On the Performance of UML State Machine Interpretation at Runtime

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Motivation

Autonomic Systems Engineering

Self-Awareness*
The ability of a system to perceive its own operational state

➠ Requires representation of system behaviour

Homeostasis**
The ability of a system to adapt to environmental changes

➠ Requires support for functional scalability at runtime

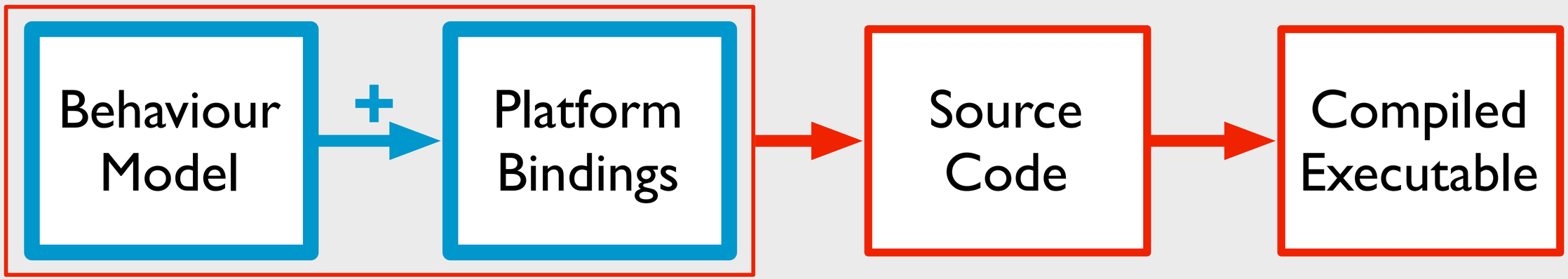
➠ Use of behaviour models + runtime interpretation

* See M. Smirnow et al., *Demystifying Self-awareness of Autonomic Systems*, 2009

** See Chapter 5 in W. R. Ashby, *Design for a Brain*, Chapman & Hall, 1960

Execution of Behaviour Models

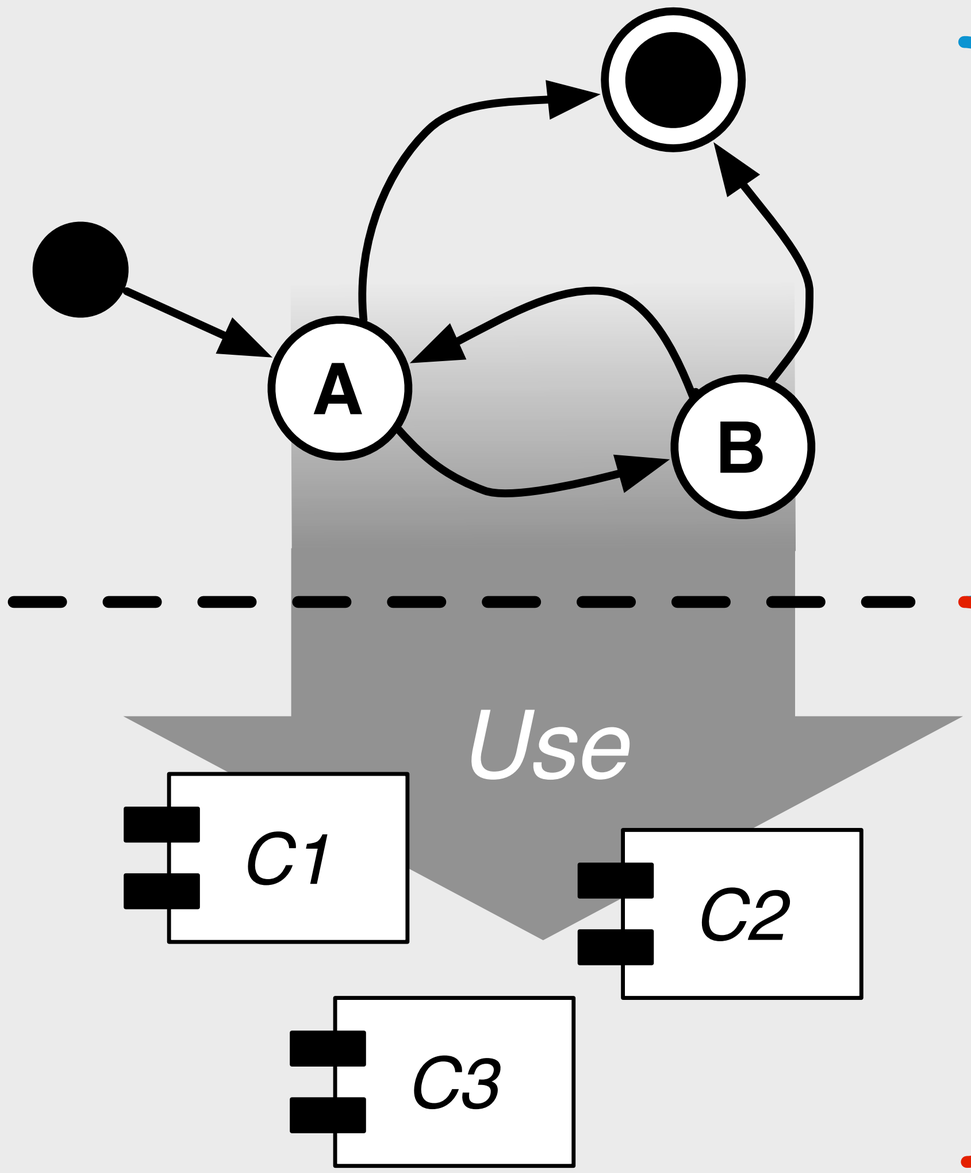
Interpretation is different than compilation



➠ This approach makes runtime adaptation easy

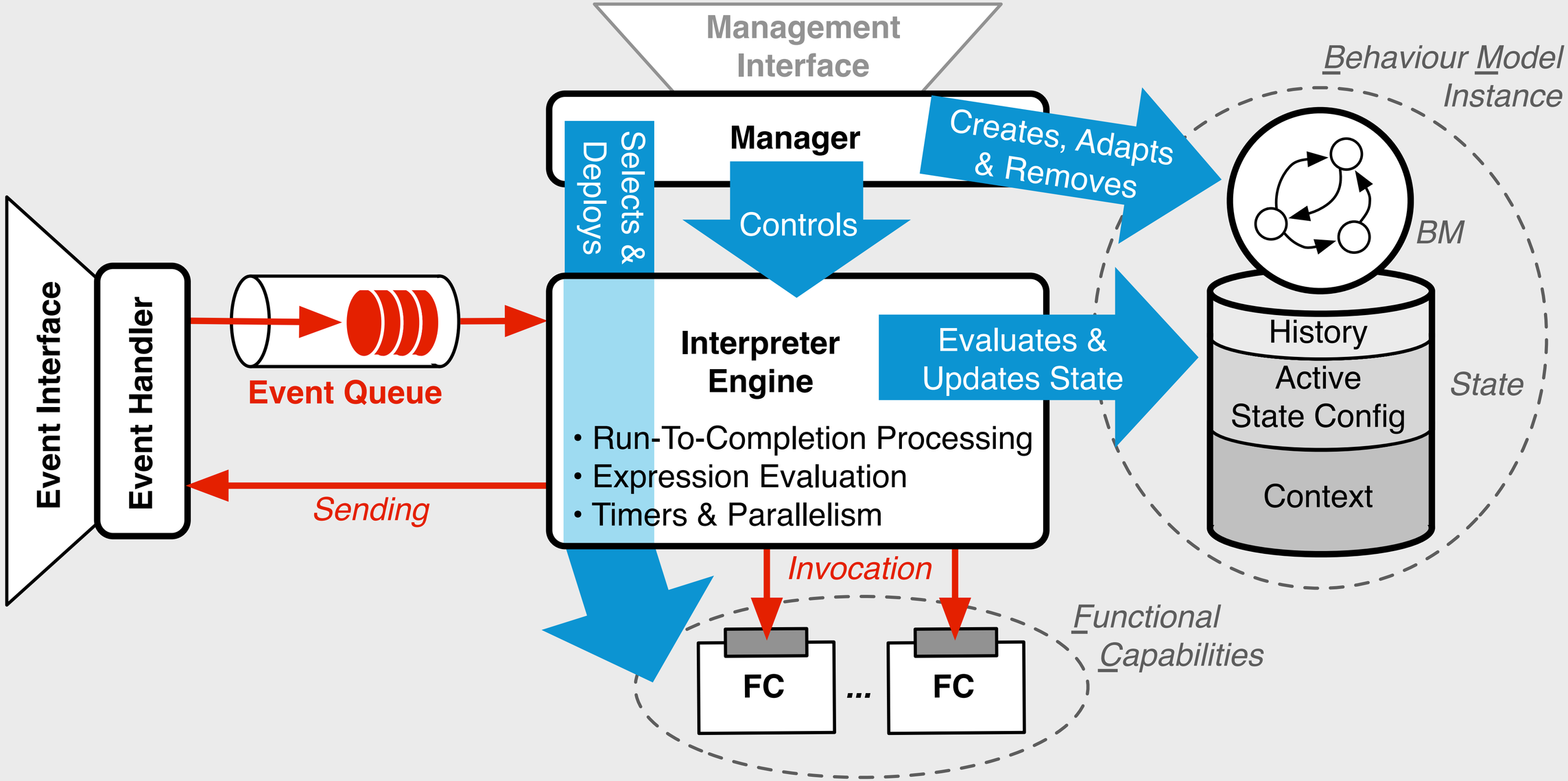
➠ With this approach runtime adaptation is difficult or impossible

Splitting Behaviour Representation



Application logic as model (UML State Machines) — interpreted at runtime

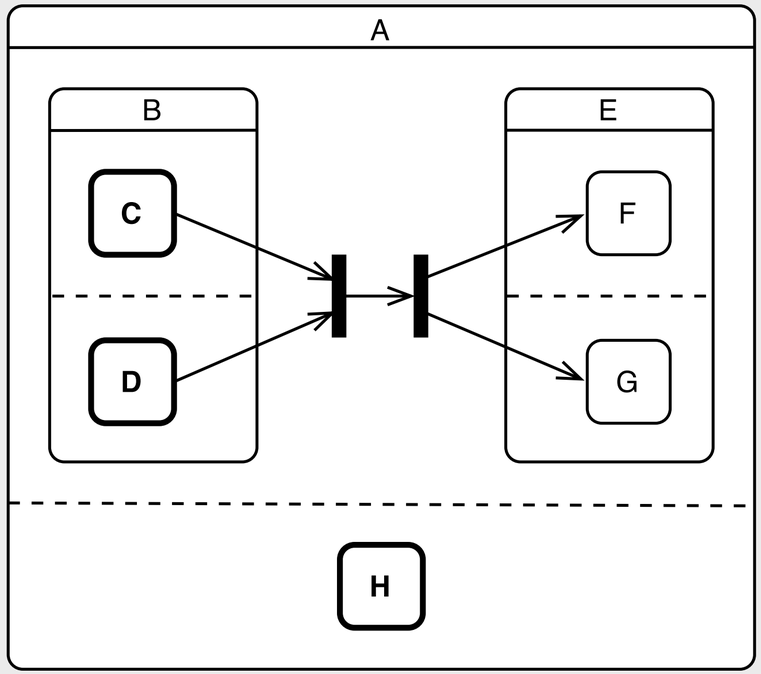
Platform code as static components — dynamic deployment & linkage

