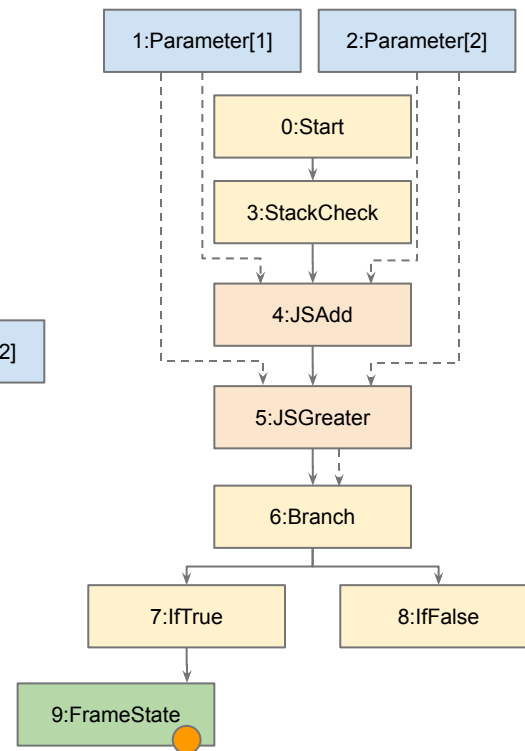
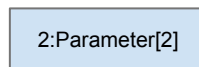
Parameters



