

Too Many Knobs to Tune? Towards Faster Database Tuning by Pre-selecting Important Knobs

Konstantinos Kanellis, Ramnatthan Alagappan, Shivaram Venkataraman



Database tuning is important!

Realizing *high performance* requires finding **optimal** values for configuration knobs

```
...  
commitlog_sync_period_in_ms: 10000  
commitlog_segment_size_in_mb: 32  
compaction_throughput_mb_per_sec: 16  
concurrent_reads: 32  
concurrent_writes: 32  
memtable_heap_space_in_mb: 2048  
memtable_cleanup_threshold: 0.33  
native_transport_max_threads: 128
```



Cassandra Default Configuration

Tuning
→
Process

```
...  
commitlog_sync_period_in_ms: 50000  
commitlog_segment_size_in_mb: 128  
compaction_throughput_mb_per_sec: 16  
concurrent_reads: 128  
concurrent_writes: 64  
memtable_heap_space_in_mb: 1024  
memtable_cleanup_threshold: 0.85  
native_transport_max_threads: 256
```



Cassandra Tuned Configuration

Properly tuned database systems can achieve **2-3x** higher throughput (or lower 99-tile latency) compared to *default* configuration (PostgreSQL) [1]

... but it's hard ...

- **100s** knobs in a typical system
- Most knobs take *continuous* values
- Unknown **interactions** among knobs
- Evaluating a single configuration is expensive

Earlier tuning efforts relied on experience from human experts



```
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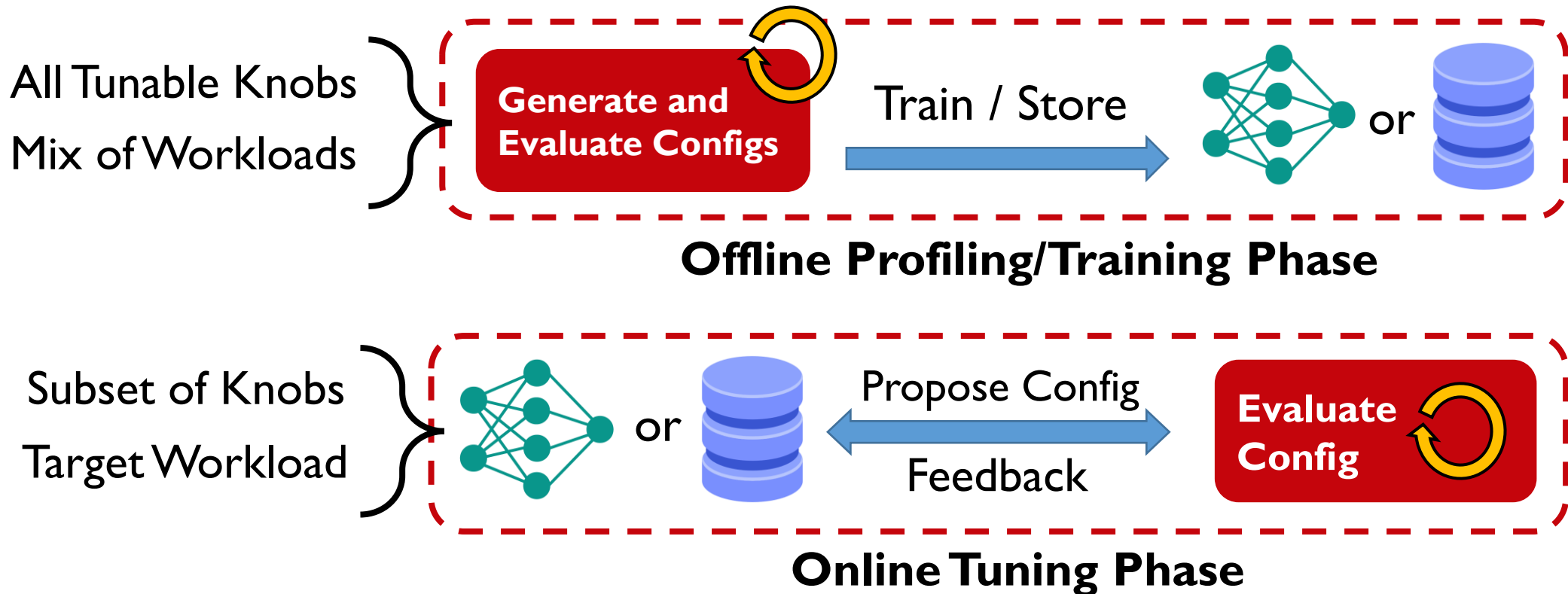
Cassandra configuration

Recently proposed tuning frameworks can **automate** the procedure

Can achieve same (or even better) performance compared to manual tuning [2]

Automated database tuning

Most existing auto-tuning database frameworks consist of (a) initial **offline profiling** phase and (b) an online *tuning* phase



Motivation

Offline profiling is **vital** for the quality of proposed configurations
Yet, this phase may account for **>95%** of the *entire* tuning time



How many knobs do we need to achieve “good” performance?
