SETTLE: A Tuple Space Benchmarking and Testing Framework

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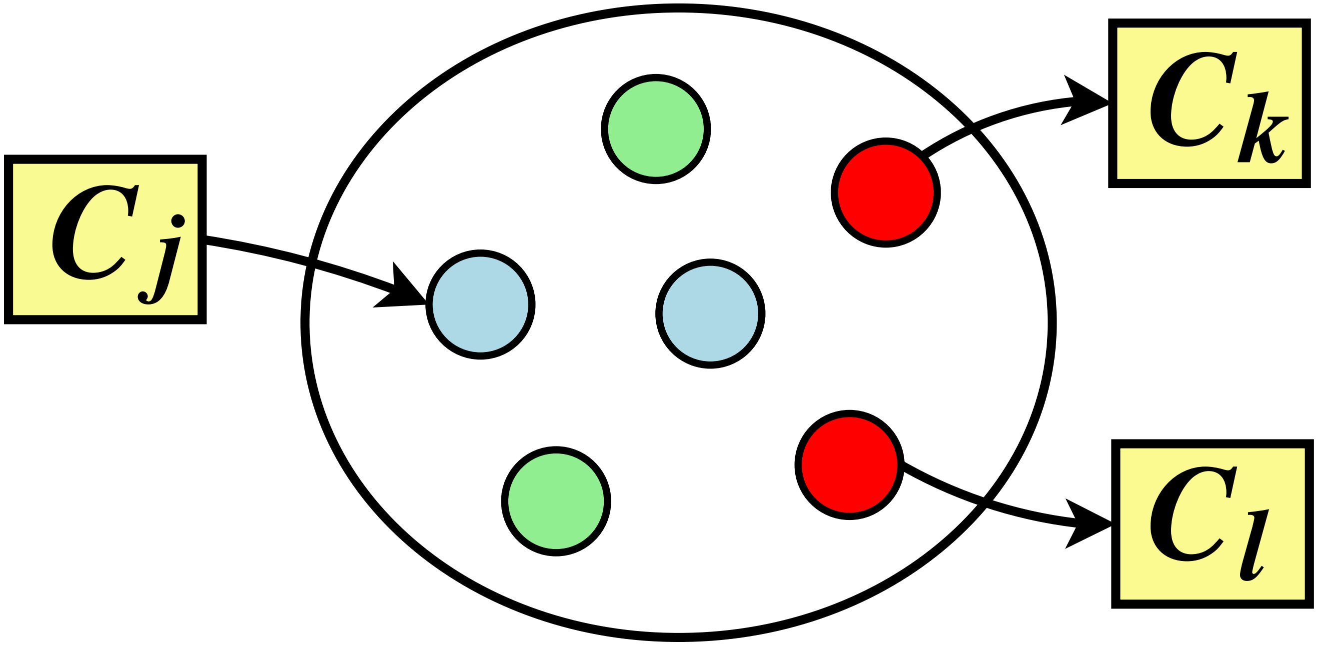
Contributions

- Benchmarking framework that can measure throughput and response time while varying the number of clients
- Tuple space aging technique that automatically populates tuple space before benchmark execution
- Detailed empirical study that evaluates tuple space performance, time overhead associated with aging, and impact of aging on space performance

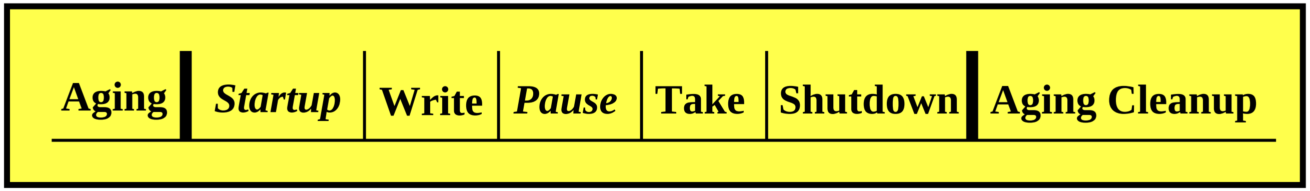
Introduction to Tuple Spaces



- Space clients can `write`, `take`, and `read` `Entry` objects

SETTLE Approach

- q space clients execute the same benchmark in phases
- Client C_j starts up $T_{delay} \in [T_{min}, T_{min} + V]$ ms after C_{j-1}
- Client pauses for T_{delay} ms between the `write` and `take` phases
- Measure response time, $R(S_i, C_j, O)$, and throughput, $X(S_i, O, q)$



