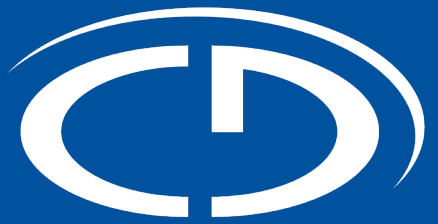

Time Matters
Minimizing Garbage Collection Overhead with Minimal Effort

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2015-11-05

Configuration Hell

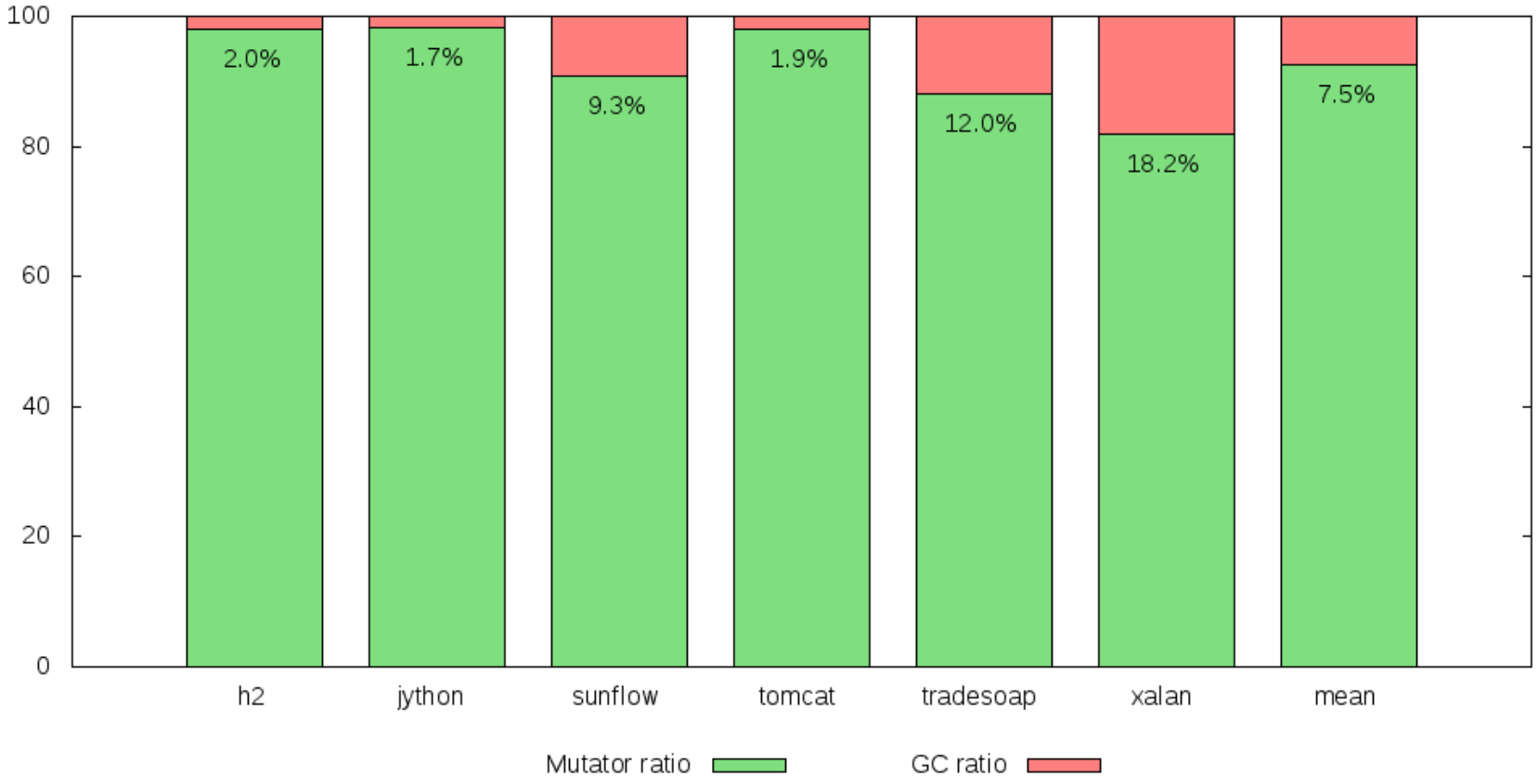
	A	B	C	D	E	F	G
1	FenceInstruction	SelectivePhiFunctions	MinJumpTableSize	SpecialStringCompareTo	UseLargePagesIndividualAllocation	CMSBootstrapOccupancy	CMSYield
2	ReadPrefetchInstr	StressLinearScan	MultiArrayExpandLimit	SpecialStringEquals	UseMembar	CMSClassUnloadingEnabled	CMSYieldSleepCount
3	Use486InstrsOnly	StressLoopInvariantCodeMotion	NodeLimitFudgeFactor	SpecialStringIndexOf	UseOSErrorReporting	CMSClassUnloadingMaxInterval	CMS_FLSPadding
4	UseAVX	StressRangeCheckElimination	NumberOfLoopInstrToAlign	StressGCM	UseOnStackReplacement	CMSCleanOnEnter	CMS_FLSWeight
5	UseAddressNop	TimeEachLinearScan	OptimizeFill	StressLCM	UseTLAB	CMSCompactWhenClearAllSoftRefs	CMS_SweepPadding
6	UseCountLeadingZerosInstruction	UseC1Optimizations	OptimizePtrCompare	StressRecompilation	UseThreadPriorities	CMSConcMarkMultiple	CMS_SweepTimerThresholdMillis
7	UseFastStosb	UseFastLocking	OptimizeStringConcat	StressReflectiveCode	VMThreadStackSize	CMSConcurrentMTEnabled	CMS_SweepWeight
8	UseNewLongLShift	UseFastNewInstance	PartialPeelAtUnsignedTests	SubsumeLoads	CICompileOSR	CMSCoordinatorYieldSleepCount	CheckJNICalls
9	UseStoreImmI16	UseFastNewObjectArray	PartialPeelLoop	SuperWordRTDepCheck	CodeCacheMinBlockLength	CMSDumpAtPromotionFailure	ClassMetaspaceSize
10	UseUnalignedLoadStores	UseFastNewTypeArray	PartialPeelNewPhiDelta	UnrollLimitForProfileCheck	CodeEntryAlignment	CMSExpAvgFactor	ClassUnloading
11	UseXmmI2D	UseGlobalValueNumbering	ReassociateInvariants	Use24BitFP	ImplicitNullChecks	CMSExtrapolateSweep	ClearFPUAtPark
12	UseXmmI2F	UseLocalValueNumbering	ReduceBulkZeroing	Use24BitFPMode	InlineFrequencyCount	CMSFullGCsBeforeCompaction	ClipInlining
13	UseXmmLoadAndClearUpper	UseSlowPath	ReduceFieldZeroing	UseExactTypes	InlineIntrinsics	CMSIncrementalDutyCycle	CodeCacheFlushingMinimumFreeSpace
14	UseXmmRegToRegMoveAll	UseTableRanges	ReduceInitialCardMarks	UseUniqueSubclasses	JVMInvokeMethodSlack	CMSIncrementalDutyCycleMin	CodeCacheMinimumFreeSpace
15	IEEEPrecision	DebugInlinedCalls	SpecialEncodeISOArray	VerifyAliases	ProfileTraps	CMSIncrementalMode	CollectGen0First
16	LIRFillDelaySlots	DisableIntrinsic	SplitIfBlocks	VerifyIterativeGVN	ShareVtableStubs	CMSIncrementalOffset	CompactFields
17	SafepointPollOffset	DominatorSearchLimit	TrackedInitializationLimit	WarmCallMaxSize	UncommonNullCast	CMSIncrementalPacing	CompilationPolicyChoice
18	CSEArrayLength	EliminateAutoBox	TypeProfileMajorReceiverPercent	WarmCallMaxWork	AdaptiveSizeDecrementScaleFactor	CMSIncrementalSafetyFactor	CompilerThreadHintNoPreempt
19	RoundFPResults	LoopLimitCheck	UseBimorphicInlining	WarmCallMinCount	AdaptiveSizeMajorGCDecayTimeScale	CMSIndexedFreeListReplenish	CompilerThreadPriority
20	TwoOperandLIRForm	OptimizeExpensiveOps	UseCondCardMark	WarmCallMinProfit	AdaptiveSizePausePolicy	CMSInitiatingOccupancyFraction	ConcGCThreads