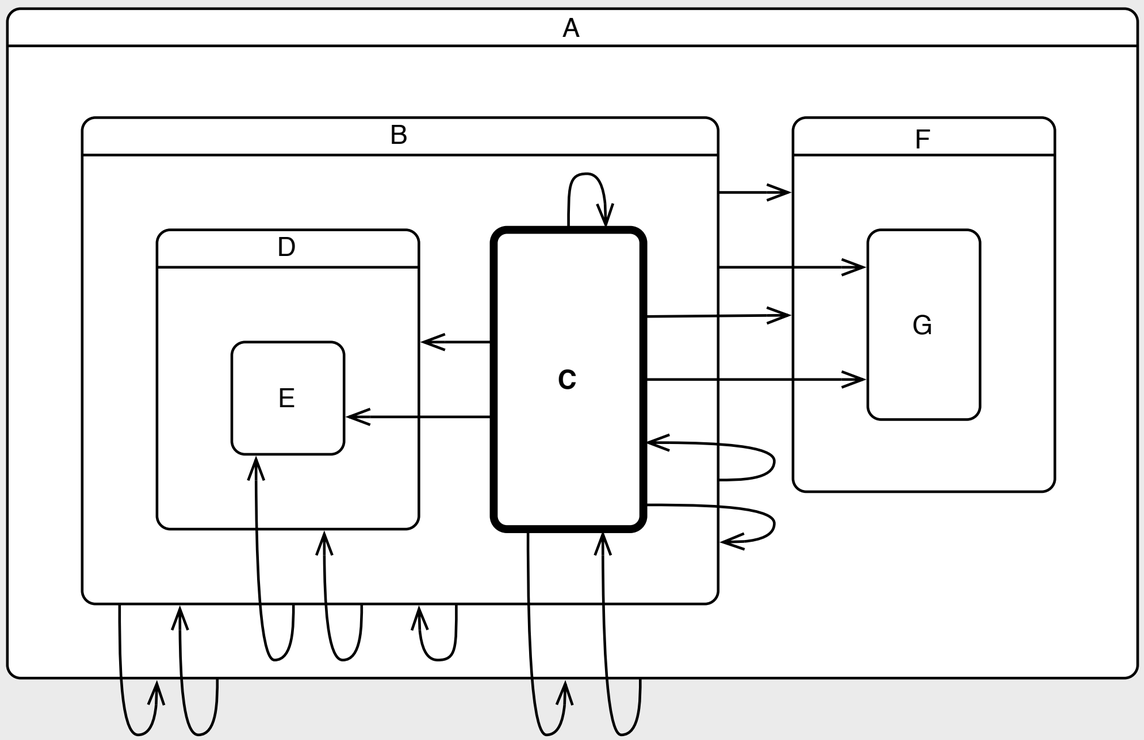


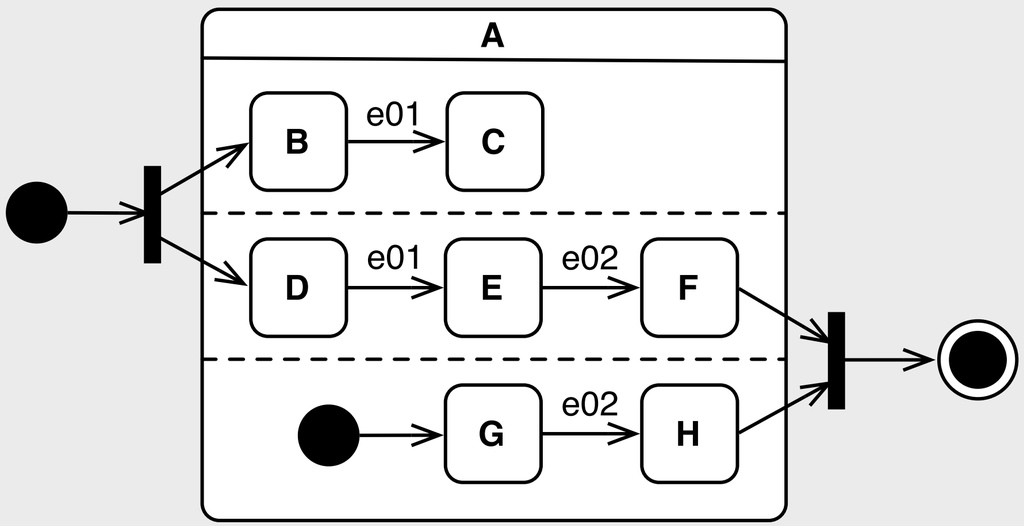
Conceptual Interpreter Architecture

Some Challenges...

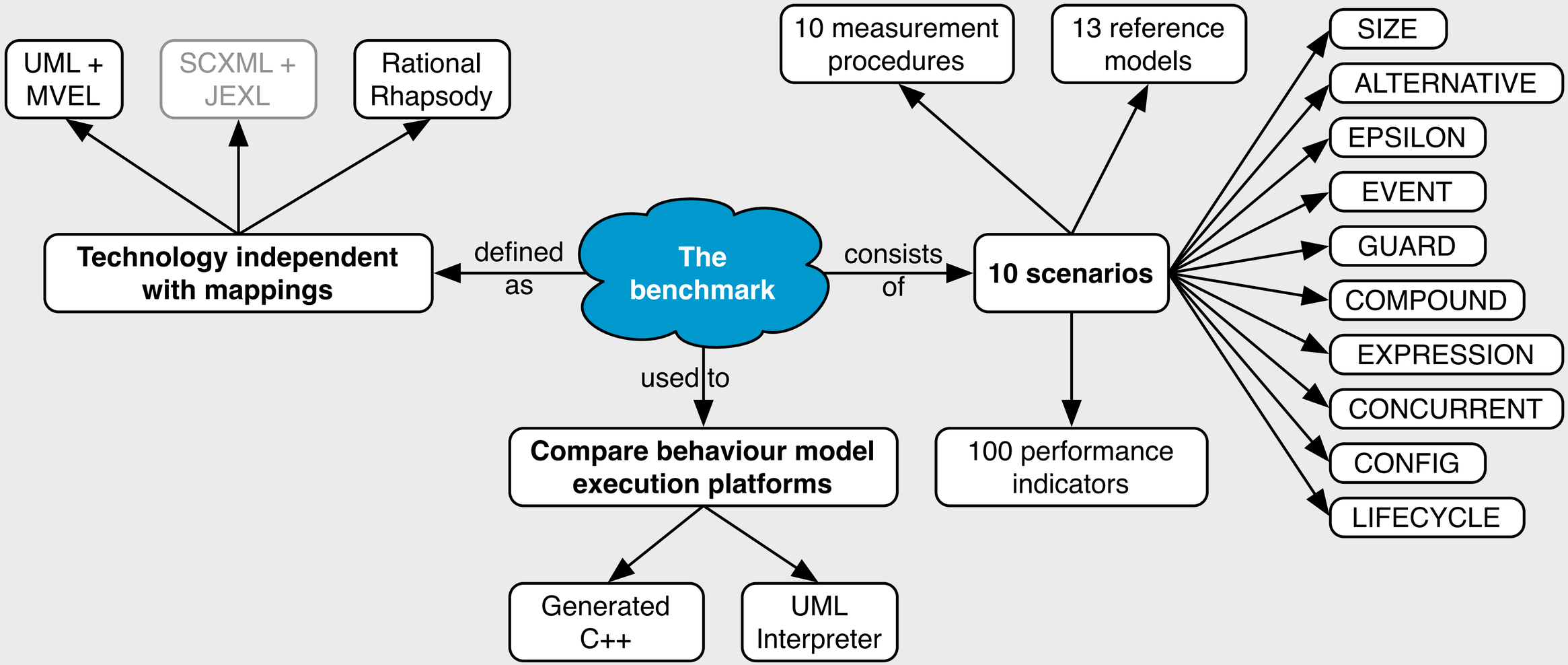
- Processing compound transitions
- Determination of entered/exited states
- Implicit Fork / Join