Registers



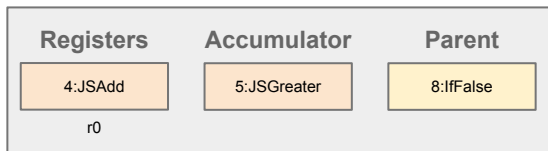
Accumulator



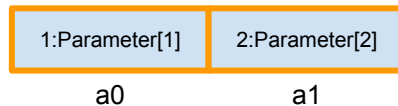
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02   Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa   Star r0
8 : 1c 02   Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
13 : 74 09   JumpIfFalse [9] (@22)
15 : 1c 02   Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa   Star r0
22 : 1c fa   Ldar r0
24 : 81      Return
```

22:



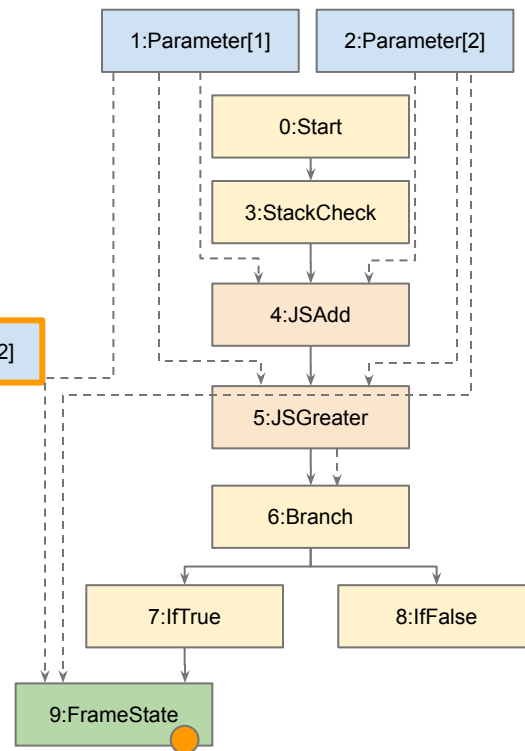
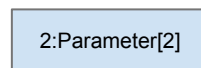
Parameters



Registers



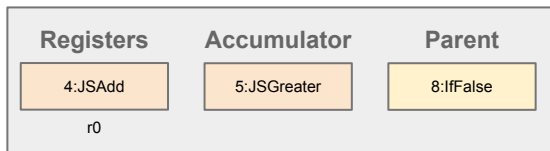
Accumulator



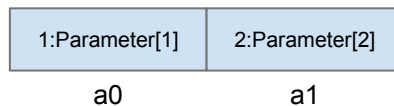
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
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20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

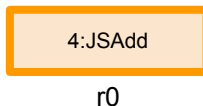
22:



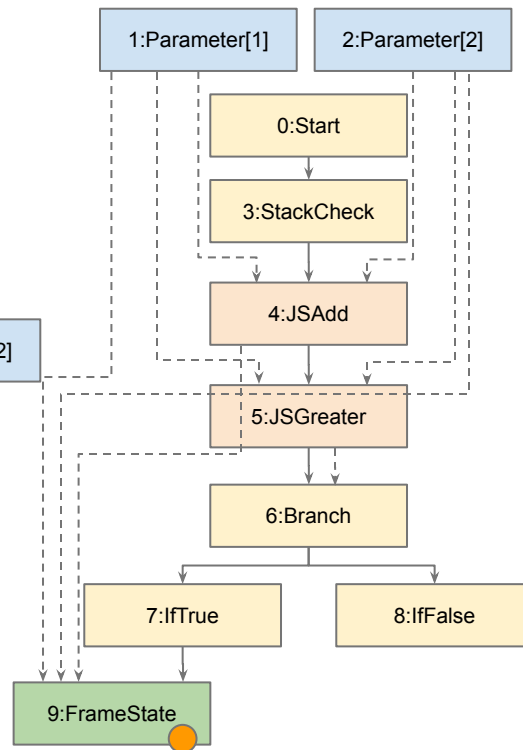
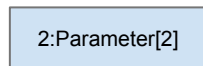
Parameters



Registers



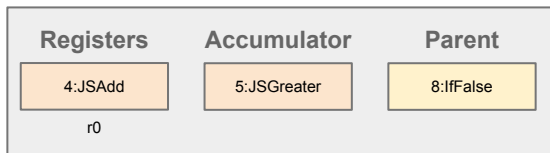
Accumulator



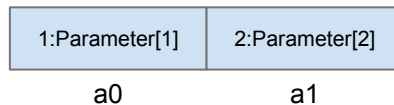
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
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17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
