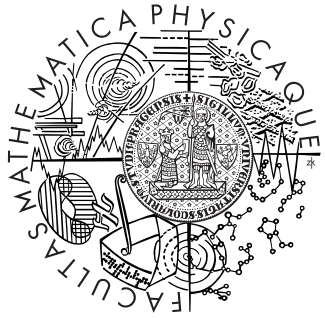
Analysis of Overhead in Dynamic Java Performance Monitoring

Vojtěch Horký, Jaroslav Kotrč, Peter Libič and Petr Tůma

Charles University in Prague

Department of Distributed and Dependable Systems



Context: Dynamic Monitoring of Production Systems

Department of Distributed and Dependable Systems
D3S

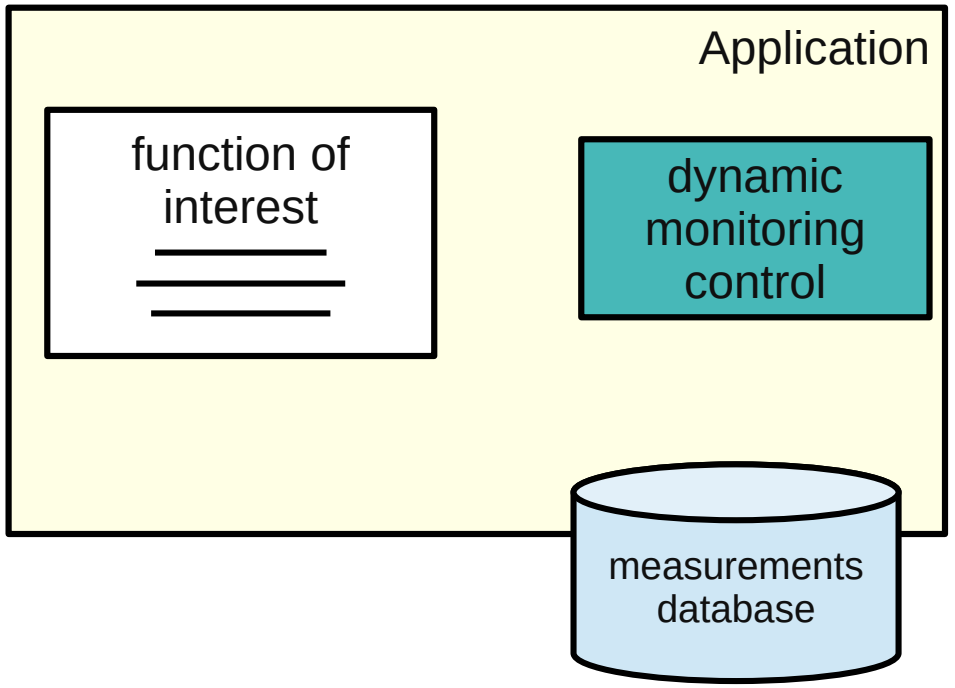
Dynamic Monitoring of Production Systems

Measurement probes are active only when needed,

measuring everything all the time might not be practical.

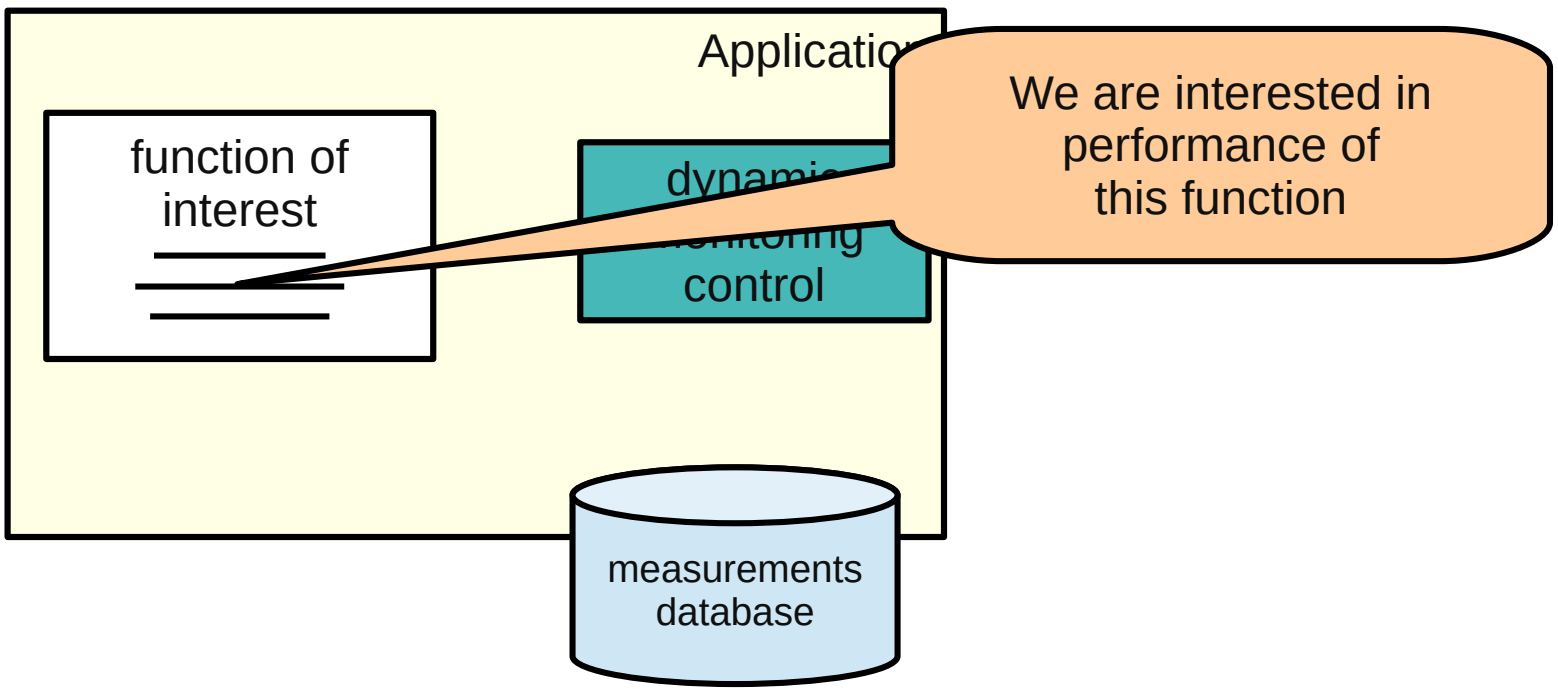
Dynamic Monitoring of Production Systems

Measurement probes are active only when needed,
measuring everything all the time might not be practical.



Dynamic Monitoring of Production Systems

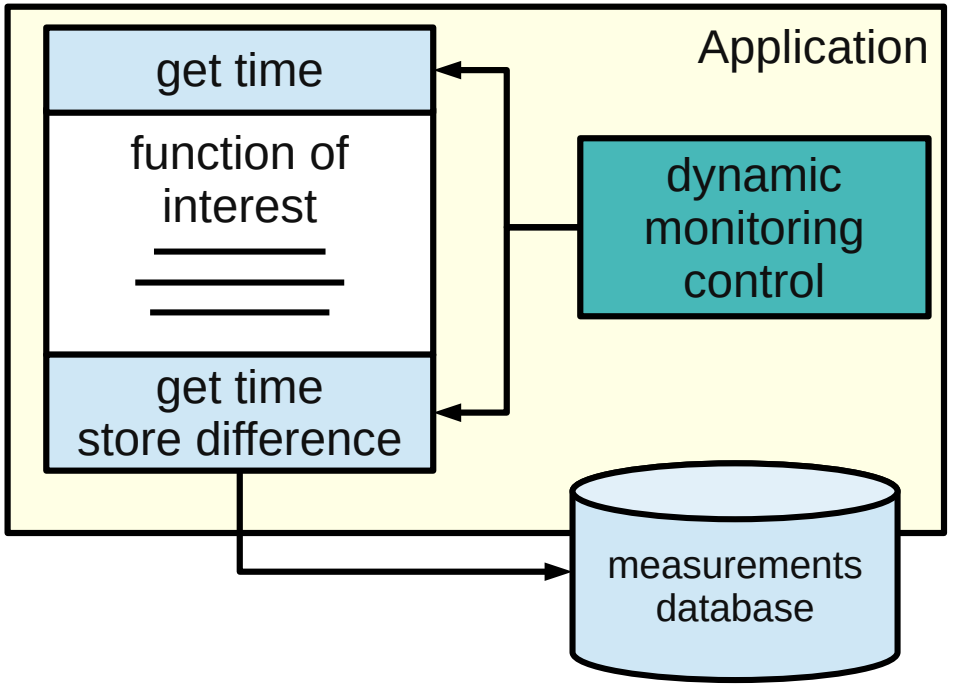
Measurement probes are active only when needed,
measuring everything all the time might not be practical.



Department of Distributed and Dependable Systems

Dynamic Monitoring of Production Systems

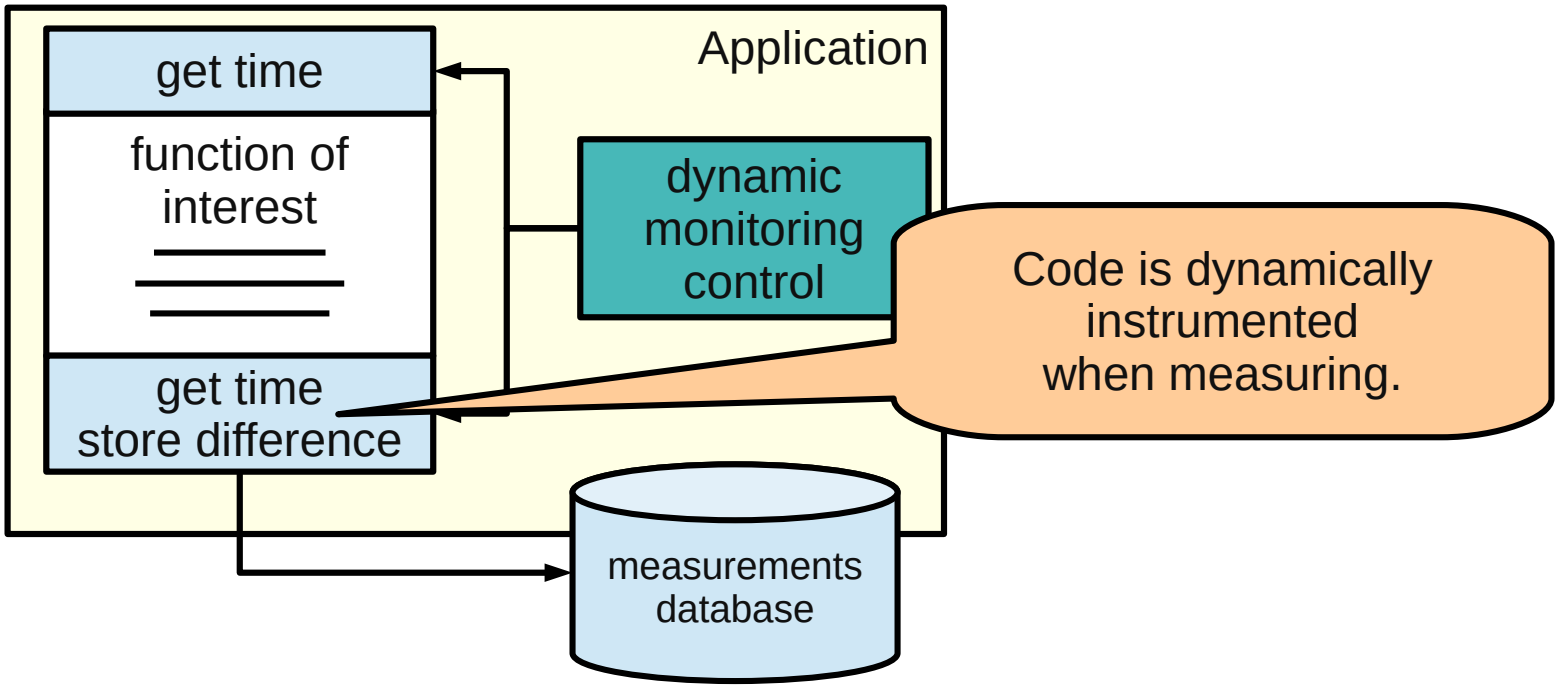
Measurement probes are active only when needed,
measuring everything all the time might not be practical.



Department of Distributed and Dependable Systems D3S

Dynamic Monitoring of Production Systems

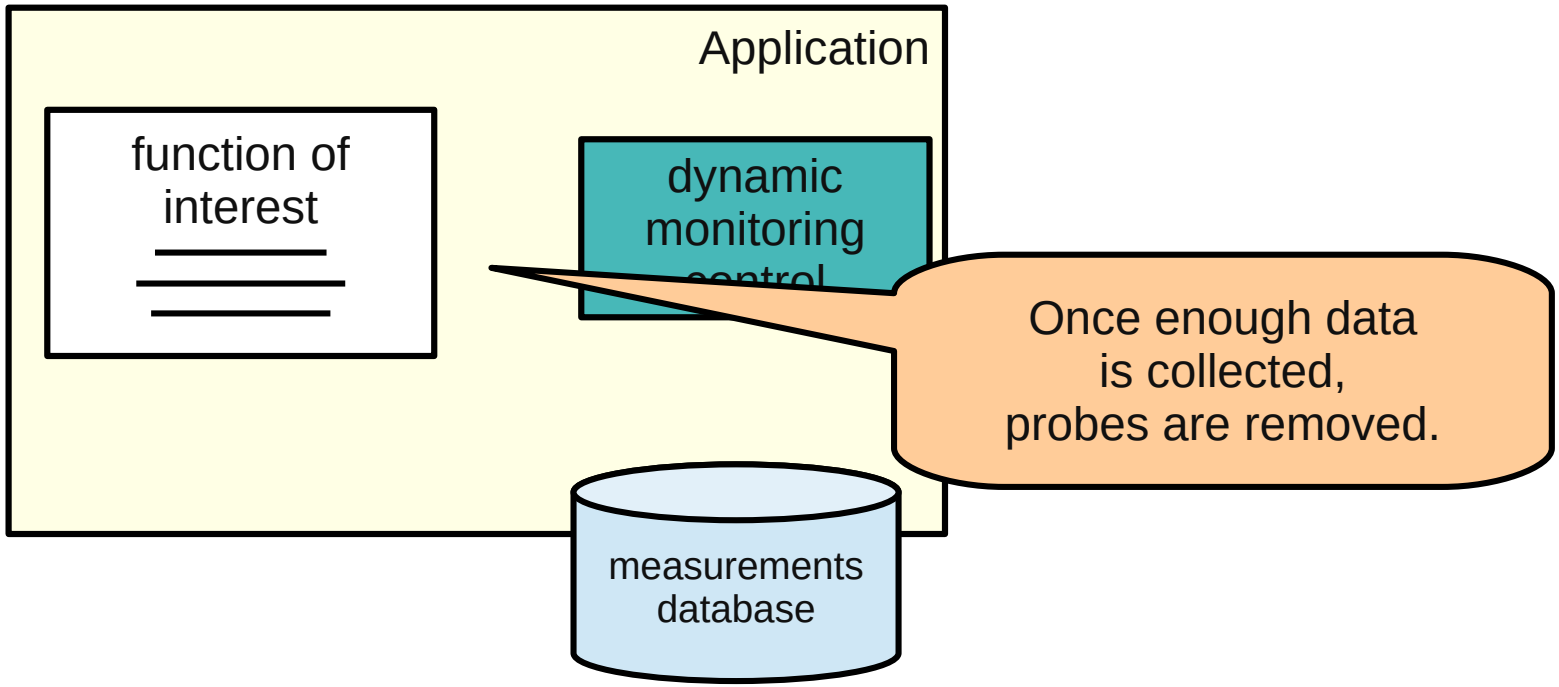
Measurement probes are active only when needed,
measuring everything all the time might not be practical.