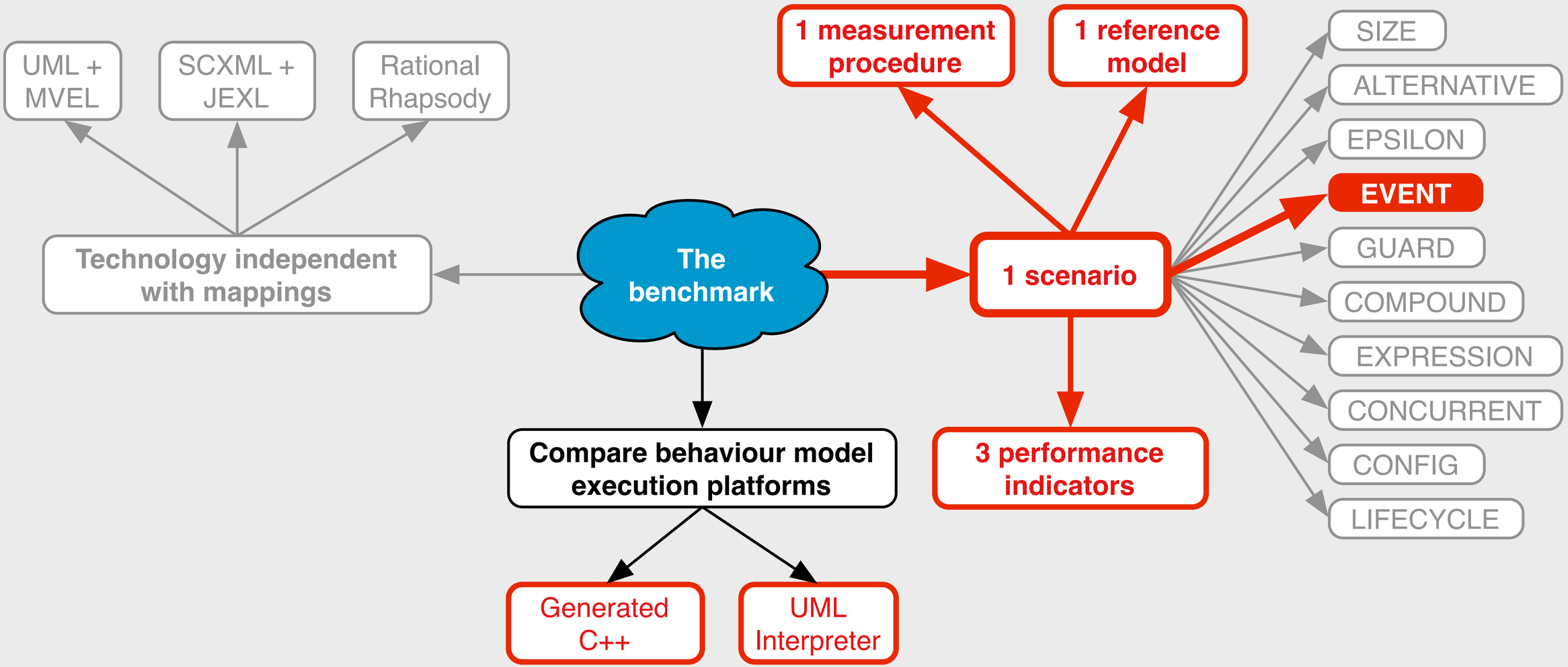




Performance Benchmark

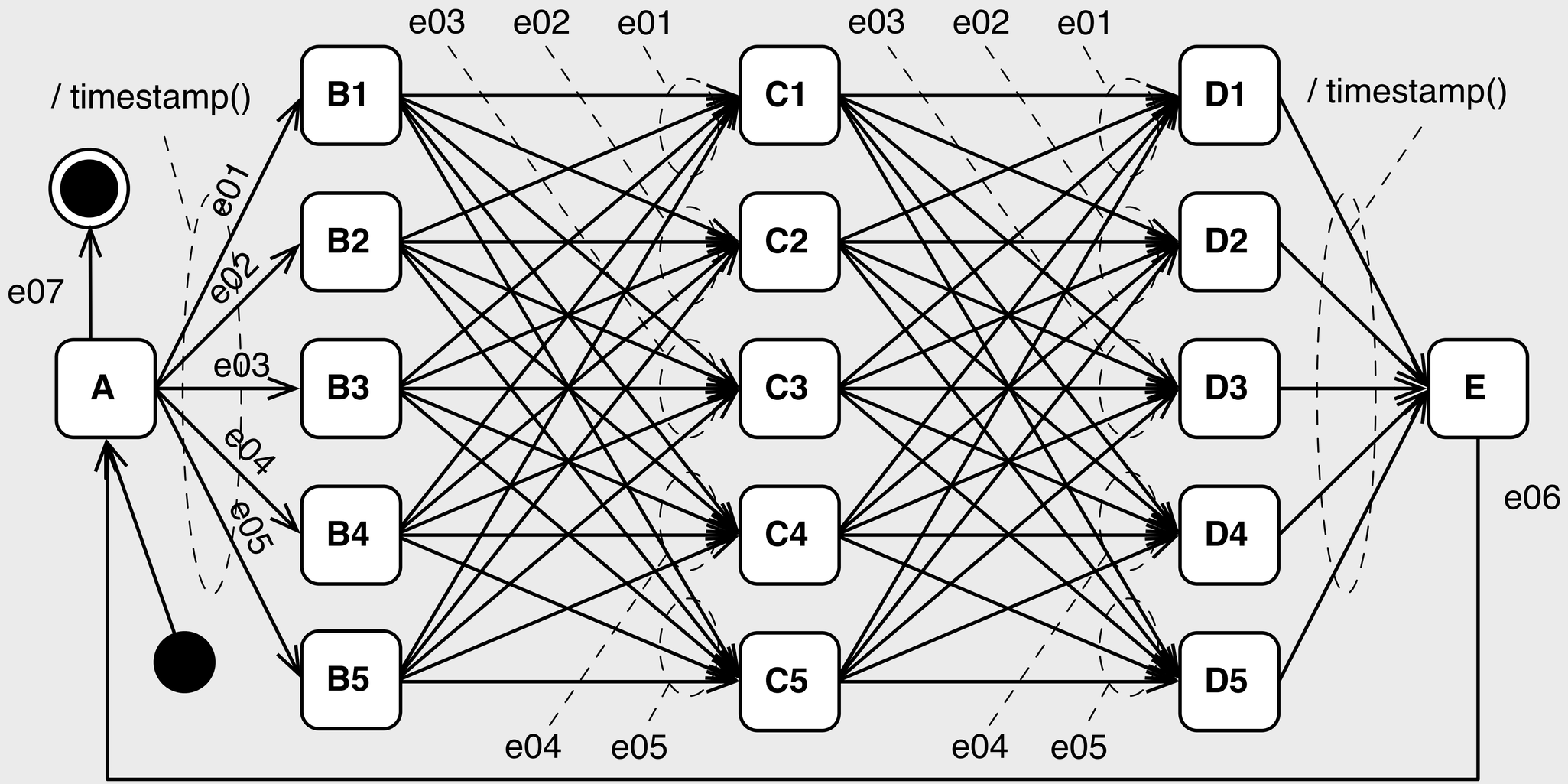


Performance Benchmark



Behaviour Model

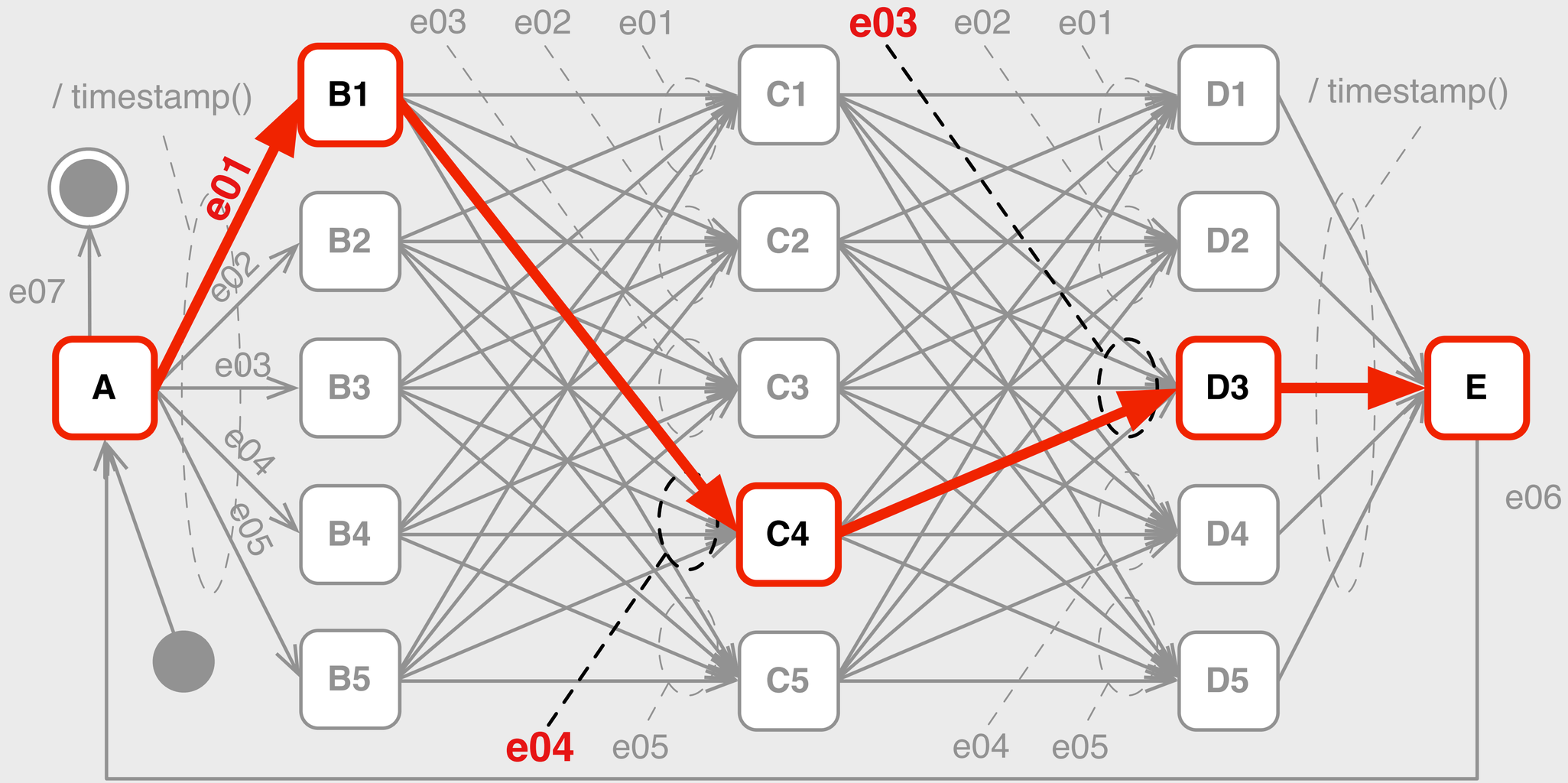
EVENT Scenario



Behaviour Model

EVENT Scenario

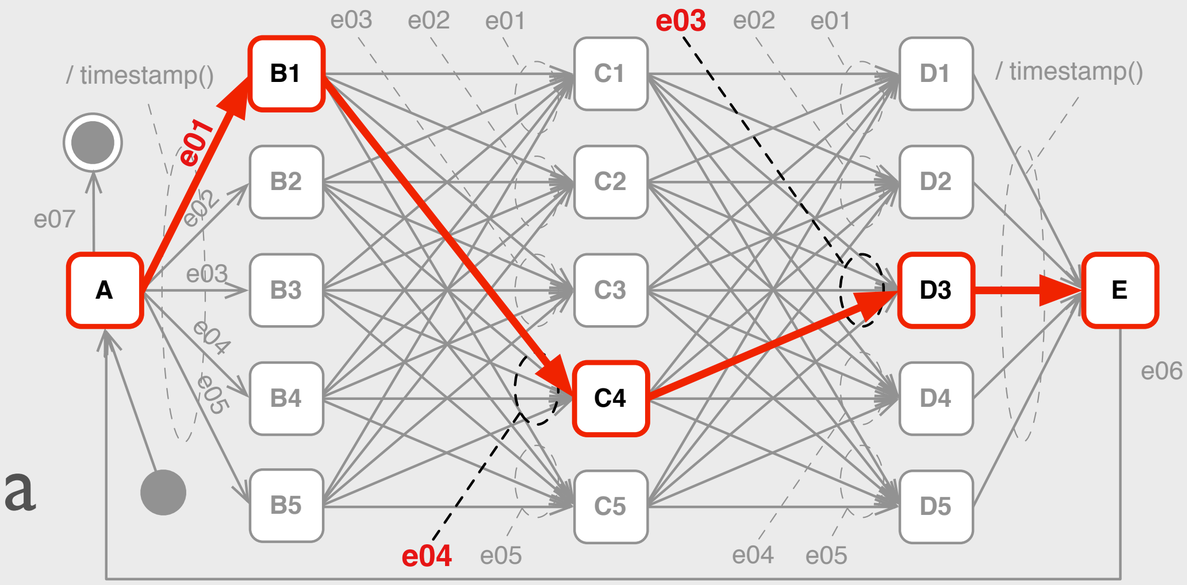
5^3 =125 different paths



Measurement Procedure

EVENT Scenario

- Execute all 125 paths (a „trial“)
  - ➠ Uses all event combinations
- Repeat trials 125 times, starting with a different path each time
  - ➠ Averages measurements
  - ➠ Distributes build-up effects
- Process 15625 timestamp pairs to calculate three performance indicators



	Compiled	Interpreted
EVENT.MIN	1µs	165µs
EVENT.AVG	23.38µs	186.45µs
EVENT.MAX	128µs	492µs

Results

- Proposed approach is feasible
- Adequate performance
  - Exception: delay-sensitive systems with timing constraints << 1ms
- Impact of model structure & model storage format

	Interpreted
SPEED	22.30 x slower
MEMORY	64.09 x more

Benefits for System Adaptation and Self-Management

- Consistency has to be ensured for only a small number of artefacts
  - Artefacts readily available during runtime, with well-defined formats
- State-transition systems are reactive
  - Quiescent between processing steps
- Application state is explicitly managed
- Models are an abstraction of system behaviour
  - Intuitive & formalised
- Model checking, simulation, testing, even proofs are possible

Thanks for Listening!