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```

22:



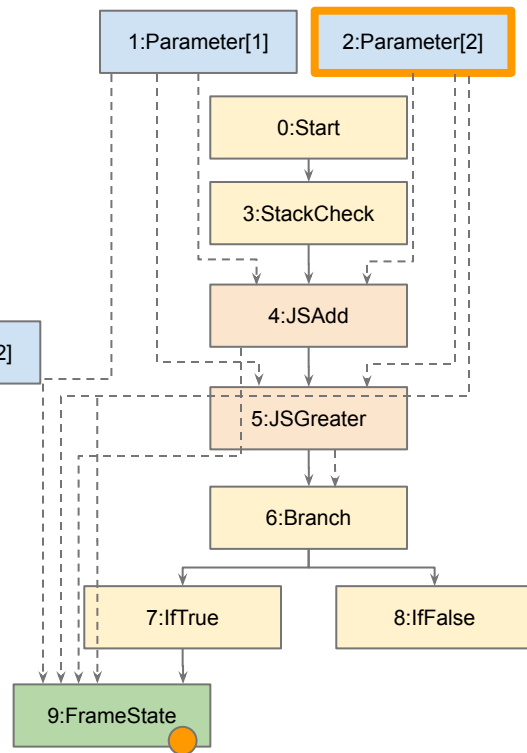
Parameters



Registers



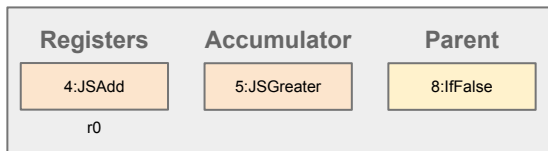
Accumulator



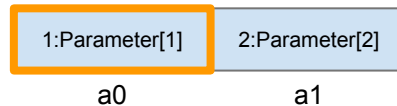
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
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```

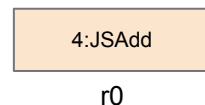
22:



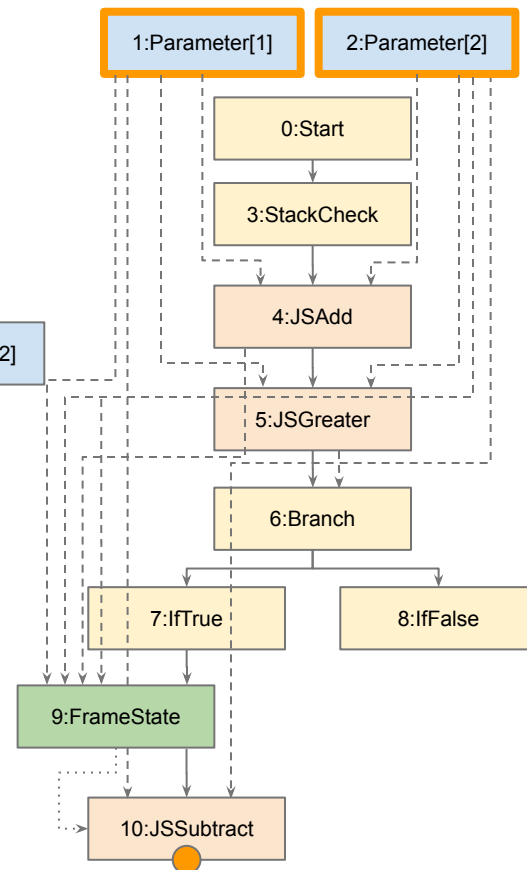
Parameters



Registers



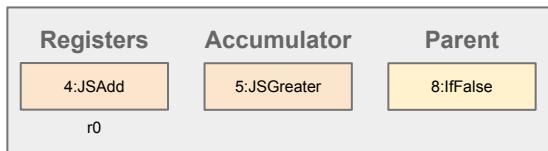
Accumulator



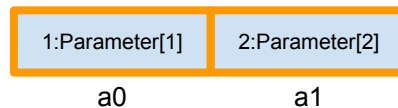
Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
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15 : 1c 02    Ldar a1
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20 : 1d fa    Star r0
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24 : 81      Return
```

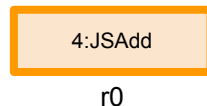
22:



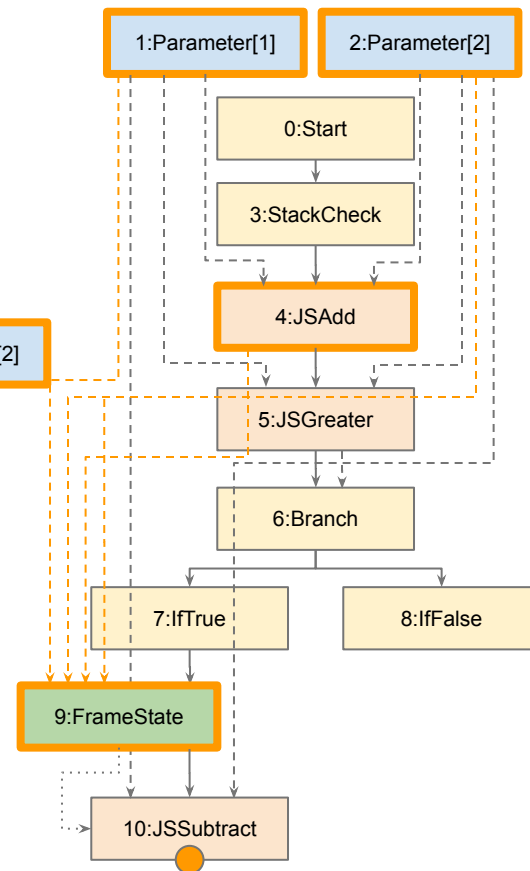
Parameters



Registers



Accumulator



Building a graph

```
0 : 7d      StackCheck
1 : 1c 02    Ldar a1
3 : 28 03 02 Add a0, [2]
6 : 1d fa    Star r0
8 : 1c 02    Ldar a1
10 : 4f 03 03 TestGreaterThan a0, [3]
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15 : 1c 02    Ldar a1
17 : 29 03 04 Sub a0, [4]
20 : 1d fa    Star r0
22 : 1c fa    Ldar r0
24 : 81      Return
```