Department of Distributed and Dependable Systems D3S

Dynamic Monitoring of Production Systems

Measurement probes are active only when needed,
measuring everything all the time might not be practical.



Issues of Dynamic Monitoring

In managed environments, code is compiled at run-time;
probe insertion (removal) causes recompilation.
Monitored application can thus behave differently.

Issues of Dynamic Monitoring

In managed environments, code is compiled at run-time;
probe insertion (removal) causes recompilation.
Monitored application can thus behave differently.

Interesting Questions

How do the code manipulations affect the application?

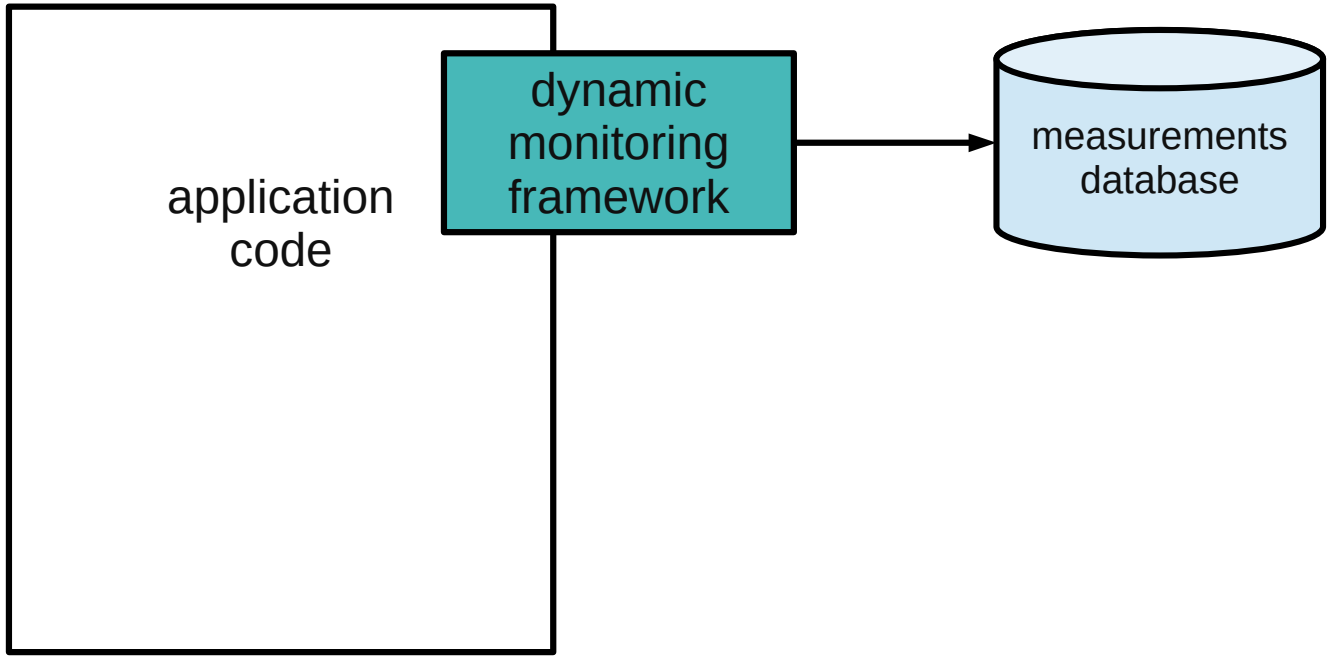
What is the overhead of such probe?

Is the observed performance representative?

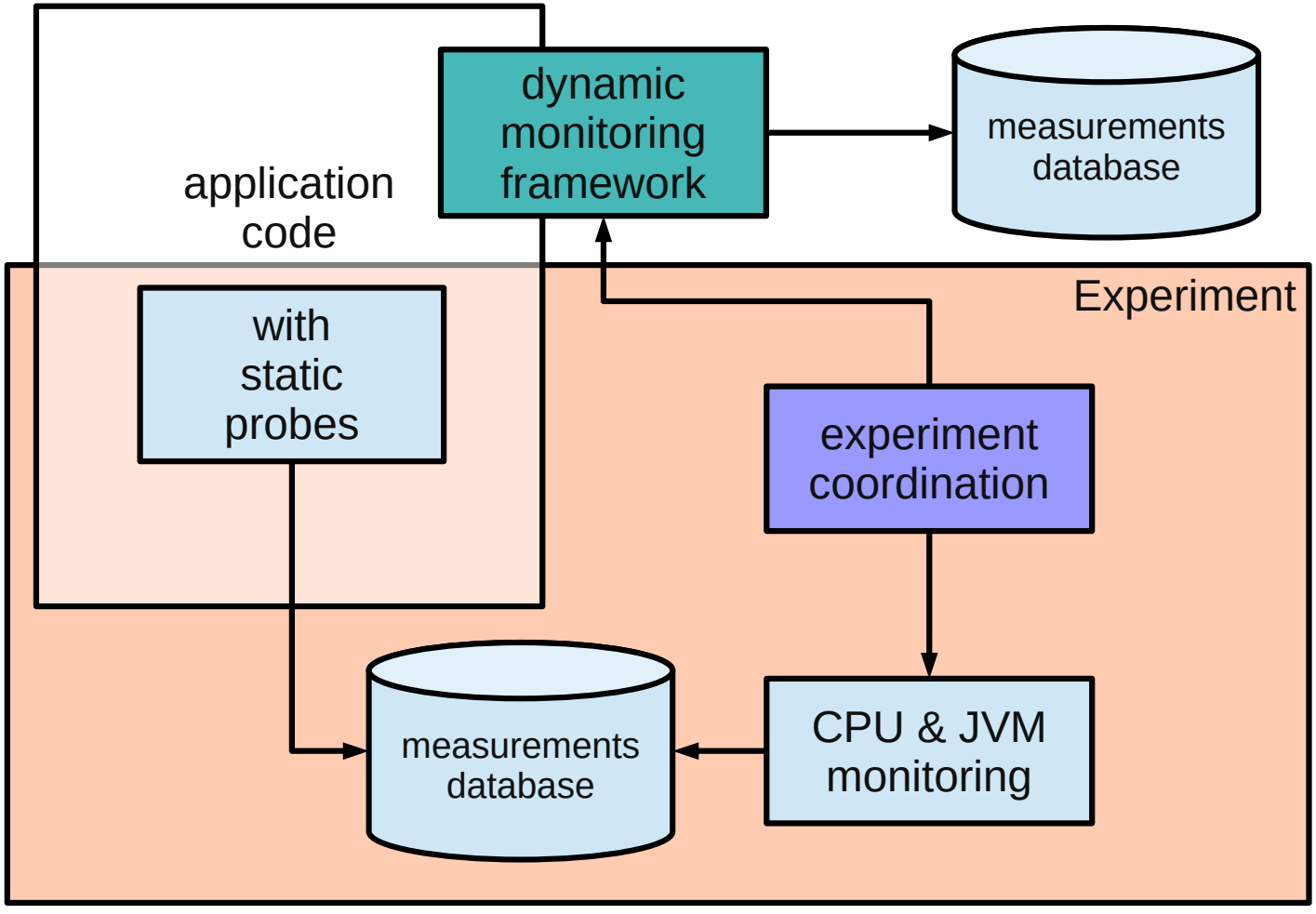
Is there zero overhead once the probe is removed?

Experiment Setup

Experiment Coordination



Experiment Coordination



Two Measurement Infrastructures

Self-measurement	Dynamic monitoring

Two Measurement Infrastructures

	Self-measurement	Dynamic monitoring
Performance	Baseline	“Observed”

Two Measurement Infrastructures

	Self-measurement	Dynamic monitoring
Performance	Baseline	"Observed"
Location	Method entry and exit points (both)	

Two Measurement Infrastructures

	Self-measurement	Dynamic monitoring
Performance	Baseline	"Observed"
Location	Method entry and exit points (both)	
Instrumentation	Static	Dynamic (run-time)

Two Measurement Infrastructures

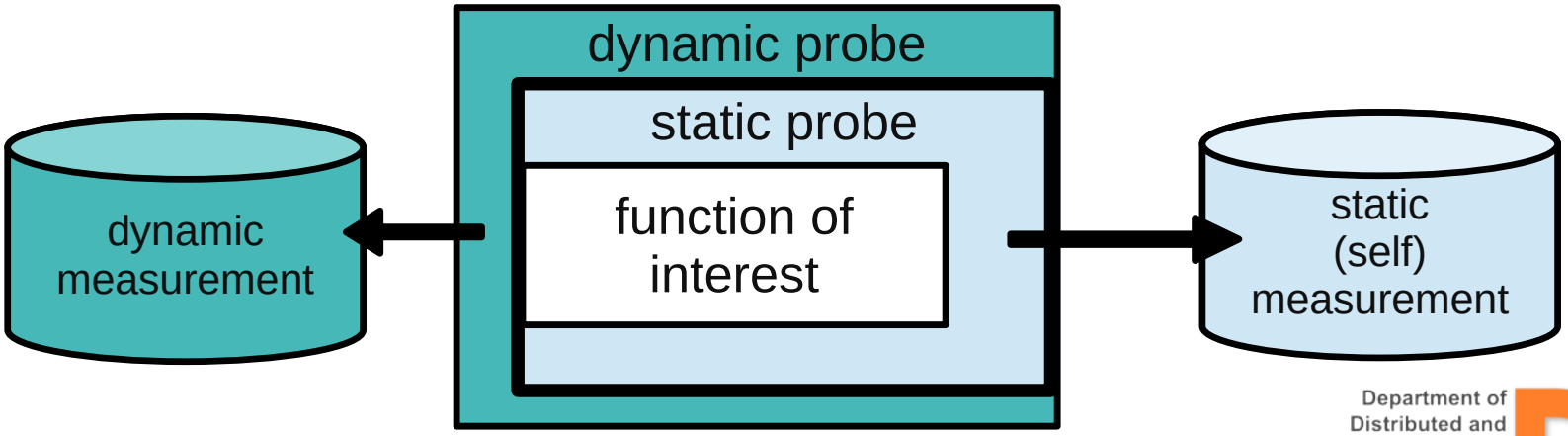
	Self-measurement	Dynamic monitoring
Performance	Baseline	"Observed"
Location	Method entry and exit points (both)	
Instrumentation	Static	Dynamic (run-time)
Data collection	Continuous	On demand

Two Measurement Infrastructures

	Self-measurement	Dynamic monitoring
Performance	Baseline	"Observed"
Location	Method entry and exit points (both)	
Instrumentation	Static	Dynamic (run-time)
Data collection	Continuous	On demand
Implementation	Native method (in C)	Pure Java

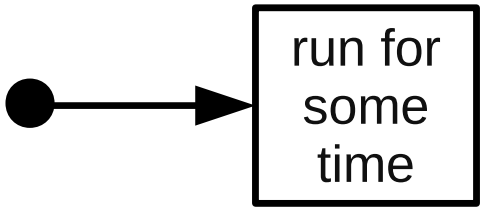
Two Measurement Infrastructures

	Self-measurement	Dynamic monitoring
Performance	Baseline	"Observed"
Location	Method entry and exit points (both)	
Instrumentation	Static	Dynamic (run-time)
Data collection	Continuous	On demand
Implementation	Native method (in C)	Pure Java