Questions?

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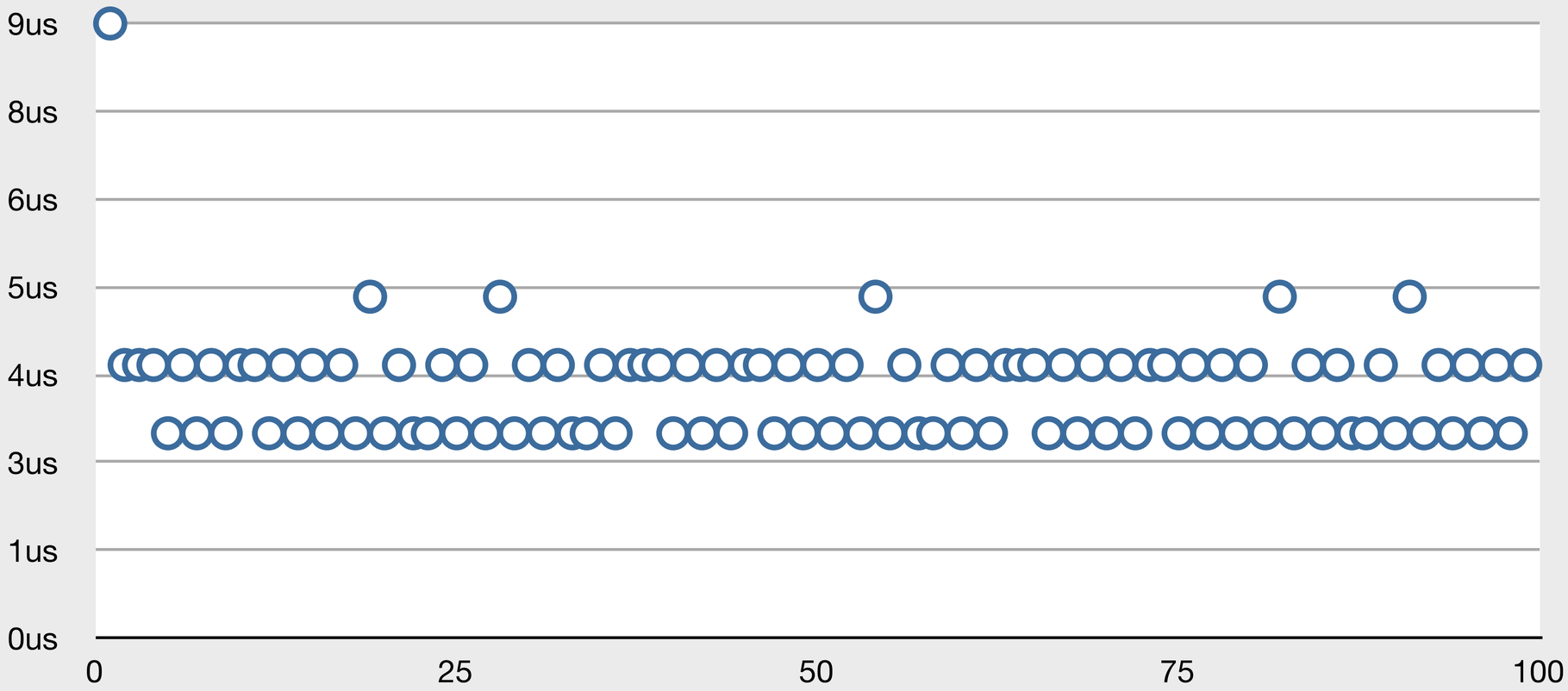
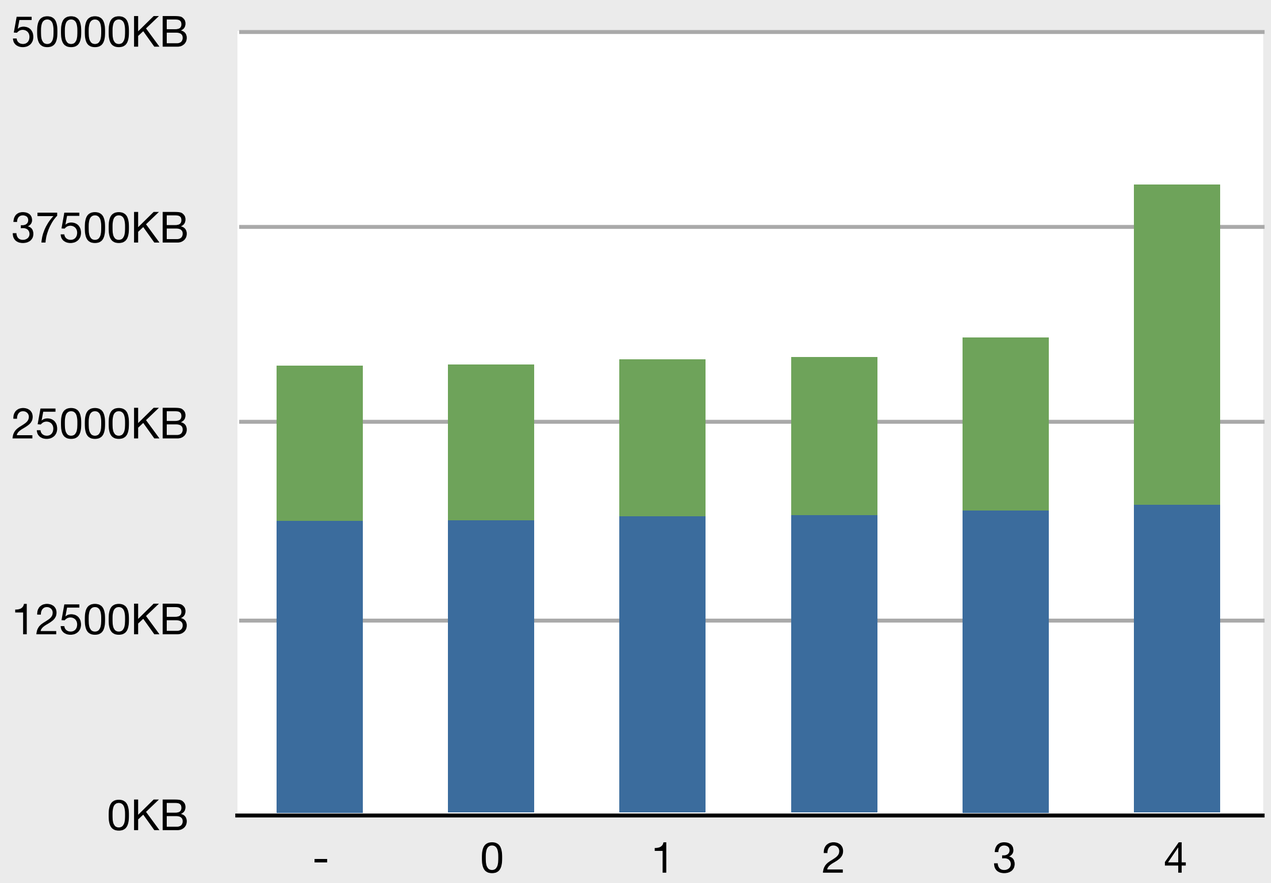
UML Interpreter + MVEL