Parameters

0xfe902ab5	0x1237ab57
a0	a1

Registers

0xba8320fd
r0

Accumulator

0x1237ab57

Building a graph

```
0 : 7d      StackCheck
1 : 1c 02   Ldar a1
3 : 28 03 02 Add a0, [2]
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24 : 81      Return
```

Parameters

0xfe902ab5	0x1237ab57
a0	a1

Registers

0xba8320fd
r0

Accumulator

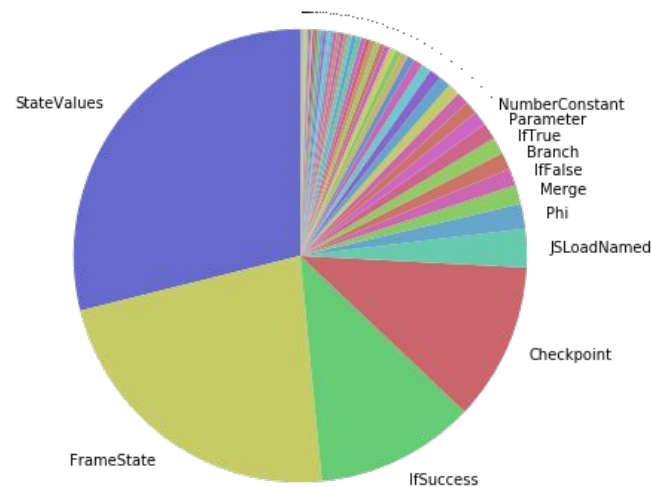
0xad80b1cf

Bytecode Restrictions to Simplifying Graph Creation

- Always deopt to a bytecode
- Well-scoped basic blocks
 - Exception handlers cover a single linear range of bytecode
- No irreducible control flow
- Single backwards-branch to loop header
- Registers in loop-closed form

Static analysis of bytecode

- Pre-analyze bytecode before building graph
 - Liveness analysis (for deoptimisation frame states)
 - Loop assignment analysis (for loopphis)
- Don't generate unnecessary nodes
 - Avoid memory overhead (40+ bytes per node)
 - Avoid graph traversals

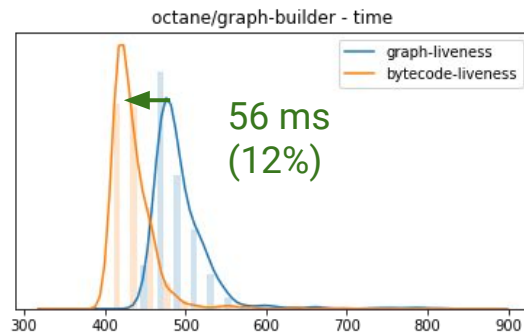
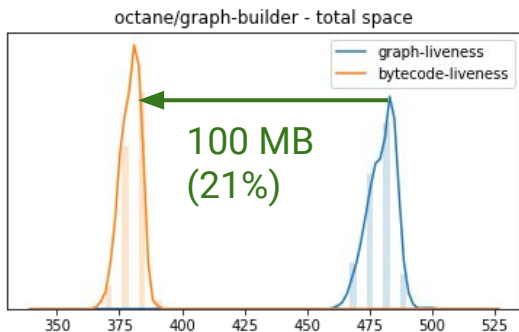


Liveness analysis

- Previously iterated traversal over basic blocks
 - Create liveness maps and state value nodes during graph building
 - Re-create state value nodes based on liveness afterward
- Now iterated passes over bytecode array
 - State value nodes created only once

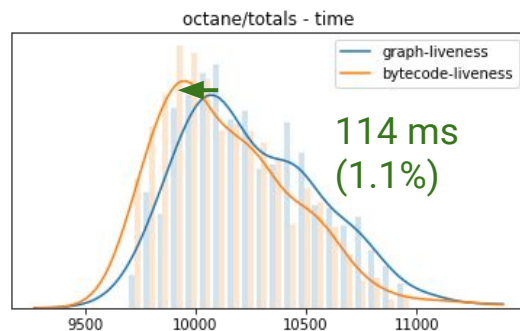
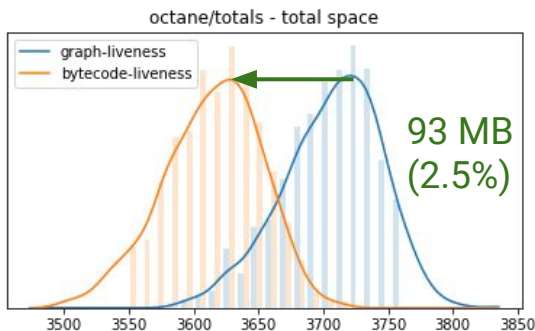
Liveness analysis