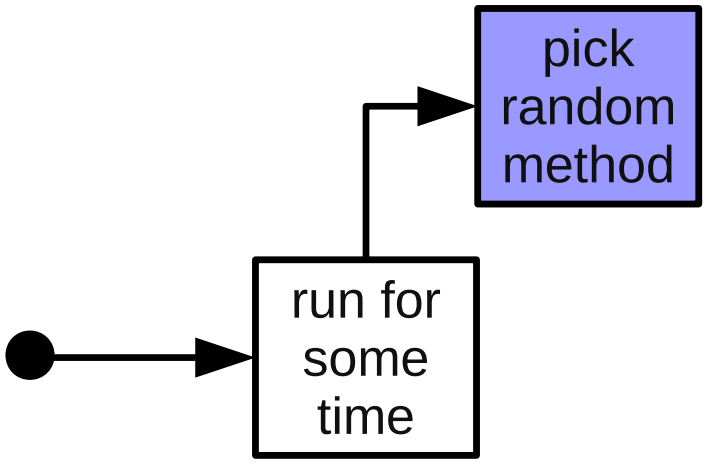


Experiment Process

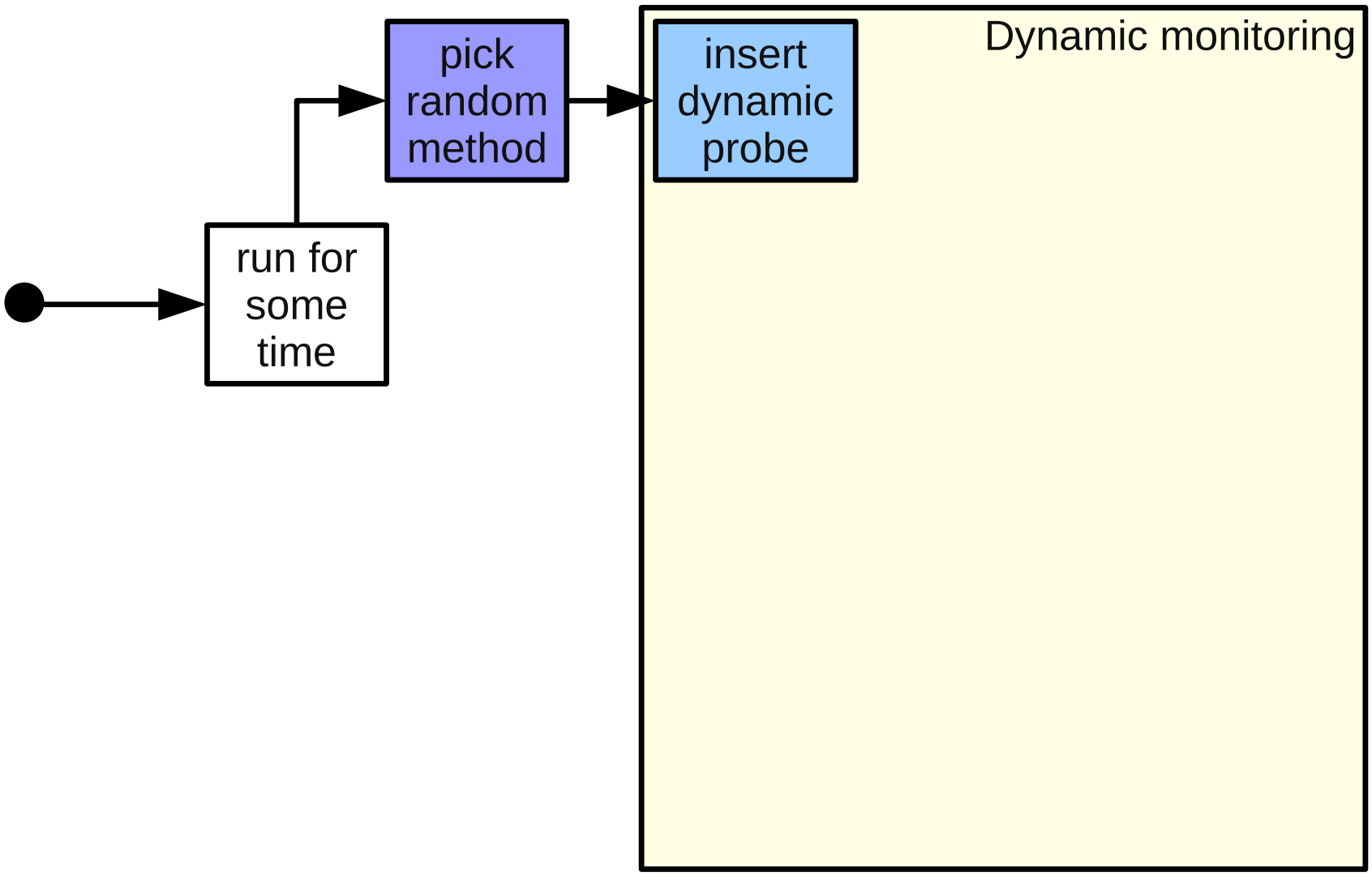
Experiment Process



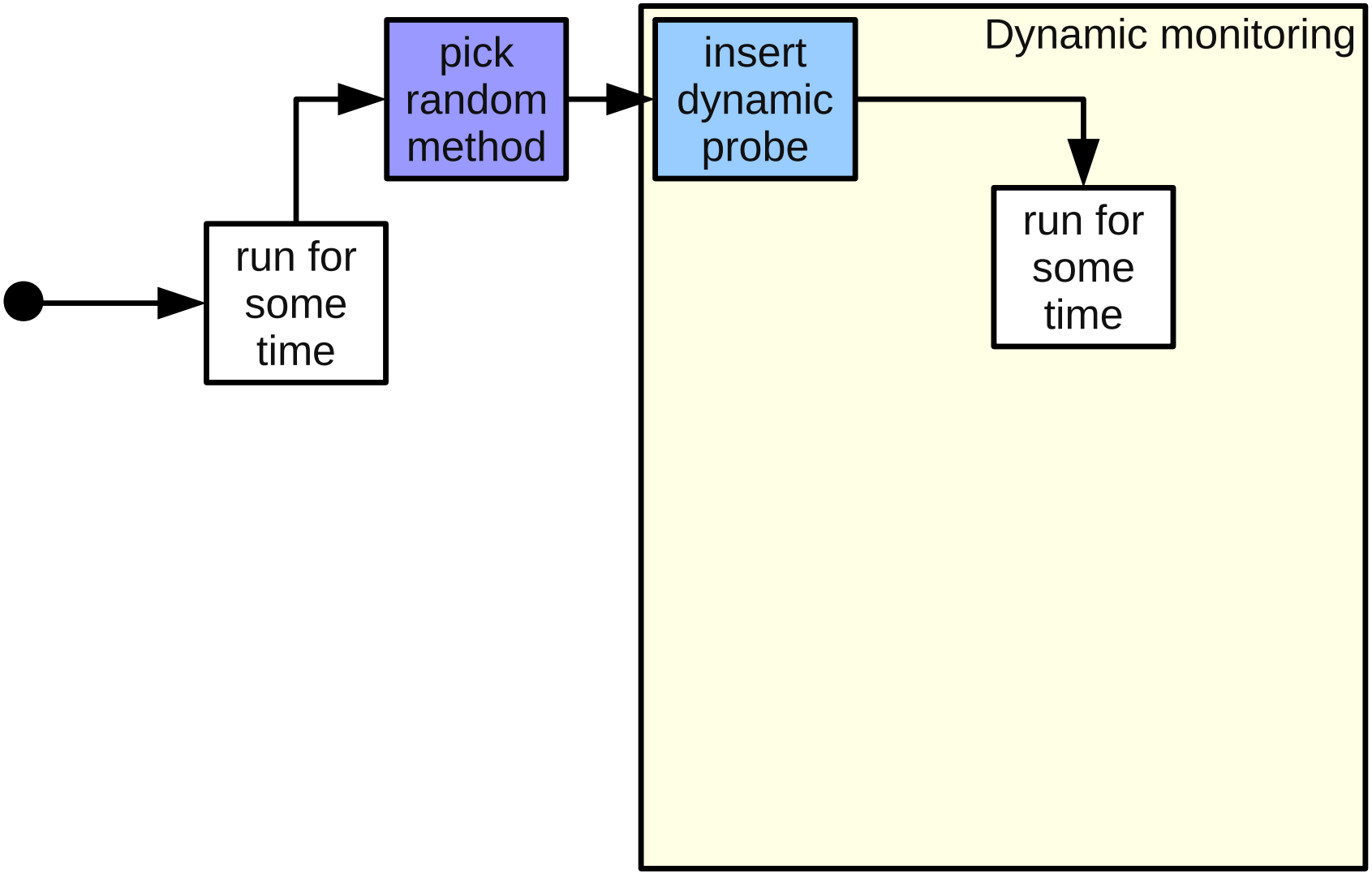
Experiment Process



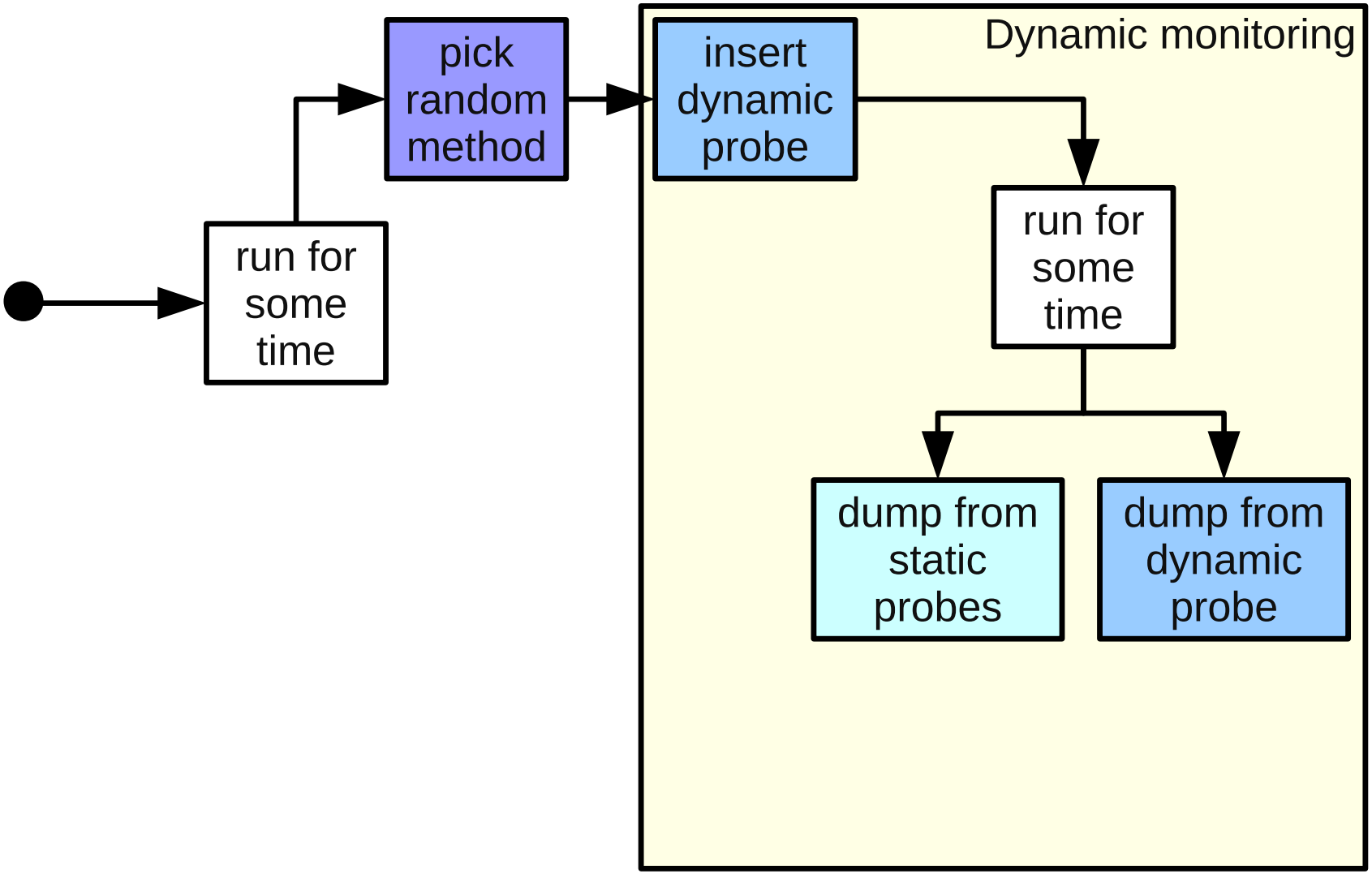
Experiment Process



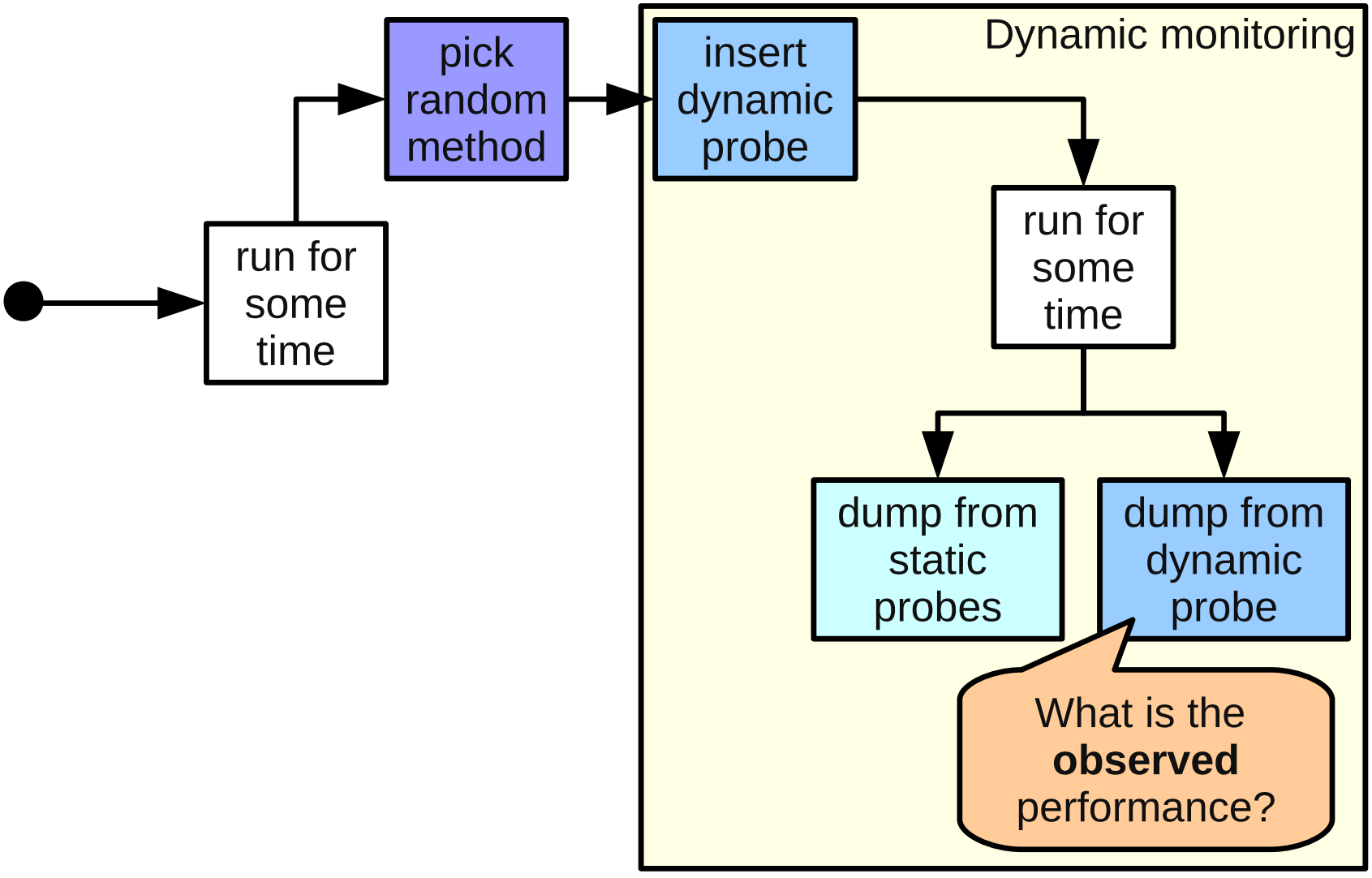
Experiment Process



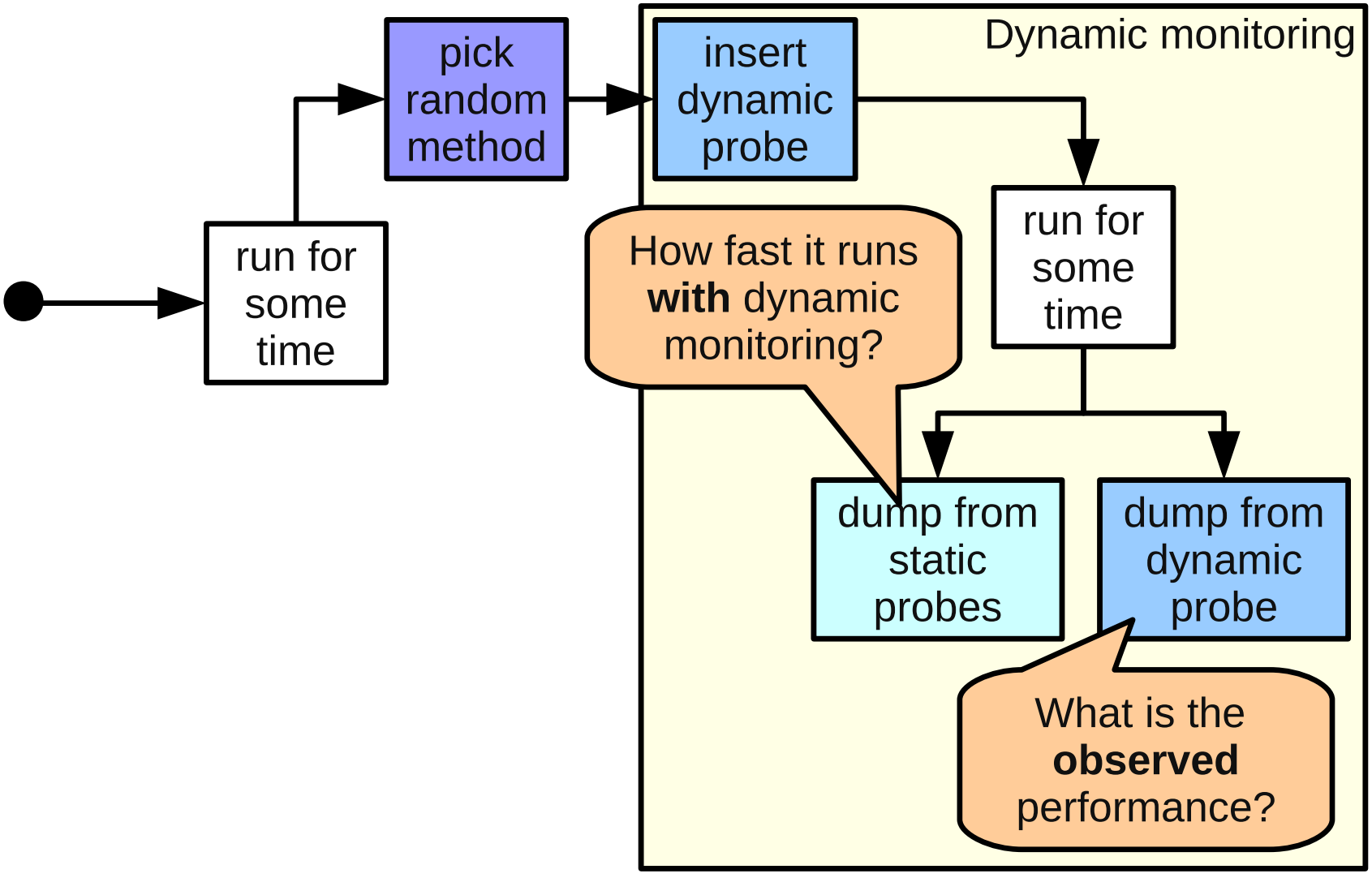
Experiment Process



Experiment Process

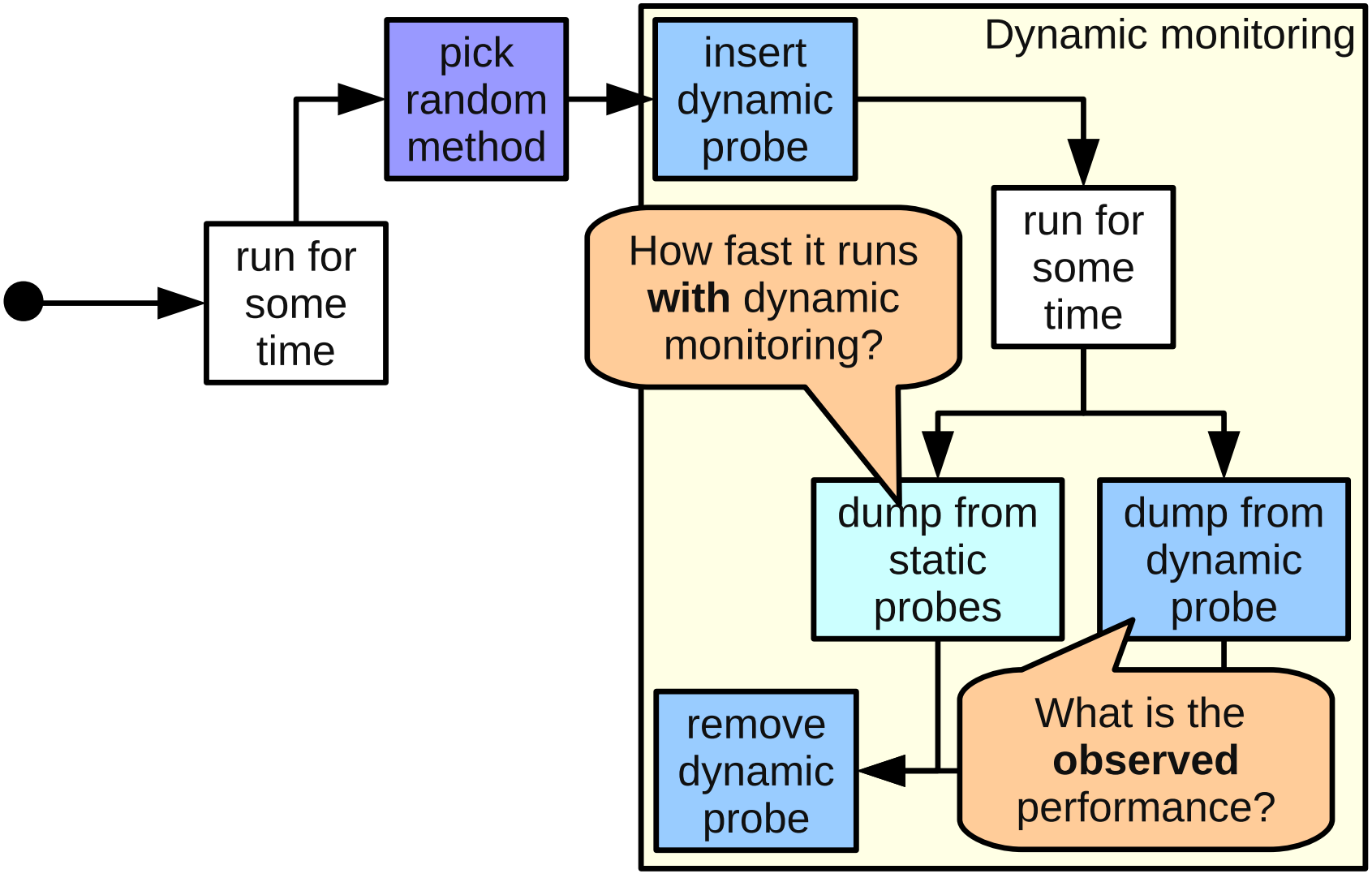


Experiment Process

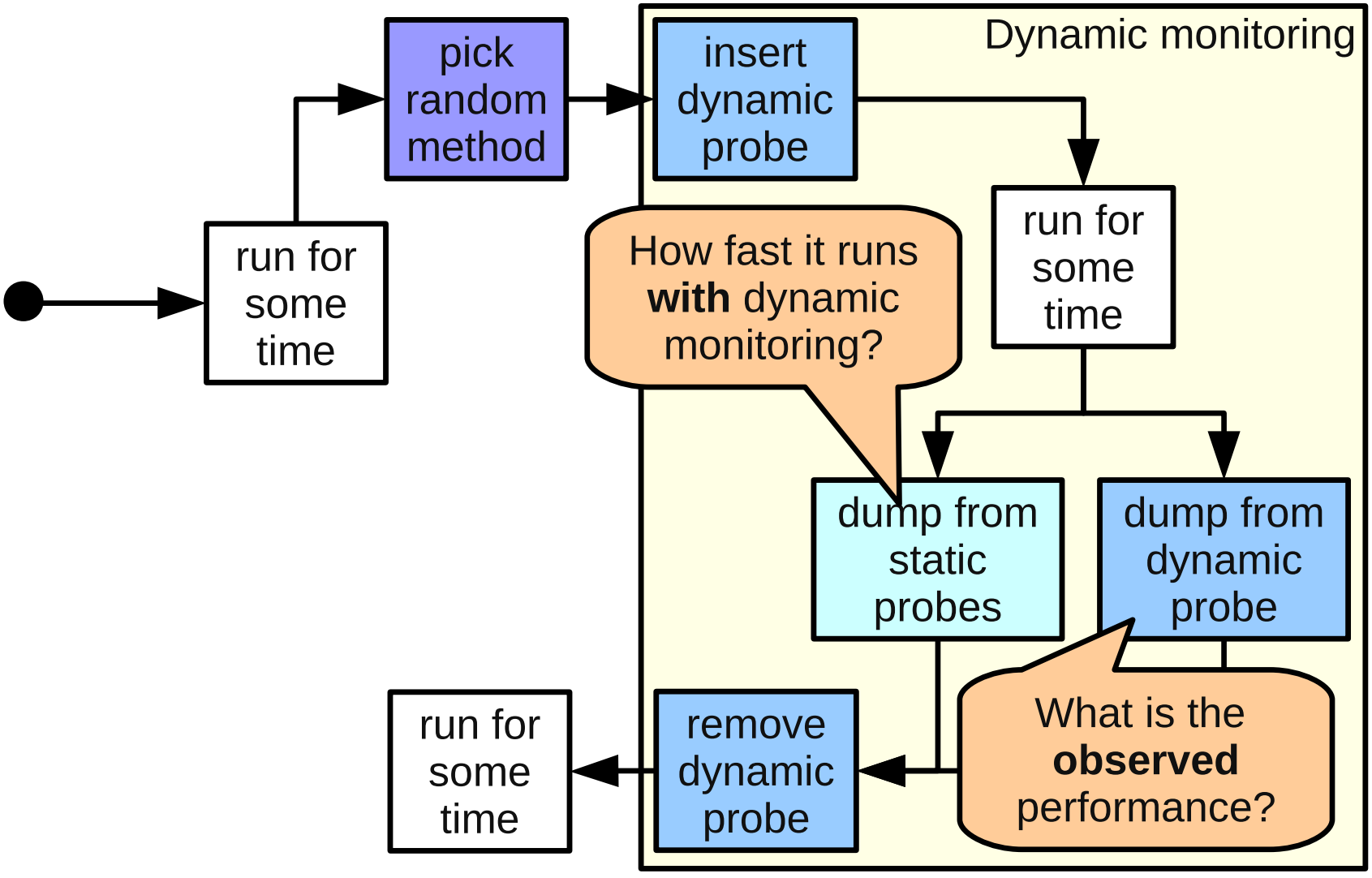


Department of Distributed and Dependable Systems D3S

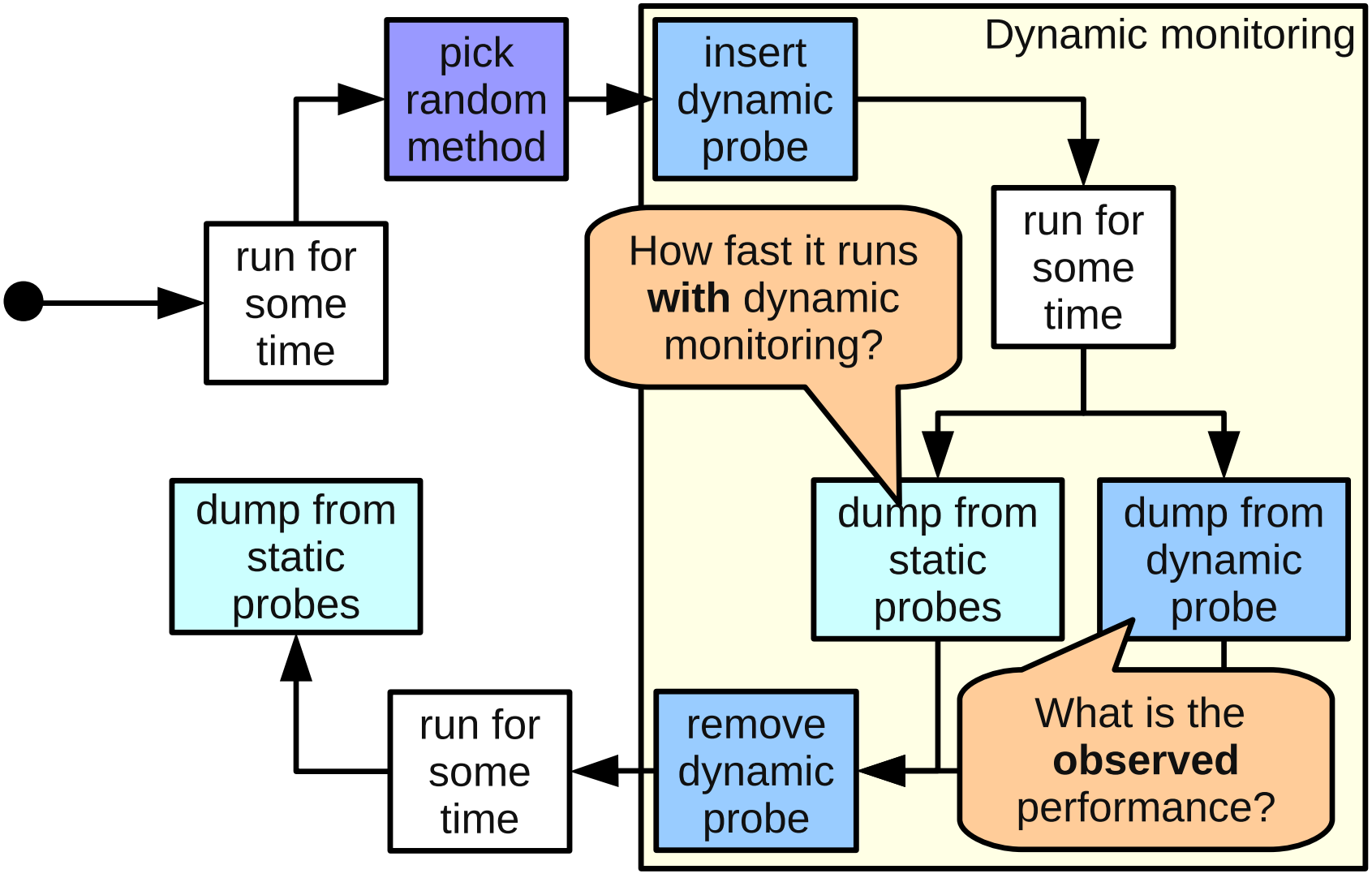
Experiment Process



Experiment Process

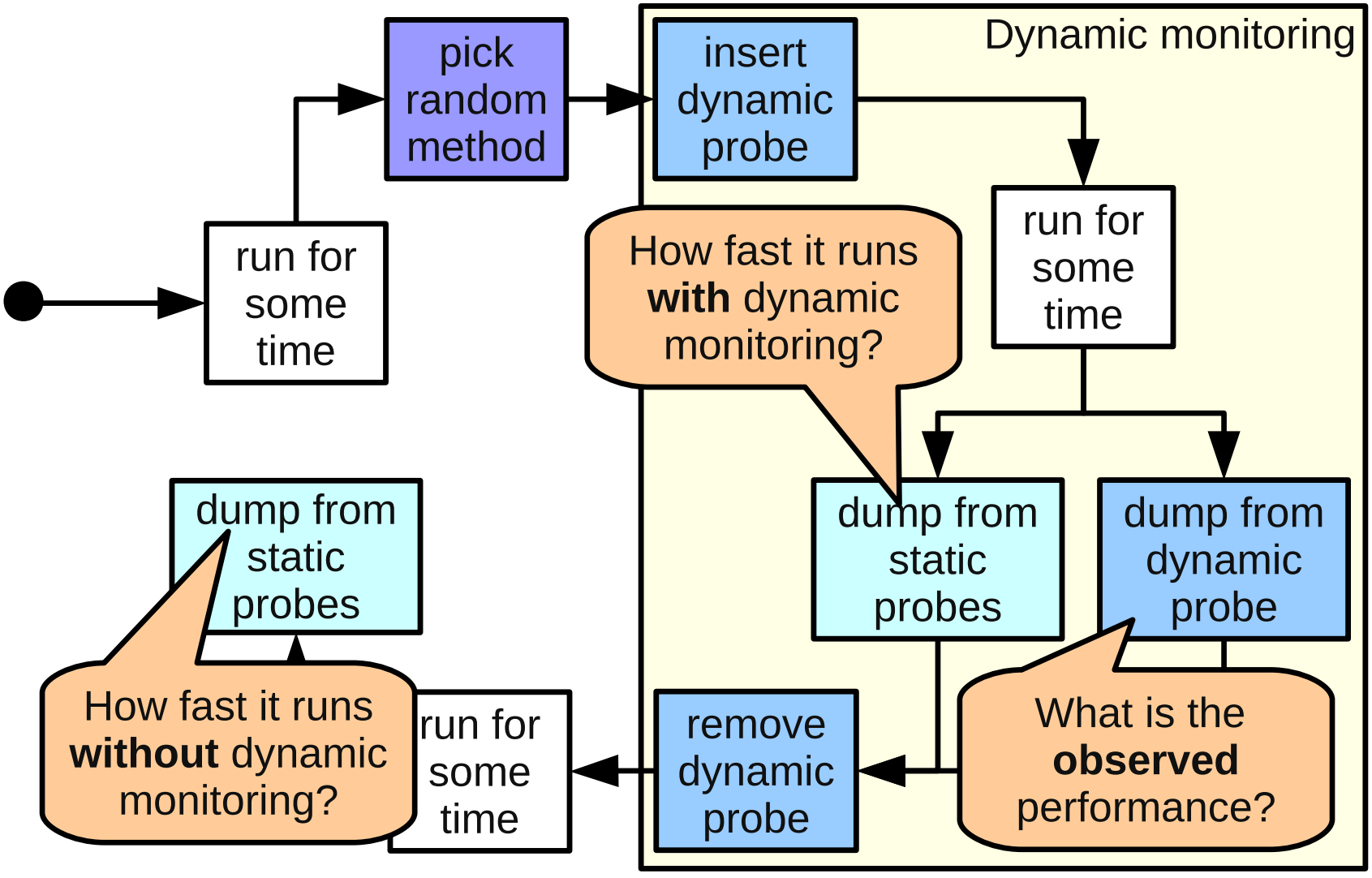


Experiment Process