Can we *exploit* this to accelerate the offline phase?

Experimental study

How **many knobs** do we need to achieve “good” performance?

Cassandra
YCSB-A

5 out of 55!

Do similar results hold for *different* **workloads**?

Cassandra
YCSB-B

Same 5 knobs!

Do similar results hold for a *different* **database system**?

PostgreSQL
YCSB-A, YCSB-B

Yes!

Outline

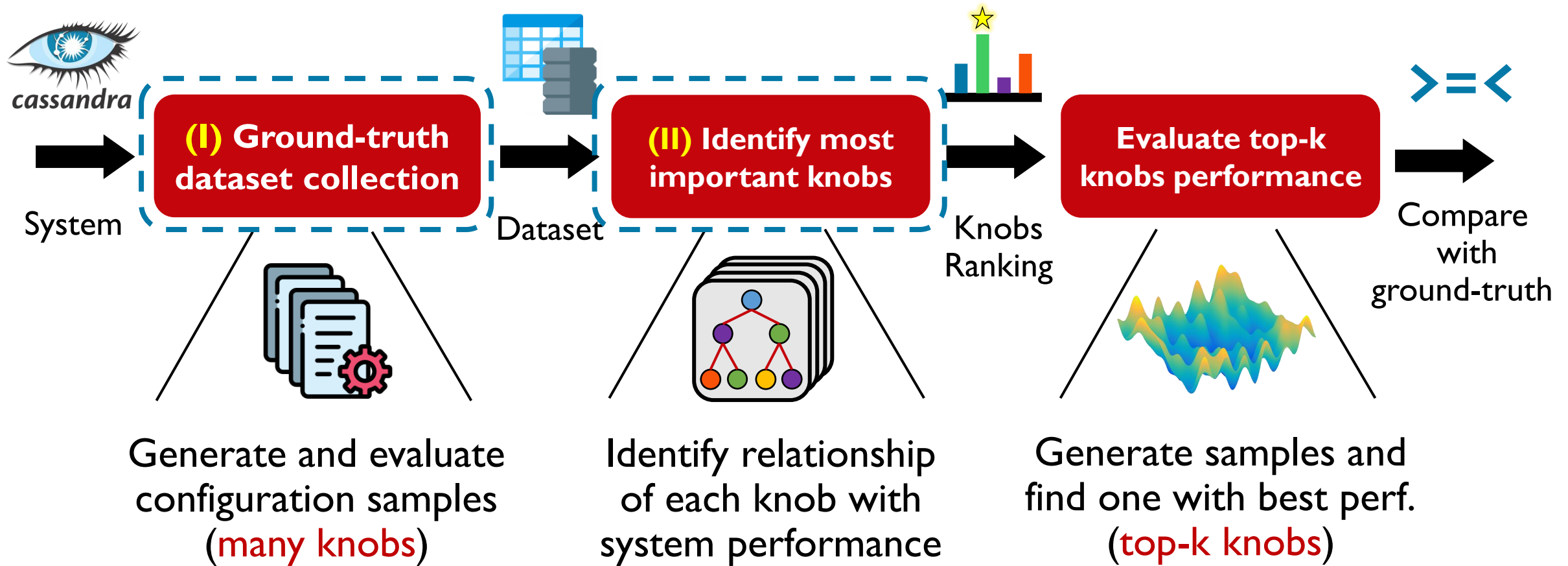
Background & Motivation

Methodology

Results

Towards Faster Database Tuning

Methodology



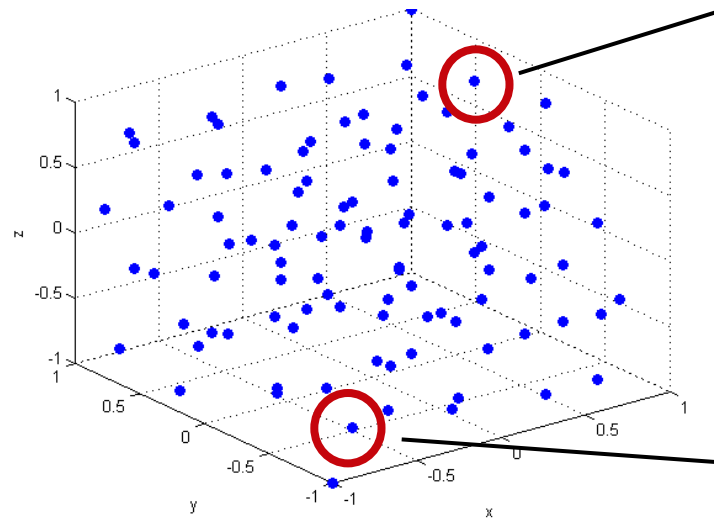
(I) Generate and collect configuration samples