- Previously iterated traversal over basic blocks
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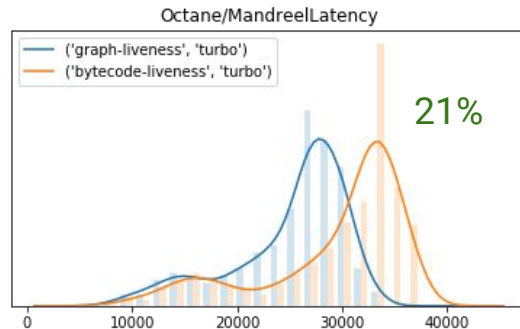
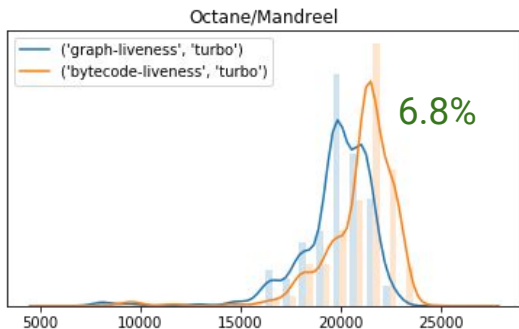
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Burning away complex control (Generators)

- Javascript Generators can `yield` expressions at arbitrary points
 - Can introduce irreducible control flow
 - Solution: transform into switch statements on hidden token in prologue and loop headers
 - Result: Turbofan doesn't need to know anything about generator control flow

Burning away complex control (Generators)

```
function* f() {  
  var i = 0;  
  while (true) {  
    yield i++;  
  }  
}
```



```
function f(hidden_token) {  
  switch(hidden_token)  
    case %normal%: break;  
    case %resume%: goto loop;  
  var i = 0;  
loop:  
  switch(hidden_token)  
    case %normal%: break;  
    case %resume%: goto resume;  
  hidden_token = %resume%;  
  return i++;  
resume:  
  hidden_token = %normal%;  
  goto loop;  
}
```

Burning away complex control (try-finally)

- try-finally exception handlers
 - Exit differently depending on what triggered the finally block (fall-through, return or throw)
 - Solution: switch statement at end of finally block
 - Result: Turbofan doesn't need to know anything about try-finally control flow

Burning away complex control (try-finally)

```
try {  
    if a() return;  
} finally {  
    b();  
}
```



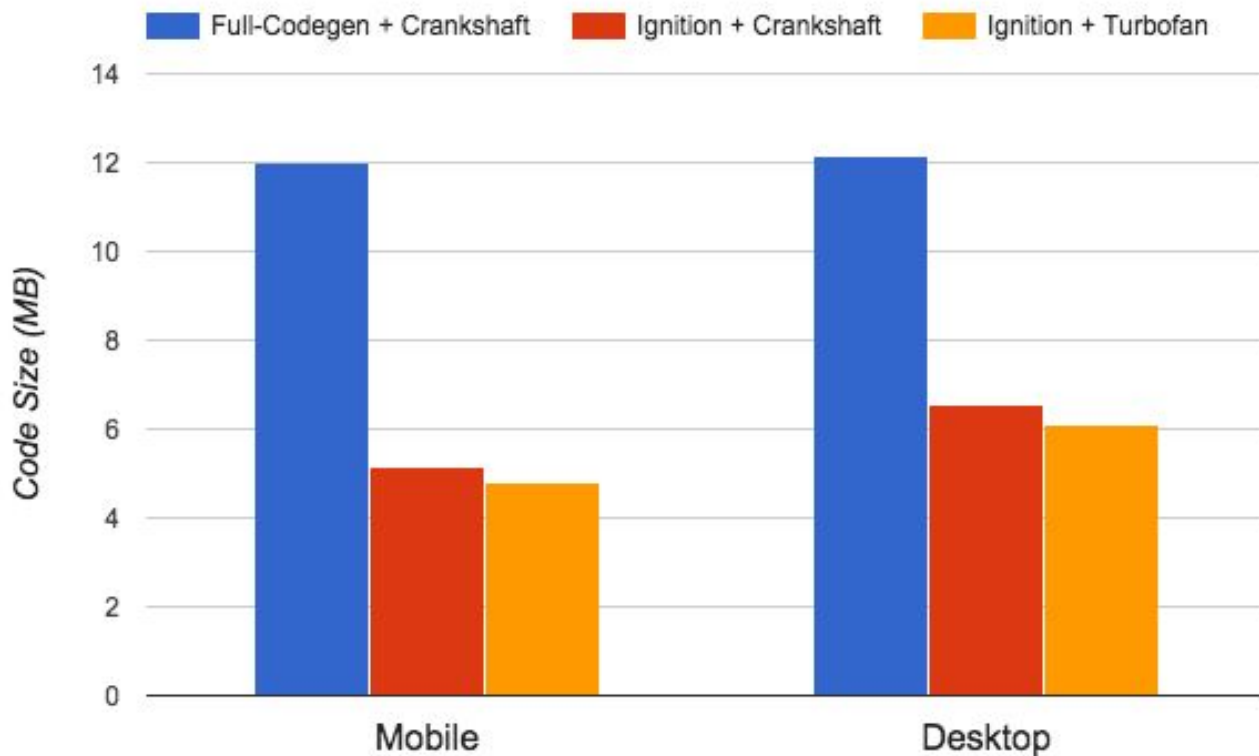
```
try:  
    if a() {  
        finally_token = %return%;  
        goto finally;  
    }  
    finally_token = %fallthrough%;  
    goto finally;
```

```
throw_handler:  
    finally_token = %throw%;
```