- TIMESTAMP
- SIZE
- ALTERNATIVE
- EPSILON
- EVENT
- GUARD
- COMPOUND
- EXPRESSION
- CONCURRENT
- CONFIG
- LIFECYCLE

TIMESTAMP

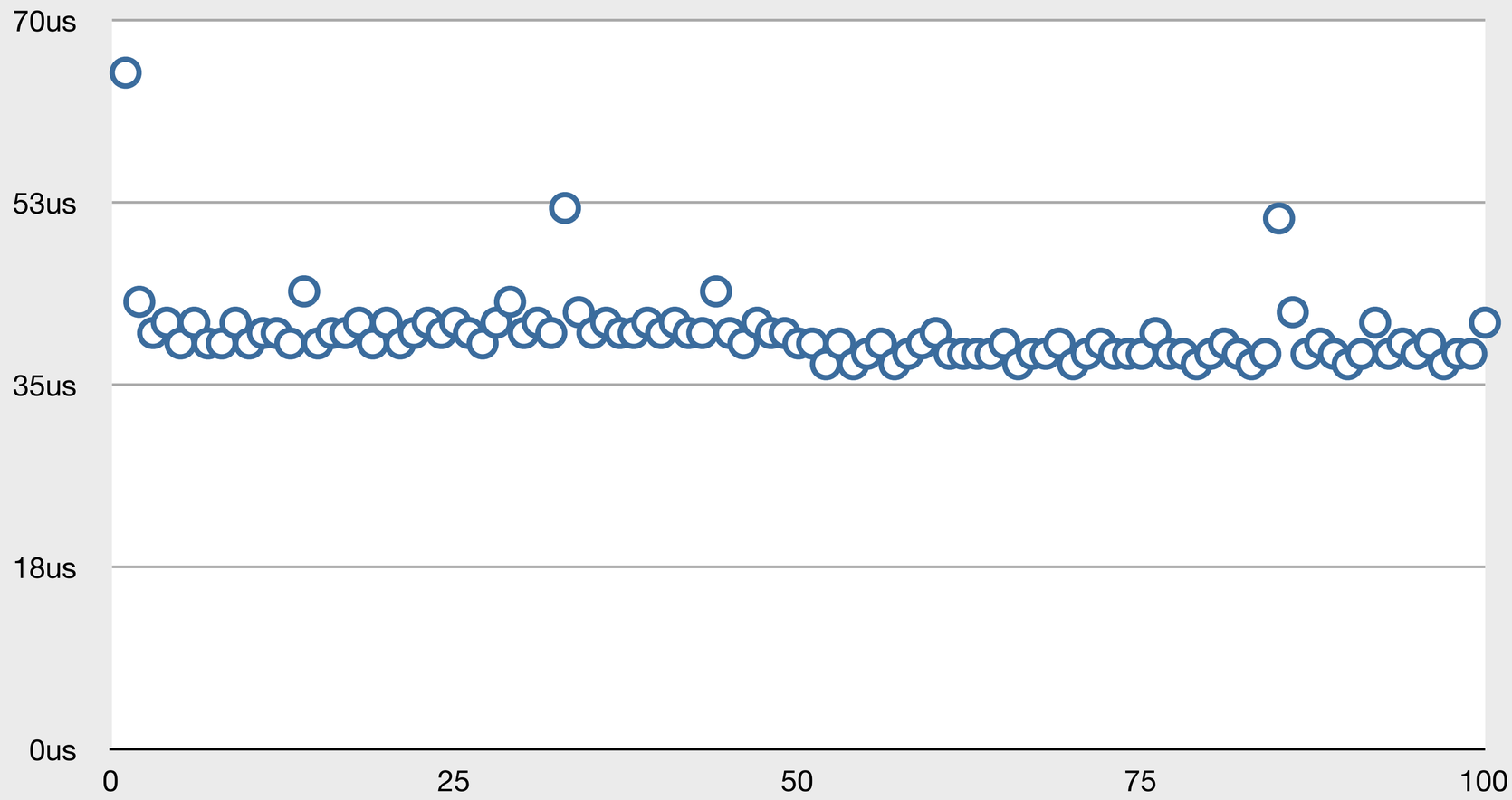


SIZE

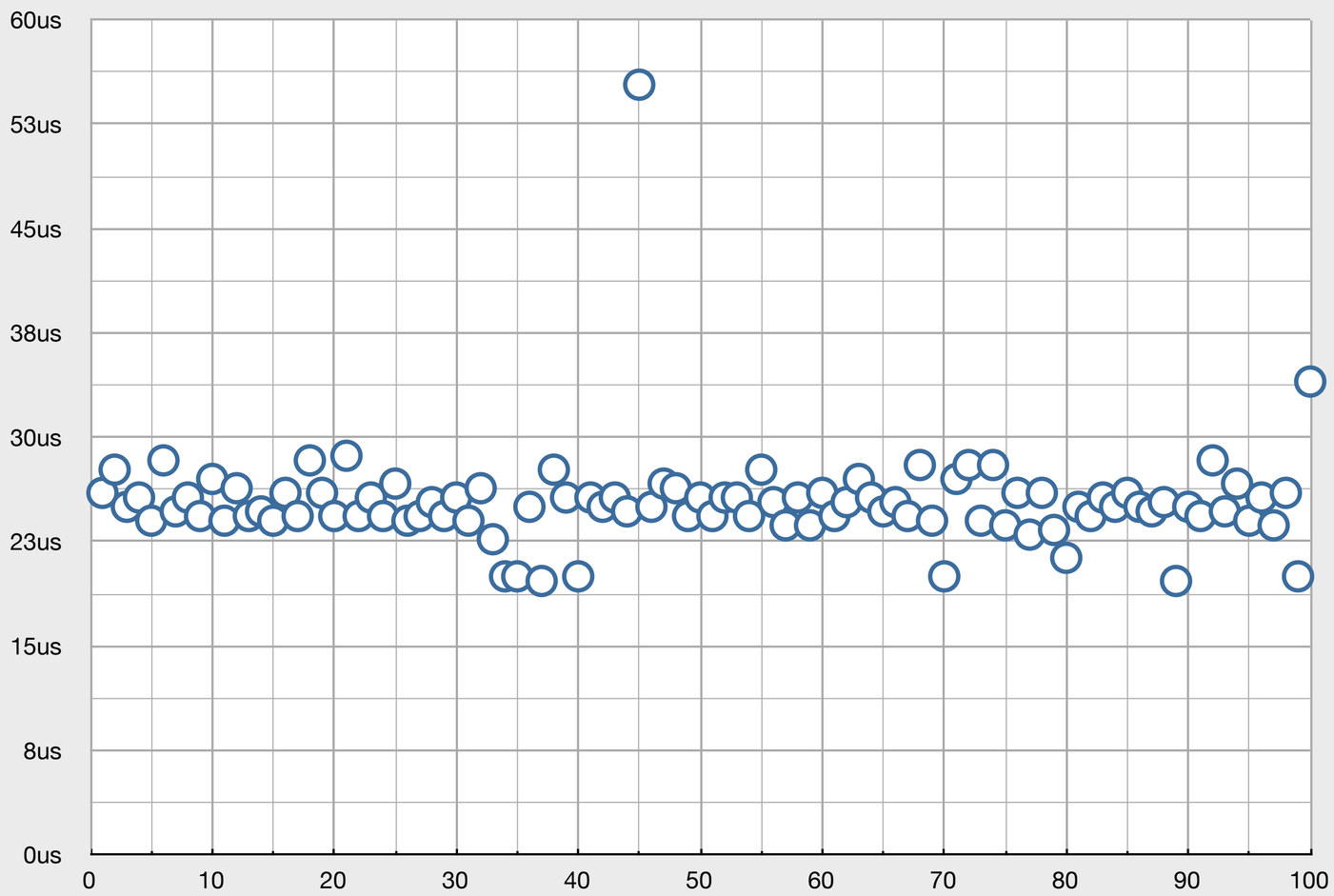


Executable size is always size of JVM

ALTERNATIVE

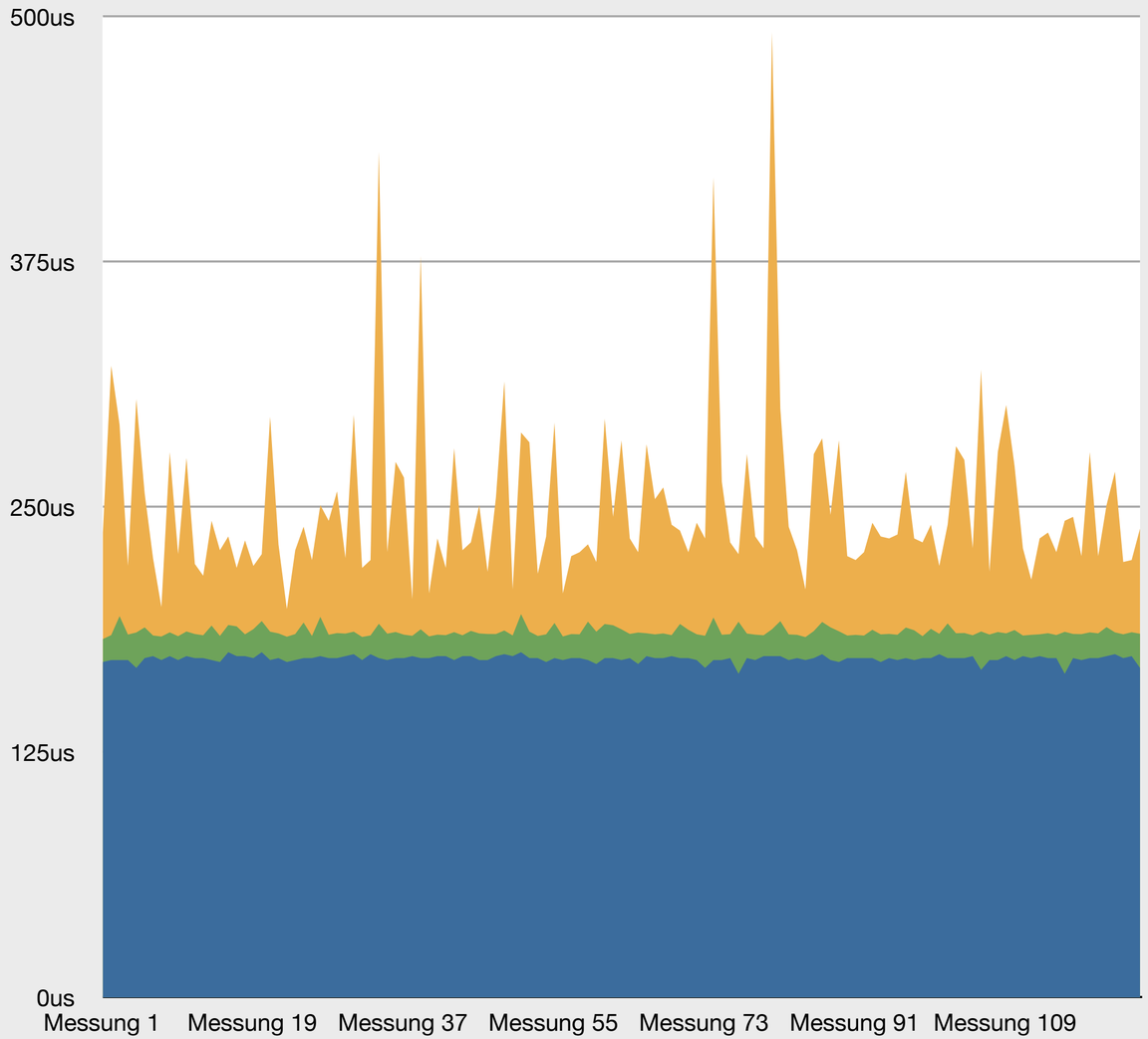


EPSILON

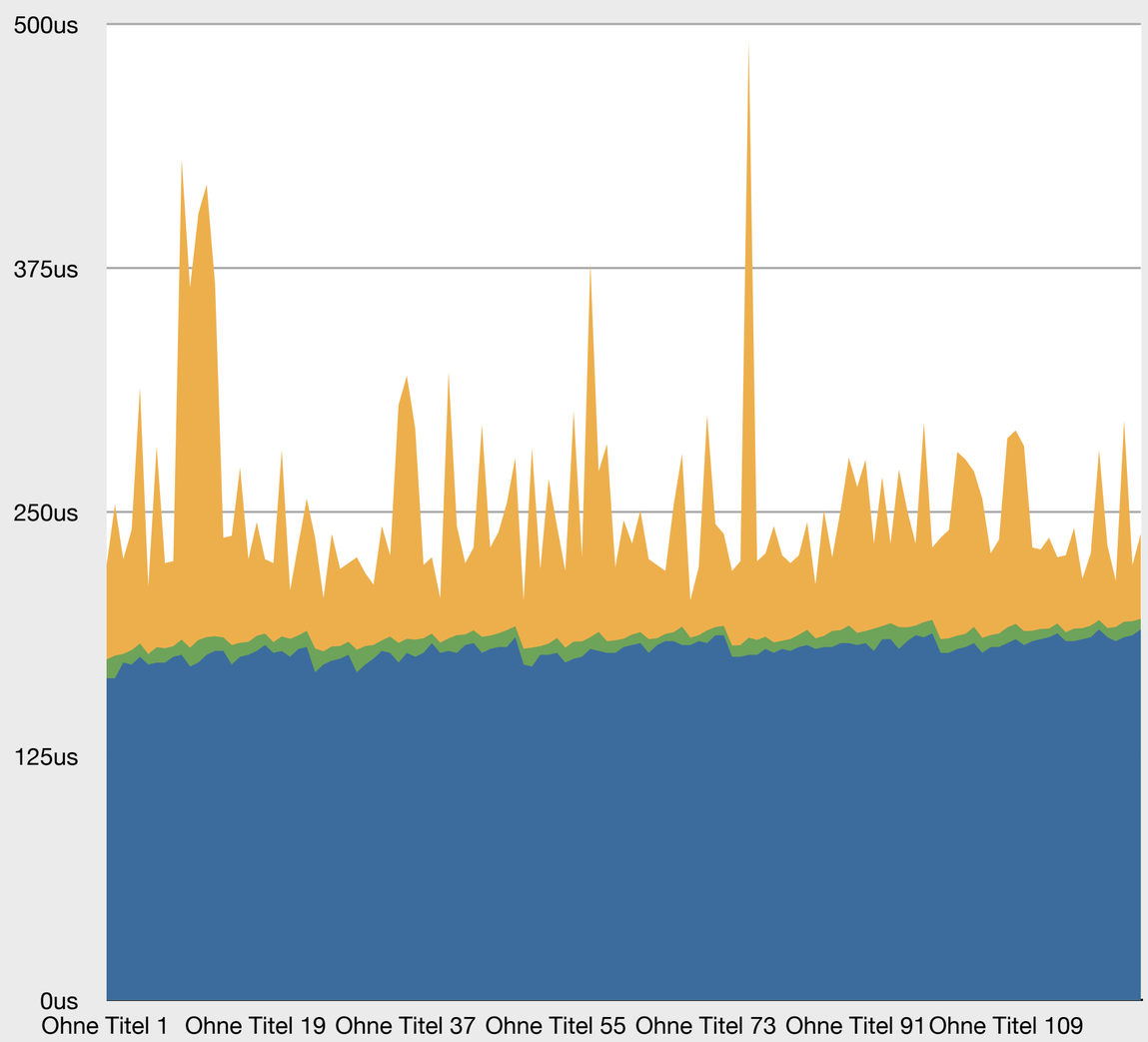