21	C1OptimizeVirtualCallProfiling	PrintIntrinsics	UseDivMod	ObjectAlignmentInBytes	AdaptiveSizePolicyCollectionCostMargin	CMSIsTooFullPercentage	ContendedPaddingWidth
22	C1ProfileBranches	PrintPreciseBiasedLockingStatistics	UseFPUForSpilling	UseCompressedKlassPointers	AdaptiveSizePolicyInitializingSteps	CMSLargeCoalSurplusPercent	ConvertYieldToSleep
23	C1ProfileCalls	ProfileDynamicTypes	UseJumpTables	UseCompressedOops	AdaptiveSizePolicyOutputInterval	CMSLargeSplitSurplusPercent	CreateMinidumpOnCrash
24	C1ProfileCheckcasts	RangeLimitCheck	UseLoopPredicate	CMSAbortablePrecleanWaitMillis	AdaptiveSizePolicyWeight	CMSLoopWarn	CriticalJNINatives
25	C1ProfileInlinedCalls	TraceTypeProfile	UseOldInlining	CMSWaitDuration	AdaptiveSizeThroughPutPolicy	CMSMaxAbortablePrecleanLoops	Debugging
26	C1ProfileVirtualCalls	UnrollLimitCheck	UseOnlyInlinedBimorphic	HeapDumpAfterFullGC	AggressiveOpts	CMSMaxAbortablePrecleanTime	DefaultMaxRAMFraction
27	C1UpdateMethodData	ConditionalMoveLimit	UseOptoBiasInlining	HeapDumpBeforeFullGC	AllocateInstancePrefetchLines	CMSOldPLABMax	DefaultThreadPriority
28	CompilationRepeat	InteriorEntryAlignment	UseRDPCForConstantTableBase	HeapDumpOnOutOfMemoryError	AllocatePrefetchDistance	CMSOldPLABMin	DeferPollingPageLoopCount
29	InlineSynchronizedMethods	LoopUnrollLimit	UseSuperWord	BackEdgeThreshold	AllocatePrefetchInstr	CMSOldPLABNumRefills	DeferThrSuspendLoopCount
30	TimeLinearScan	OptoBundling	ValueSearchLimit	BackgroundCompilation	AllocatePrefetchLines	CMSOldPLABReactivityFactor	DeoptimizeRandom
31	UseLoopInvariantCodeMotion	OptoScheduling	AlwaysIncrementalInline	CMSYoungGenPerWorker	AllocatePrefetchStepSize	CMSOldPLABResizeQuicker	DisableAttachMechanism
32	ValueMapInitialSize	FLOATPRESSURE	BailoutToInterpreterForThrows	CodeCacheExpansionSize	AllocatePrefetchStyle	CMSOldPLABToleranceFactor	DisableExplicitGC
33	ValueMapMaxLoopSize	INTPRESSURE	ConvertCmpD2CmpF	CompileThreshold	AllowJNIEnvProxy	CMSPLABRecordAlways	DisplayVMOutputToStderr
34	AssertRangeCheckElimination	OptoPeephole	ConvertFloat2IntClipping	CompilerThreadStackSize	AllowNonVirtualCalls	CMSParPromoteBlocksToClaim	DisplayVMOutputToStdout
35	BailoutAfterHIR	RegisterCostAreaRatio	ExitEscapeAnalysisOnTimeout	ConvertSleepToYield	AllowParallelDefineClass	CMSParallelRemarkEnabled	DontCompileHugeMethods
36	BailoutAfterLIR	UseCISCSpill	FreqCountInvocations	DontYieldALot	AllowUserSignalHandlers	CMSParallelSurvivorRemarkEnabled	DumpSharedSpaces
37	BailoutOnExceptionHandlers	AliasLevel	HotCallCountThreshold	FreqInlineSize	AlwaysActAsServerClassMachine	CMSPrecleanDenominator	EagerXrunInit
38	C1Breakpoint	AlignVector	HotCallProfitThreshold	HeapBaseMinAddress	AlwaysCompileLoopMethods	CMSPrecleanIter	EmitSync
39	CanonicalizeNodes	AutoBoxCacheMax	HotCallTrivialSize	InitialCodeCacheSize	AlwaysLockClassLoader	CMSPrecleanNumerator	EnableContended
40	CommentedAssembly	BlockLayoutByFrequency	HotCallTrivialWork	InlineSmallCode	AlwaysPreTouch	CMSPrecleanRefLists1	ErgoHeapSizeLimit