Tuple Space Aging: Preliminaries

- Could execute benchmark with an empty tuple space but `take` will execute faster than normal
- Age with either automatically generated or recorded/derived workloads
- $\{r, t, w\}$-frequency defines the fraction of the workload that will be associated with each space operation
- Define a frequency for each possible `Entry` type so that

$$freq(Null) = .45 + freq(String) = .15 + freq(Array) = .25 + \cdots$$

$$\cdots + freq(File) = .15 = 1$$

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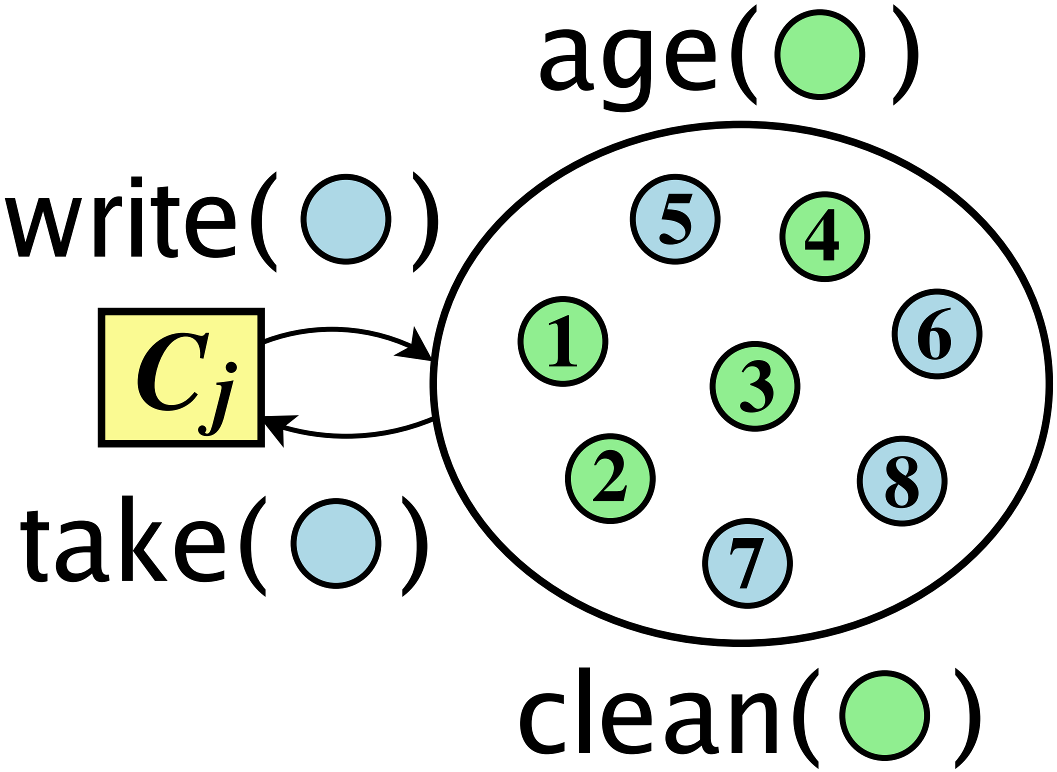
Tuple Space Aging: Example



- Automatically populate space with `Entry` objects of same type but different fi eld values

Experiment Design

- Dual Intel Xeon Pentium III processors and 512 MB main memory
- GNU/Linux kernel 2.4.18-14smp, Java 1.4.2 compiler, Java 1.4.2 VM in HotSpot client mode, Jini 1.2.1
- LinuxThreads 0.10 was confi gured with a one-to-one mapping between Java threads and kernel processes
- Clients $C_1, \ldots, C_q$ executed on the same machine as JavaSpace S_i
- Other confi gurations are possible and additional experiments are currently being conducted

Experiment Parameters

Parameter	**Value(s)**
T_{min}	200 ms
V	50 ms
T_{delay}	$[200, 250]$ ms
# of `Entry` Objects	$\{1000\}$
Aging Workload Size ($\|W\|$)	$\{1000, 3000, 6000, 12000\}$
# of Clients (non-aged) (q)	$\{2, 8, 14, 22\}$
# of Clients (aged) (q)	$\{8, 14\}$
$\{r, t, w\}$-frequency	$\{0, 0, 100\}$
`Entry` Objects	$\{$`Null`, `String`, `Array`, `File`$\}$

