Adrenaline

Pinpointing and Reining in Tail Queries with Quick Voltage Boosting

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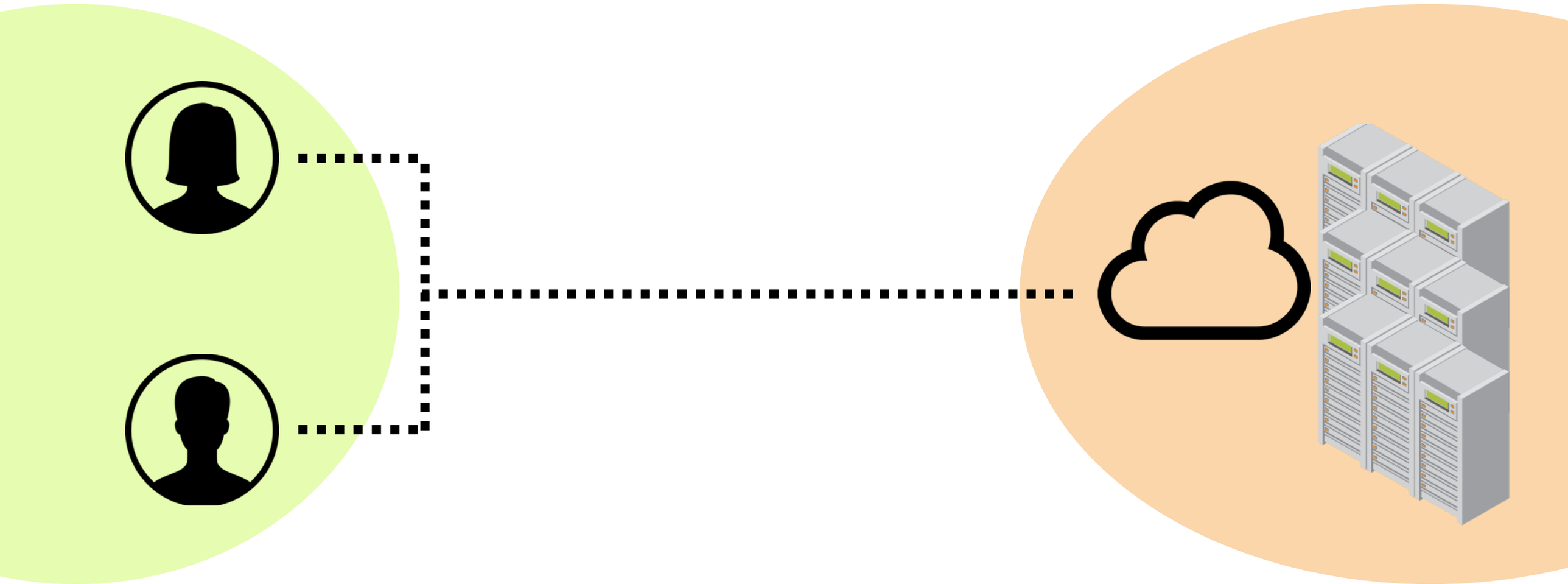
UNIVERSITY OF MICHIGAN

When datacenters meet users



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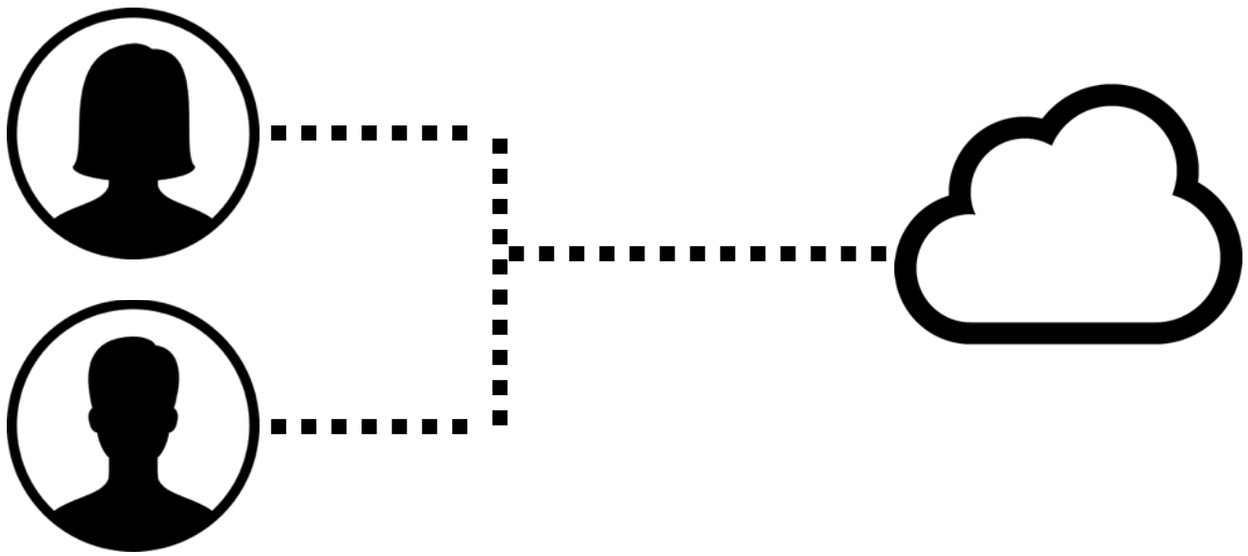
User-facing services are everywhere!