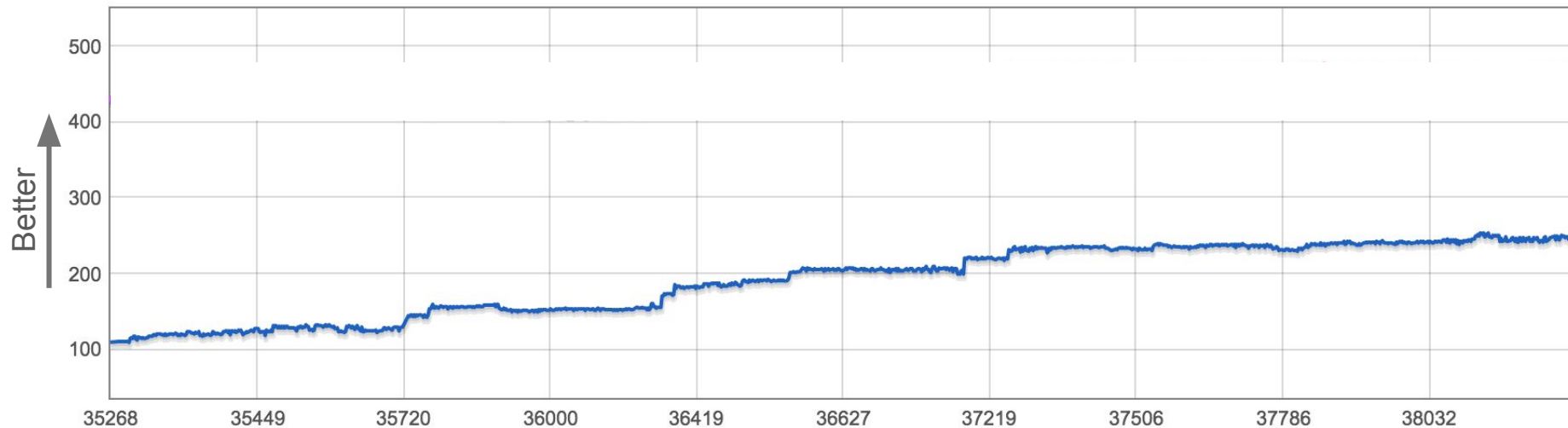
```
finally:  
    b();  
    switch(finally_token)  
        case %return%: return;  
        case %throw%: rethrow();  
        case %fallthrough%: break;
```

Performance Results

Code Memory Usage (Real Websites)

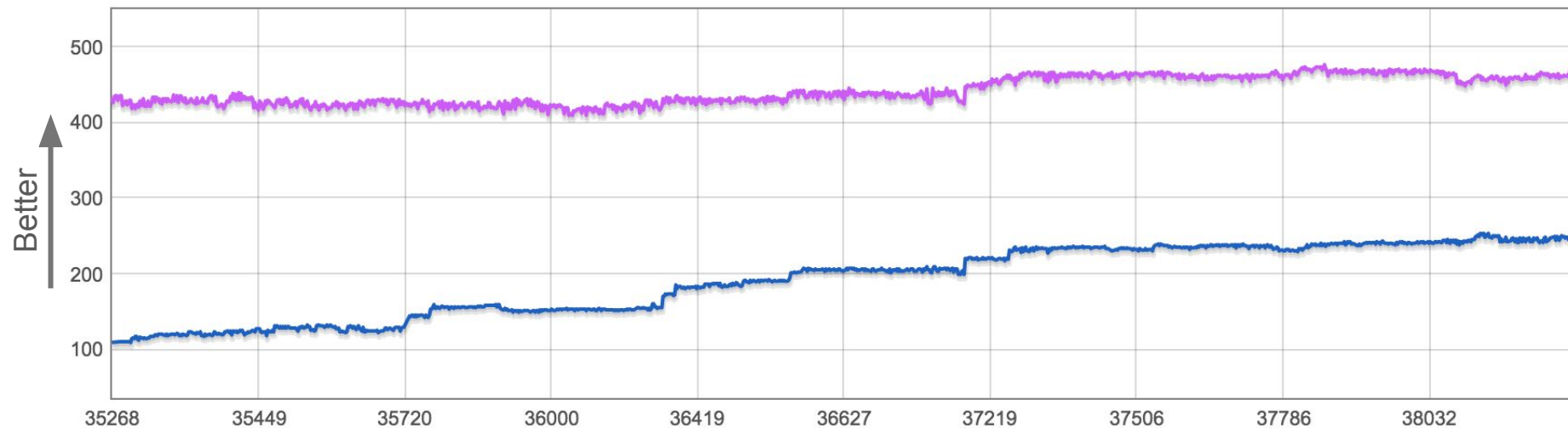


Ignition vs Full-Codegen



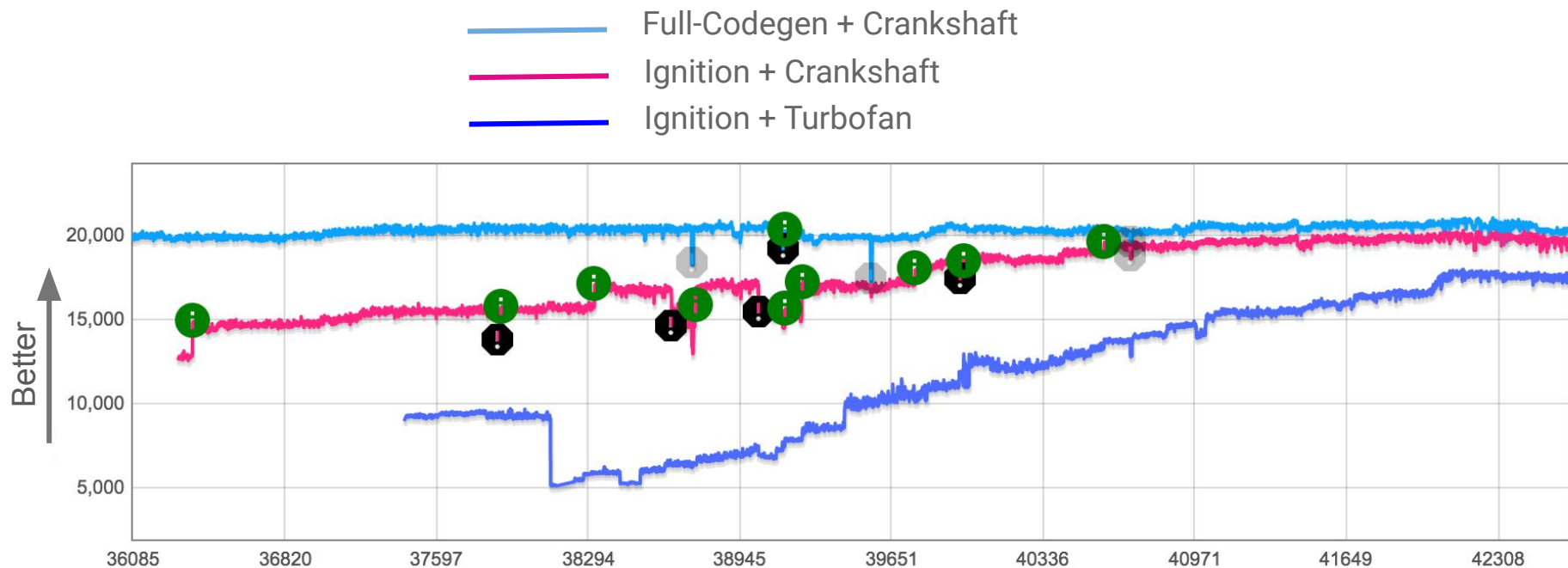
Octane (Nexus 5)
Crankshaft and TurboFan disabled