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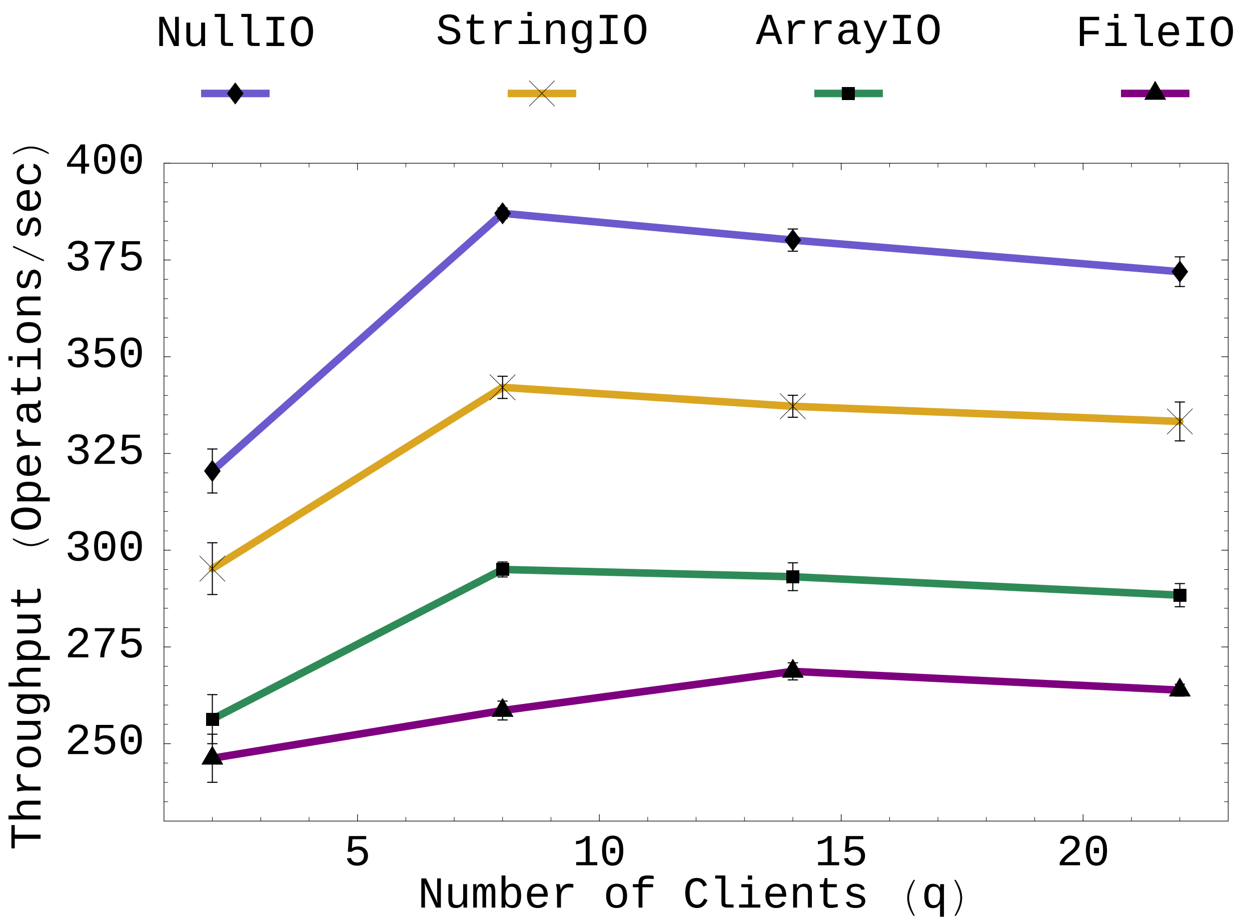
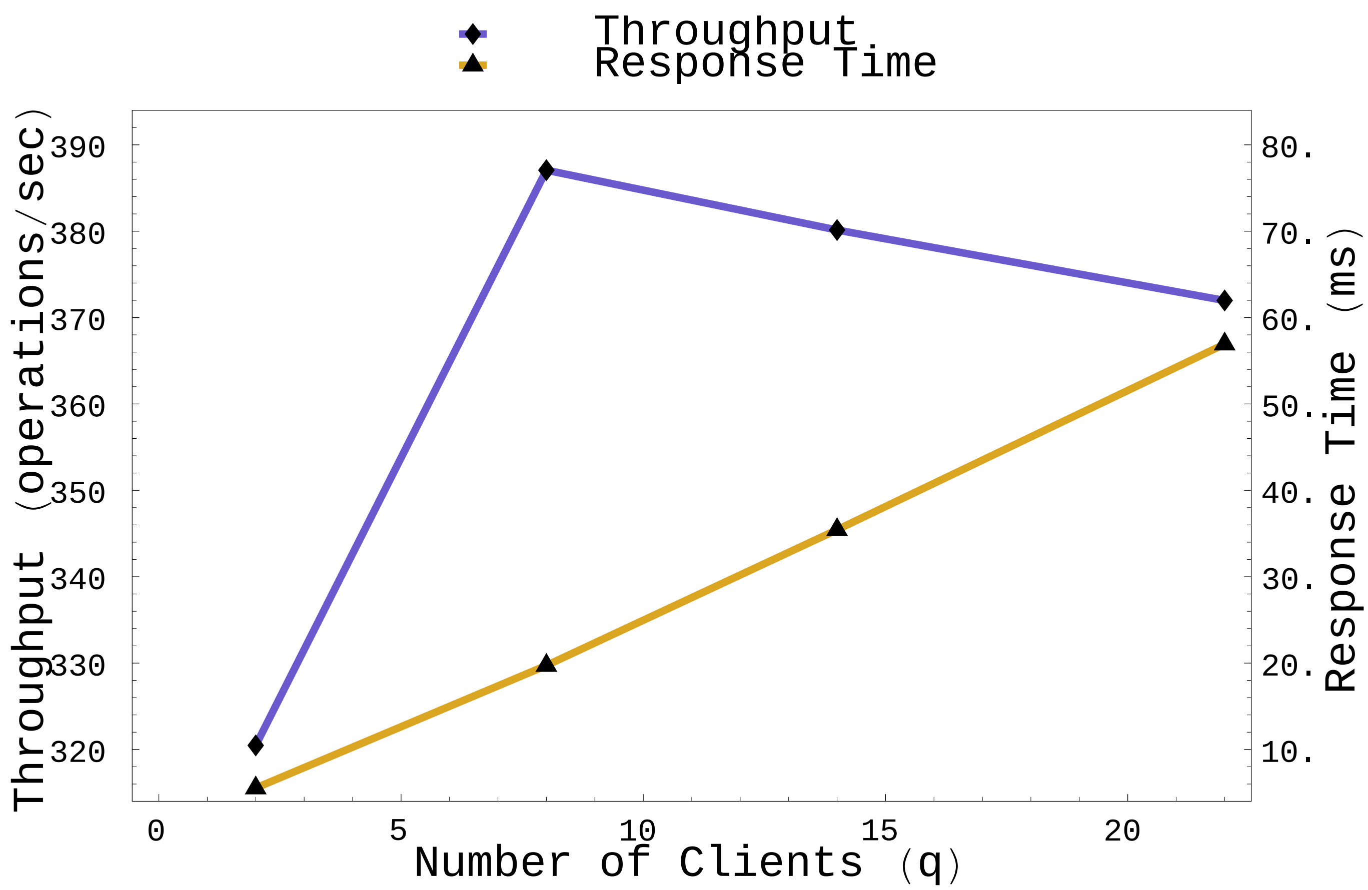
Tuple Space Throughput