60us
53us
45us
38us
30us
23us
15us
8us
0us
0
10
20
30
40
50
60
70
80
90
100

EVENT

Trials

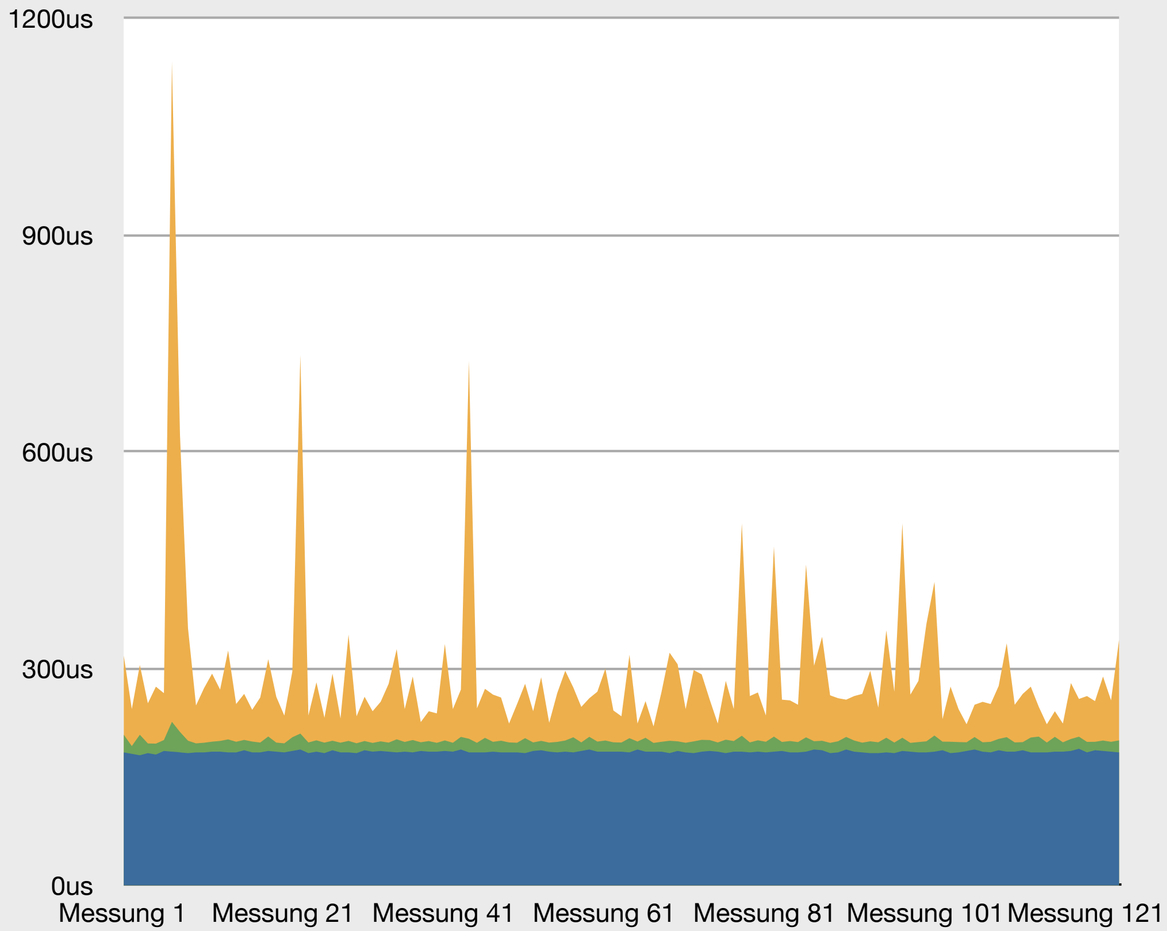


Paths

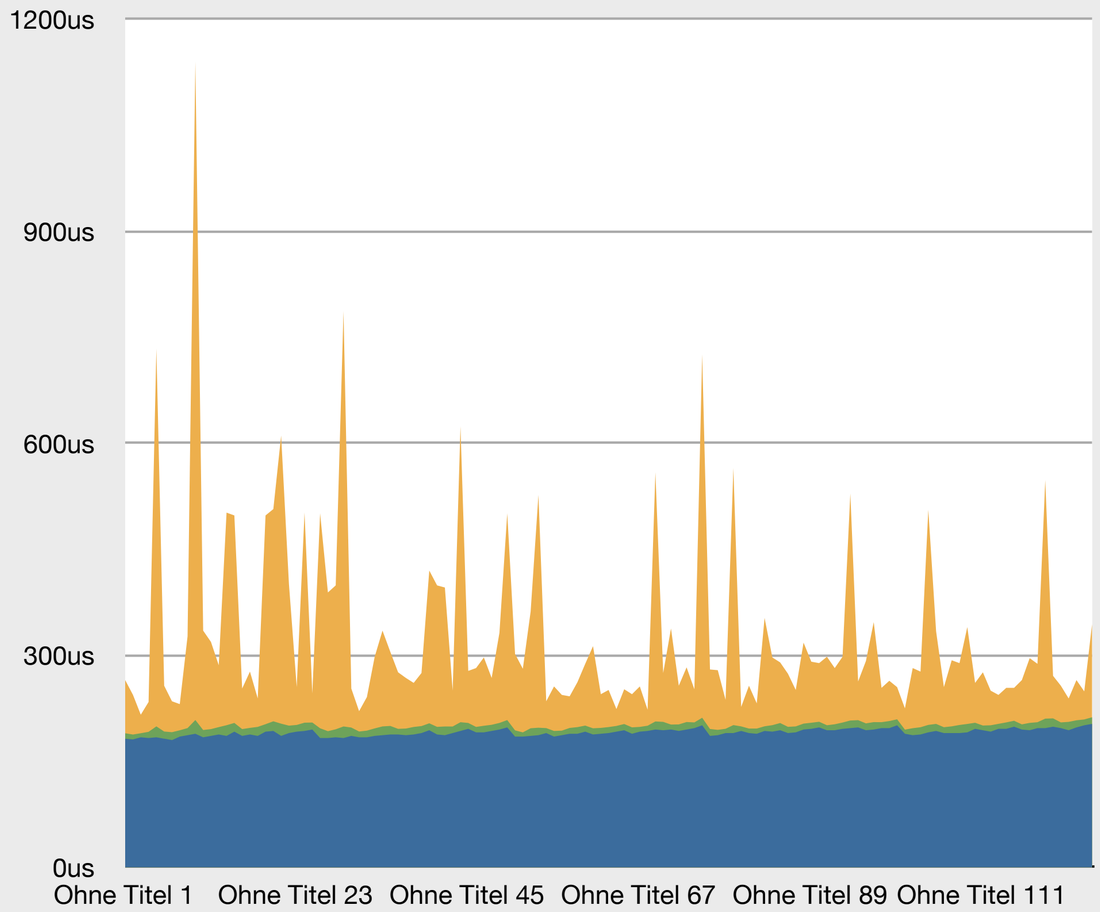


GUARD

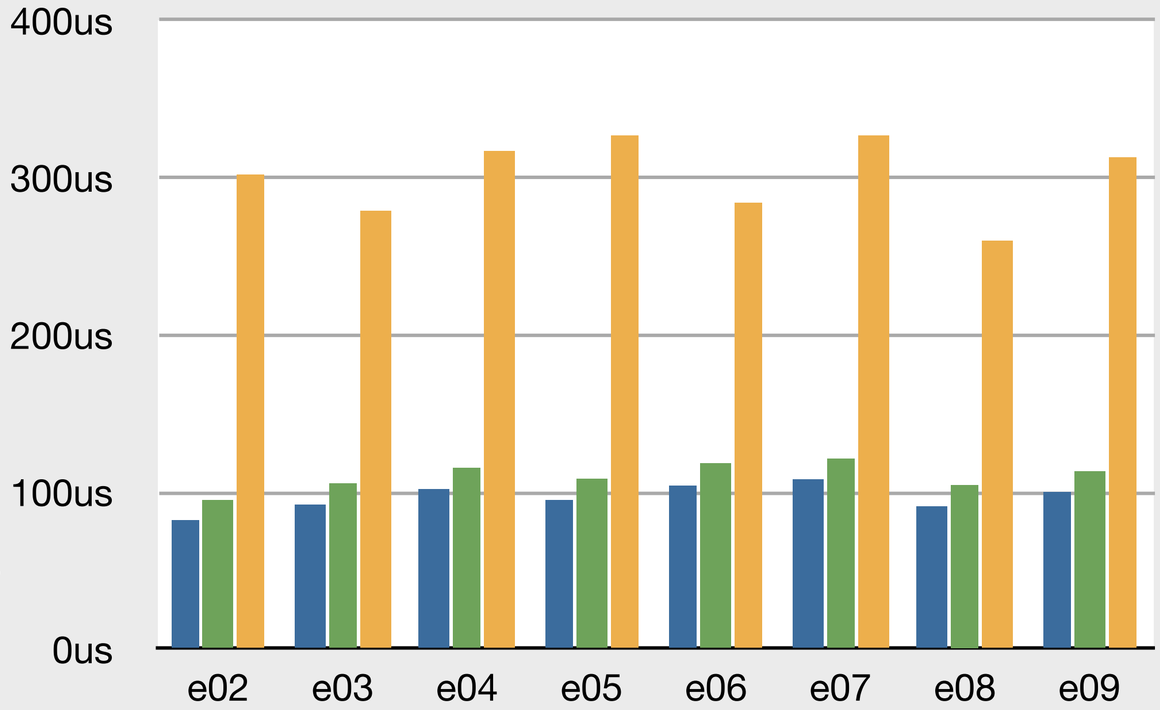
Trials



Paths

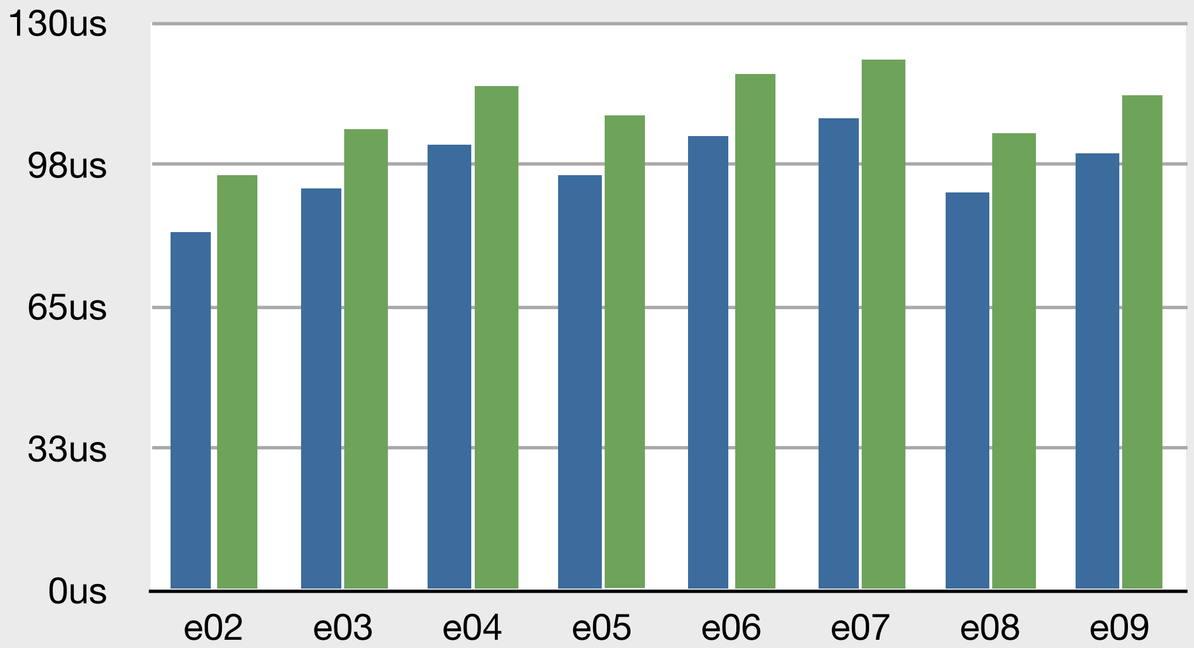


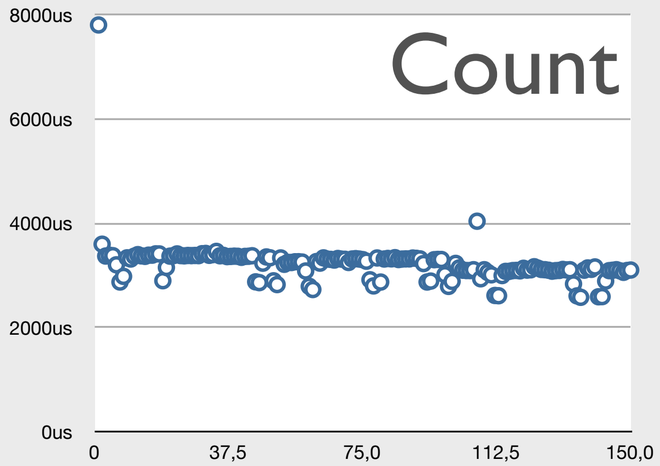
COMPOUND