41	ComputeExactFPURegisterUsage	BlockLayoutMinDiamondPercentage	IdealizedNumerics	MaxRAM	AlwaysRestoreFPU	CMSPrecleanRefLists2	EstimateArgEscape
42	CountLinearScan	BlockLayoutRotateLoops	ImplicitNullCheckThreshold	MetaspaceSize	AlwaysTenure	CMSPrecleanSurvivors1	ExplicitGCInvokesConcurrent
43	DoCEE	BranchOnRegister	InlineAccessors	NeedsDeoptSuspend	AssertOnSuspendWaitFailure	CMSPrecleanSurvivors2	ExplicitGCInvokesConcurrentAndUnloadsClasses
44	EliminateBlocks	DoEscapeAnalysis	InlineObjectCopy	NeverActAsServerClassMachine	AssumeMP	CMSPrecleanThreshold	FLSAlwaysCoalesceLarge
45	EliminateFieldAccess	EliminateAllocationArraySizeLimit	InlineReflectionGetCallerClass	NewSizeThreadIncrease	AutoGCSelectPauseMillis	CMSPrecleaningEnabled	FLSCoalescePolicy
46	EliminateNullChecks	EliminateAllocations	InlineWarmCalls	OnStackReplacePercentage	BCEATraceLevel	CMSPrintChunksInDump	FLSLargestBlockCoalesceProximity
47	GenerateArrayStoreCheck	EliminateLocks	MonomorphicArrayCheck	OptoLoopAlignment	BaseFootPrintEstimate	CMSPrintObjectsInDump	FailOverToOldVerifier
48	ImplicitDiv0Checks	EliminateNestedLocks	NodeCountInliningCutoff	PreInflateSpin	BiasedLockingBulkRebiasThreshold	CMSRemarkVerifyVariant	FastTLABRefill
49	InlineMethodsWithExceptionHandlers	IncrementalInline	NodeCountInliningStep	PreferInterpreterNativeStubs	BiasedLockingBulkRevokeThreshold	CMSReplenishIntermediate	FieldsAllocationStyle
50	InlineNIOCheckIndex	InsertMemBarAfterArraycopy	OptoBlockListSize	ProfileInterpreter	BiasedLockingDecayTime	CMSRescanMultiple	FilterSpuriousWakeups
51	InstallMethods	LiveNodeCountInliningCutoff	OptoBreakpoint	ReservedCodeCacheSize	BiasedLockingStartupDelay	CMSSamplingGrain	ForceNUMA
52	InstructionCountCutoff	LoopOptsCount	OptoCoalesce	ResizeTLAB	BindGCTaskThreadsToCPUs	CMSScavengeBeforeRemark	ForceTimeHighResolution
53	LIRTraceExecution	LoopUnrollMin	OptoNodeListSize	RewriteBytecodes	BytecodeVerificationLocal	CMSScheduleRemarkEdenPenetration	G1ConcMarkStepDurationMillis
54	LIRTracePeephole	LoopUnswitching	OptoPeepholeAt	RewriteFrequentPairs	BytecodeVerificationRemote	CMSScheduleRemarkEdenSizeThreshold	G1ConcRefinementGreenZone
55	NMethodSizeLimit	MaxJumpTableSize	OptoPrologueNops	StackRedPages	CICompilerCount	CMSScheduleRemarkSamplingRatio	G1ConcRefinementRedZone
56	NestedInliningSizeRatio	MaxJumpTableSparseness	OptoRemoveUseless	StackShadowPages	CICompilerCountPerCPU	CMSSmallCoalSurplusPercent	G1ConcRefinementServiceIntervalMillis
57	OptimizeIfOps	MaxLabelRootDepth	PoisonOSREntry	StackYellowPages	CITime	CMSSmallSplitSurplusPercent	G1ConcRefinementThreads
58	OptimizeUnsafes	MaxLoopPad	SoftMatchFailure	ThreadStackSize	CMSAbortSemantics	CMSSplitIndexedFreeListBlocks	G1ConcRefinementThresholdStep
59	PatchALot	MaxNodeLimit	SparcV9RegsHiBitsZero	TieredCompilation	CMSAbortablePrecleanMinWorkPerIteration	CMSTriggerRatio	G1ConcRefinementYellowZone
60	PrintAllInstructions	MaxVectorSize	SpecialArraysEquals	UseLargePages	CMSBitMapYieldQuantum	CMSWorkQueueDrainThreshold	G1ConfidencePercent