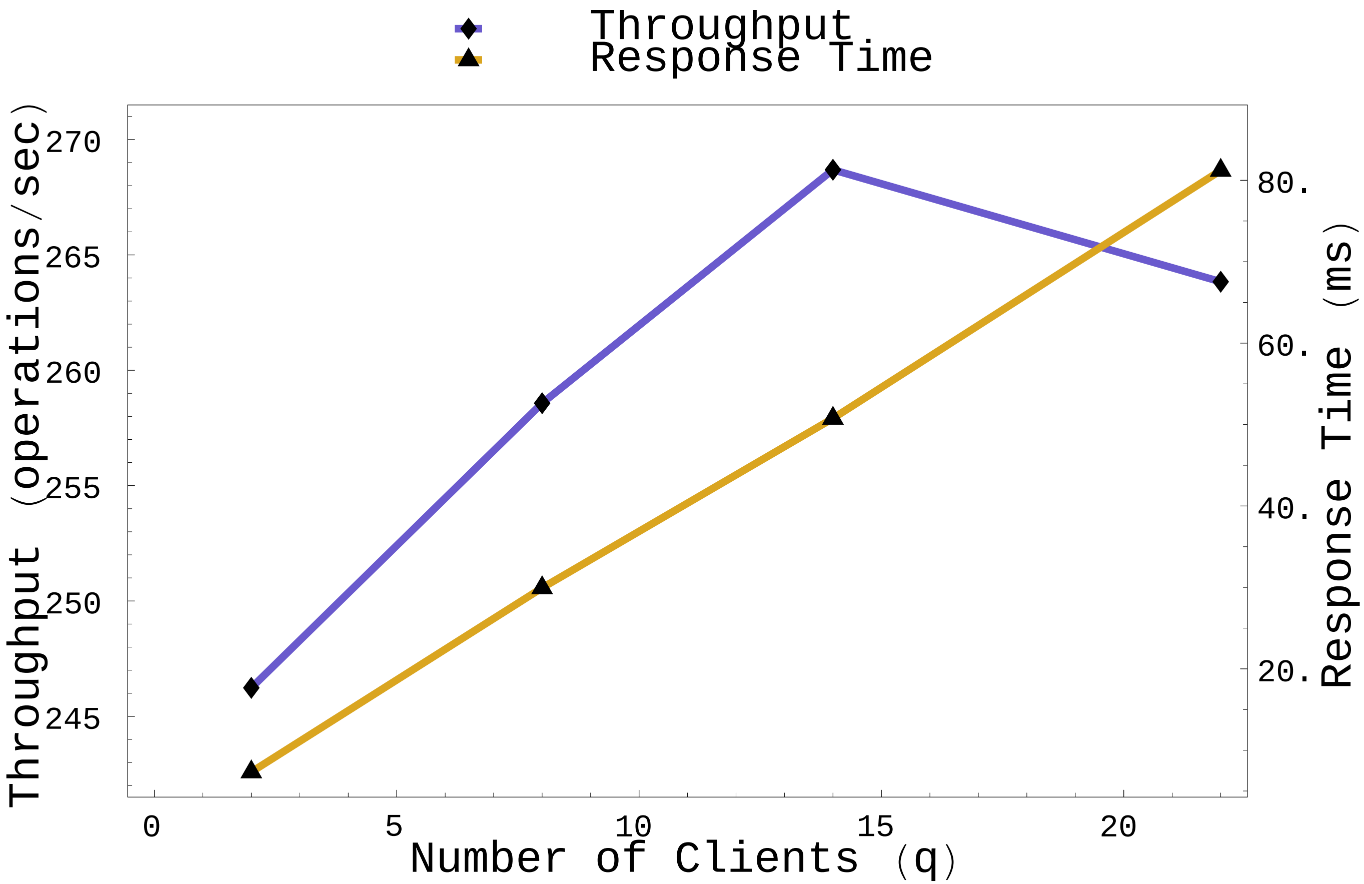
- When space is not aged, throughput knees at 8 or 14 clients