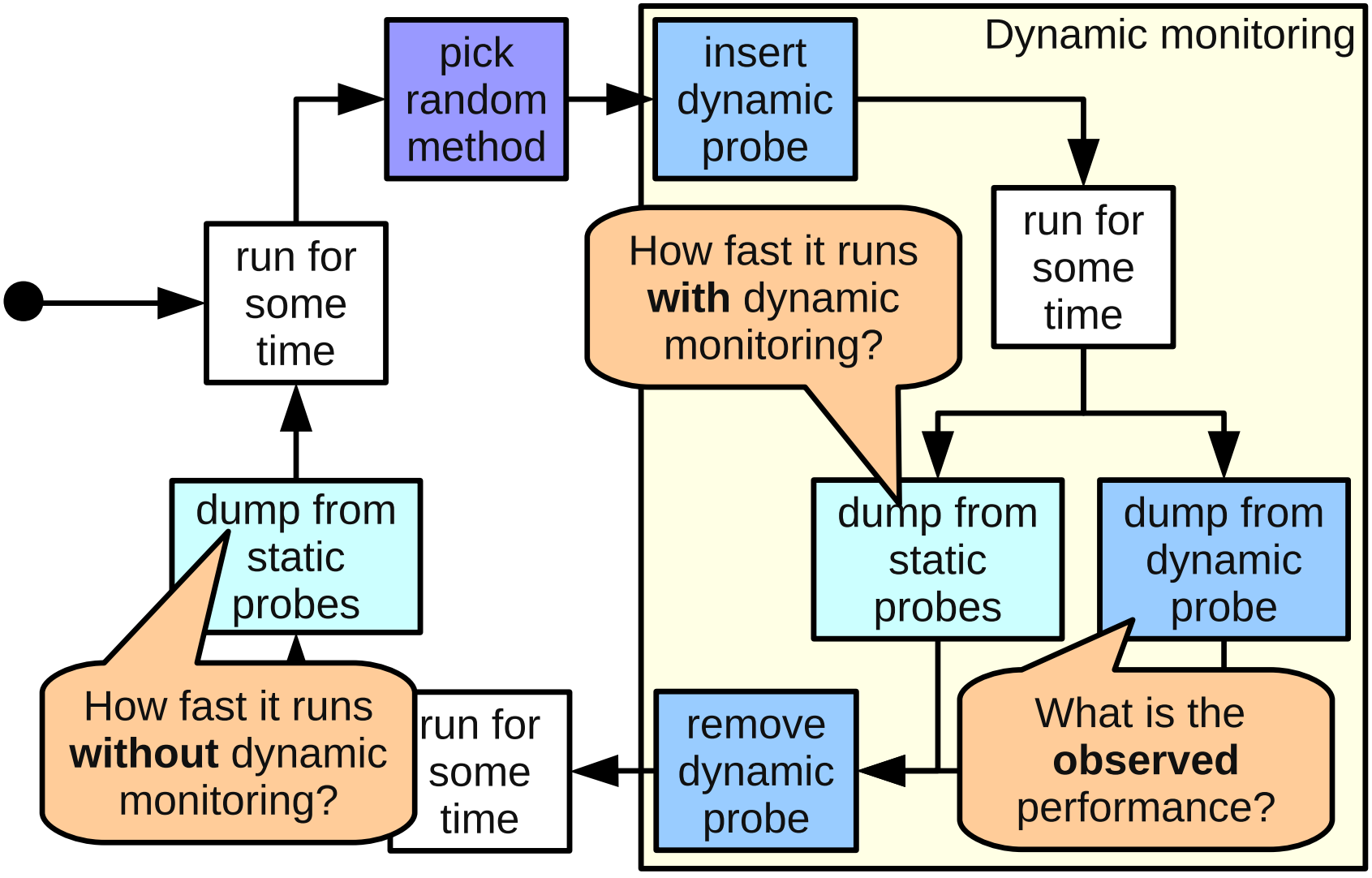


Department of Distributed and Dependable Systems D3S

Experiment Process



Experiment Process



Department of Distributed and Dependable Systems D3S

Platform and Application Details

Platform and Application Details

– Hardware: 32 CPUs, 2 NUMA nodes, 48G RAM.

Platform and Application Details

- Hardware: 32 CPUs, 2 NUMA nodes, 48G RAM.
- SPECjbb2015 augmented with static probes.
  - Fixed request rate 4 000 reqs/s.

    (Close to maximum with static probes on our hardware.)
- Over 1 200 monitored methods.
  - Business code of the benchmark.
  - Practically all methods called frequently enough.
  - About one minute of dynamic monitoring per method.

