

# Parametric Optimization of Storage Systems

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# Motivation

- Parameters → Performance, Energy, ...
- Default ≠ Optimal [FAST'10]
- Finding optimal configurations is challenging
  - ◆ Huge search space

Configuration Type	# of Useful Parameters	# of Unique Configurations	Example Parameters
Storage v1	7	<b>2,074</b>	FS, Block Size, Journal Options
Storage v2	9	<b>24,888</b>	I/O Scheduler, Disk
Local Storage + NFS	18	<b><math>1.2 \times 10^{22}</math></b>	r/wsize, a/sync, no/wdelay, NFS version

- ◆ Sensitive to environment and workload

# Possible Solutions

- Exhaustive Search
  - ◆  $10^{16}$  years
- Machine Learning
  - ◆ Long training phase
- Control Theory
  - ◆ Only for linear systems
- **Meta-Heuristics**

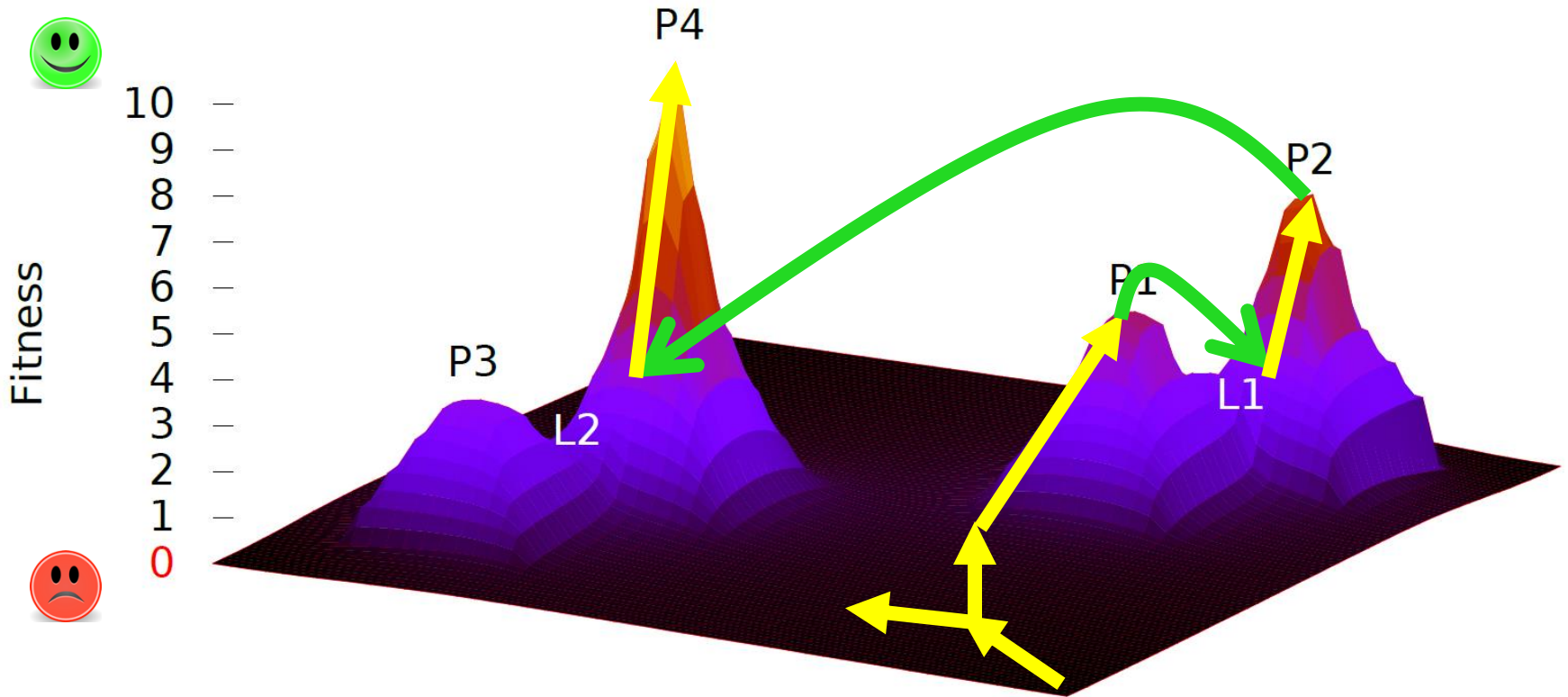
# Meta-Heuristics

- Strategies guiding the search process
  - ◆ Genetic Algorithms, Particle Swarm Intelligence, Simulated Annealing, Iterative Local Search, Tabu Search, and more...
- Applications
  - ◆ TSP and Job-shop Scheduling Problem
  - ◆ VLSI Design
  - ◆ Storage Systems (limited)

# Meta-Heuristics: Key Properties

- Fitness Function
  - ◆ Performance, energy, reliability
  - ◆ Any complex cost function
- Exploration
  - ◆ Search the space randomly
- Exploitation
  - ◆ Leverage neighborhood knowledge
- History
  - ◆ How much state is maintained