NullIO: Response Time, Throughput



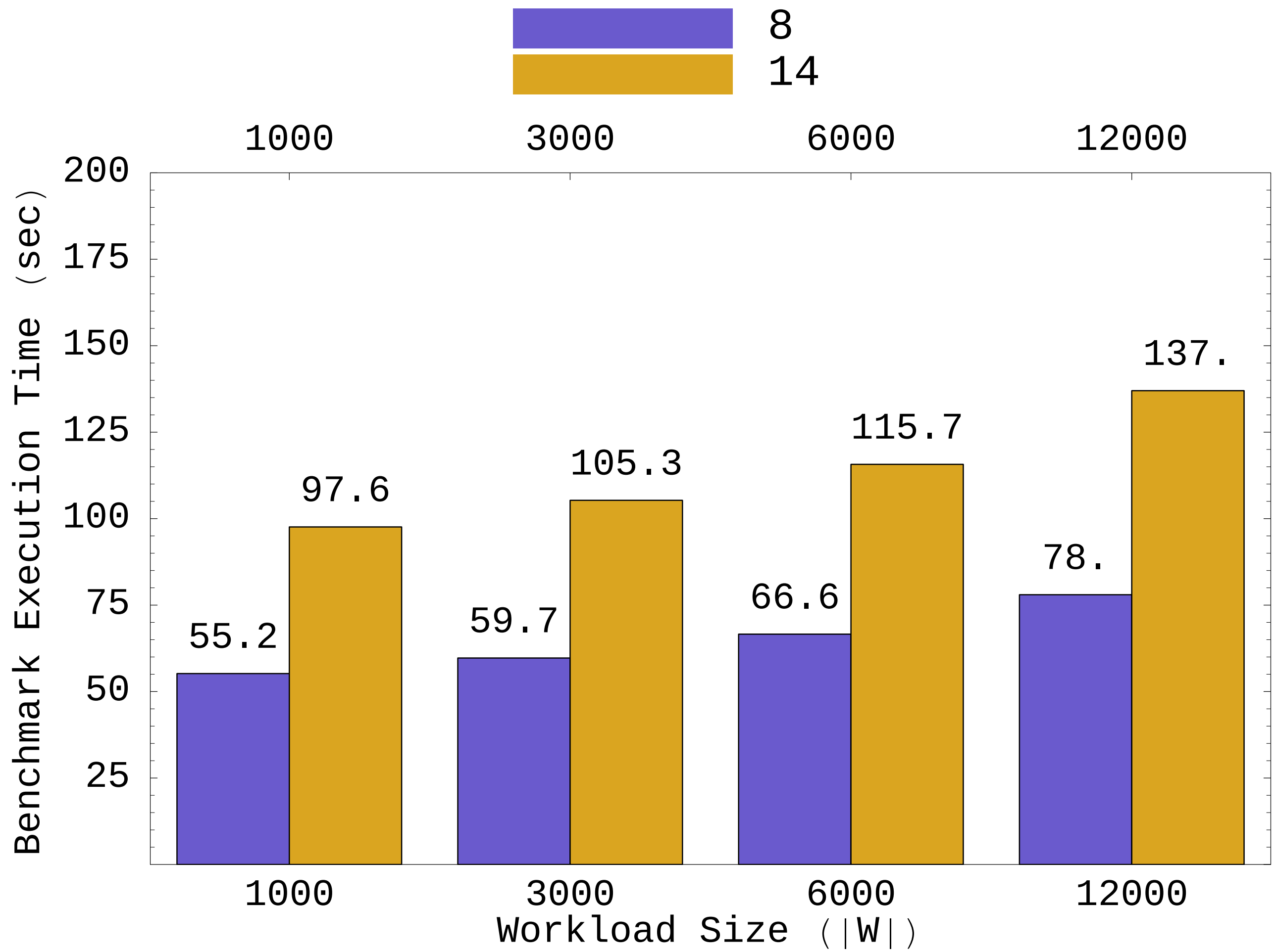
- When throughput knees at 8 clients, average response time continues to increase linearly