OpenJDK 8

681 VM parameters (1300+ including tracing and debugging flags)

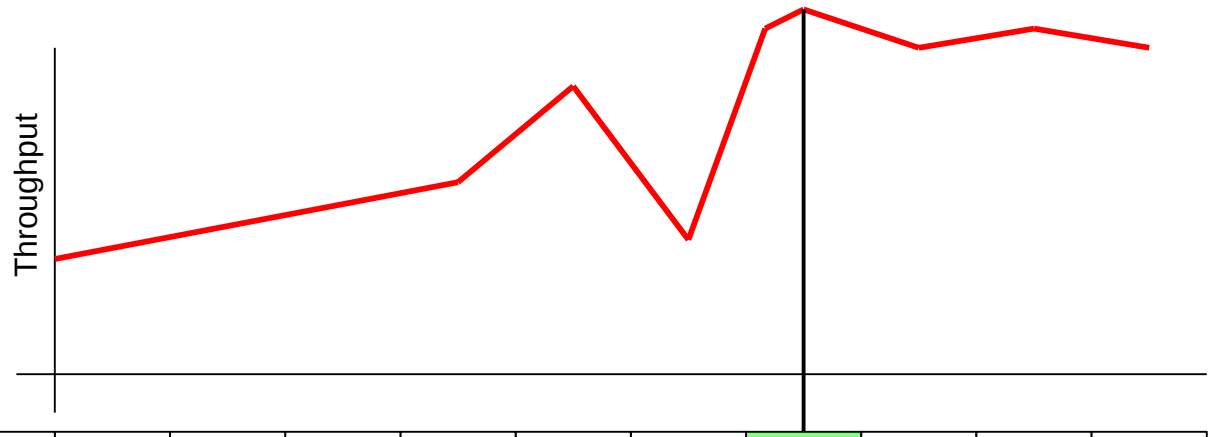
~ 10^{205} configurations assuming only boolean parameters

Garbage Collection



37 GC parameters – $7.2 * 10^{35}$ configurations

Previous Approach

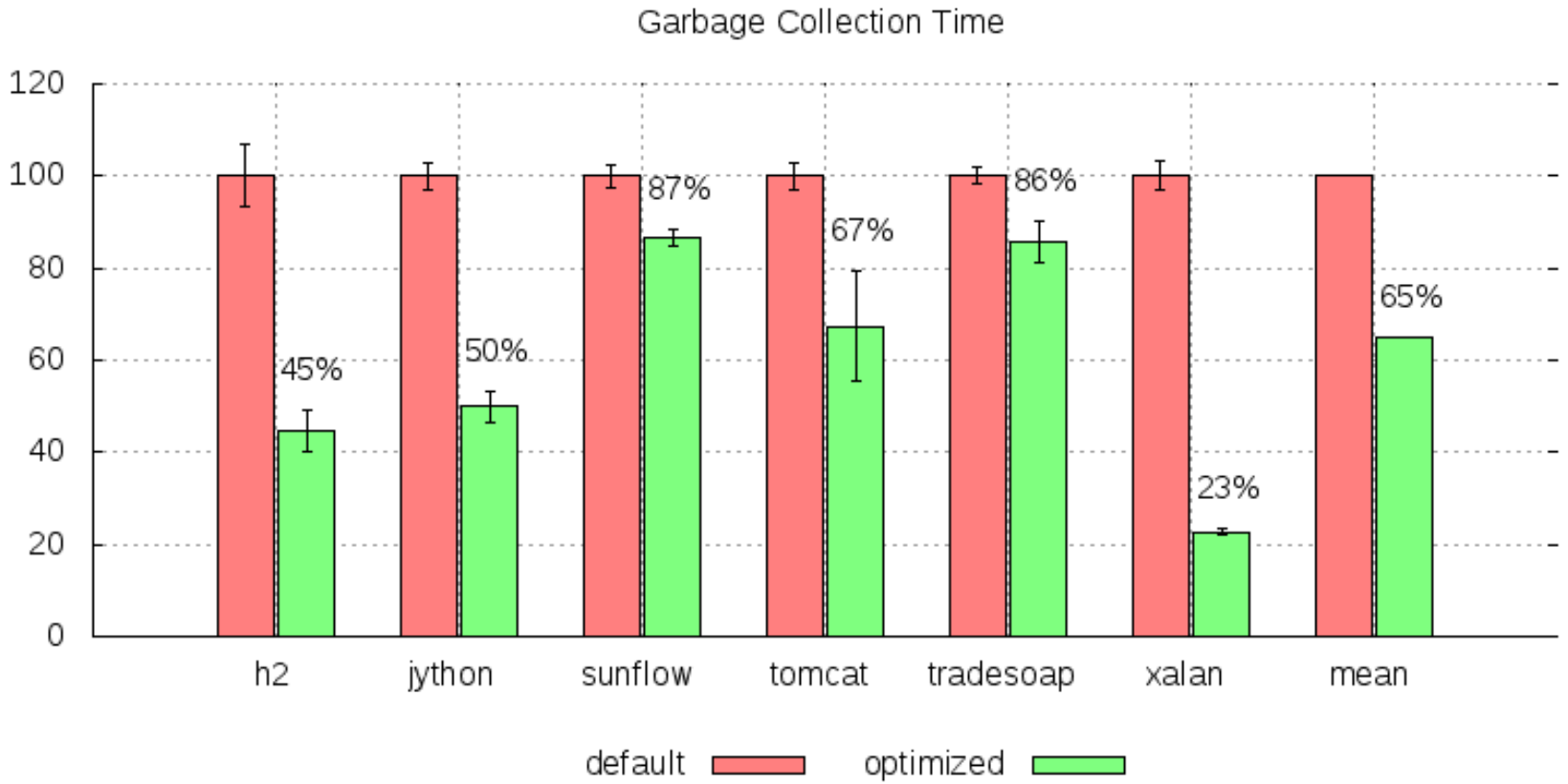


NewRatio	**2**	**3**	**4**	**5**	4	4	4	4	4	**3**
AdaptiveBoundary	**-**	-	-	-	**+**	+	+	+	+	+
PLABSize	**1024**	1024	1024	1024	1024	**512**	**2048**	**4096**	**3072**	2048

Hill Climbing (ParamILS)