Platform and Application Details

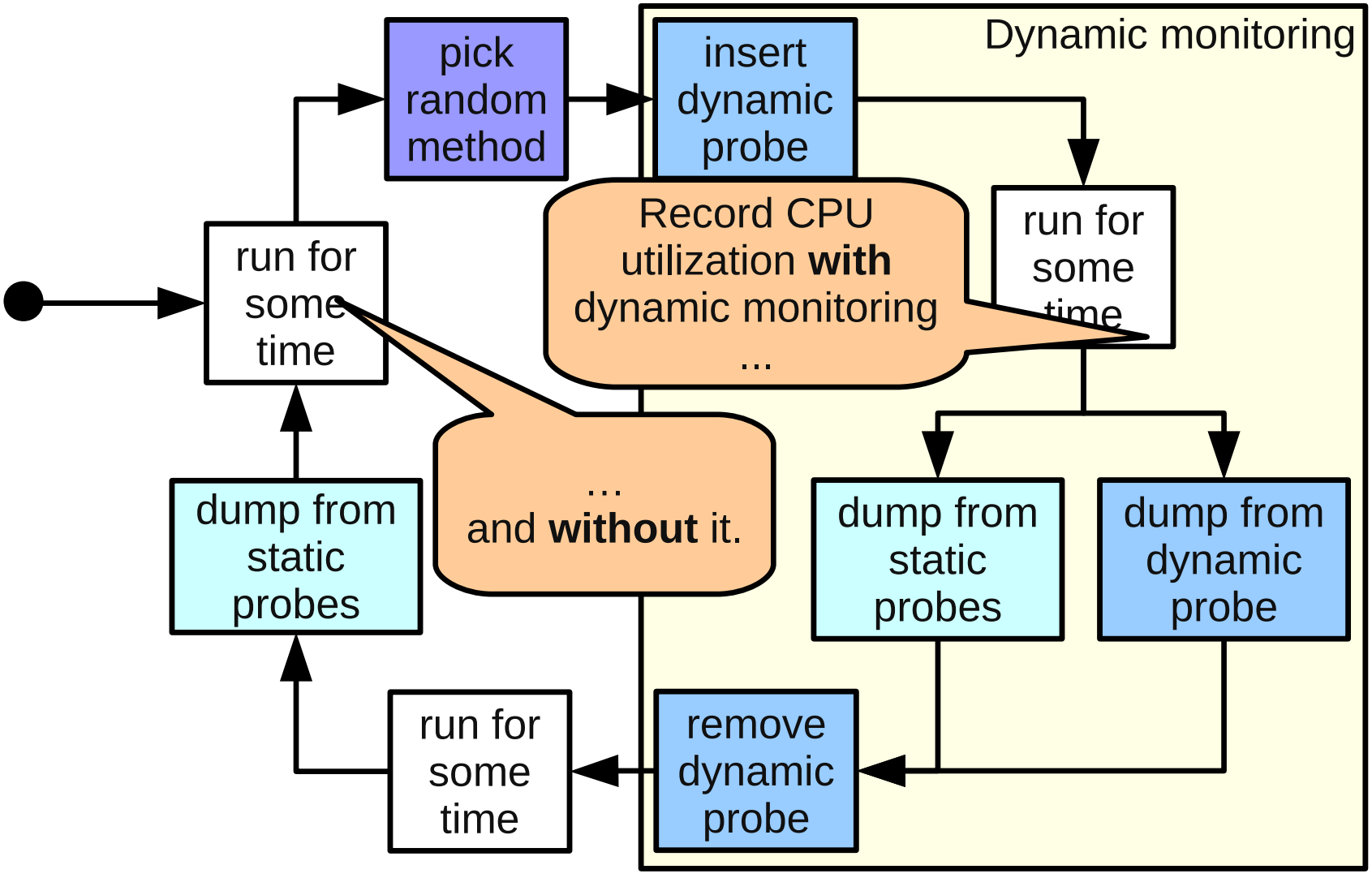
- Hardware: 32 CPUs, 2 NUMA nodes, 48G RAM.
- SPECjbb2015 augmented with static probes.
  - Fixed request rate 4 000 reqs/s.

    (Close to maximum with static probes on our hardware.)
- Over 1 200 monitored methods.
  - Business code of the benchmark.
  - Practically all methods called frequently enough.
  - About one minute of dynamic monitoring per method.
- Several TBs of raw data per week of run-time.

Results

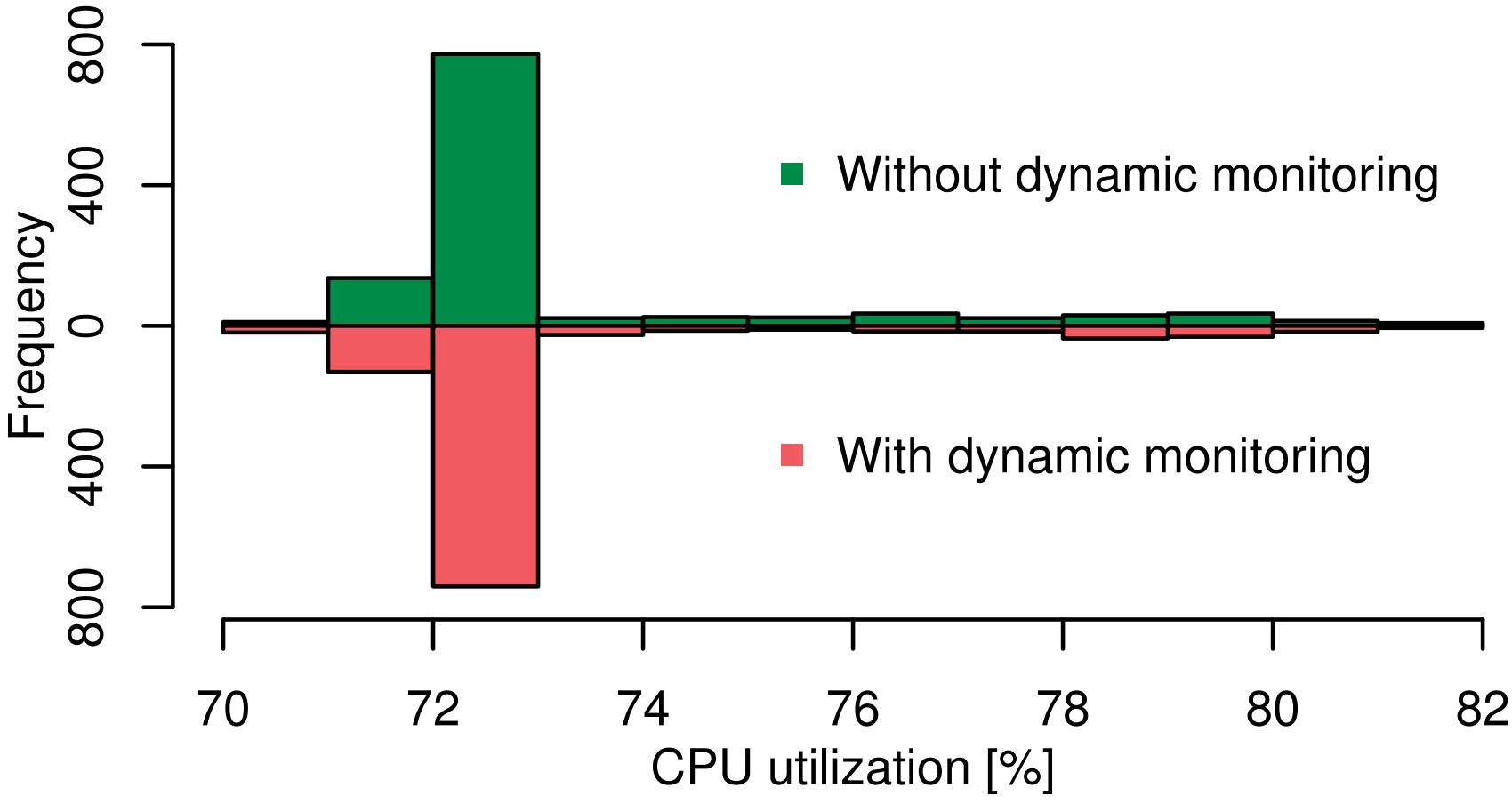
Overall Overhead of Dynamic Monitoring

Overall Overhead of Dynamic Monitoring



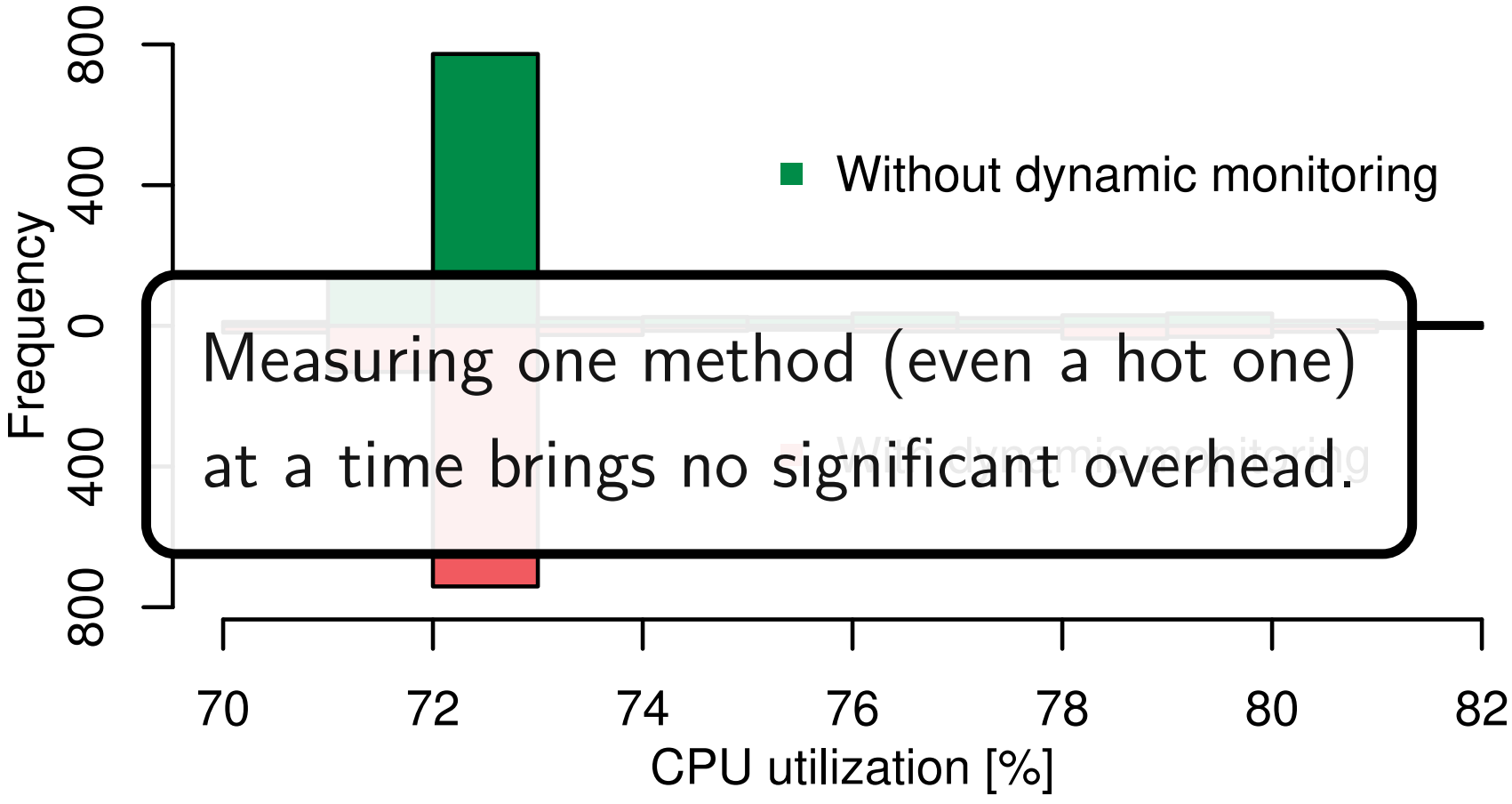
Department of Distributed and Dependable Systems D3S