User-facing services need to be FAST!



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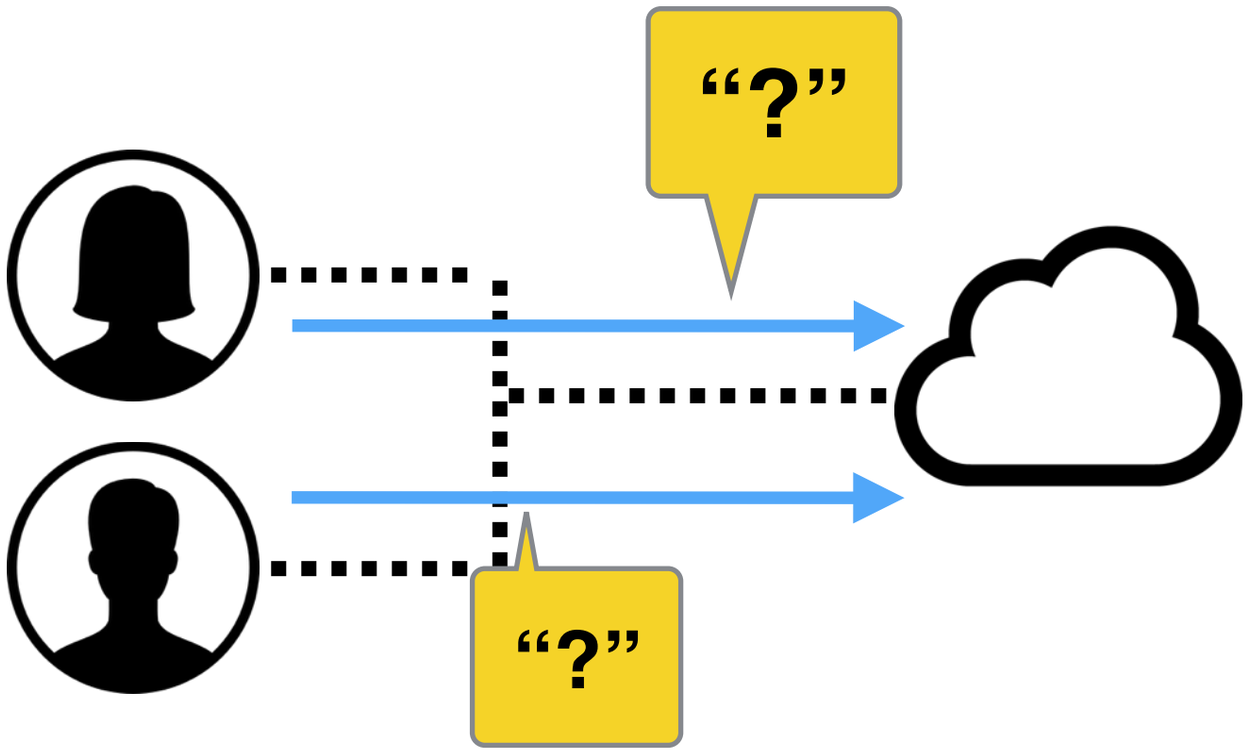