Intractable configuration space – limited number of samples

Latin Hypercube Sampling (LHS)

- **Uniformly** and **thoroughly** cover configuration space
- Employed by multiple existing systems

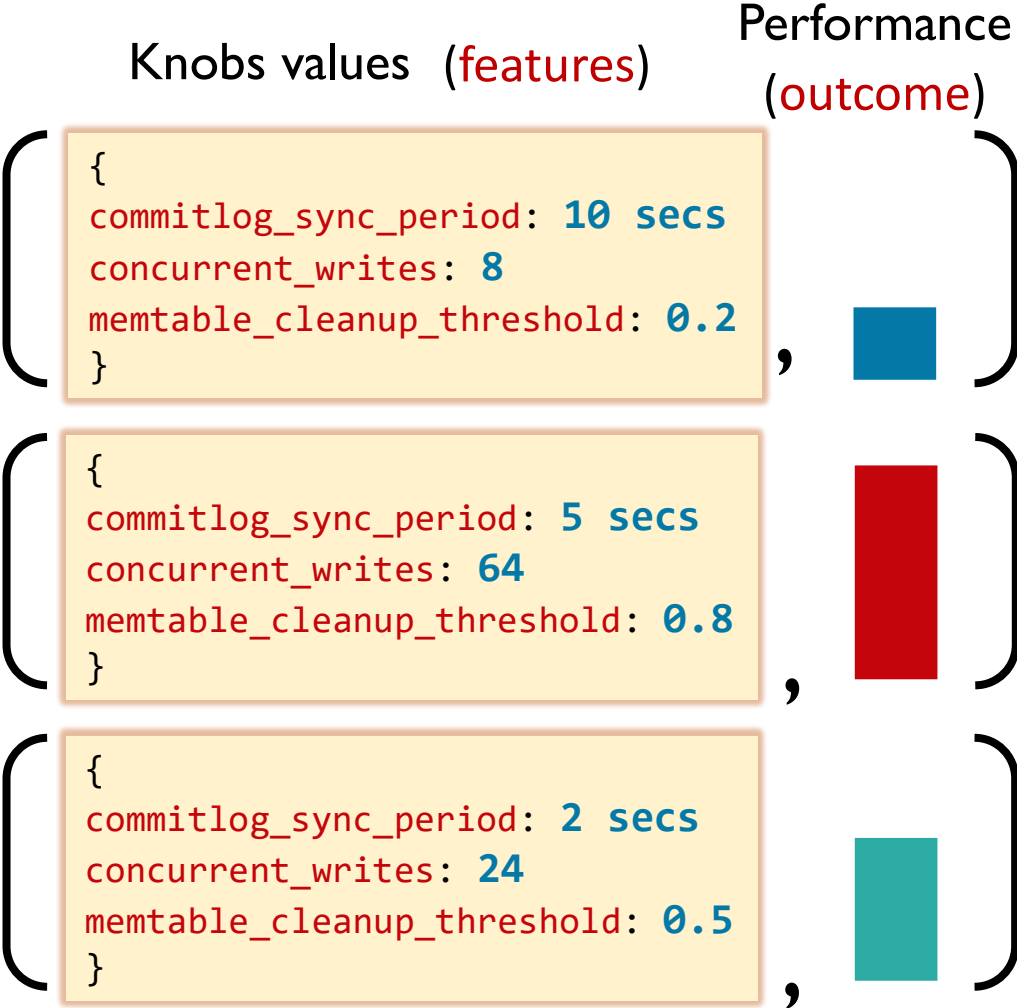
Number of Samples
Knobs / Range of values



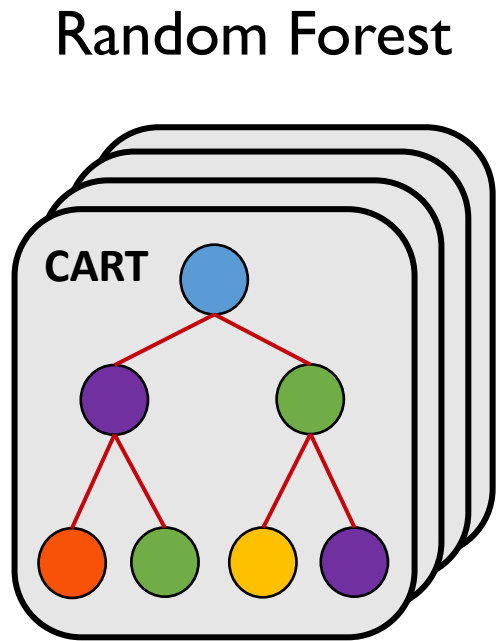
```
{  
  commitlog_sync_period: 10 ms  
  concurrent_writes: 8  
  memtable_cleanup_threshold: 0.2  
}
```

```
{  
  commitlog_sync_period: 5 ms  
  concurrent_writes: 64  
  memtable_cleanup_threshold: 0.8  
}
```

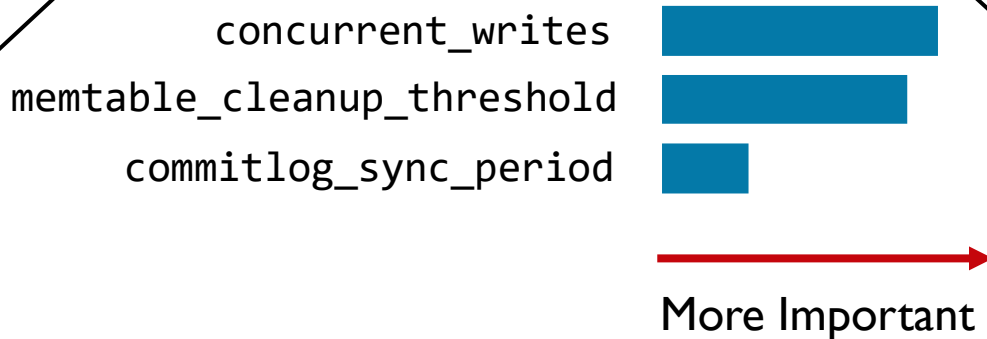