Overall Overhead of Dynamic Monitoring



Department of Distributed and Dependable Systems D3S

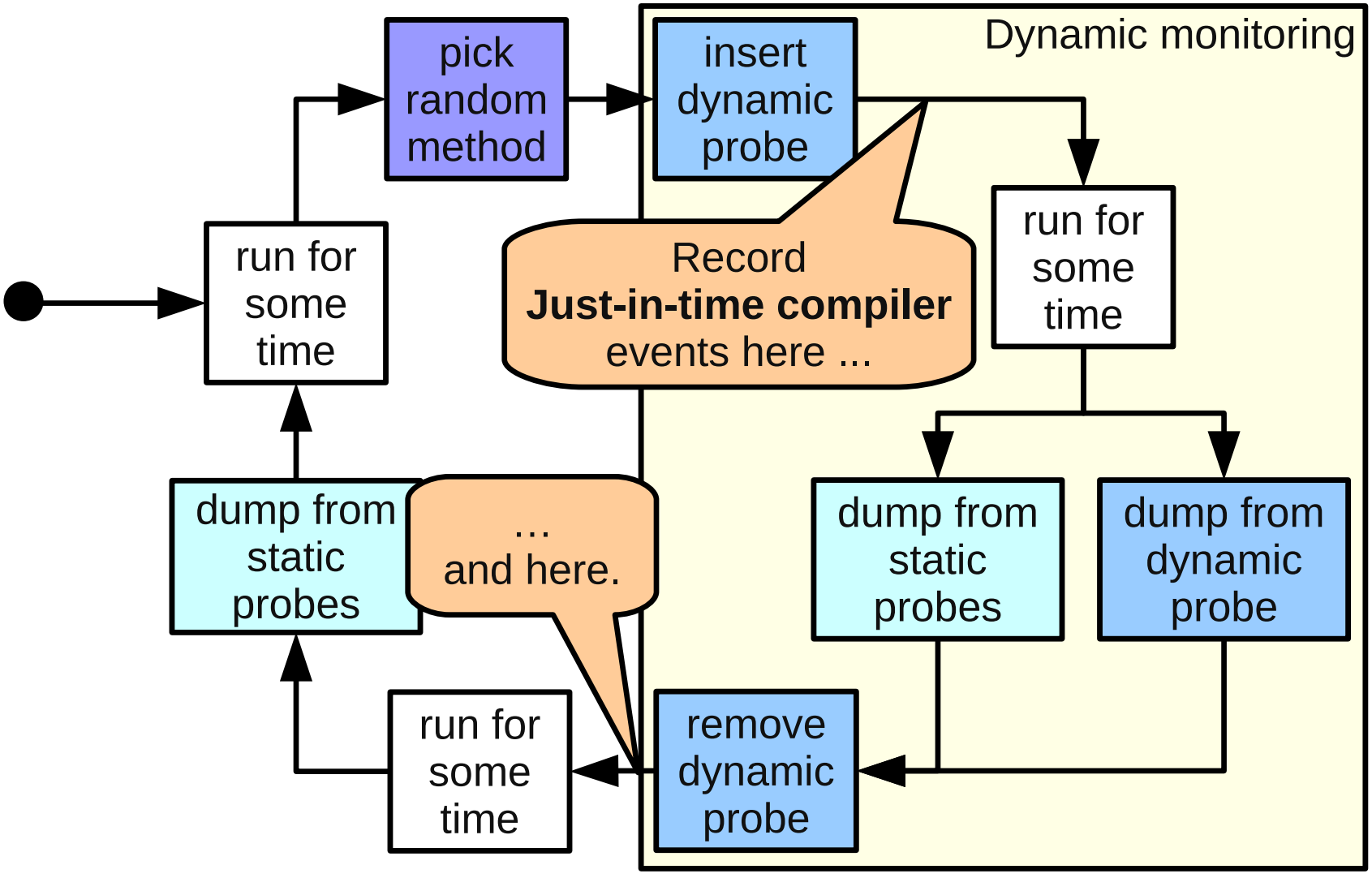
Overall Overhead of Dynamic Monitoring



Department of Distributed and Dependable Systems

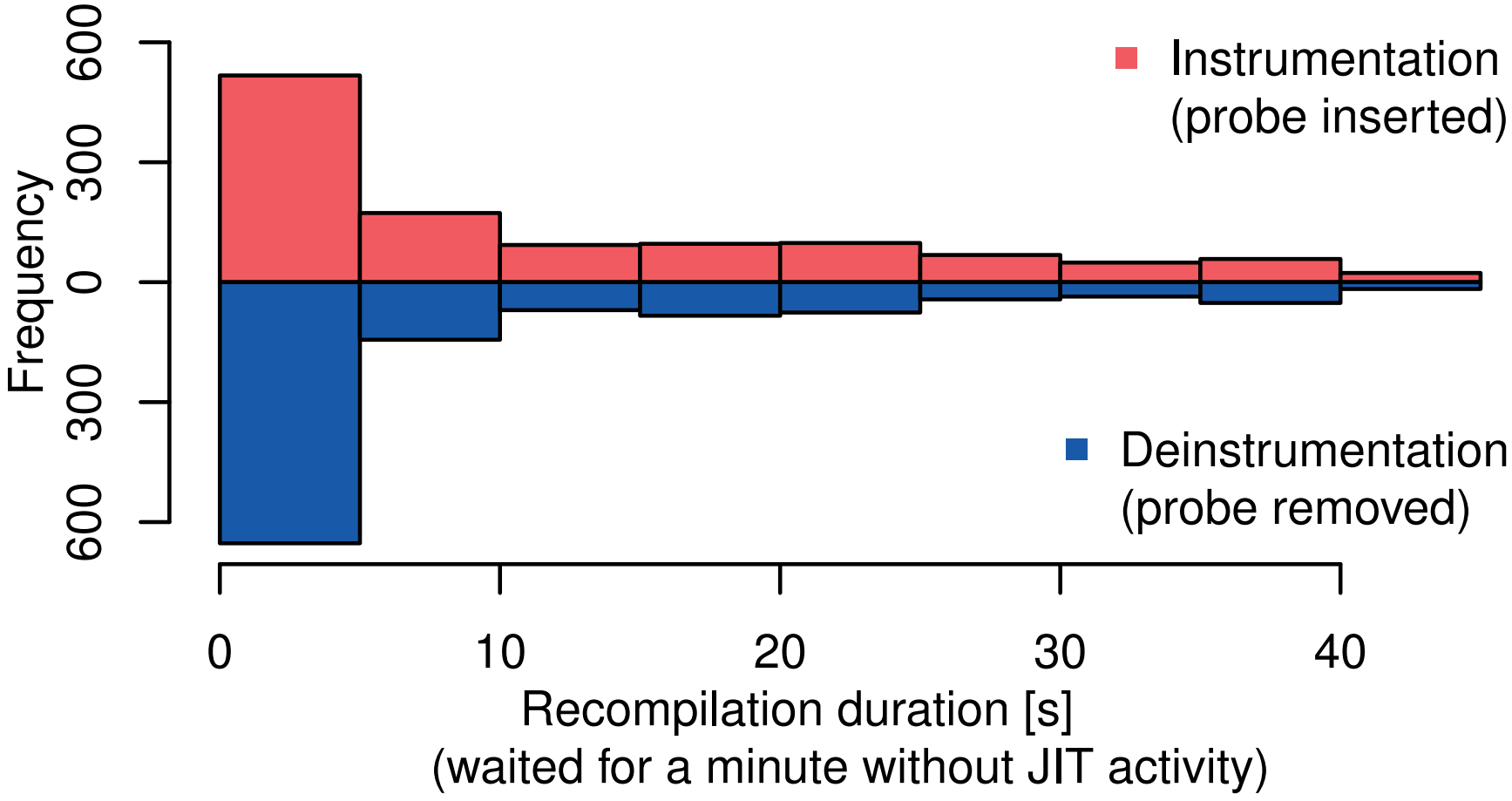
Time Needed for Just-in-time Recompilation

Time Needed for Just-in-time Recompilation



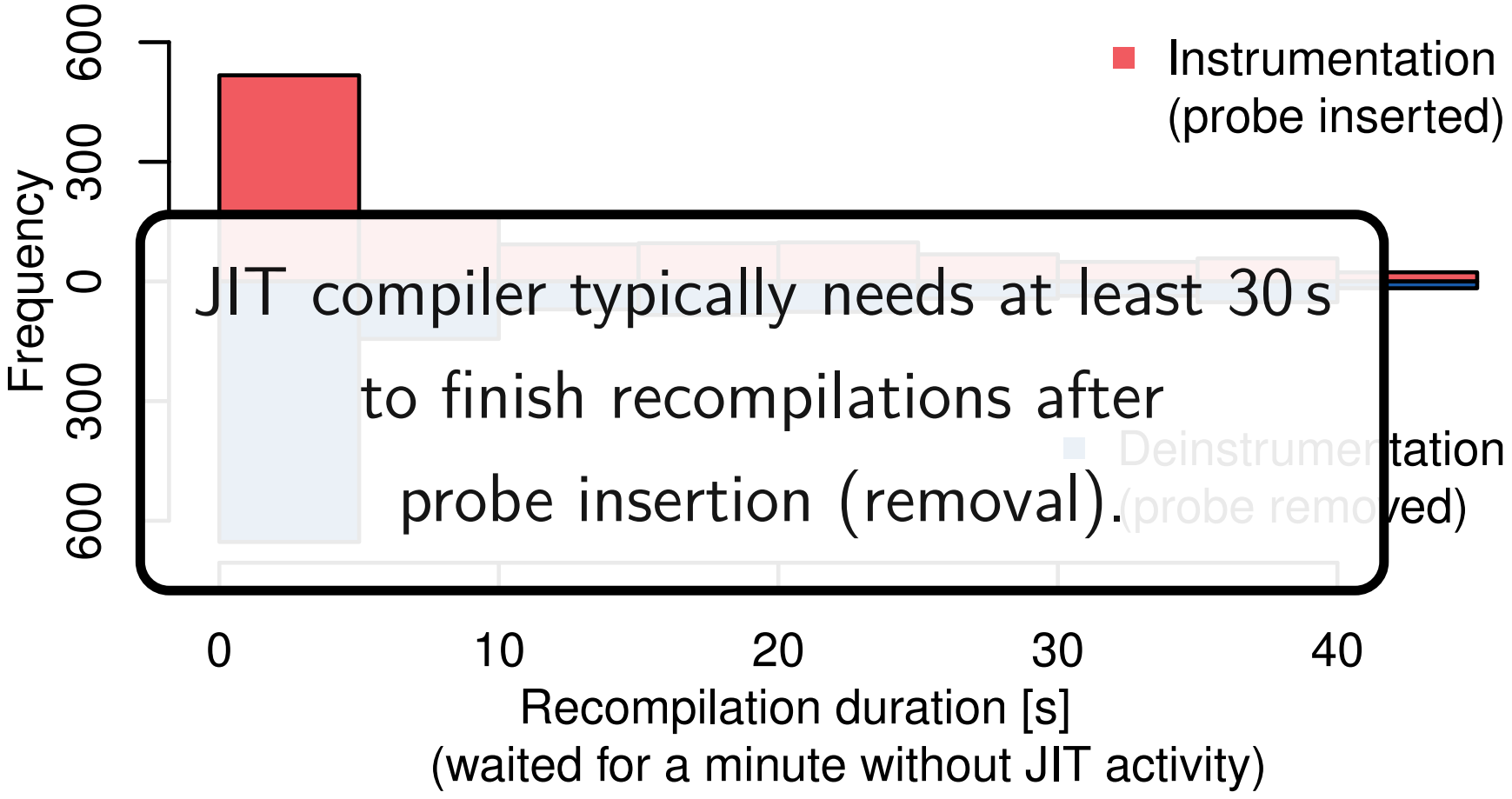
Department of Distributed and Dependable Systems D3S

Time Needed for Just-in-time Recompilation



Department of Distributed and Dependable Systems D3S

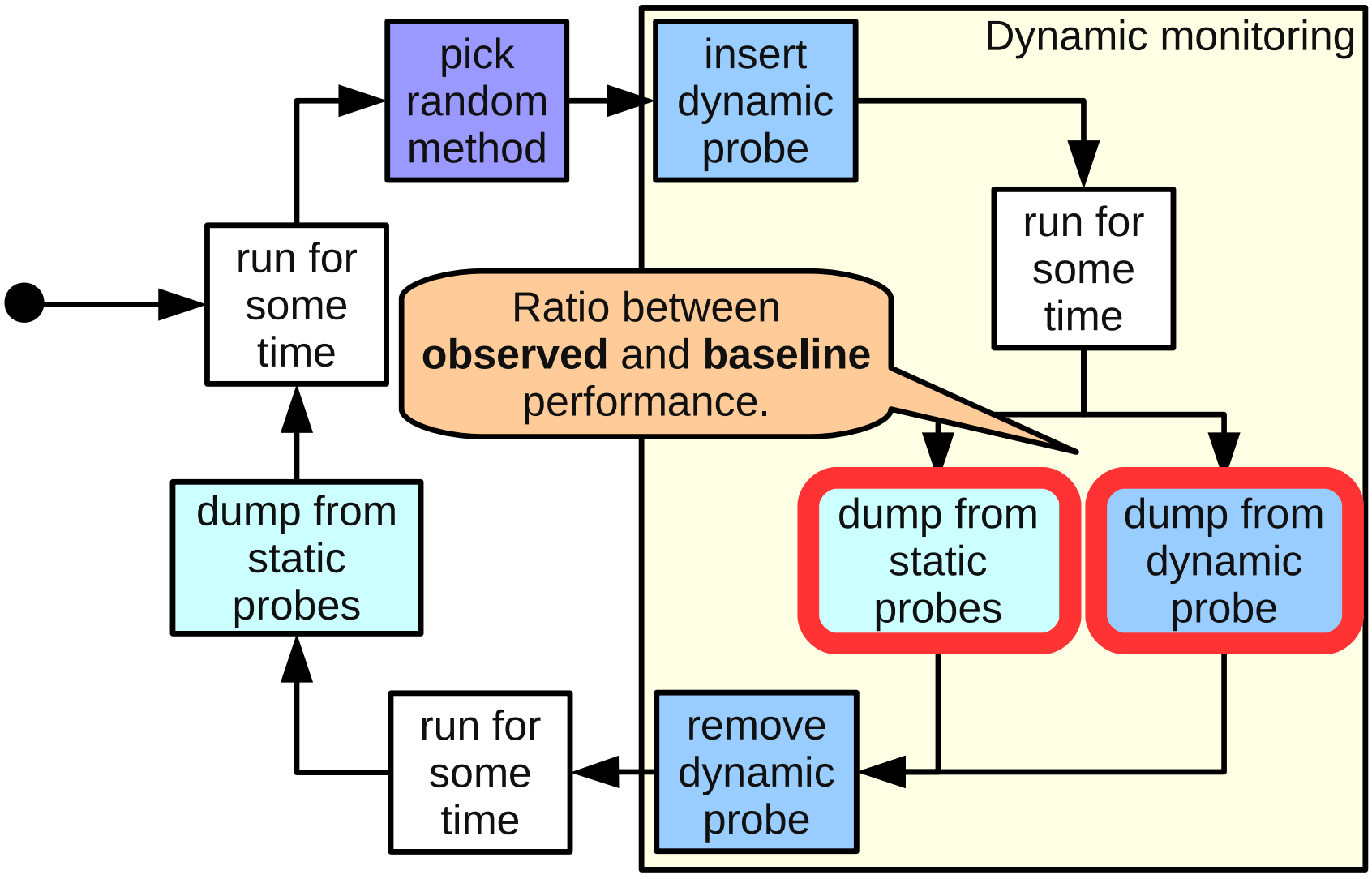
Time Needed for Just-in-time Recompilation