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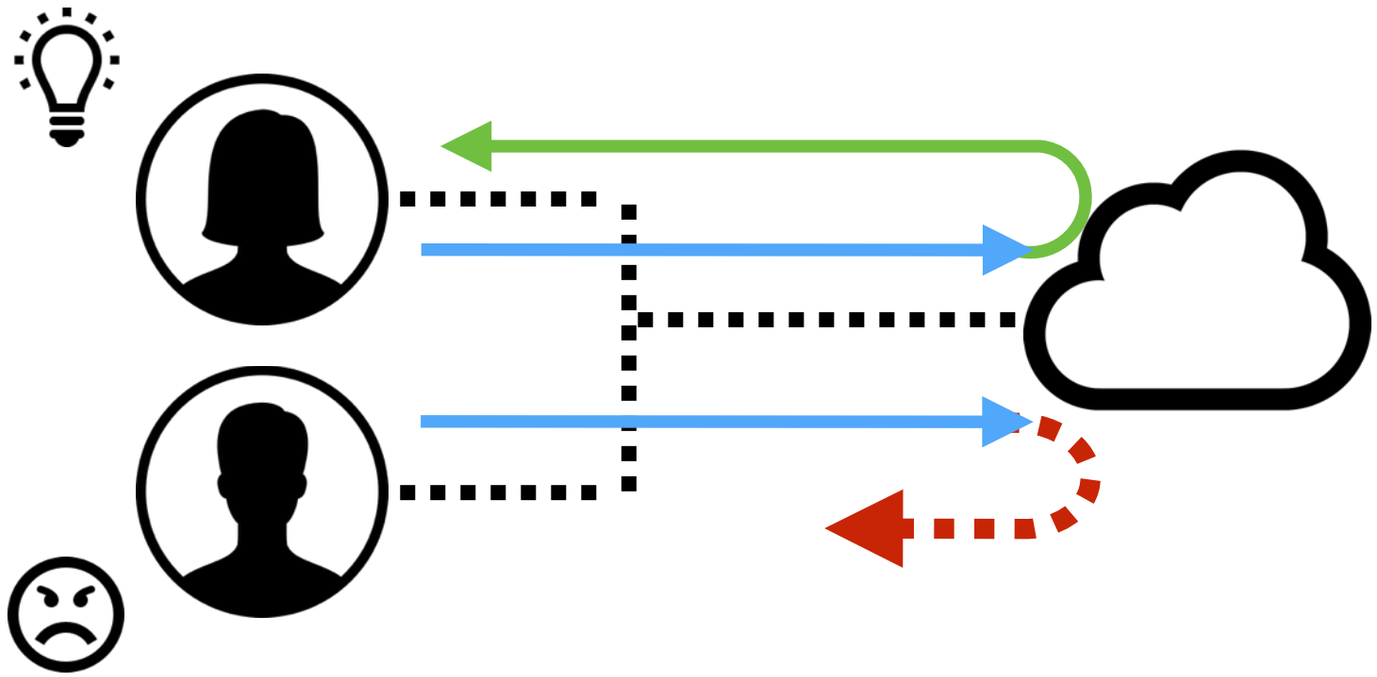

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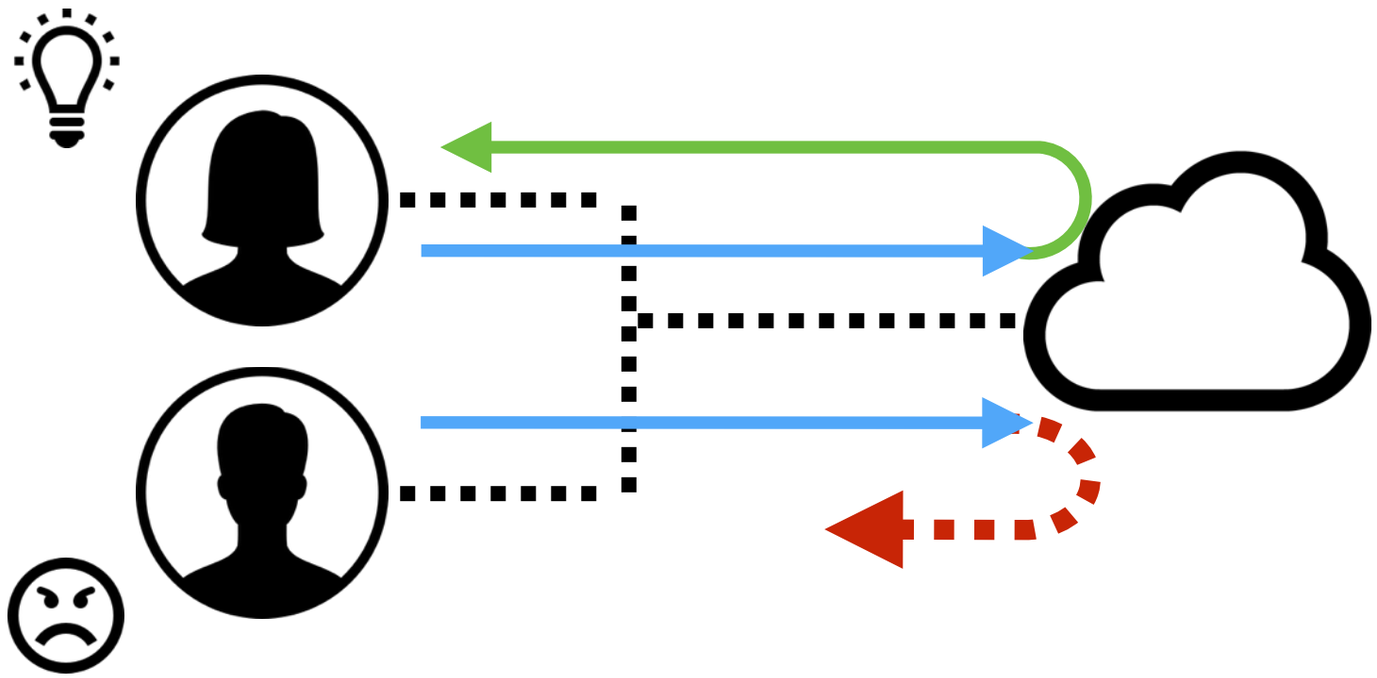

Latency is the key to the high quality of user-facing services

How fast is “FAST”?