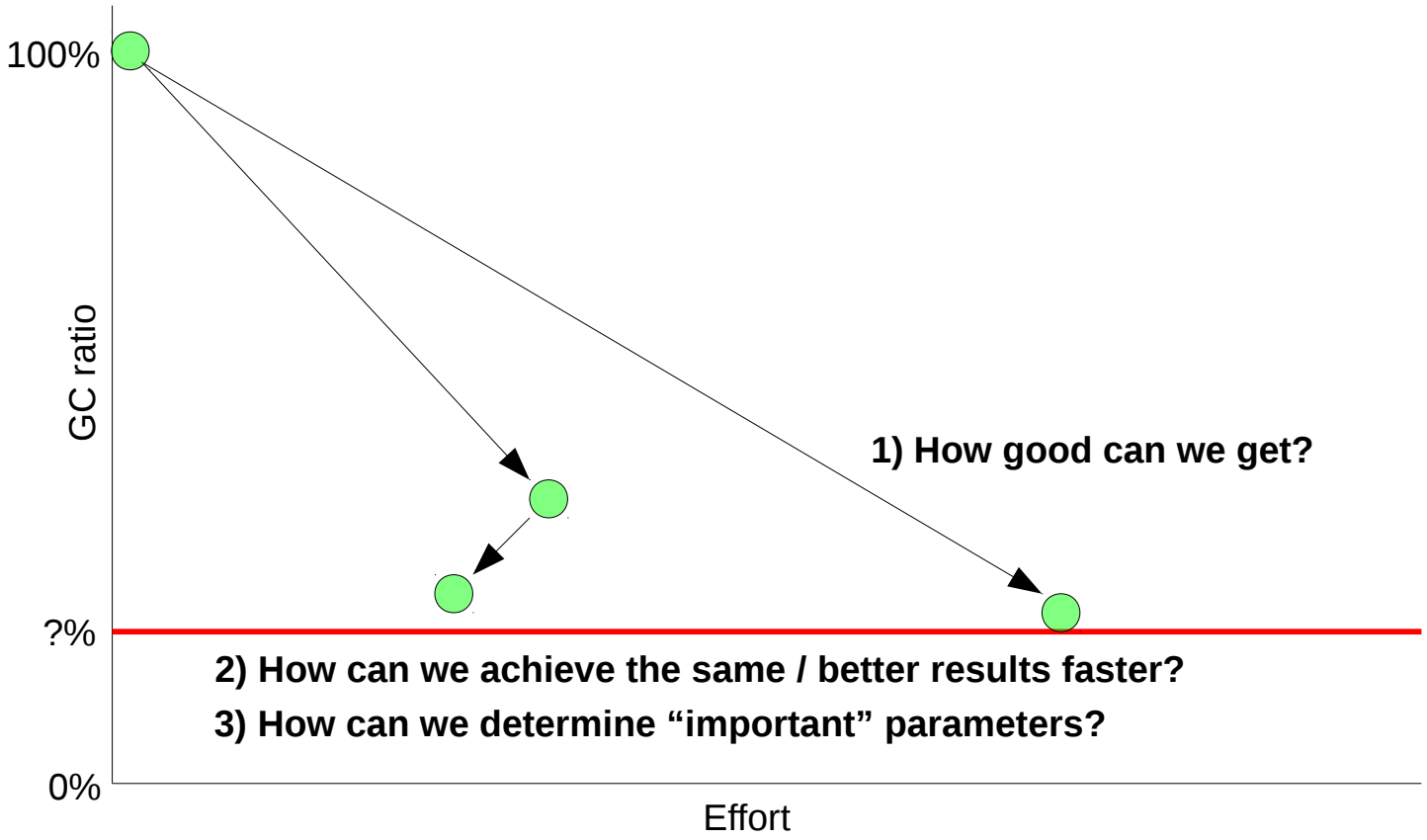
The Taming of the Shrew: Increasing Performance by Automatic Parameter Tuning for Java Garbage Collectors,
Lengauer et. al., International Conference on Performance Engineering, 2014 (ICPE'14)