Department of Distributed and Dependable Systems D3S

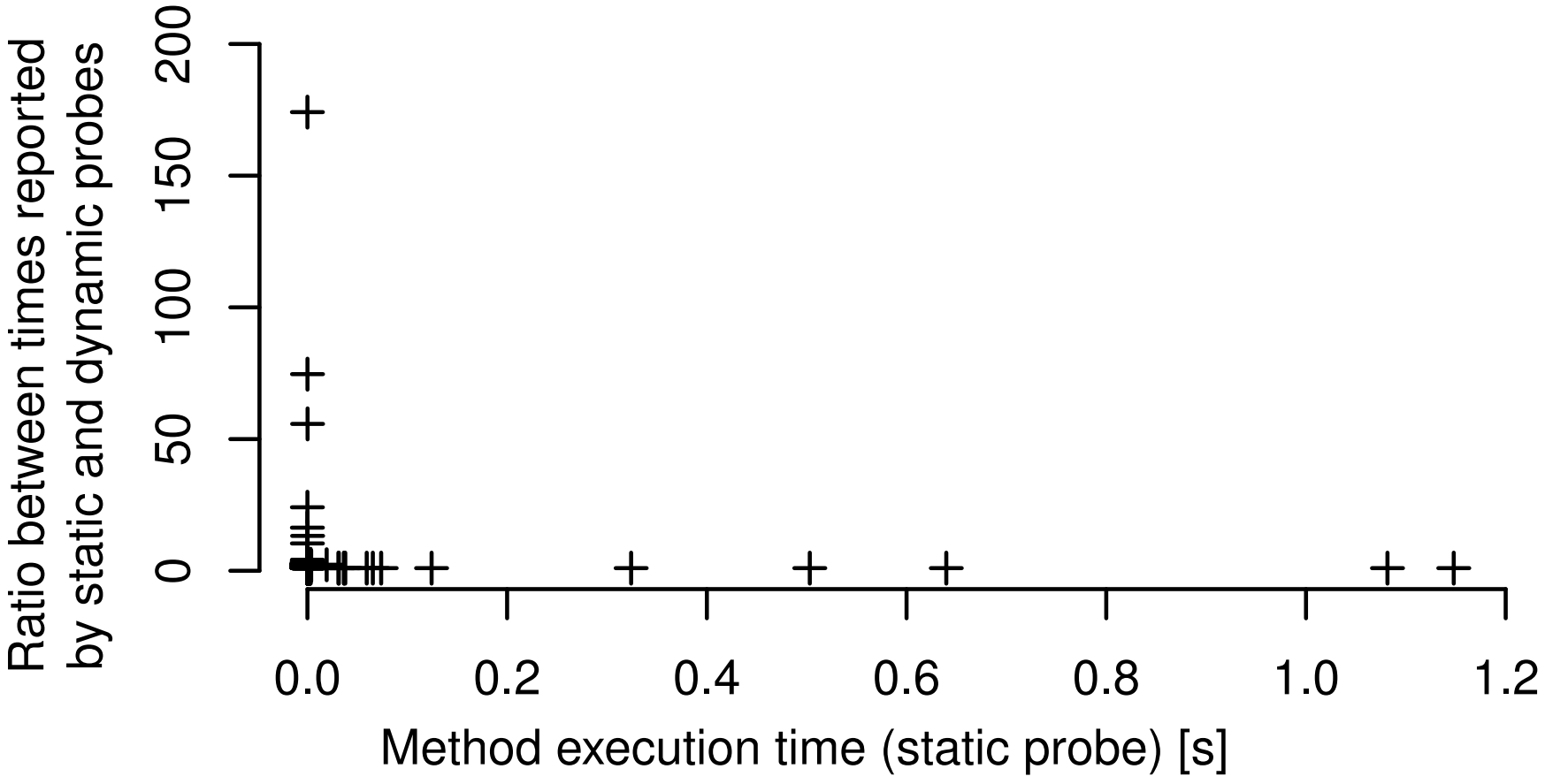
Accuracy of Collected Data

Accuracy of Collected Data



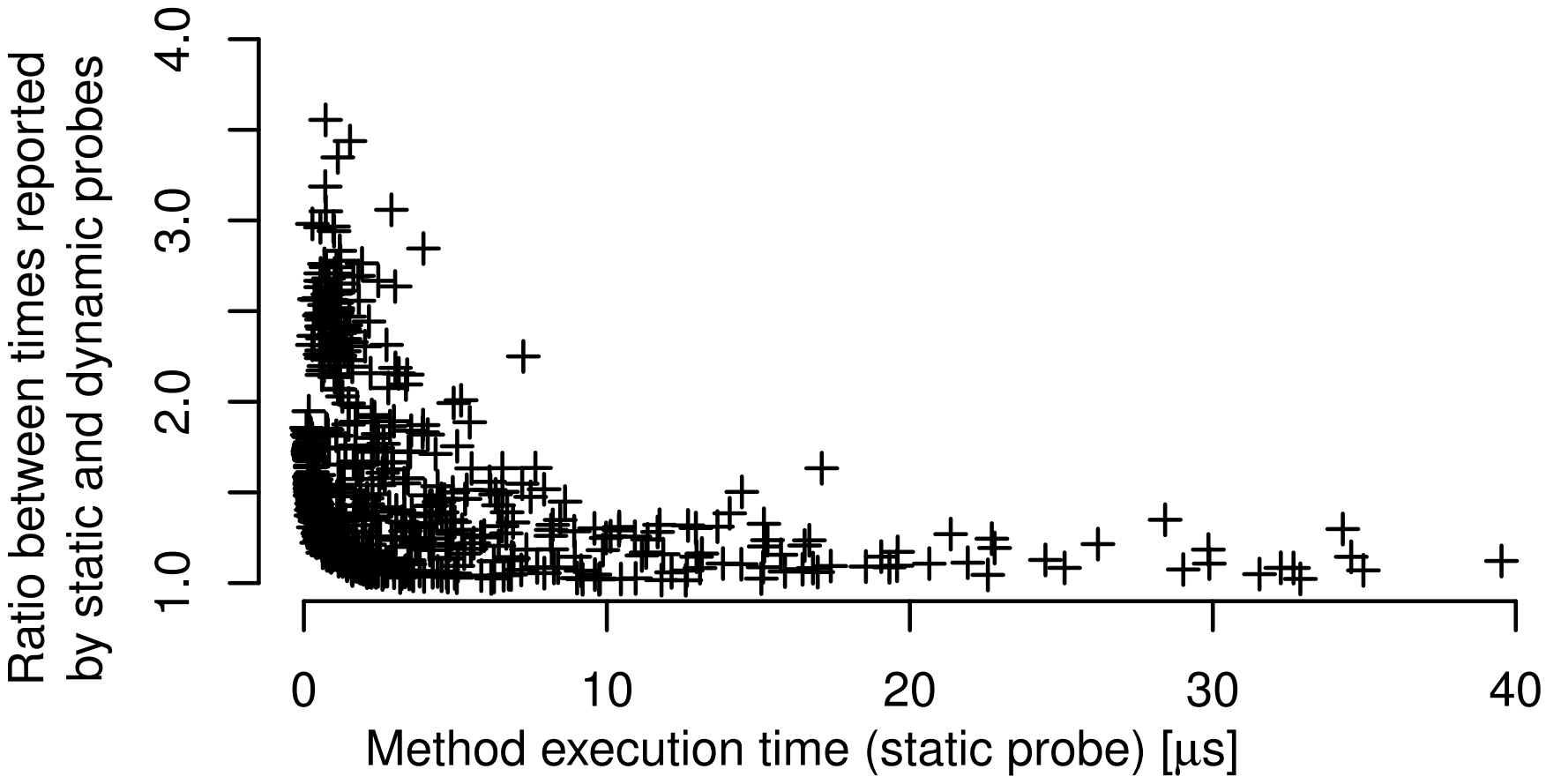
Department of Distributed and Dependable Systems D3S

Accuracy of Collected Data



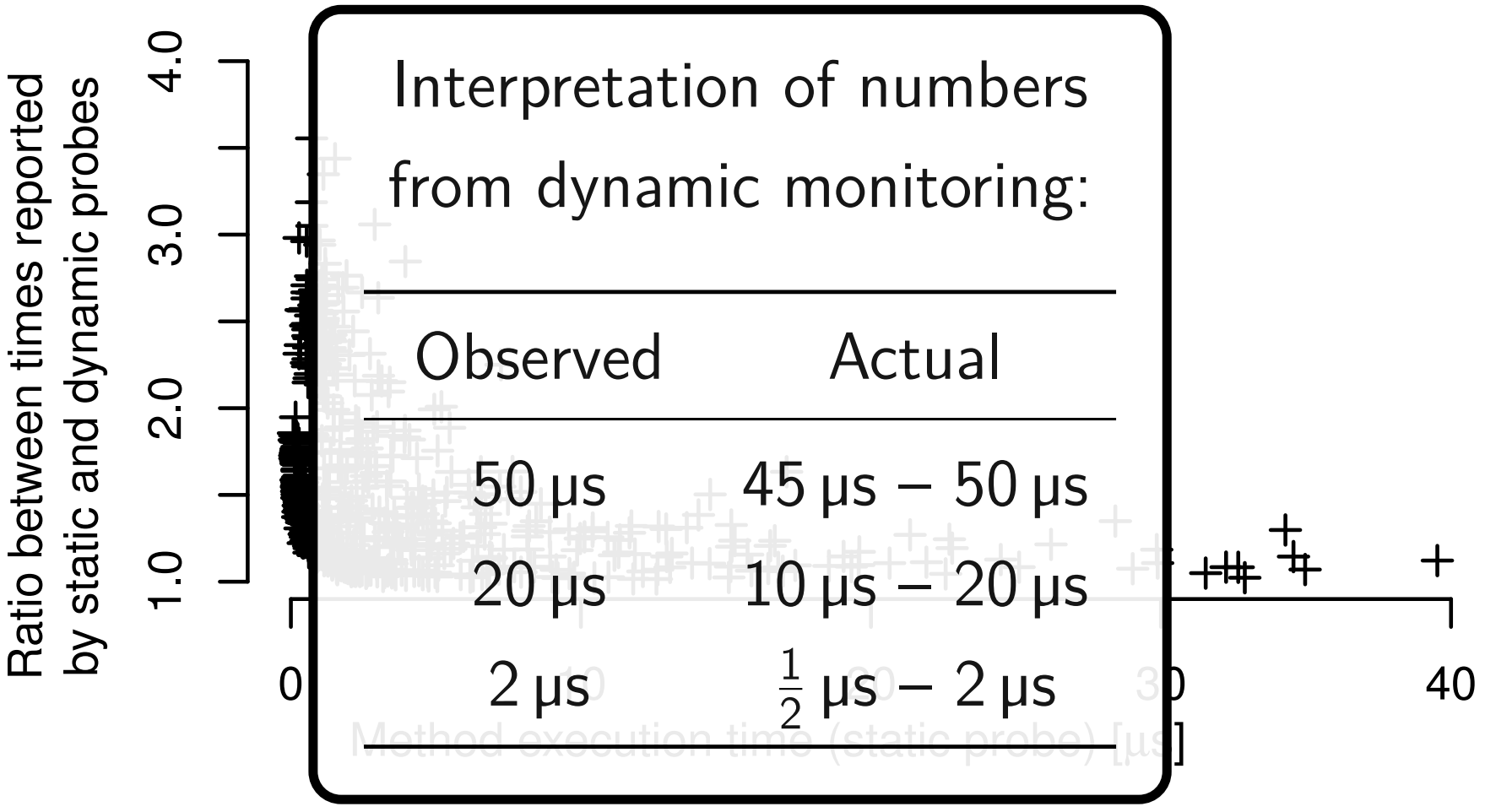
Department of Distributed and Dependable Systems

Accuracy of Collected Data



Department of Distributed and Dependable Systems
D3S

Accuracy of Collected Data



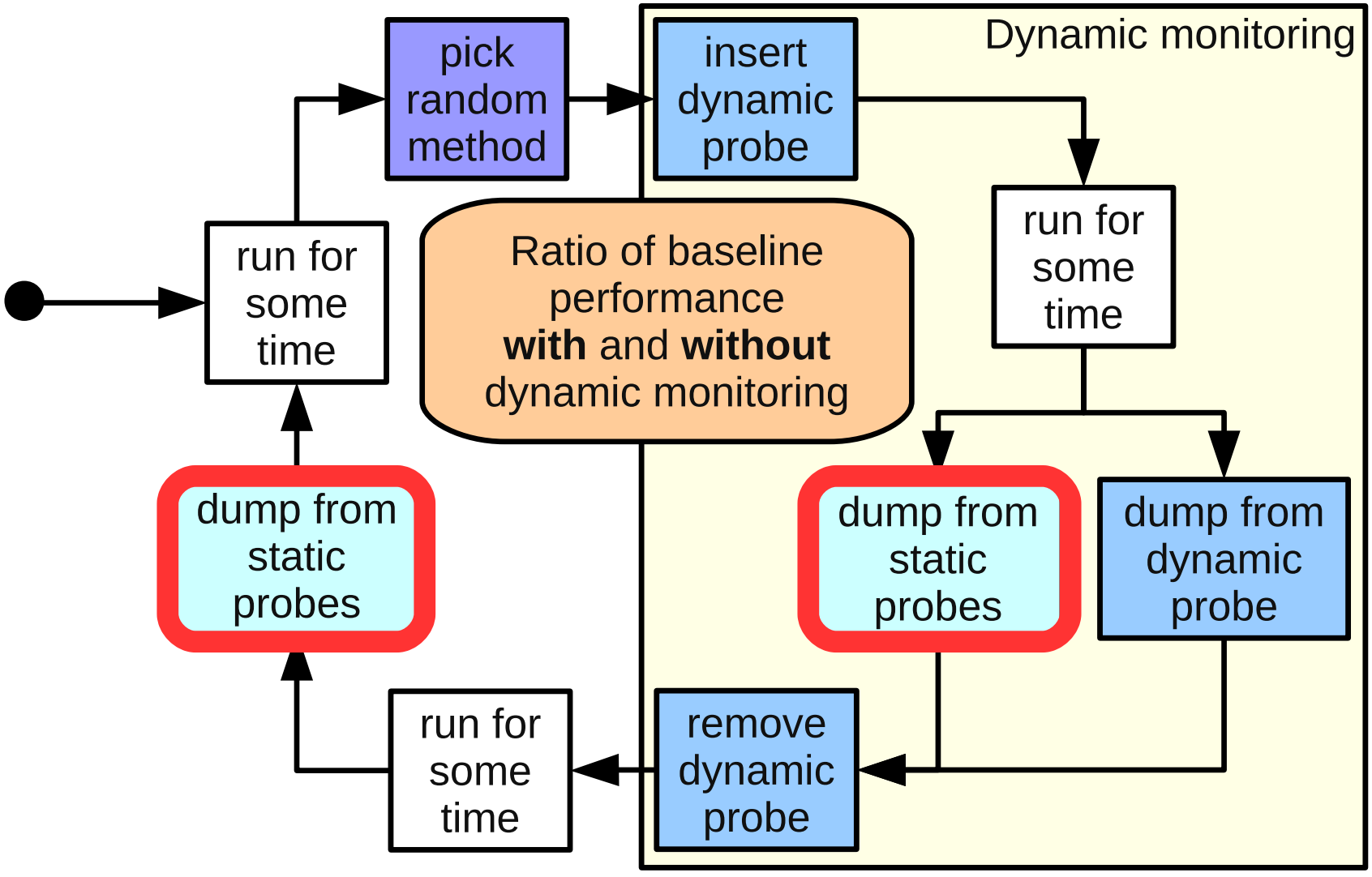
Interpretation of numbers from dynamic monitoring:

Observed	Actual
50 µs	45 µs – 50 µs
20 µs	10 µs – 20 µs
2 µs	$\frac{1}{2}$ µs – 2 µs

Department of Distributed and Dependable Systems

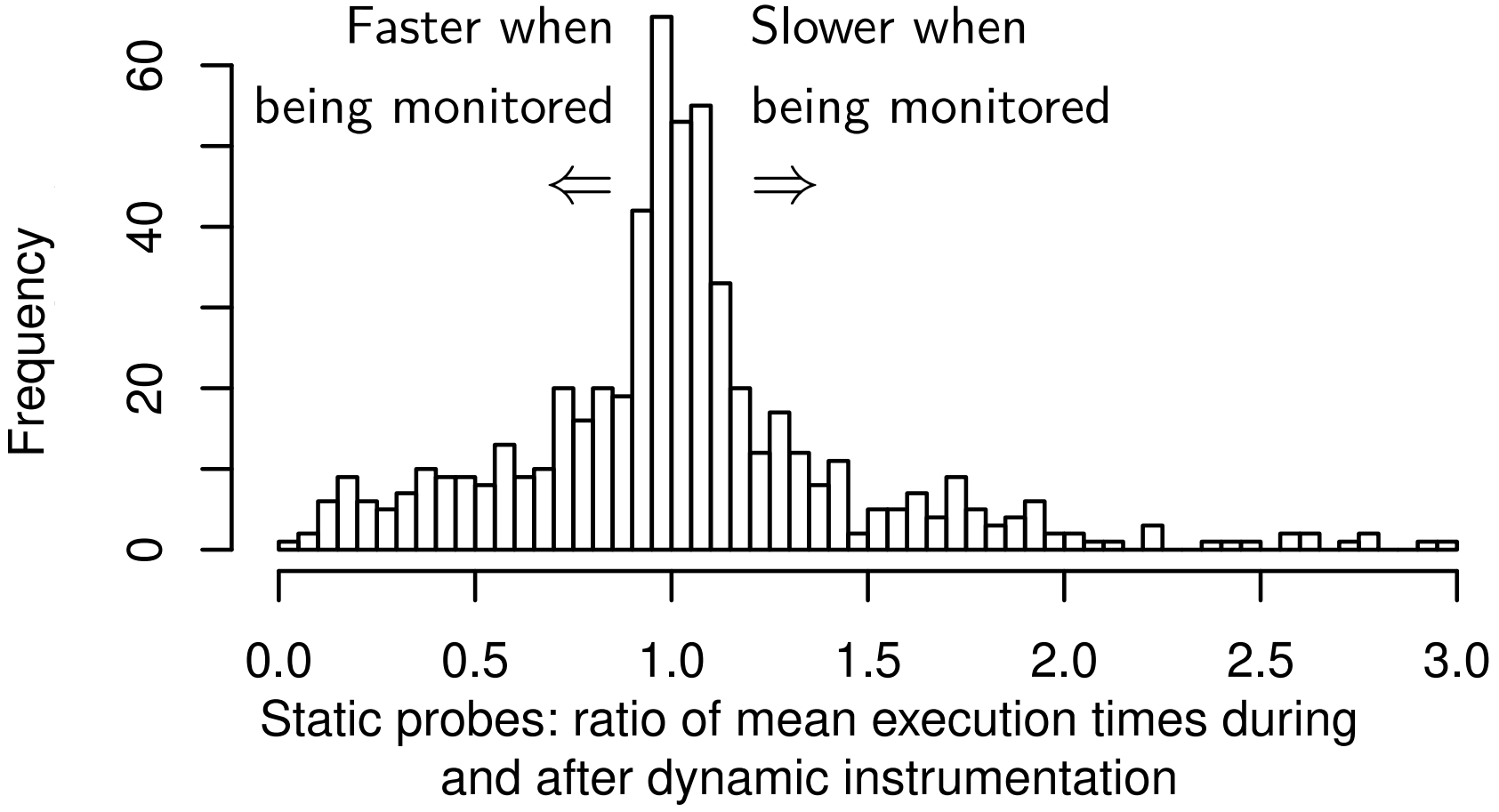
Impact of Dynamic Monitoring

Impact of Dynamic Monitoring



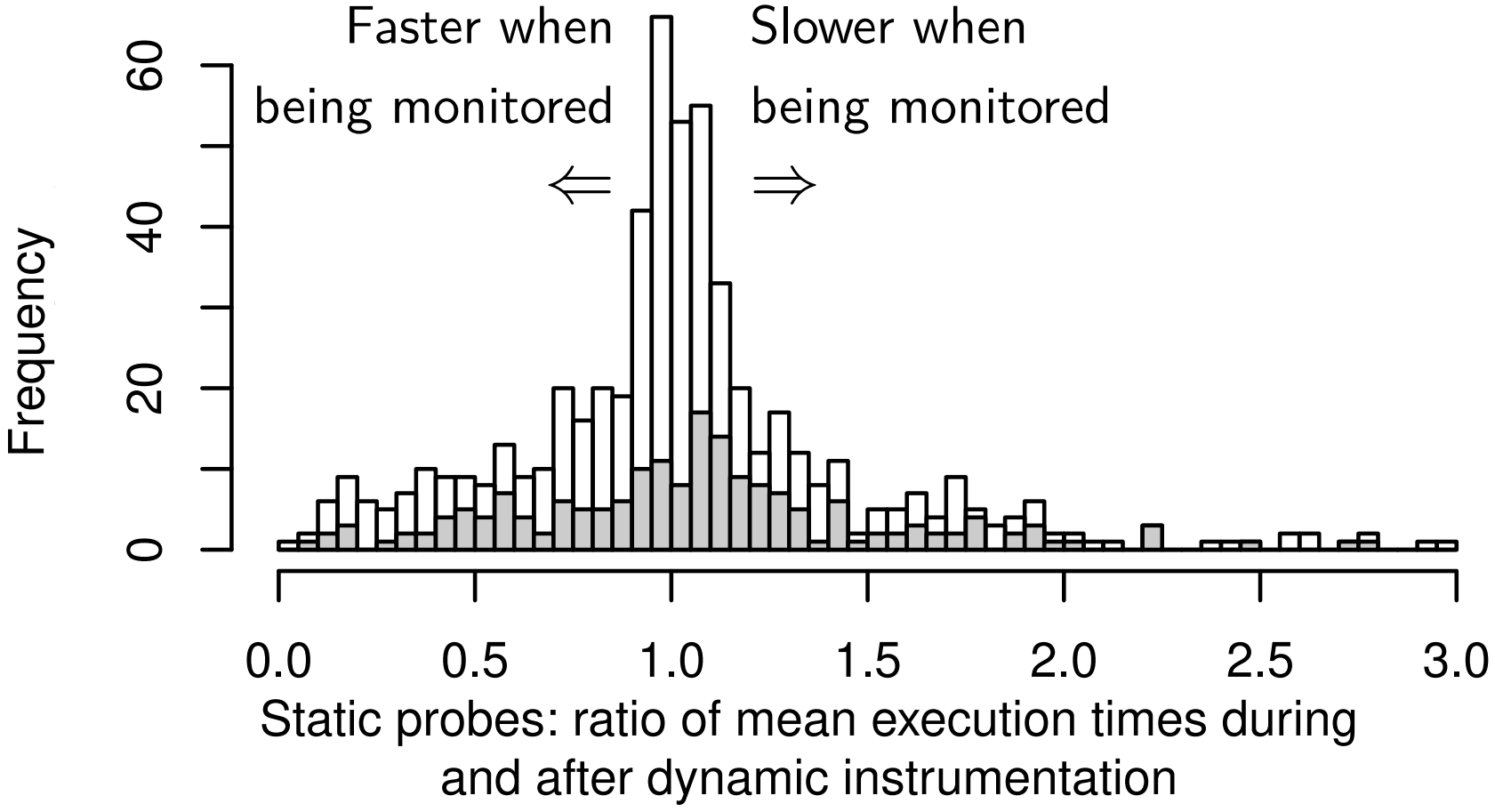
Department of Distributed and Dependable Systems D3S

Impact of Dynamic Monitoring



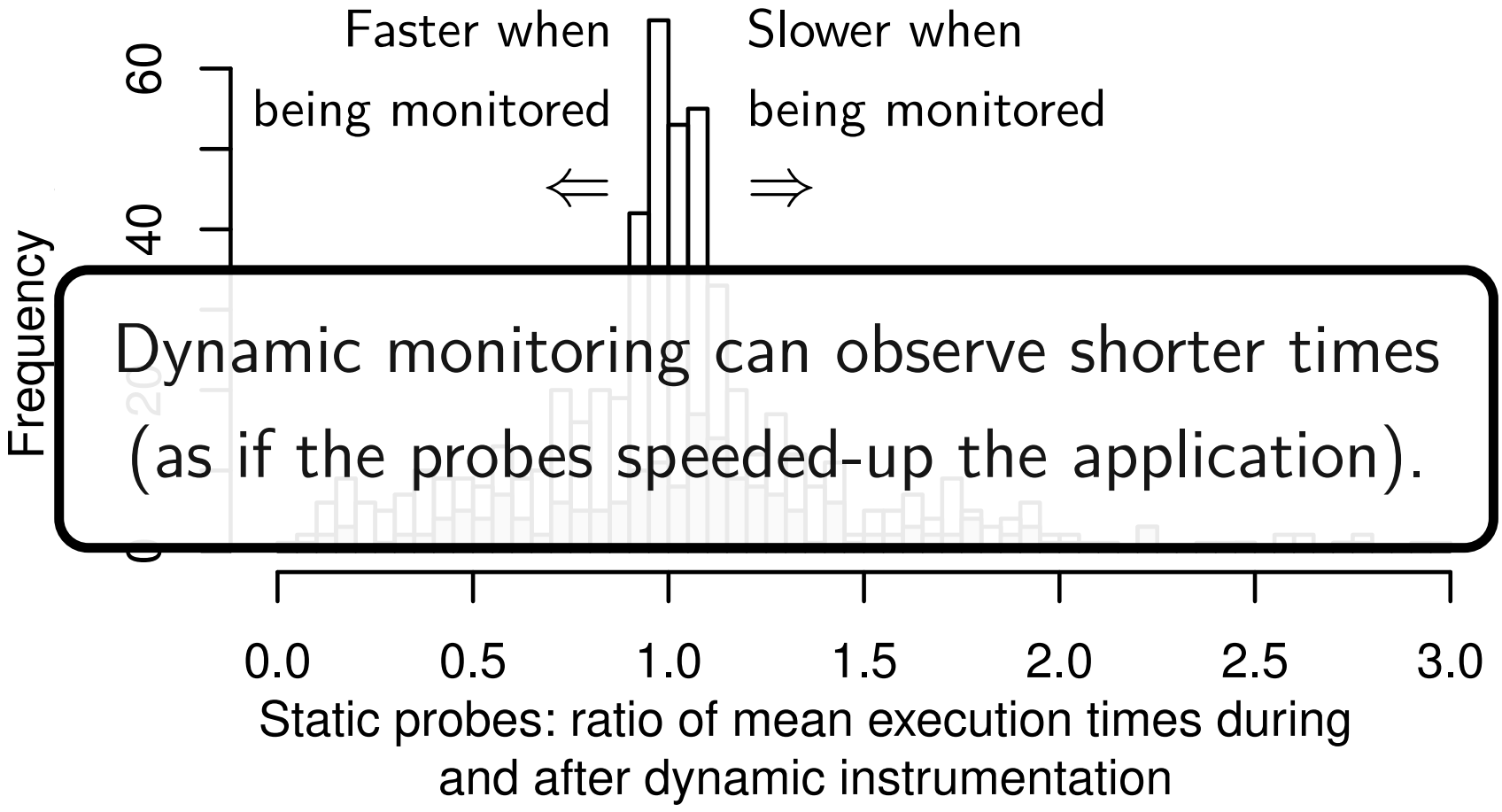
Department of Distributed and Dependable Systems D3S

Impact of Dynamic Monitoring



Department of Distributed and Dependable Systems D3S

Impact of Dynamic Monitoring



Conclusion

Analysis of Overhead in Dynamic Java Performance Monitoring

We evaluated how dynamic monitoring affects a running application and what is the accuracy of the obtained data.

Department of Distributed and Dependable Systems
D3S

Analysis of Overhead in Dynamic Java Performance Monitoring

We evaluated how dynamic monitoring affects a running application and what is the accuracy of the obtained data.

Rules of thumb coming from our experiment . . .

– Measuring one method at a time does not change CPU utilization.

– At least 30 s are needed for (JIT) recompilation.

– If the reported time is 30 µs . . .

. . . the actual duration is between 20 µs and 40 µs

(durations of at least 100 µs are more “trustworthy”, though).

Department of Distributed and Dependable Systems D3S

Analysis of Overhead in Dynamic Java Performance Monitoring

We evaluated how dynamic monitoring affects a running application and what is the accuracy of the obtained data.

Rules of thumb coming from our experiment . . .

– Measuring one method at a time does not change CPU utilization.

– At least 30 s are needed for (JIT) recompilation.

– If the reported time is 30 µs . . .

. . . the actual duration is between 20 µs and 40 µs

(durations of at least 100 µs are more “trustworthy”, though).

http://d3s.mff.cuni.cz/resources/icpe2016

Department of Distributed and Dependable Systems D3S

Analysis of Overhead in Dynamic Java Performance Monitoring

We evaluated how dynamic monitoring affects a running application and what is the accuracy of the obtained data.

Rules of thumb coming from our experiment . . .

– Measuring one method at a time does not change CPU utilization.

– At least 30 s are needed for (JIT) recompilation.

– If the reported time is 30 µs . . .

. . . the actual duration is between 20 µs and 40 µs

(durations of at least 100 µs are more "trustworthy", though).

http://d3s.mff.cuni.cz/resources/icpe2016

Thank You!

Department of Distributed and Dependable Systems D3S