How fast is “FAST”?

For user-facing services, “fast” means **low <u>tail latency</u>**

“Tail latency?”

- Tail latency is the latency of the **slowest queries** of the entire distribution

- Tail latency represents the **“worst-case” quality** of a service (worst-case QoS)

- Tail latency directly relates to **user experience**

“Fast” means low tail latency

- Imagine you are sending out search queries…

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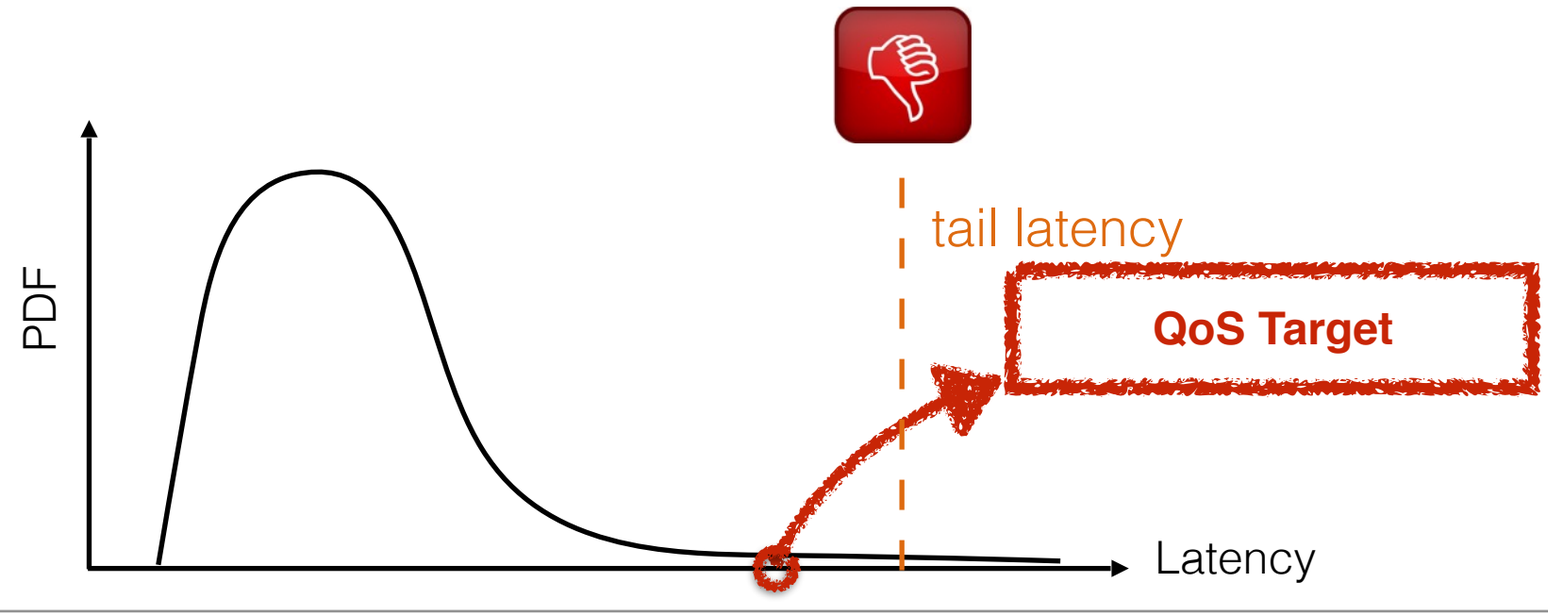