FileIO: Response Time, Throughput



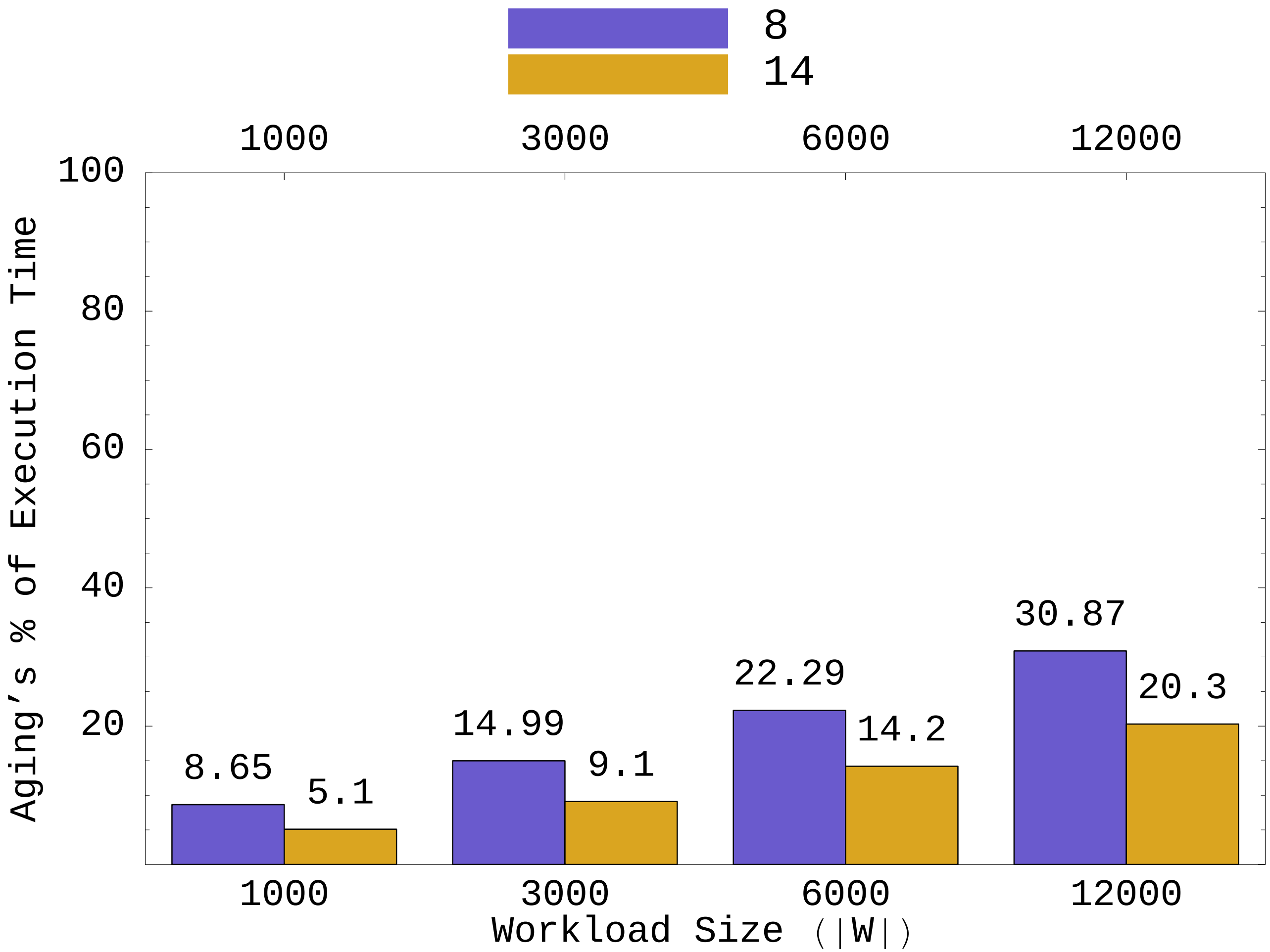
- When throughput knees at 14 clients, average response time continues to increase linearly

NullIO: Impact of Aging



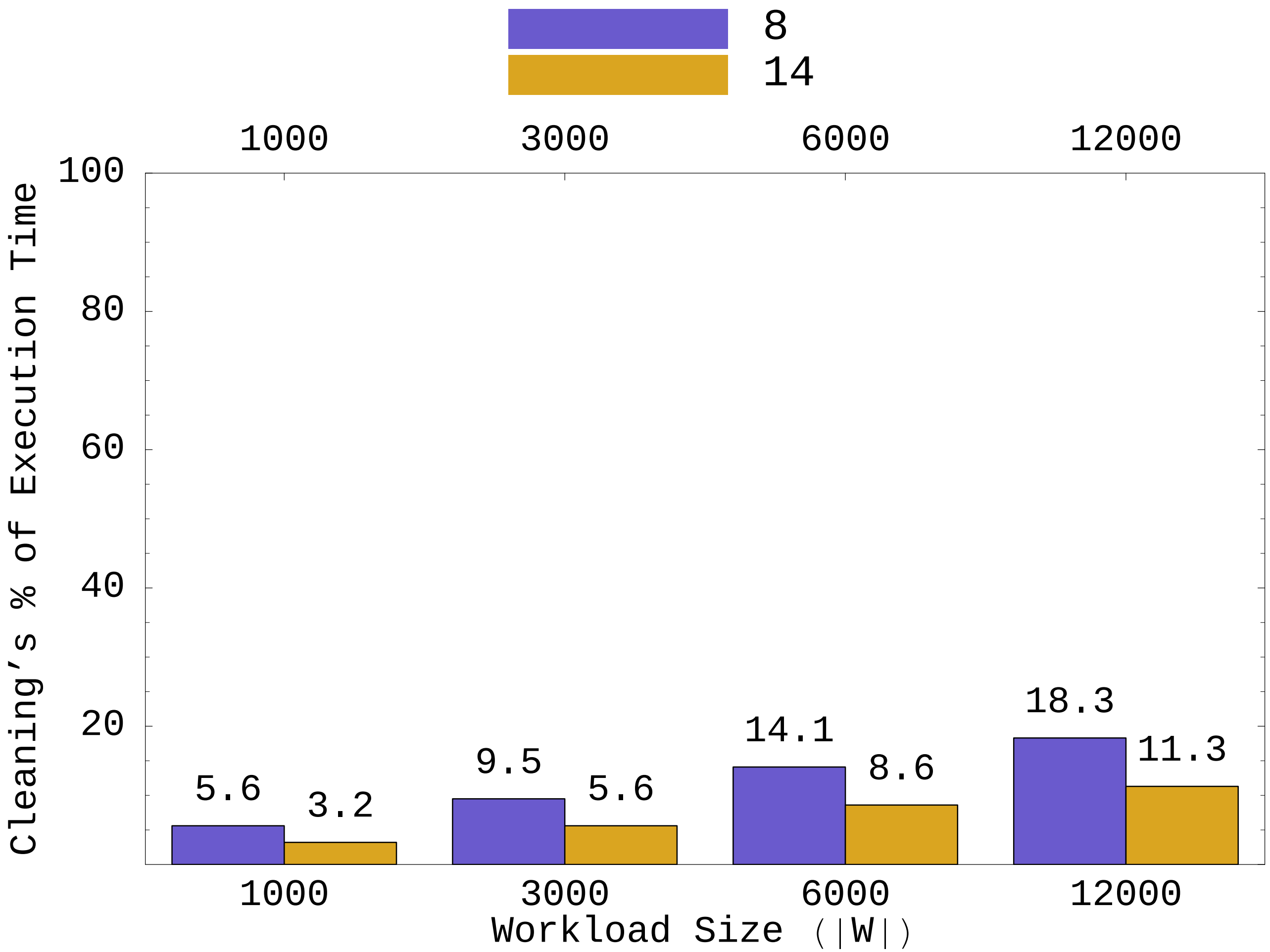
- When $|W| = 3000$ there is a 30% increase in NullIO execution time