# Meta-Heuristics: Searching



# Experimental Setup

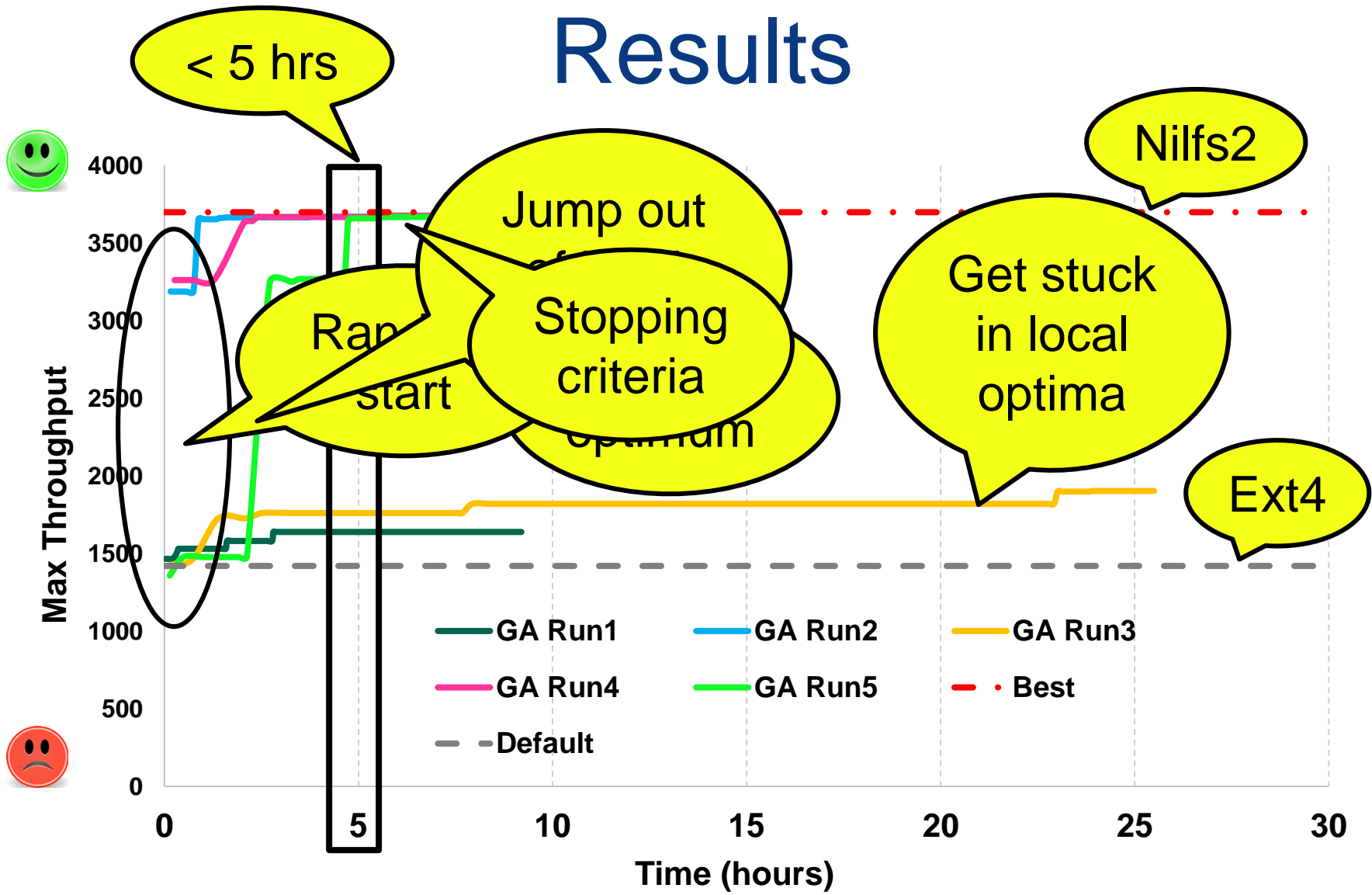
- Machines

- ◆ **M1**: 2 Intel Xeon single-core 2.8GHz CPU, 2G RAM, 73GB Seagate SCSI drives
- ◆ **M2**: 1 Intel Xeon quad-core 2.4GHz CPU, 24G RAM, 4 drives (2 SAS, 1 SATA, SSD)

- Filebench workloads

- ◆ Mailserver
- ◆ Fileserver
- ◆ Dbserver

# Results



Workload: mailserver; Machine: M1; Algorithm: Simple GA



< 5 hrs

Nilfs2

Running start

Jump out of local optima

Get stuck in local optima

Ext4

- GA Run1
- GA Run2
- GA Run3
- GA Run4
- GA Run5
- Best
- Default



# Search Efficiency

	Methodology	# Configs	Estimated Time
Storage V1 (2 min/ config)	Exhaustive Search	2,074	104 hrs
	Simple GA	125	5 hrs
Storage V2 (4 min/ config)	Exhaustive Search	24,888	1,659 hrs (69 days)
	Simple GA	869	58 hrs (2.4 days)