Previous Results

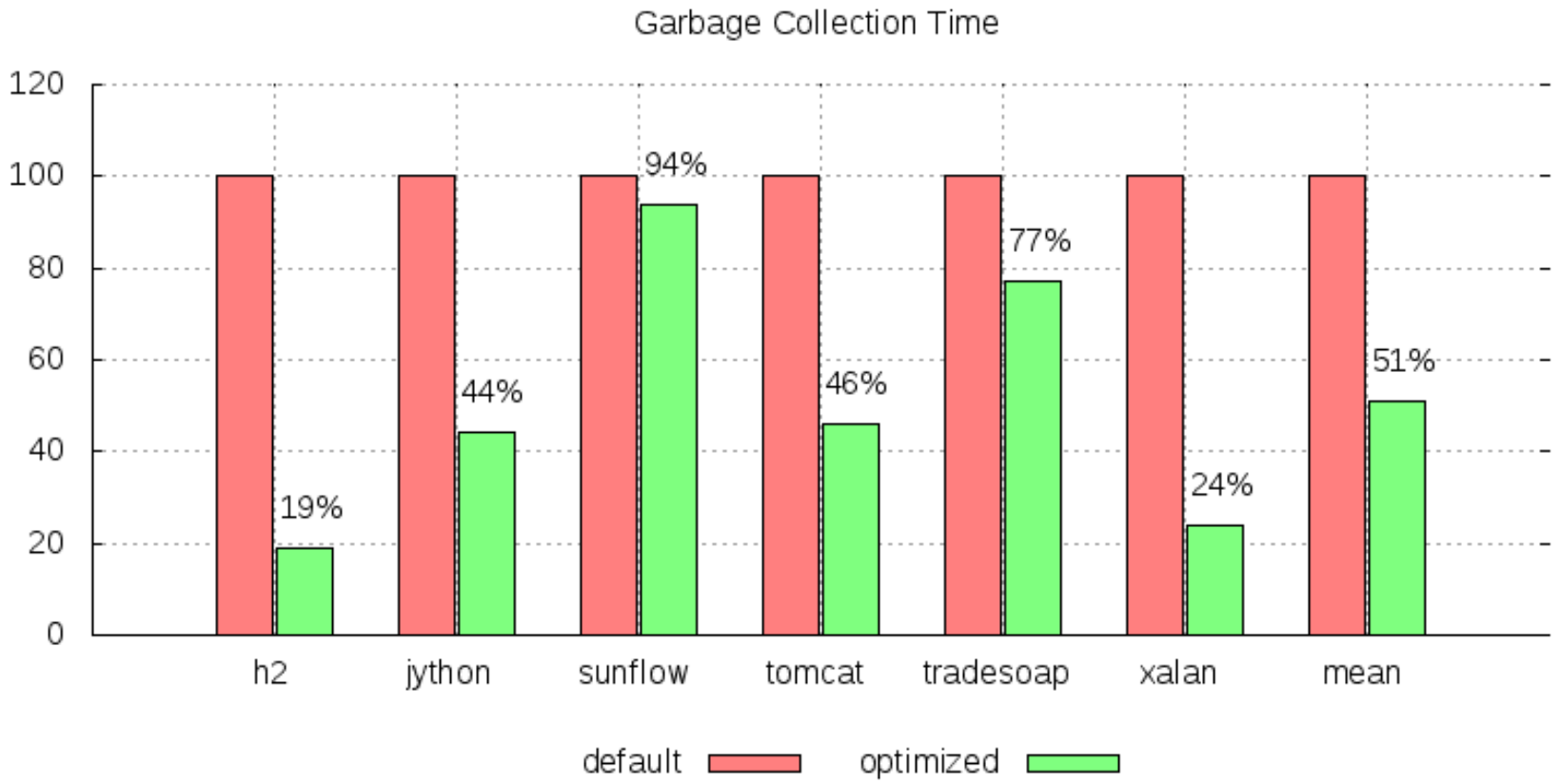


100 – 400 configurations tested

Goal

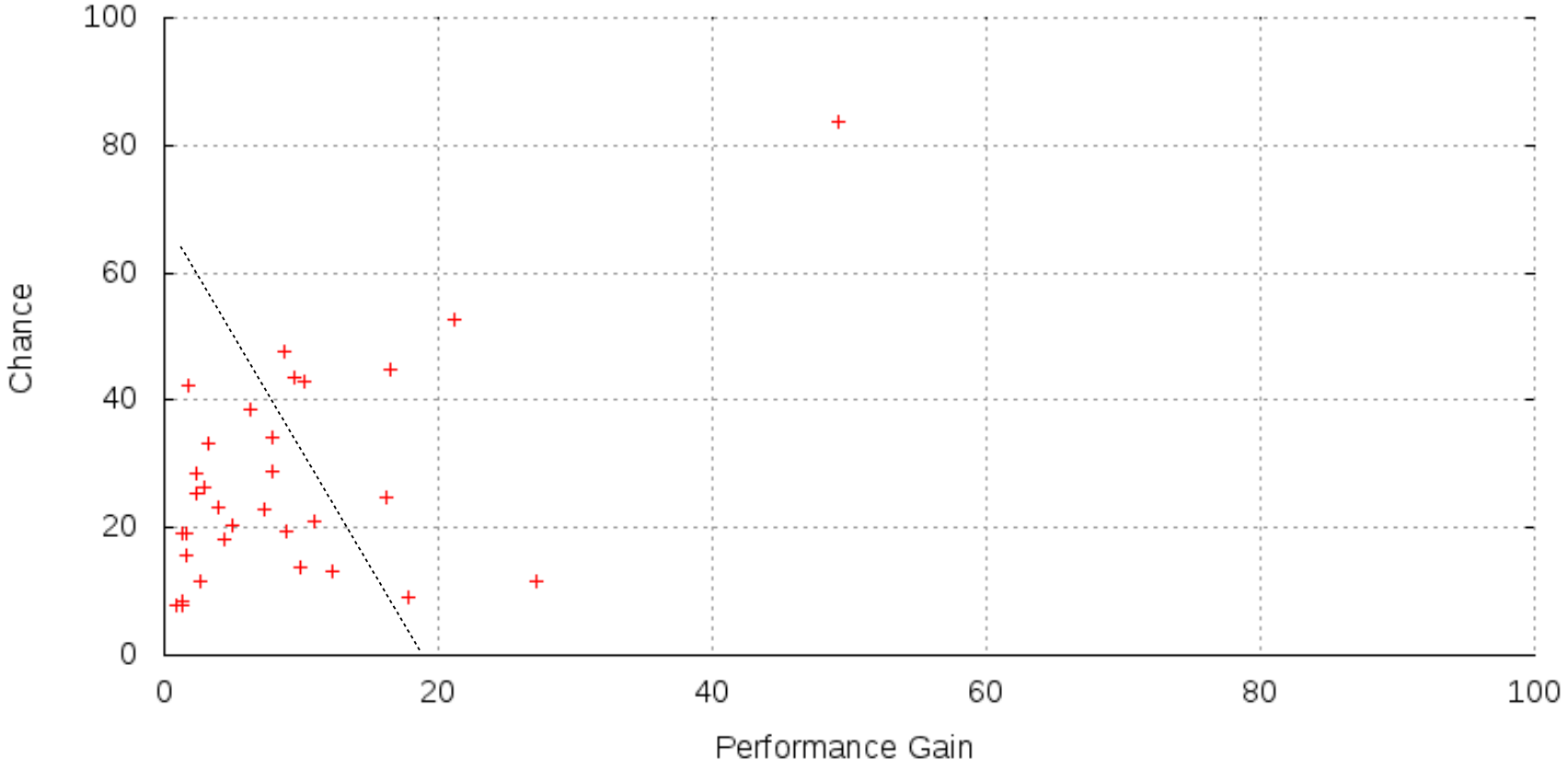

100%
GC ratio
?%
0%
Effort
1) How good can we get?
2) How can we achieve the same / better results faster?
3) How can we determine “important” parameters?