(II) Identify Important Knobs



Train Regression
Model



Knob Relative Importance Ranking



Experimental Setup

Machine hardware

- Intel Xeon Silver 4114 CPU, 64 GB RAM, 480GB SSD, Ubuntu 18.04
- Employ 30 identical machines to parallelize the evaluation process (CloudLab)

Ground-truth sample collection

- Apache Cassandra v3.11, PostgreSQL v9.6
- YCSB-A (50% read/50% write), YCSB-B (95% read/5% write)
- **25,000 samples** with LHS – tweaking ~30 knobs for both systems
- Each sample takes ~9 minutes to evaluate



cassandra



PostgreSQL

Outline

Background & Motivation

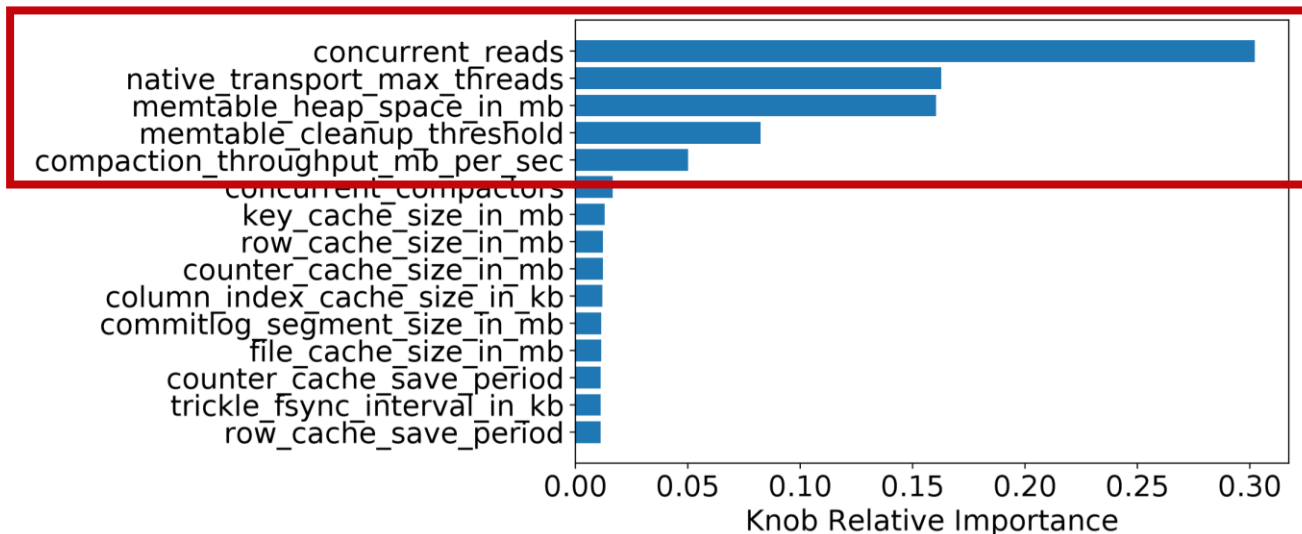
Methodology

Results

Towards Faster Database Tuning

How many knobs matter?

Apache Cassandra – YCSB-A



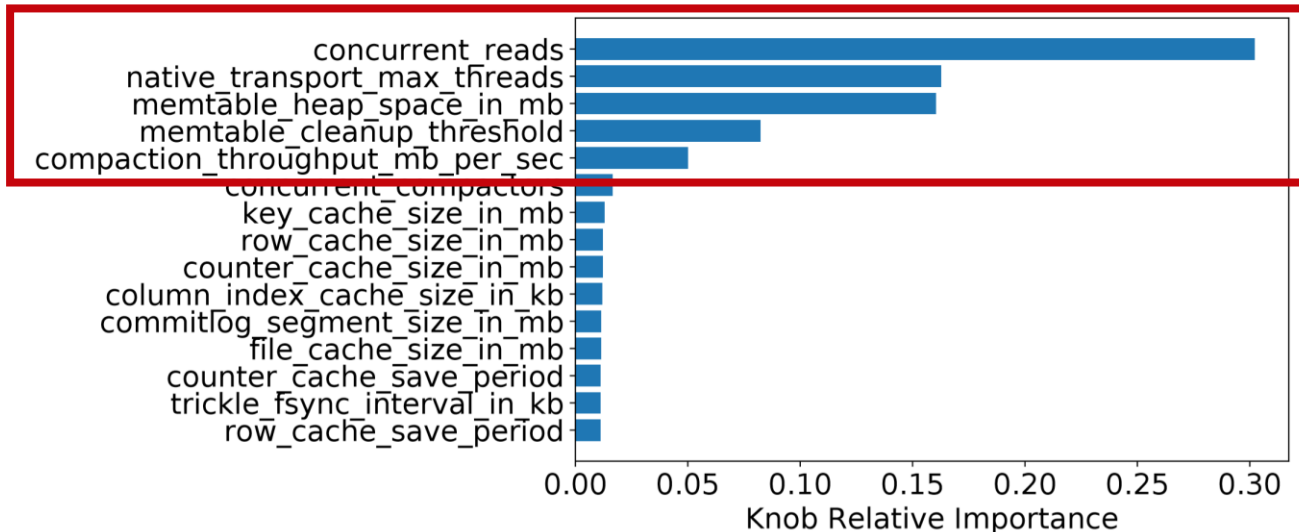
According to the ML model, these **5** knobs have the **most impact** on system performance

Most important knobs

- **concurrent_reads**: number of concurrent read operations
- **native_transport_max_threads**: number of threads used to handle requests
- **memory table–related** knobs: size of memtable, when to flush to disk

...but how much *performance* can we achieve?