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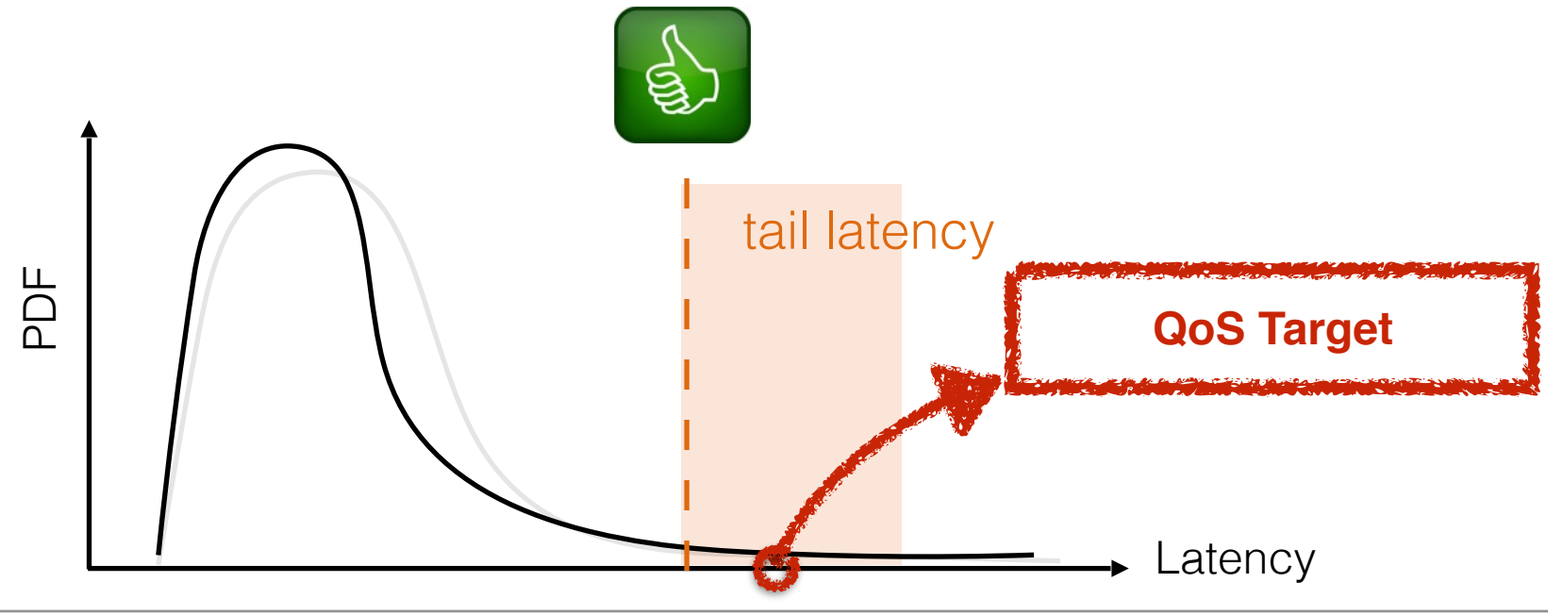
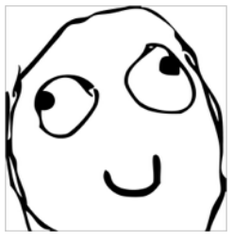
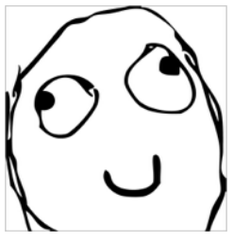




OK, I'll **boost the voltage/frequency of my cores** when the load is high, making the service run fast



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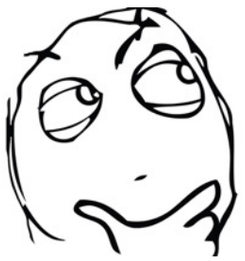

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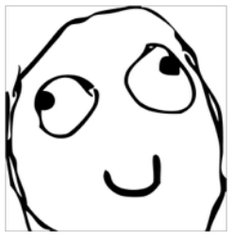
That means **A LOT of extra energy**! No!!



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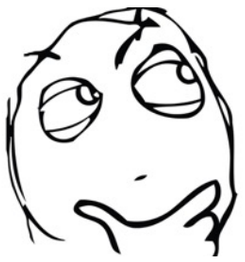

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Can I have a **fast service** with only **little energy overhead**?

Yes! We can achieve that goal if we can

1. **pinpoint those queries in the tail**
2. **boost these tail queries** specifically

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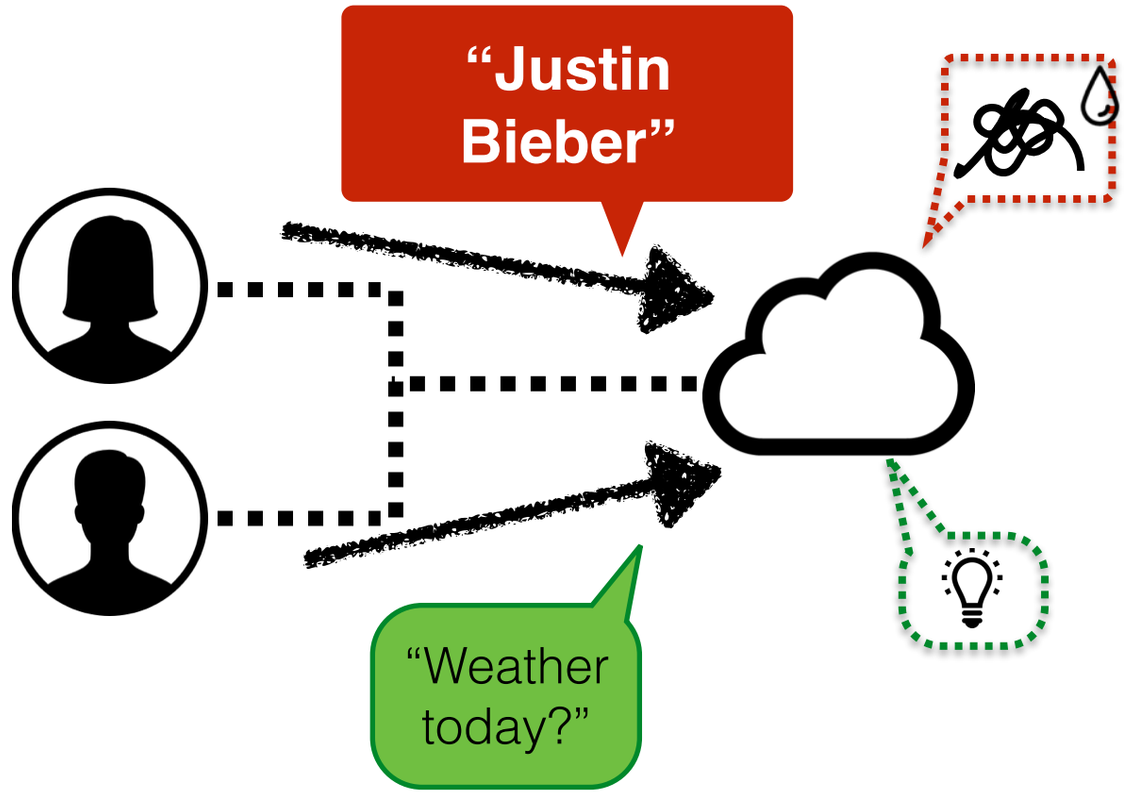
Adrenaline introduces query-level boosting