Brute Force



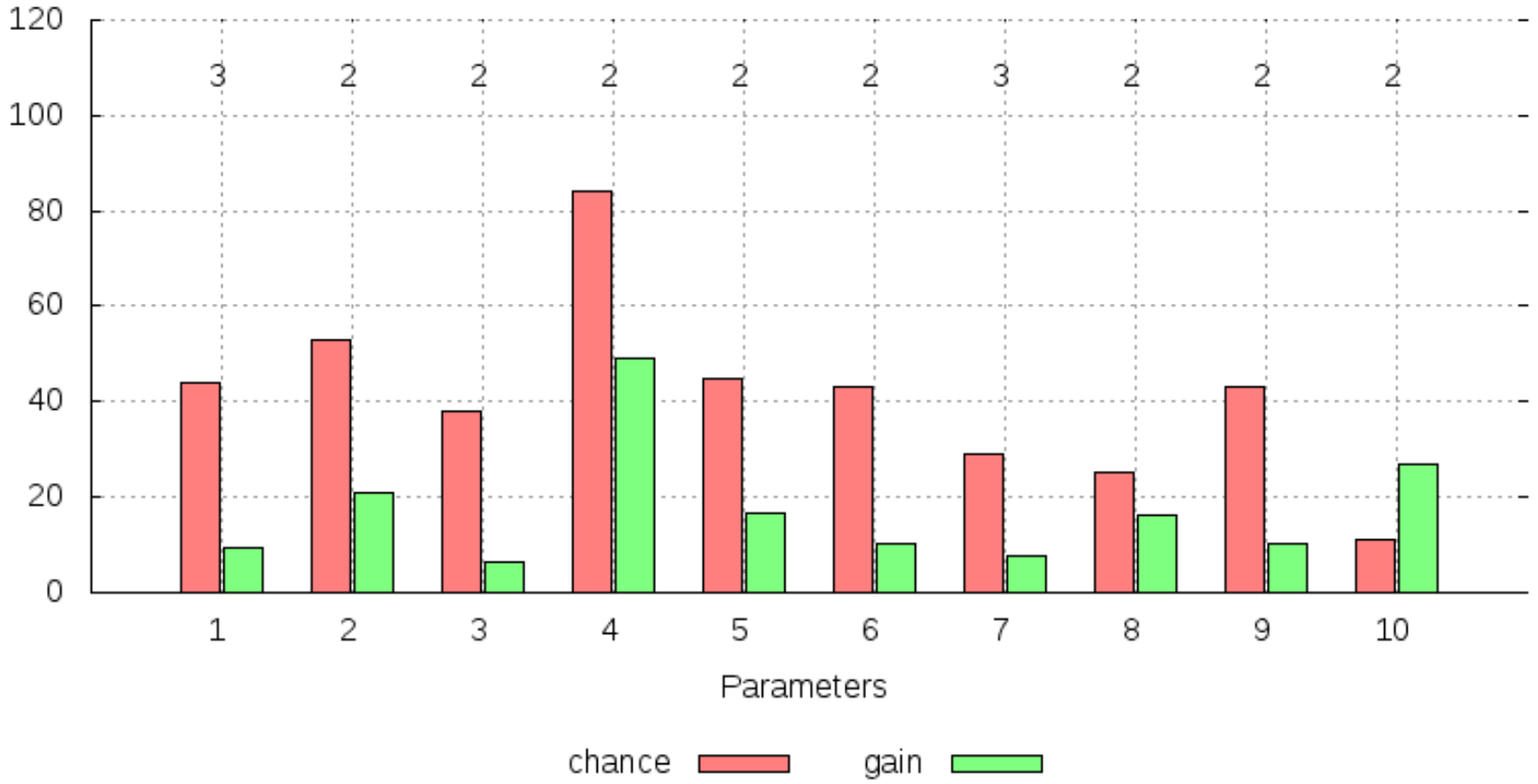
14879 configurations tested

Parameter Relevance



Work with “Top 10” Parameters

Signficant Parameters



2304 configurations

1 … AdaptiveSizeDecrementScaleFactor
2 … MaxTenuringThreshold
3 … MaxHeapFreeRatio
4 … UseAdaptiveGCBoundary
5 … SurvivorPadding
6 … AdaptiveSizePolicyWeight
7 … MinHeapFreeRatio
8 … YoungPLABSize
9 … UseAdaptiveSizePolicyWithSystemGC
10 … NewRatio

Experiment Sequence

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	10	9
1	2	3	4	5	6	7	9	8	10
1	2	3	4	5	6	7	10	9	8

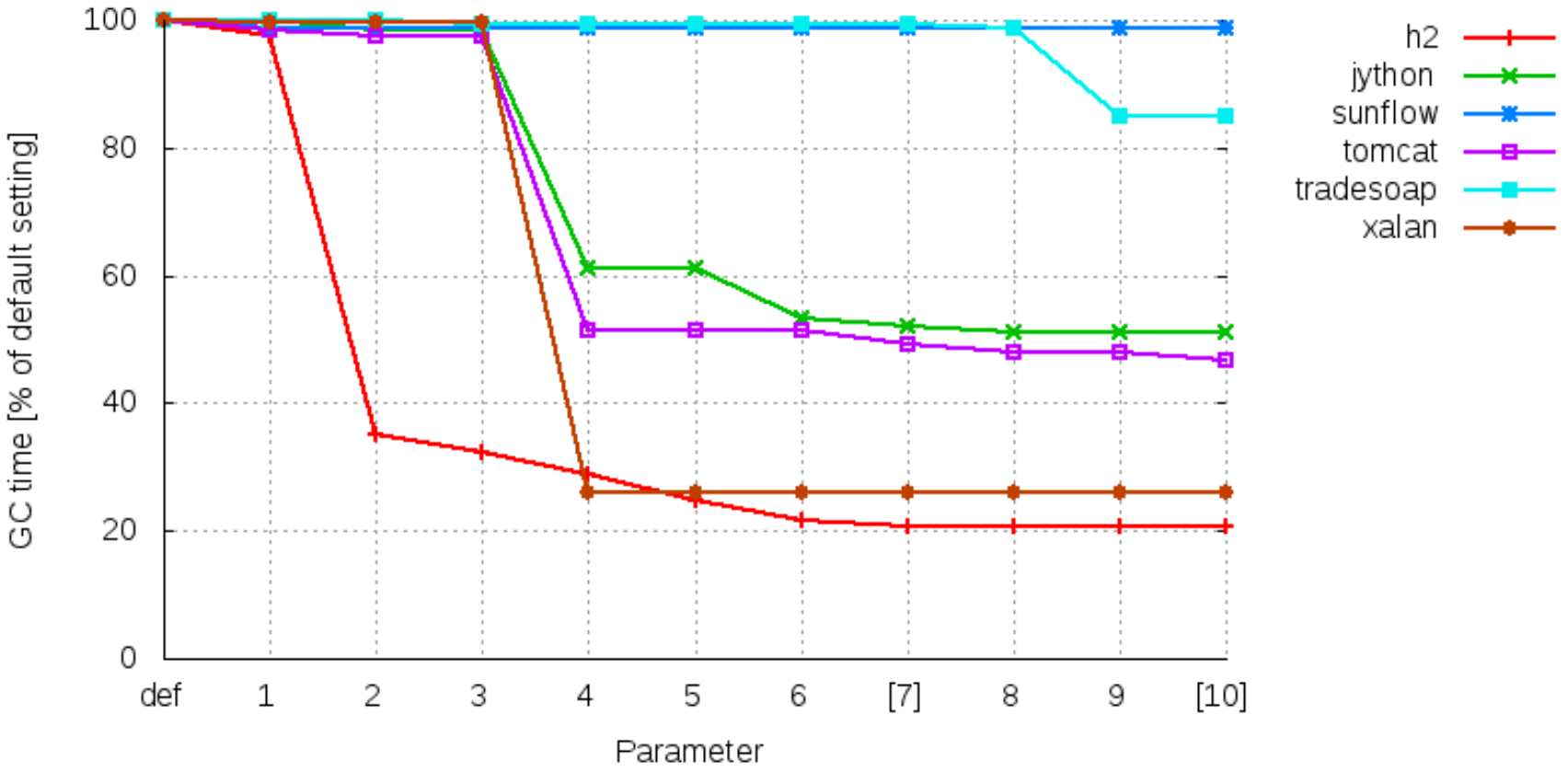
...