Apache Cassandra – YCSB-A

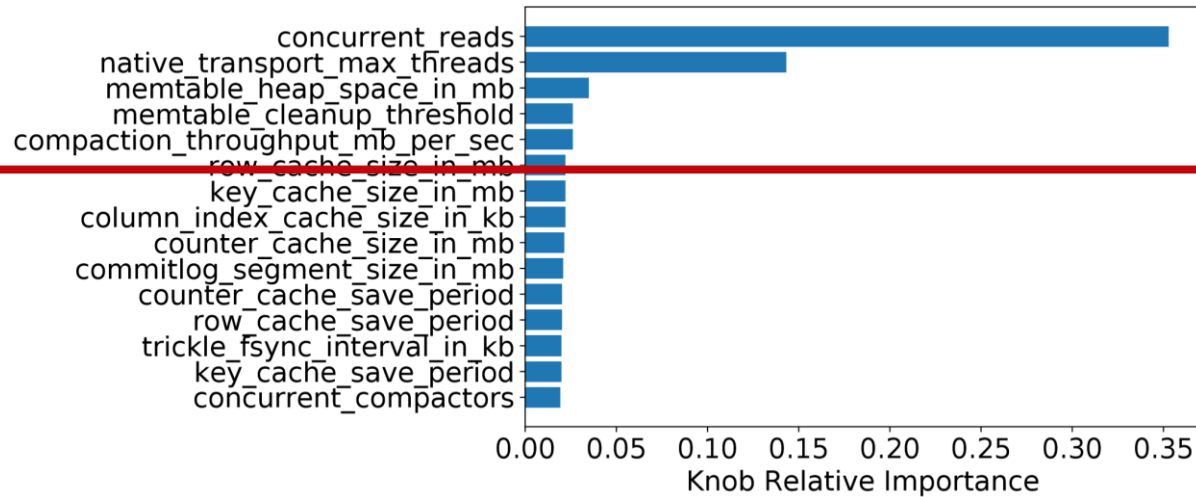


Tuning just a **few** *important* knobs can still yield *high* performance!

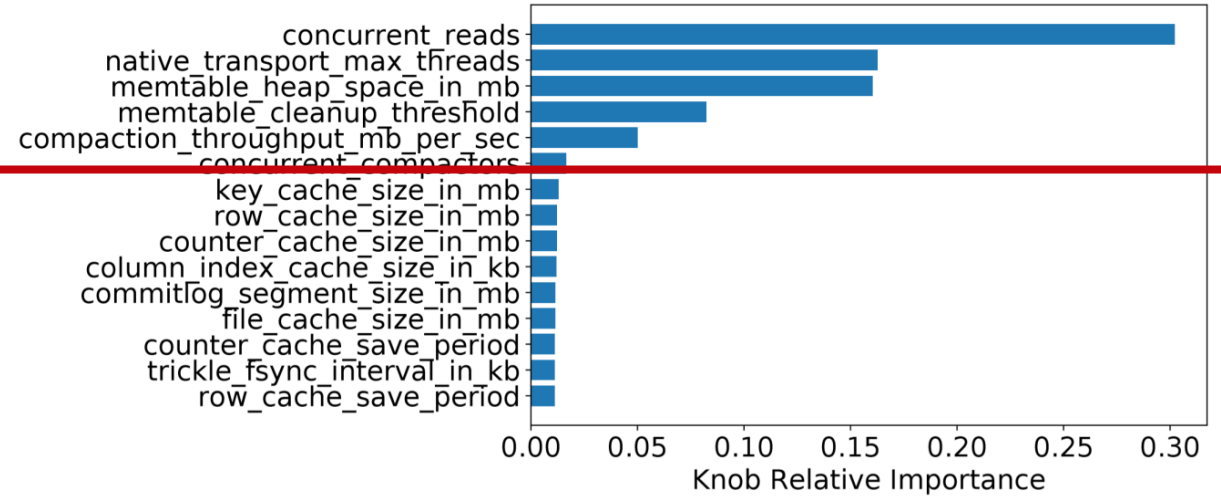
Best Configuration Performance	Throughput (ops/sec)	Read Latency (micro-seconds)	Write Latency (micro-seconds)
Tuning 30 knobs	74780.33	744.34	302.82
Tuning 5 knobs	74304.42	750.56	308.08
% of tuning 30 knobs	99.36%	100.84%	101.41%

What about a different workload?