- ✓ Identify and take advantages of the differences among queries
- ✓ Switching core's voltage/frequency quickly to boost for the slow-running queries

Adrenaline insights

Queries are highly variable

- Even for the same web service, queries
  - **come from different users**
  - **have different contents**
  - **require different actions**



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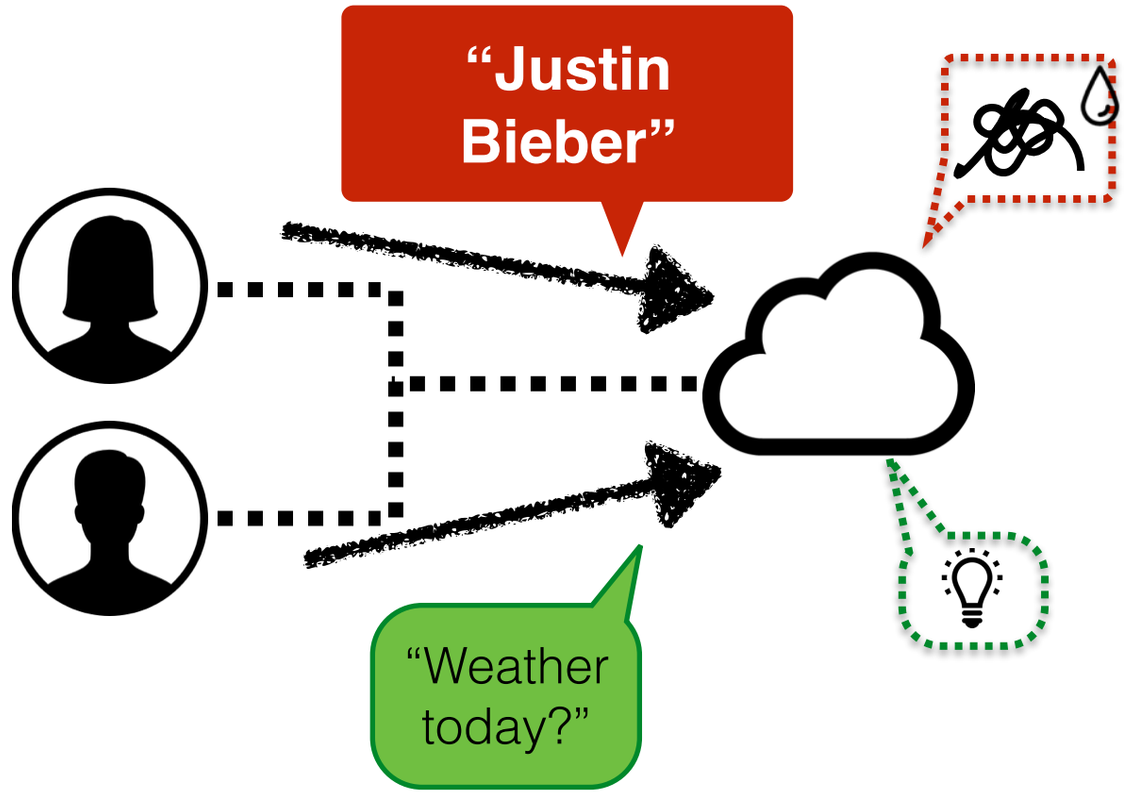