NullIO: Aging Time Overhead



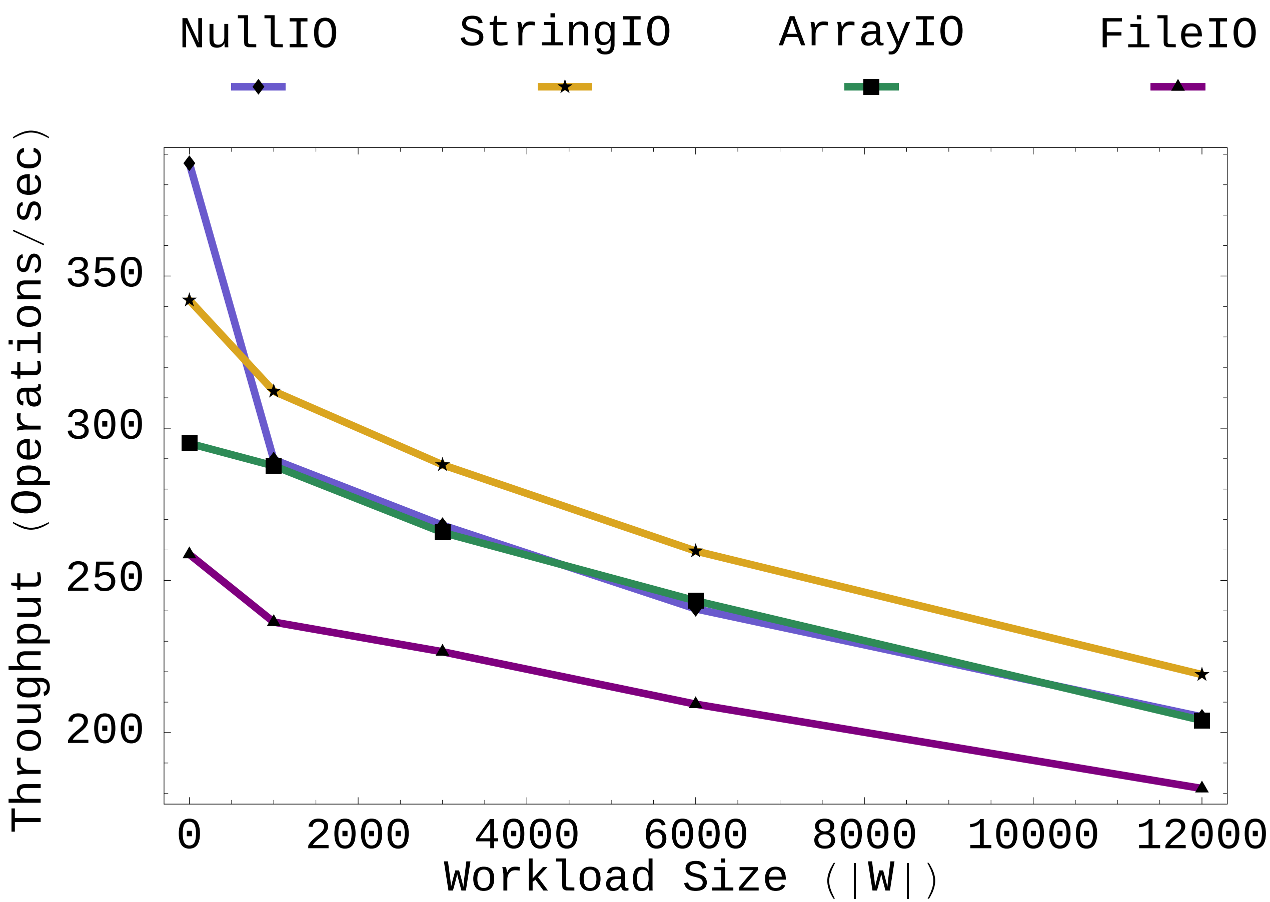
- Aging never consumes more than 31% of entire benchmark time