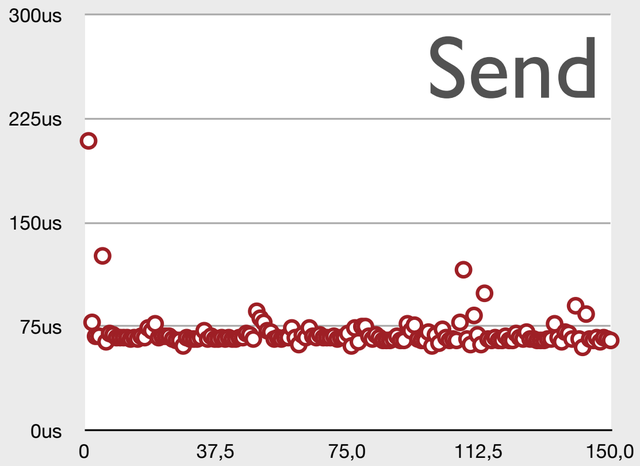


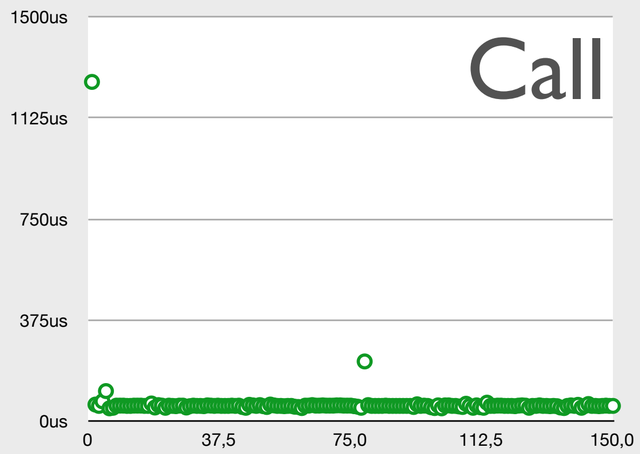
With MAX values

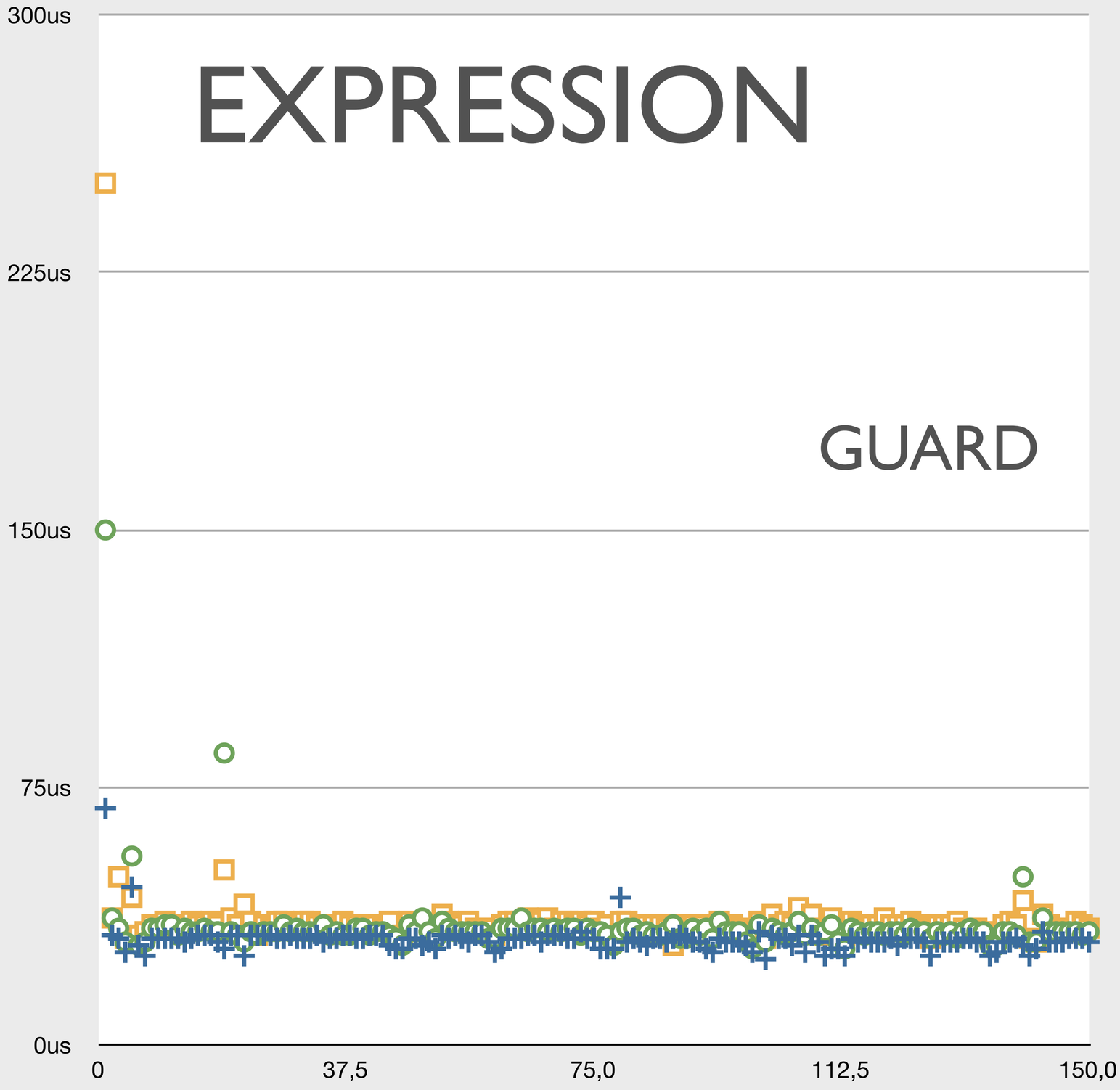
Only MIN, AVG



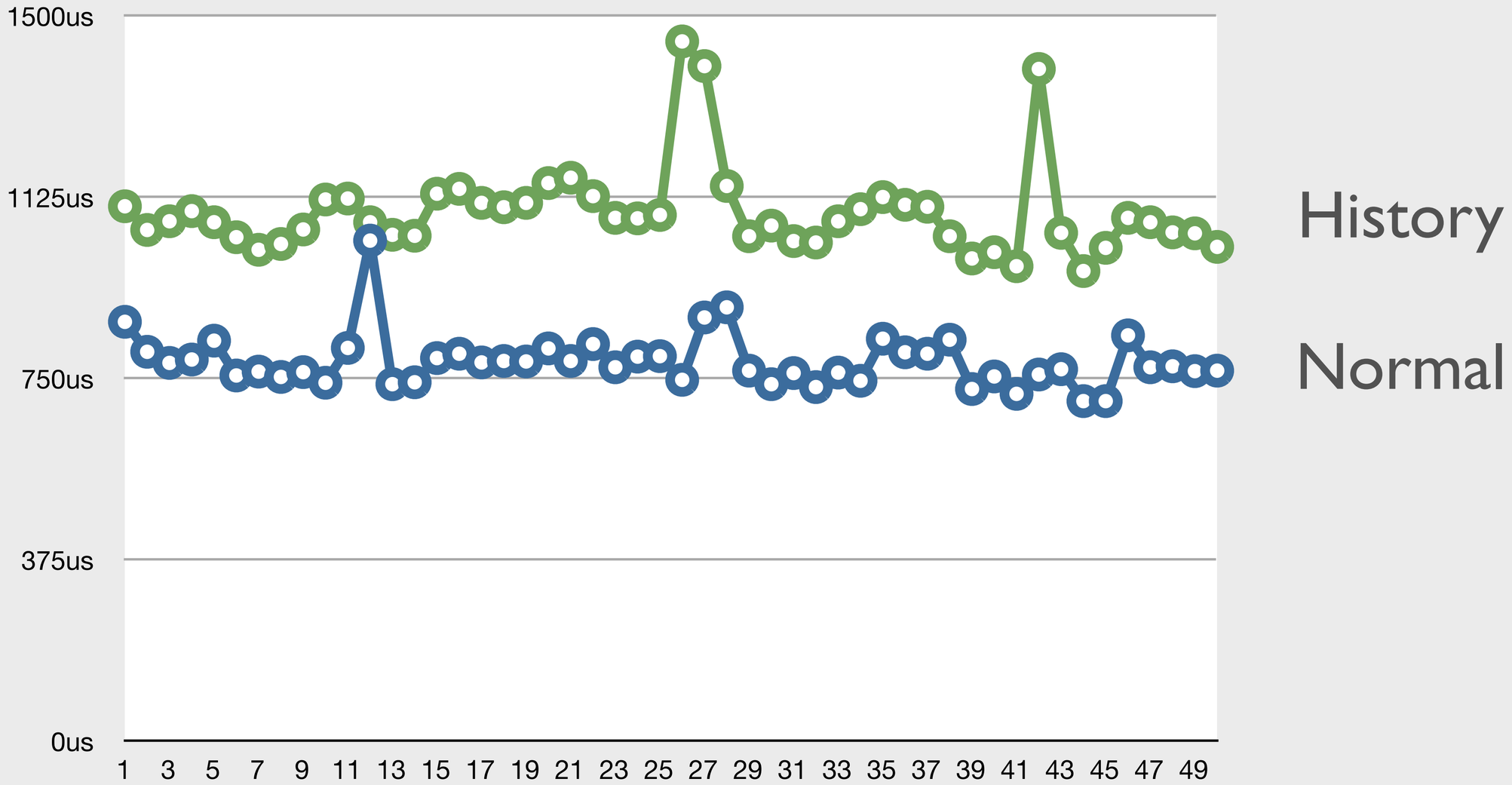

Count
8000us
6000us
4000us
2000us
0us
0
37,5
75,0
112,5
150,0


Send
300us
225us
150us
75us
0us
0
37,5
75,0
112,5
150,0

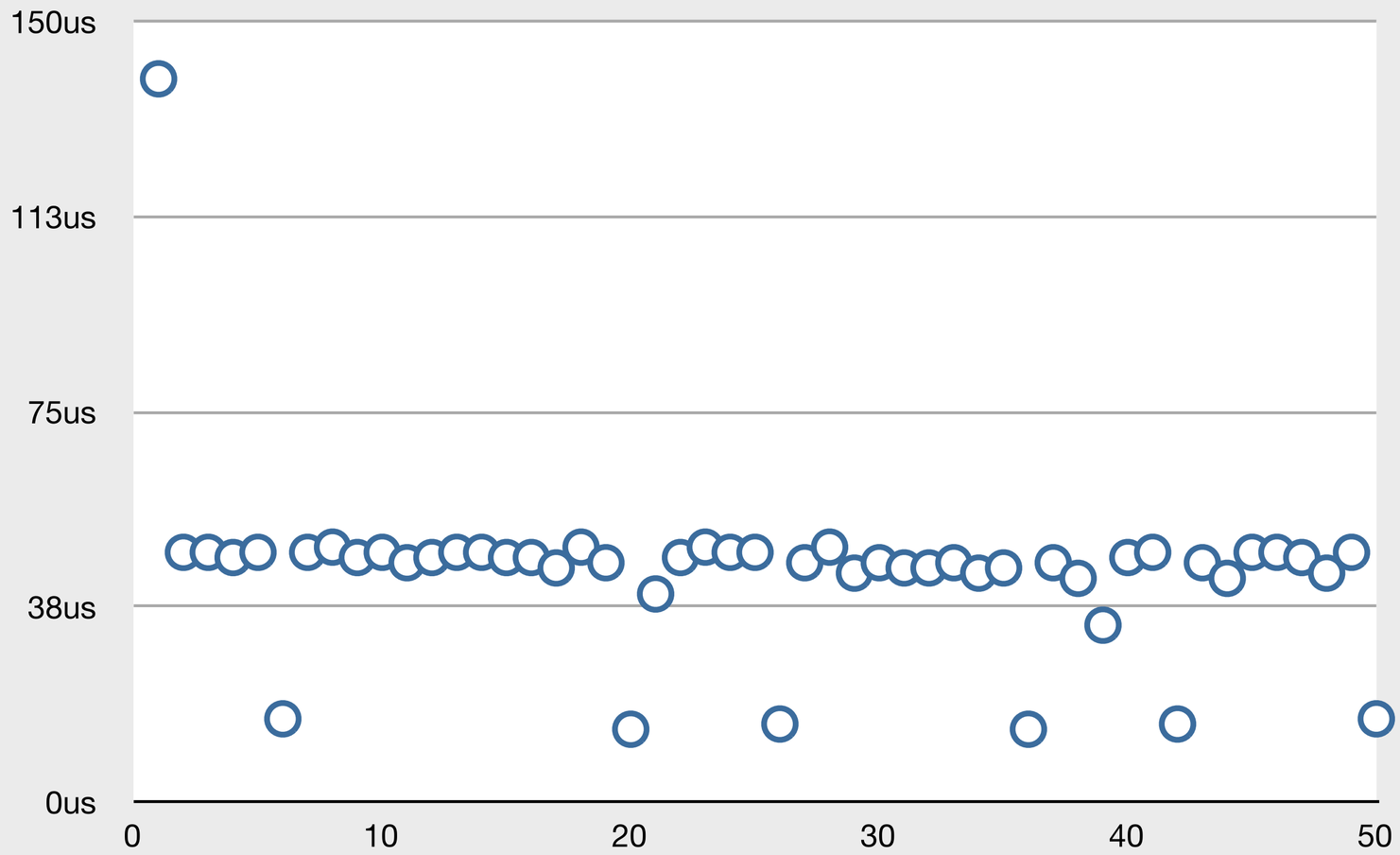

Call
1500us