**17.3x**

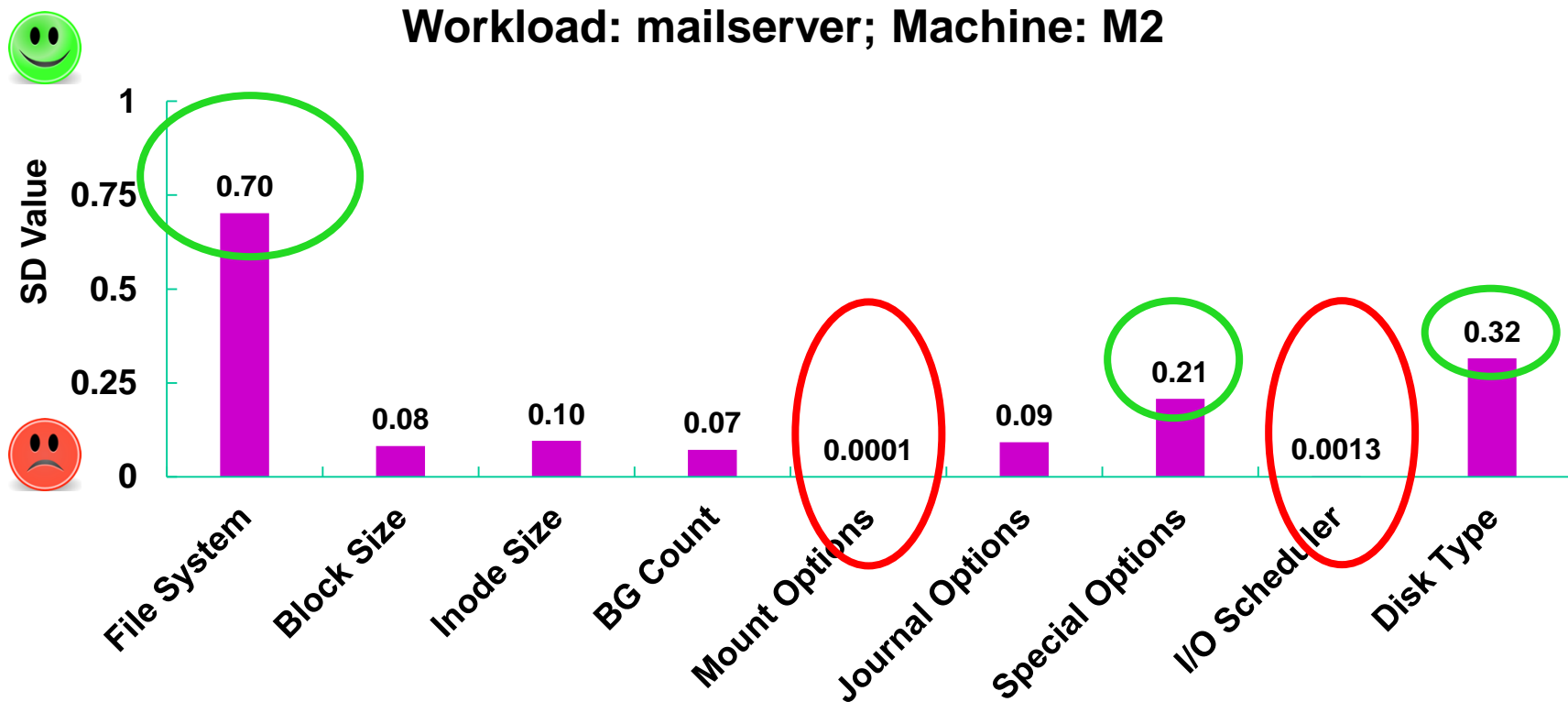
**29x**

# Sensitivity to Environment

	M1 - Mailserver	M1 - Fileserver	M2 - Mailserver
File System	NilFS2	Ext4	Ext2
Block Size	2,048	4,096	4,096
Inode Size	n/a	128	256
BG Count	256	2	8
Mount Options	atime	noatime	atime
Journal Options	order=relaxed	no journal	n/a
Special Options	n/a	n/a	n/a
I/O Scheduler	(deadline)	(deadline)	noop
Disk Type	(SATA)	(SATA)	SSD

# Future Work

- Eliminate less important parameters
  - ◆ Statistical Dependency (SD)



# Future Work

- Eliminate less important parameters
- Choose parameters of metaheuristics
  - ◆ GA: elitism, mutation rate
- Stopping criteria
  - ◆ And when to restart
- Investigate other and Hybrid techniques
  - ◆ Iterative local search, Q-learning, etc.

***We're collecting 100,000 data points (33% done after 6 months) and will share with the community***

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# Thank You

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