NullIO: Cleaning Time Overhead



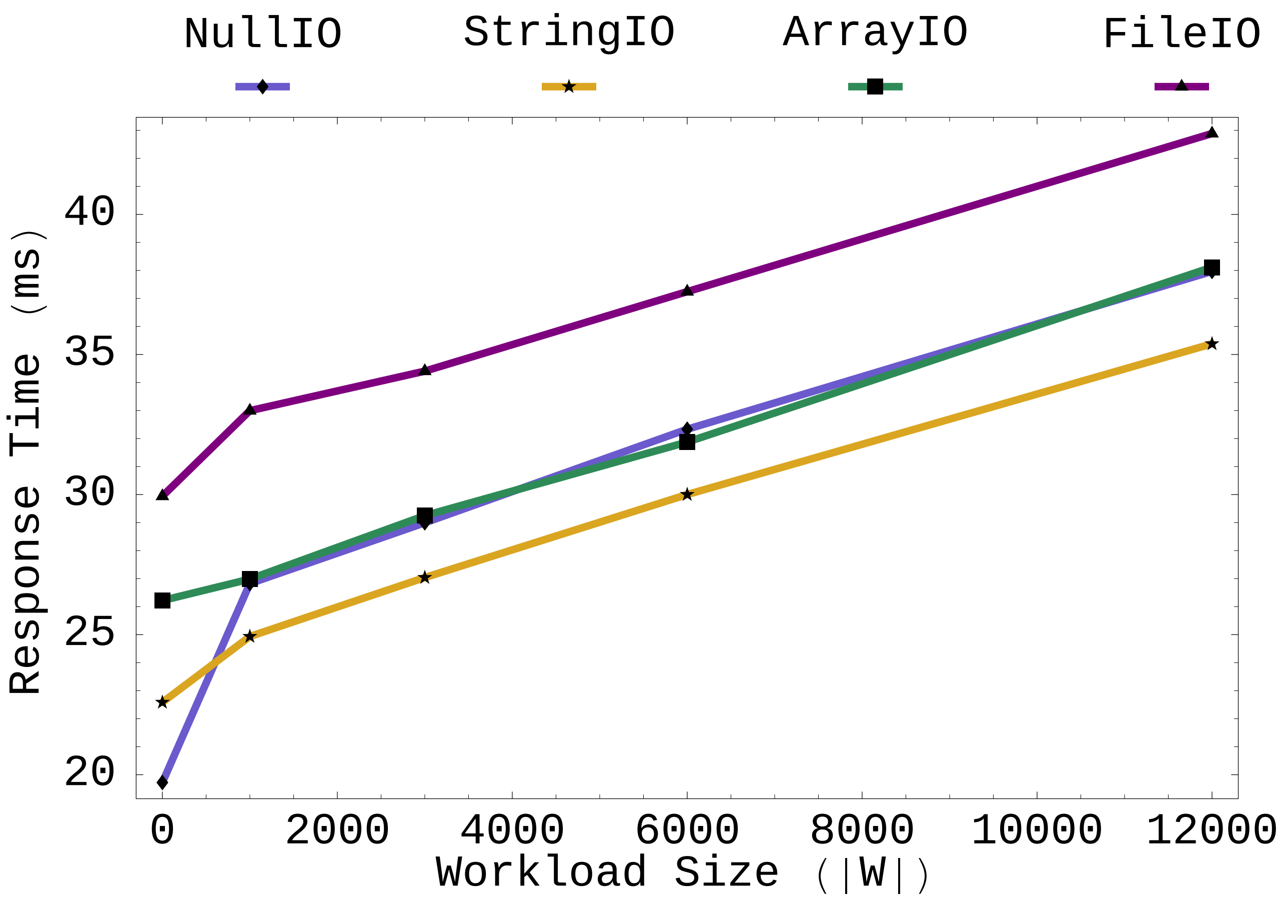
- Cleaning incurs less time overhead than aging due to `snapshot`

Aging's Impact on Throughput

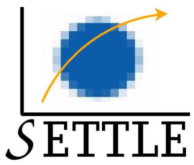


- Aging reduces tuple space throughput as workload size increases

Aging's Impact on Response Time



- Aging increases tuple space response time as workload size increases



Related Work

- Bulej et al. focus on regression benchmarking
- Sterk et al. evaluate tuple space performance in the context of bioinformatics
- Noble and Zlateva measure tuple space performance for astrophysics computations
- Hancke et al. and Neve et al. measure tuple space performance through the use of statistically guided experiments
- Smith and Seltzer introduced fi le system aging

Future Work

- Additional experiments: (i) transient vs. persistent tuple spaces, (ii) remote client interactions, (iii) different tuple space implementations, (iv) new versions of Jini and JavaSpaces
- Workload studies for tuple space-based applications
- Additional micro, macro, and application-specifi c benchmarks
- Defi nition-use testing for tuple space-based applications: *how do you know your application puts the right data into the space?*

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Conclusions

- SETTLE measures throughput and response time and supports automatic tuple space aging
- In current SETTLE configuration, JavaSpaces can support between eight and fourteen concurrent local clients without reducing average response time
- Tuple space aging can be performed with acceptable time overhead
- Aging does support the characterization of worst-case performance

Resources

- Fiedler et al. Towards the Measurement of Tuple Space Performance. In *ACM SIGMETRICS Performance Evaluation Review*. December, 2005.

http://cs.allegheny.edu/~gkapfham/research/settle/