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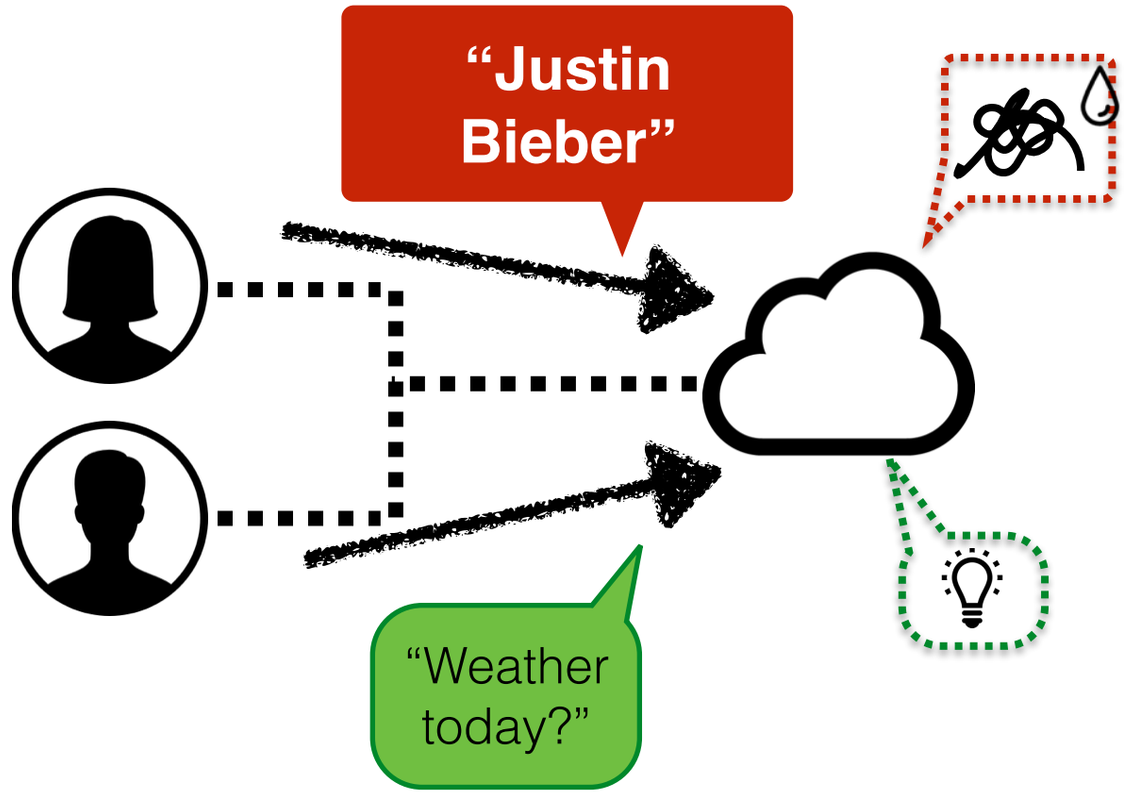

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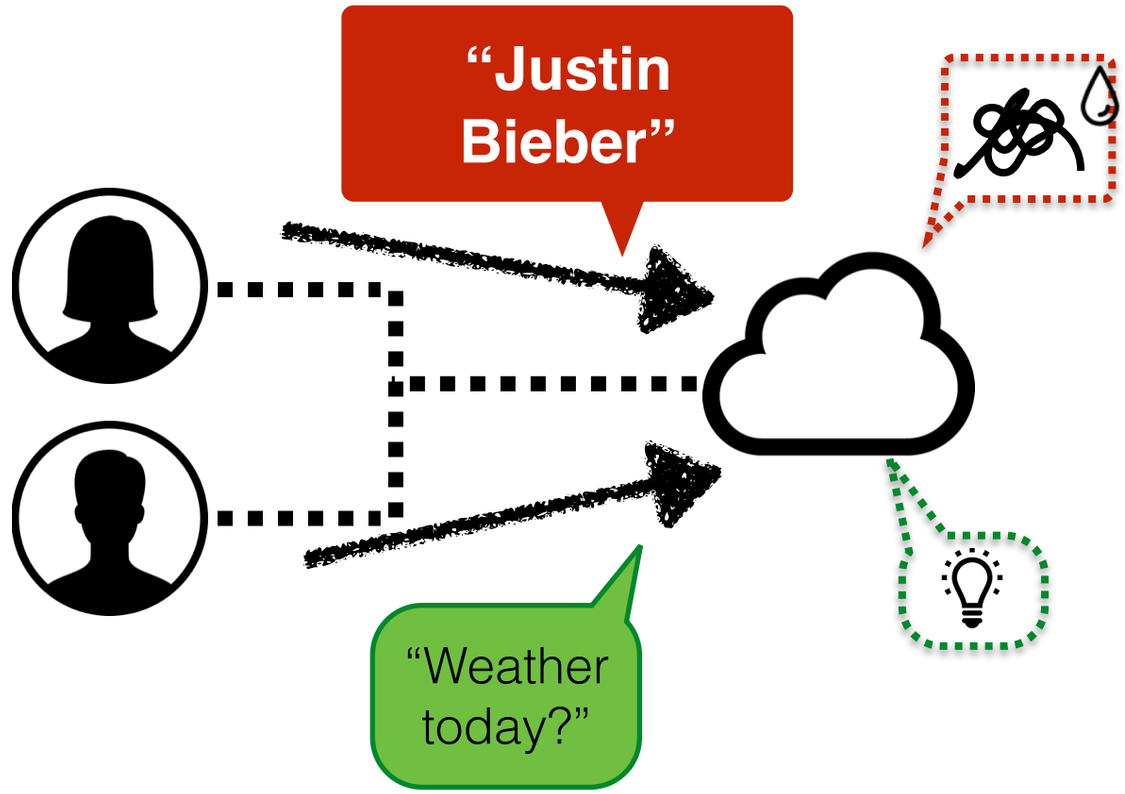

We observe that…

➡ they need different amount of time to process

➡ they react differently to core’s V/f scaling

Variability matters!