Ignition vs Full-Codegen

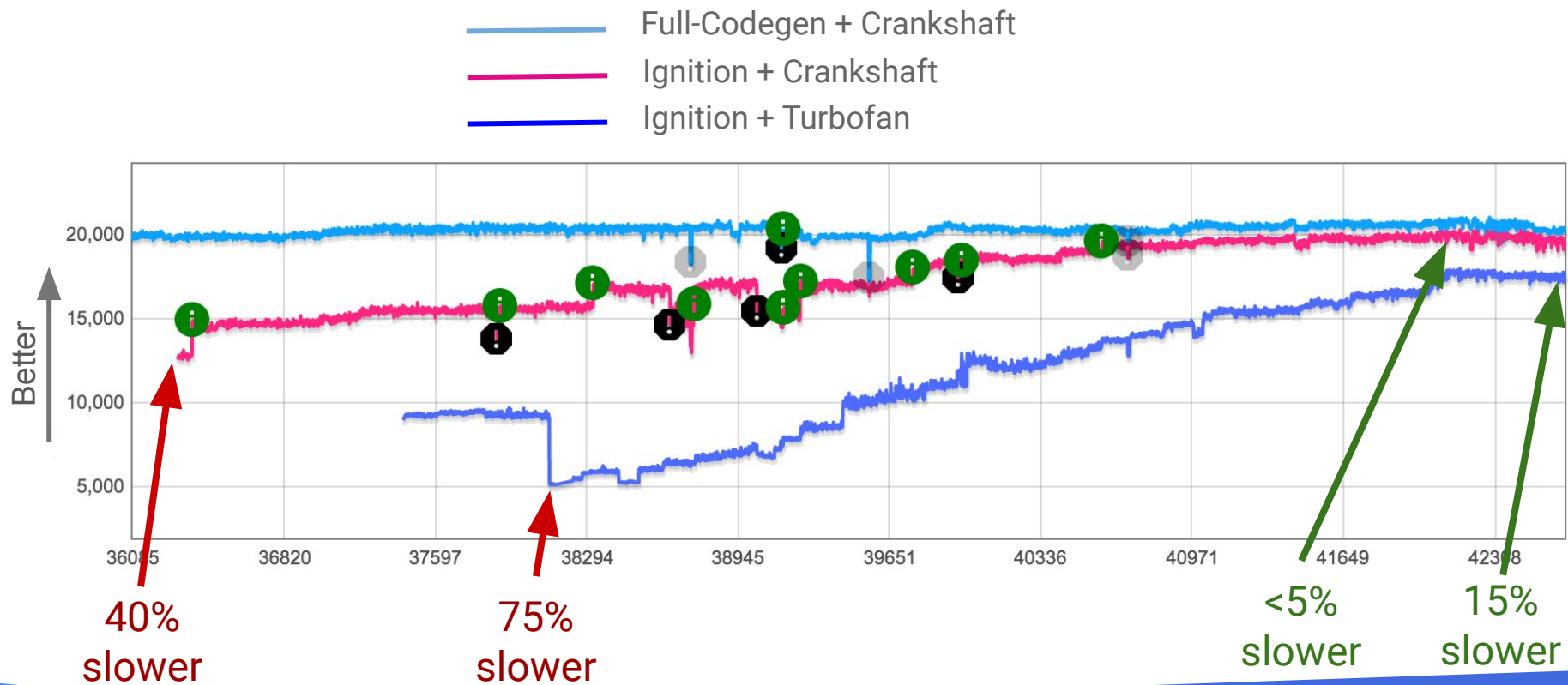


Octane (Nexus 5)
Crankshaft and TurboFan disabled

Octane Performance

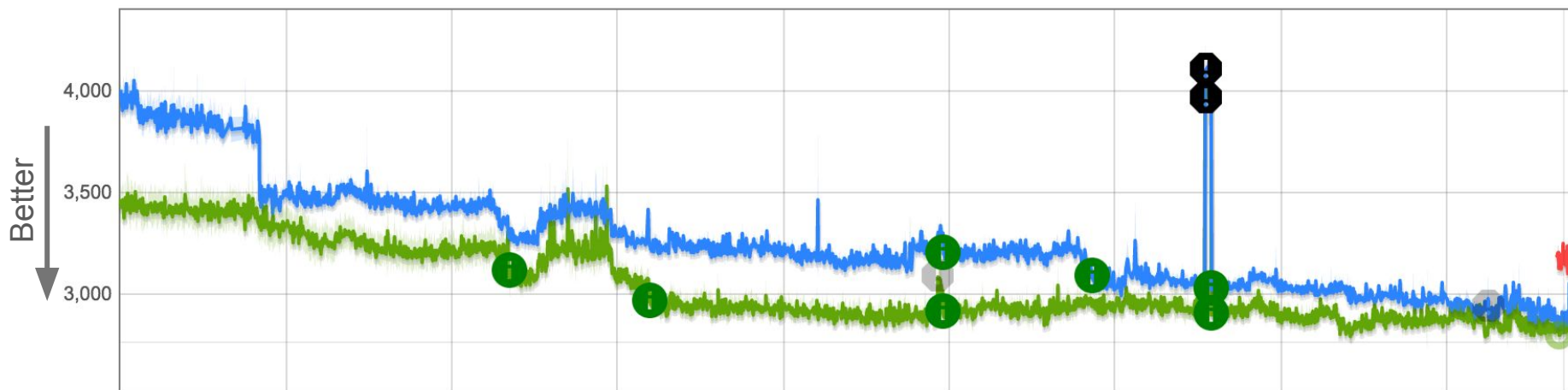


Octane Performance



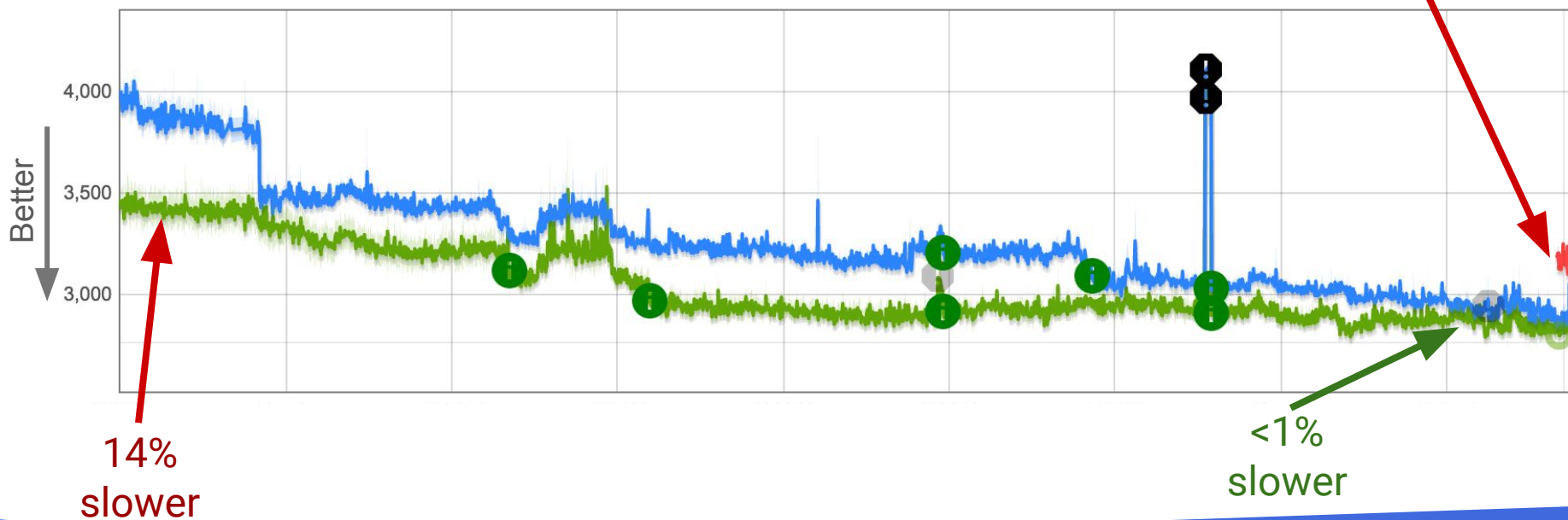
Speedometer Performance

- Full-Codegen + Crankshaft
- Ignition + Crankshaft
- Ignition + Turbofan

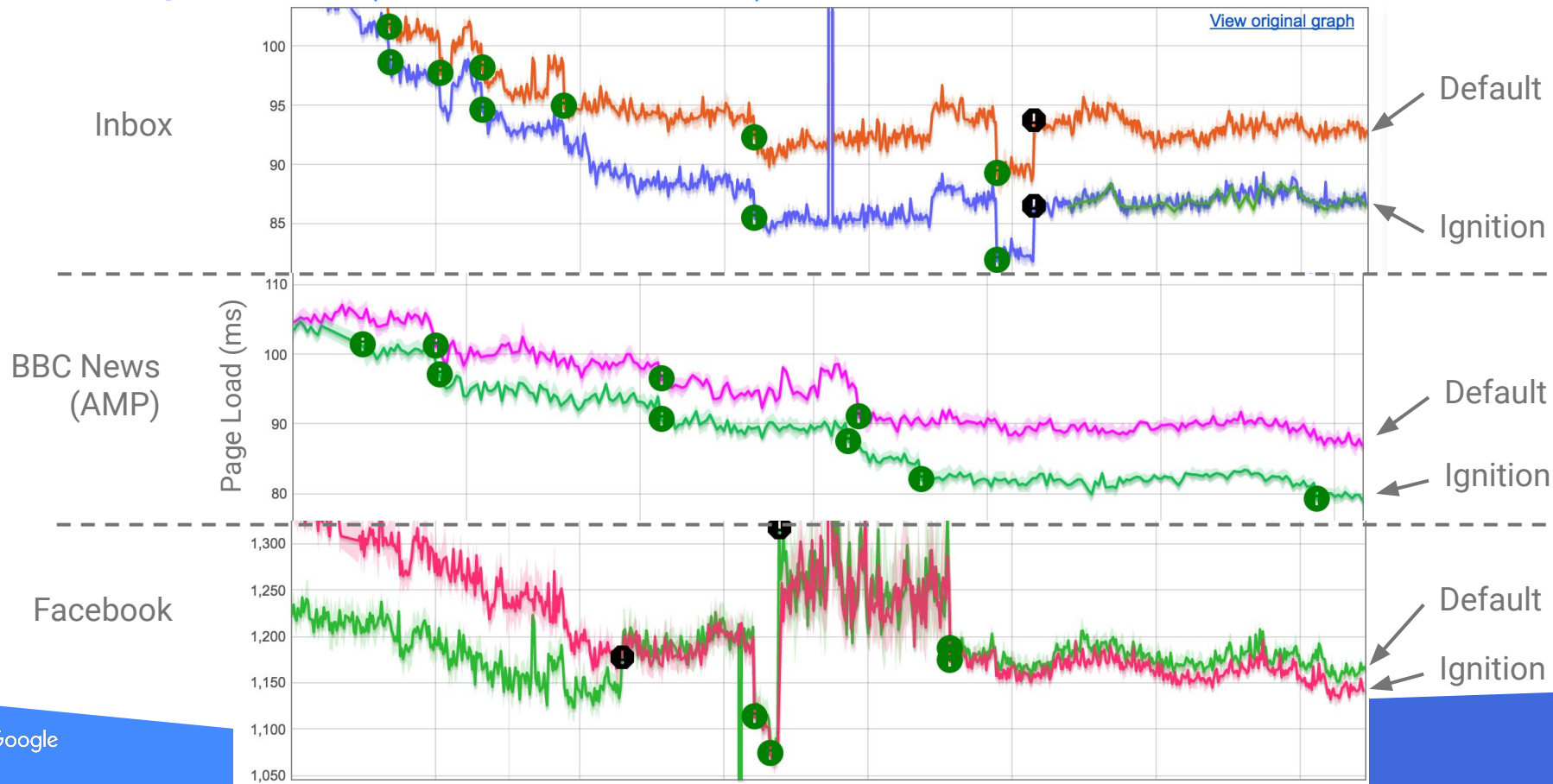


Speedometer Performance