Apache Cassandra – YCSB-B



YCSB-B (95%/5% r/w)

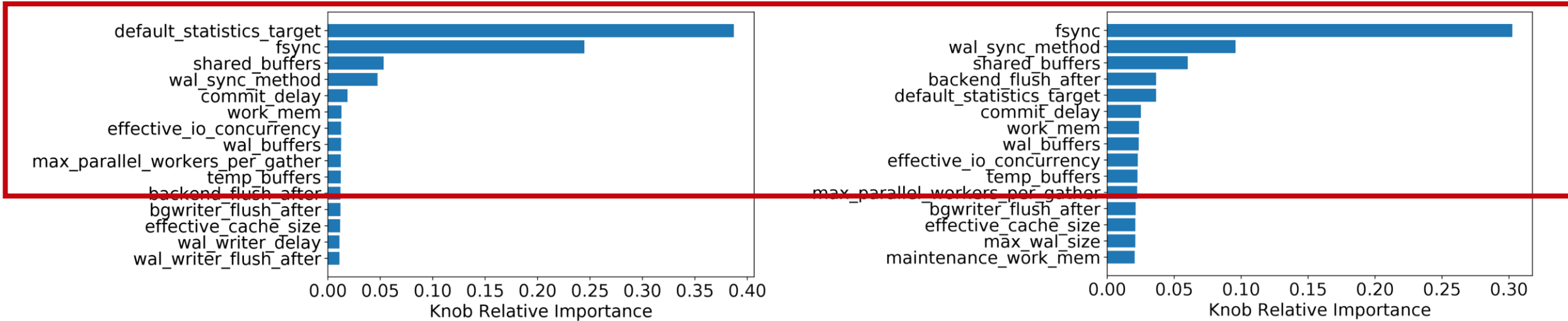


YCSB-A (50%/50% r/w)

- #1: A handful of knobs affect the performance for YCSB-B
- #2: **Overlap** of important knobs across the two workloads

What about a different **database system**?

PostgreSQL – YCSB-A, YCSB-B



YCSB-A (50%/50% r/w)

YCSB-B (95%/5% r/w)

In general, we observe **similar** results for PostgreSQL
Knob importance **ranking** more *diverse* between the workloads
... still top-8 knobs are *almost* identical

Outline

Background & Motivation

Methodology

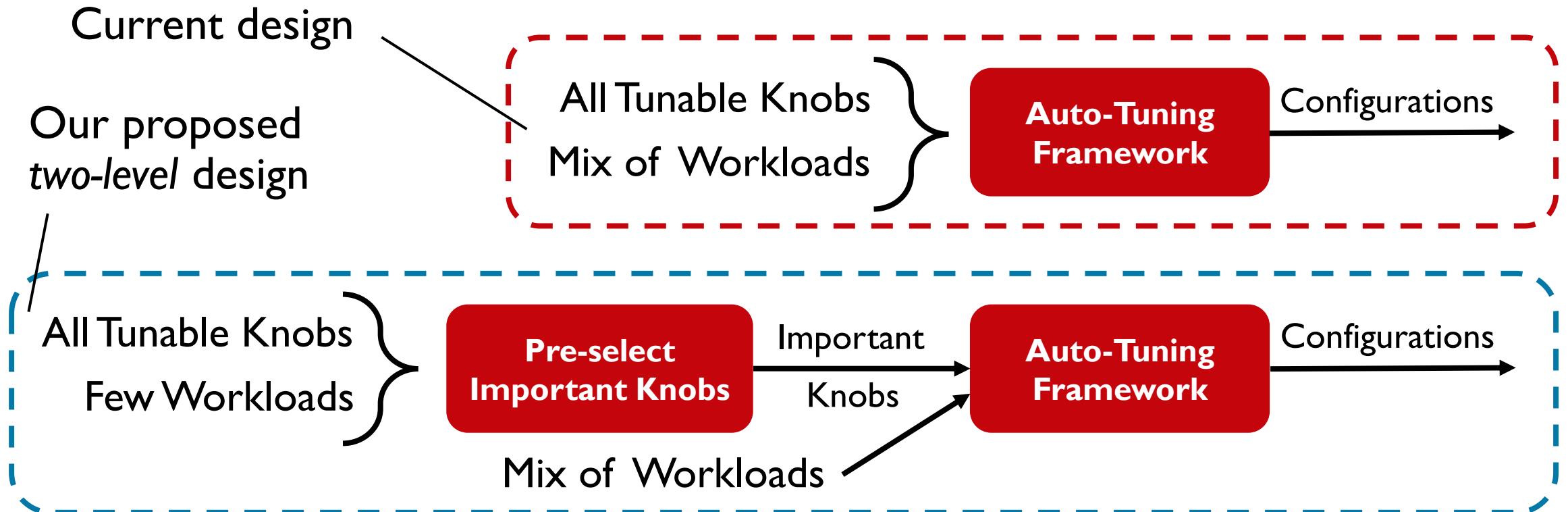
Results

Towards Faster Database Tuning

Pre-selecting Important Knobs

Utilize the ML model to identify important knobs **before** running the tuner

Reduces configuration search space size / training dataset of tuners



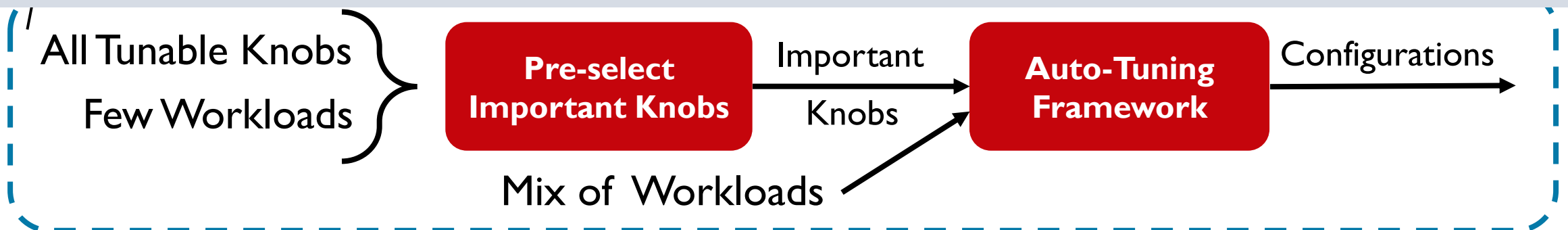
Pre-selecting Important Knobs

Utilize the ML model to identify important knobs **before** running the tuner

Early results with an existing tuner, *BestConfig*.

When tuning **top-5** knobs the best performance is reached with **5x fewer iterations** compared to tuning 30 knobs

(Apache Cassandra, YCSB-A)



Discussion

Can we make the *pre-selection* step cheaper? (25,000 samples)

- With our ML-based method **~400** samples are needed (early results)
- Can we use some other (cheaper) method? (evaluate *few* workloads?)

How does the hardware affect the important knobs?

- Can we avoid (or minimize) tuner adaptation time to new hardware?

Can we account for system **reliability** when tuning?

- Existing tuners may *sacrifice* reliability for performance
- fsync / recovery-related flags / checkpointing settings

Summary

Tuning with **few important** knobs can yield **high performance**

- Trend seems to hold across different **workloads** and **systems**
- Significant **overlap** of top knobs across different workloads

Proposed an **initial design** to accelerate database auto-tuners

- Pre-selecting important knobs *reduces* configuration search space
- Exploit top knobs similarity across workloads to make it faster?

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Thank you! Questions?

Reach me at kkanelis@cs.wisc.edu