10	9	8	7	6	5	4	3	2	1

Select best value one after the other
→ Linear number of experiments (22)
“Pseudo Brute Force”

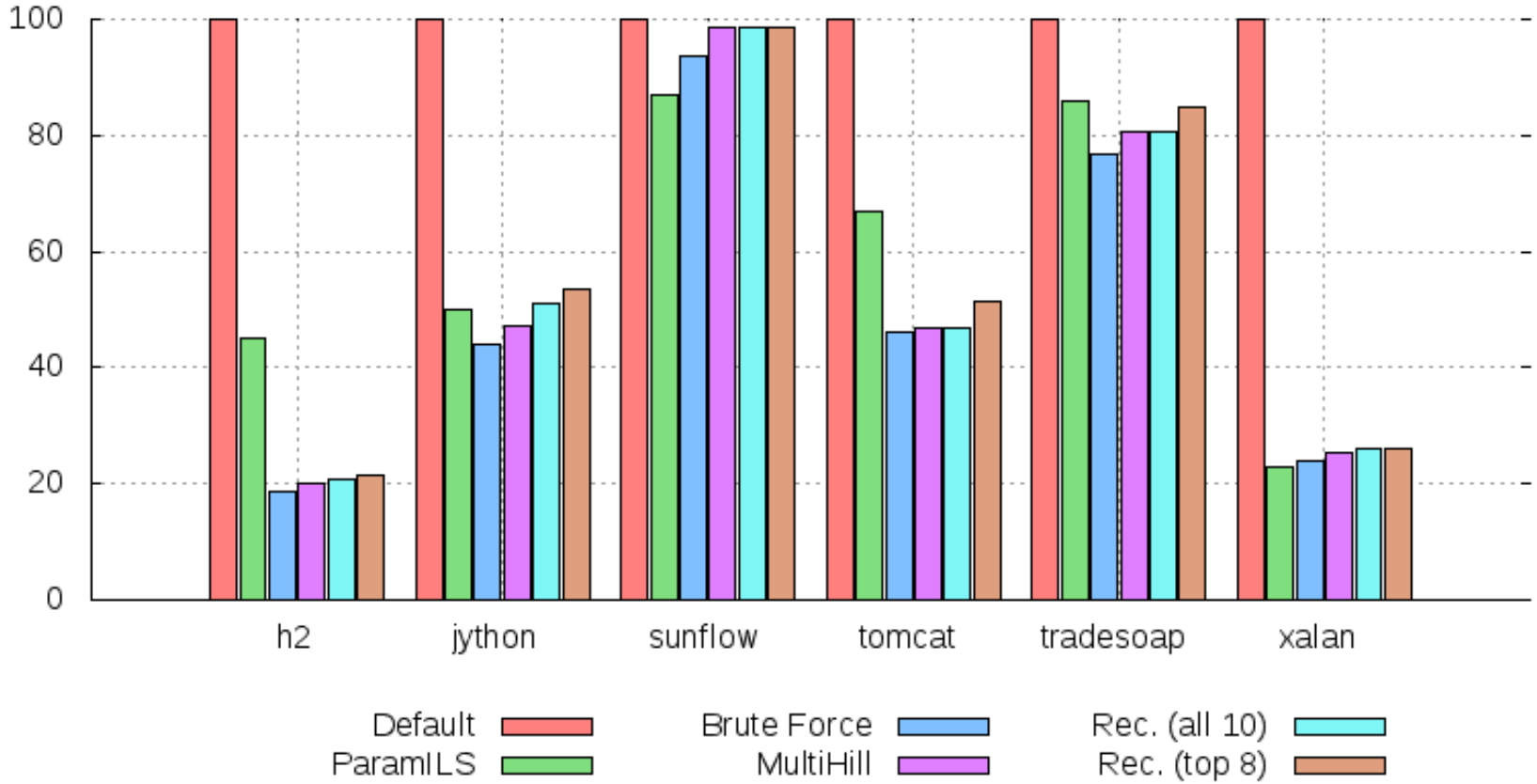
Try all permutations of parameters

Omitting Parameters



Try all combinations of omissions
(Pseudo brute force)

Final Result



Recommendation

#	Parameter	default	alt.
1	AdaptiveSizeDecrementScaleFactor	4	5, 6
2	MaxTenuringThreshold	15	1
3	MaxHeapFreeRatio	70	50
4	UseAdaptiveGCBoundary	0	1
5	SurvivorPadding	3	1
6	AdaptiveSizePolicyWeight	10	50
7	MinHeapFreeRatio	40	20, 25
8	YoungPLABSize	4096	1024
9	UseAdaptiveSizePolicyWithSystemGC	0	1
10	NewRatio	2	1

Q&A

?