- Full-Codegen + Crankshaft
- Ignition + Crankshaft
- Ignition + Turbofan



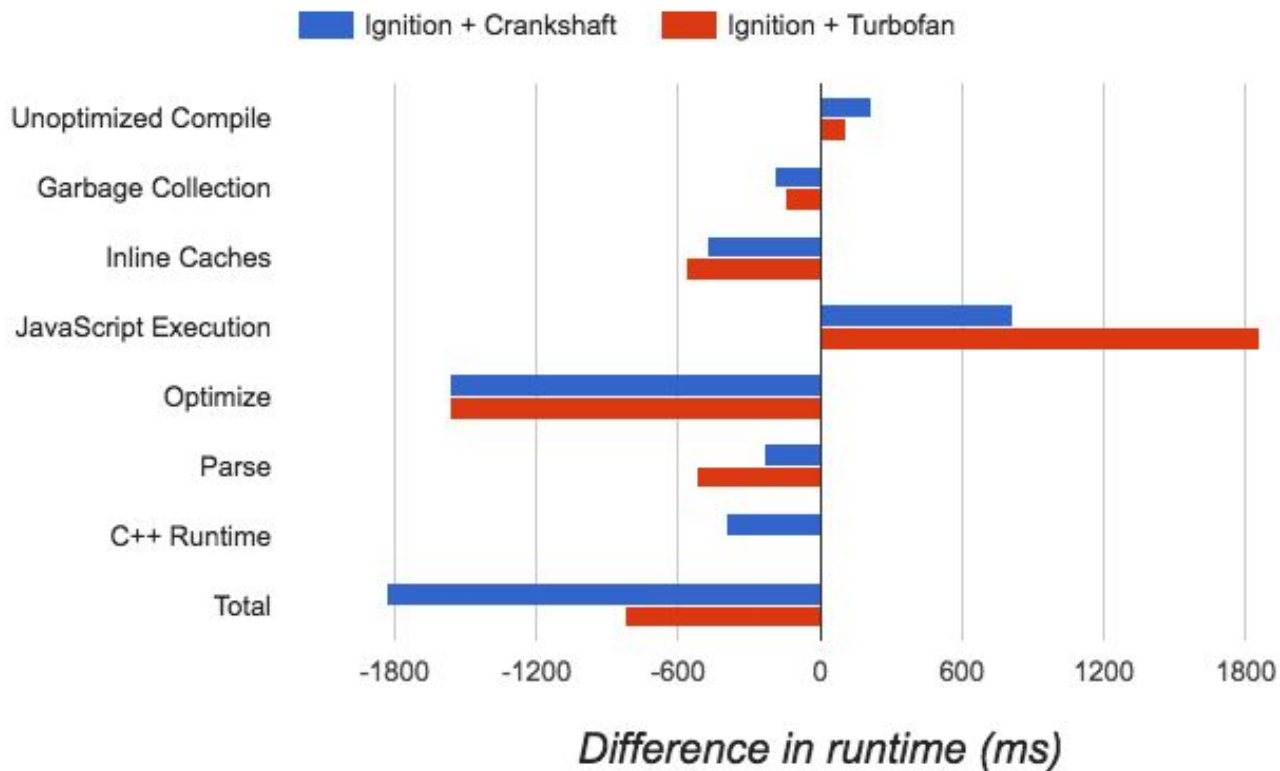
Startup Time (Real Websites)



Startup Time (Real Websites)



Where time is spent (Real Websites)



Summary

- Ignition + Turbofan is the future of V8
- Restrictions on bytecode can simplify optimized graph creation
- Optimizing for real-world exposes different trade-offs