1125us
750us
375us
0us
0
37,5
75,0
112,5
150,0


EXPRESSION
GUARD
300us
225us
150us
75us
0us
0
37,5
75,0
112,5
150,0

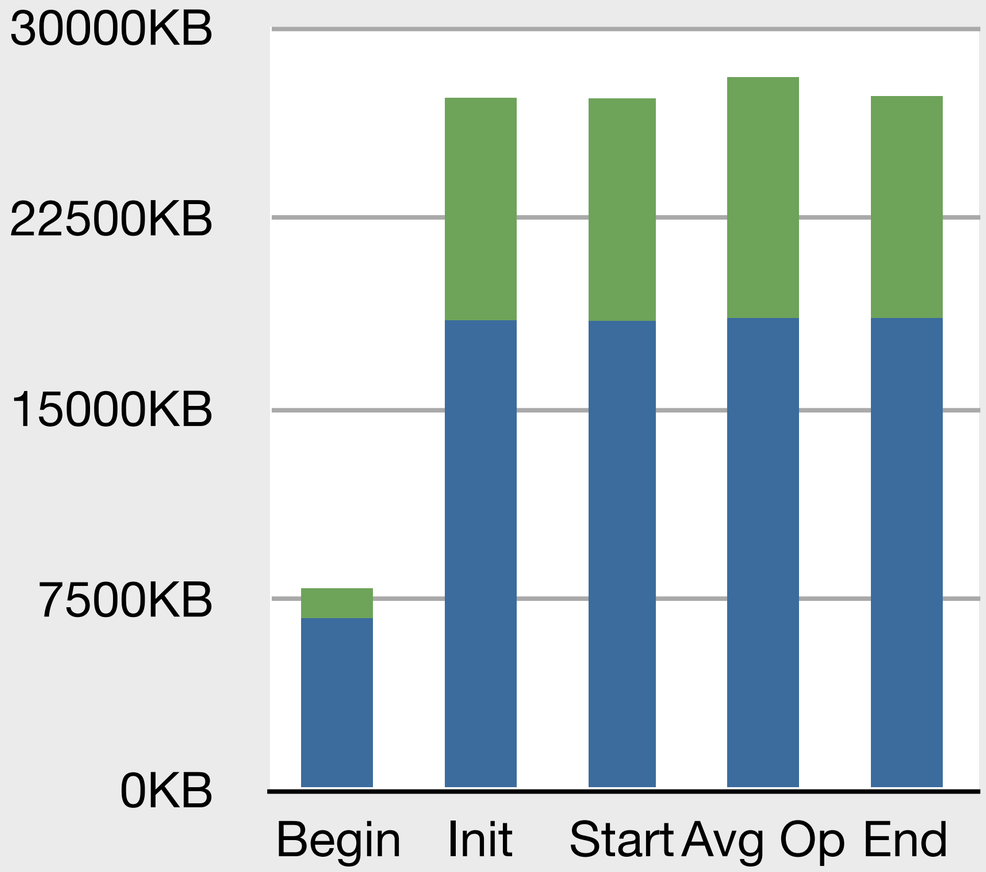
CONCURRENT


1500us
1125us
750us
375us
0us
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
History
Normal

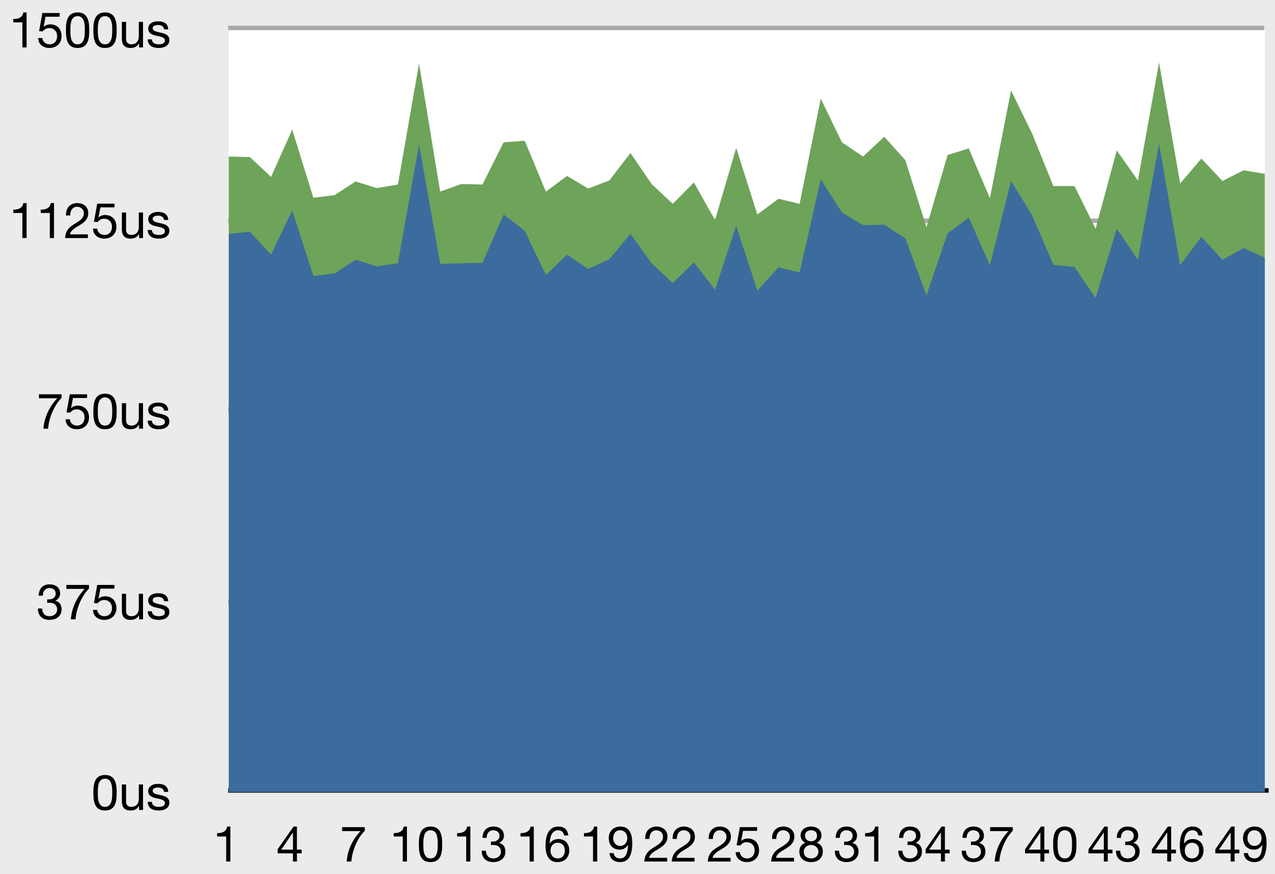
CONFIG



LIFECYCLE



Memory



Overall Delay