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Variability plays a key role in helping identify the critical and beneficial queries to boost

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Insight:

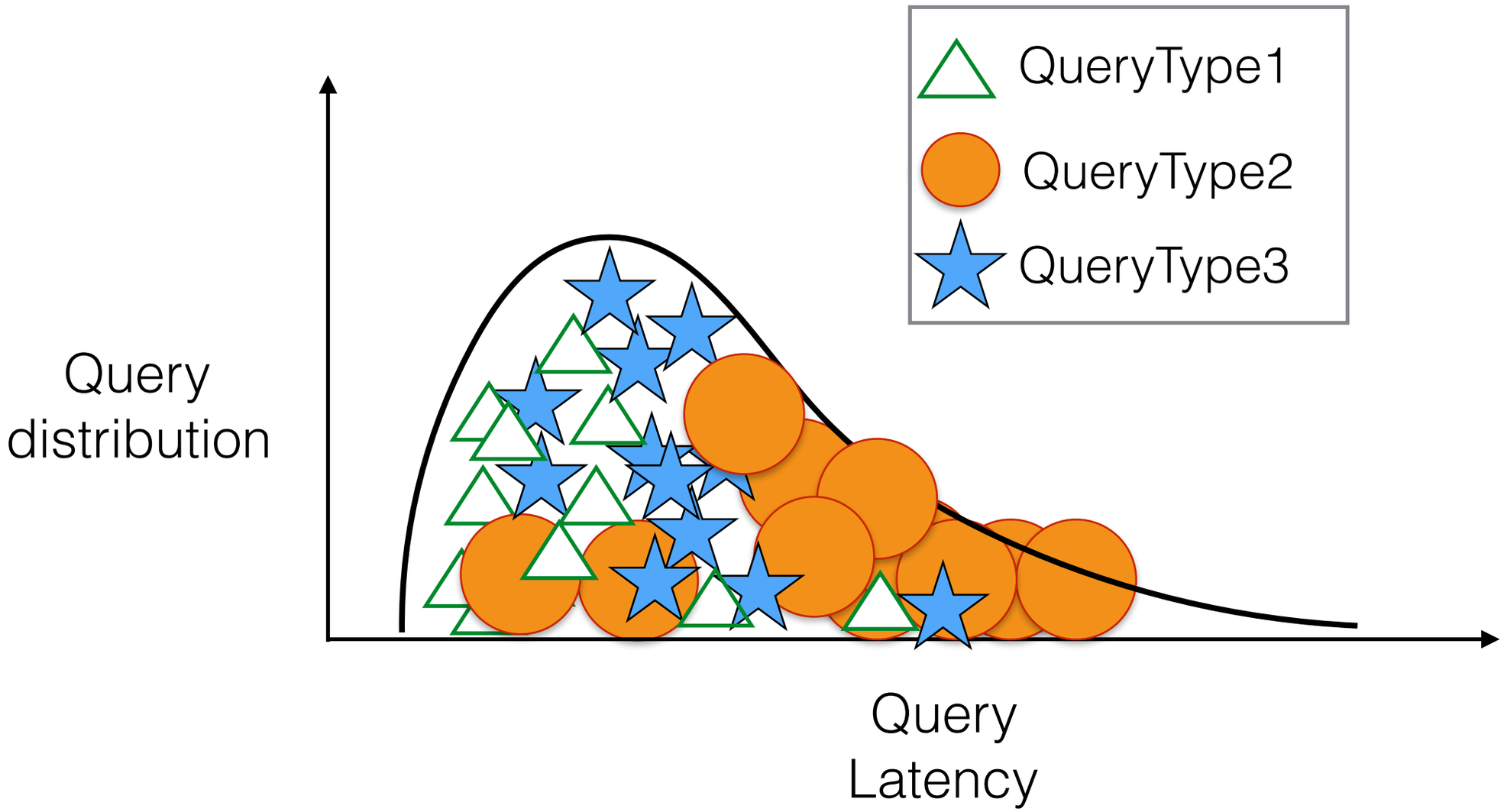
For a user-facing service, if we know

1. **"what query to target"**
2. **"how much I can boost"**

we can boost cores' V/f accordingly and intelligently

“What query to target?”

Characteristic 1: **high contribution to the tail**



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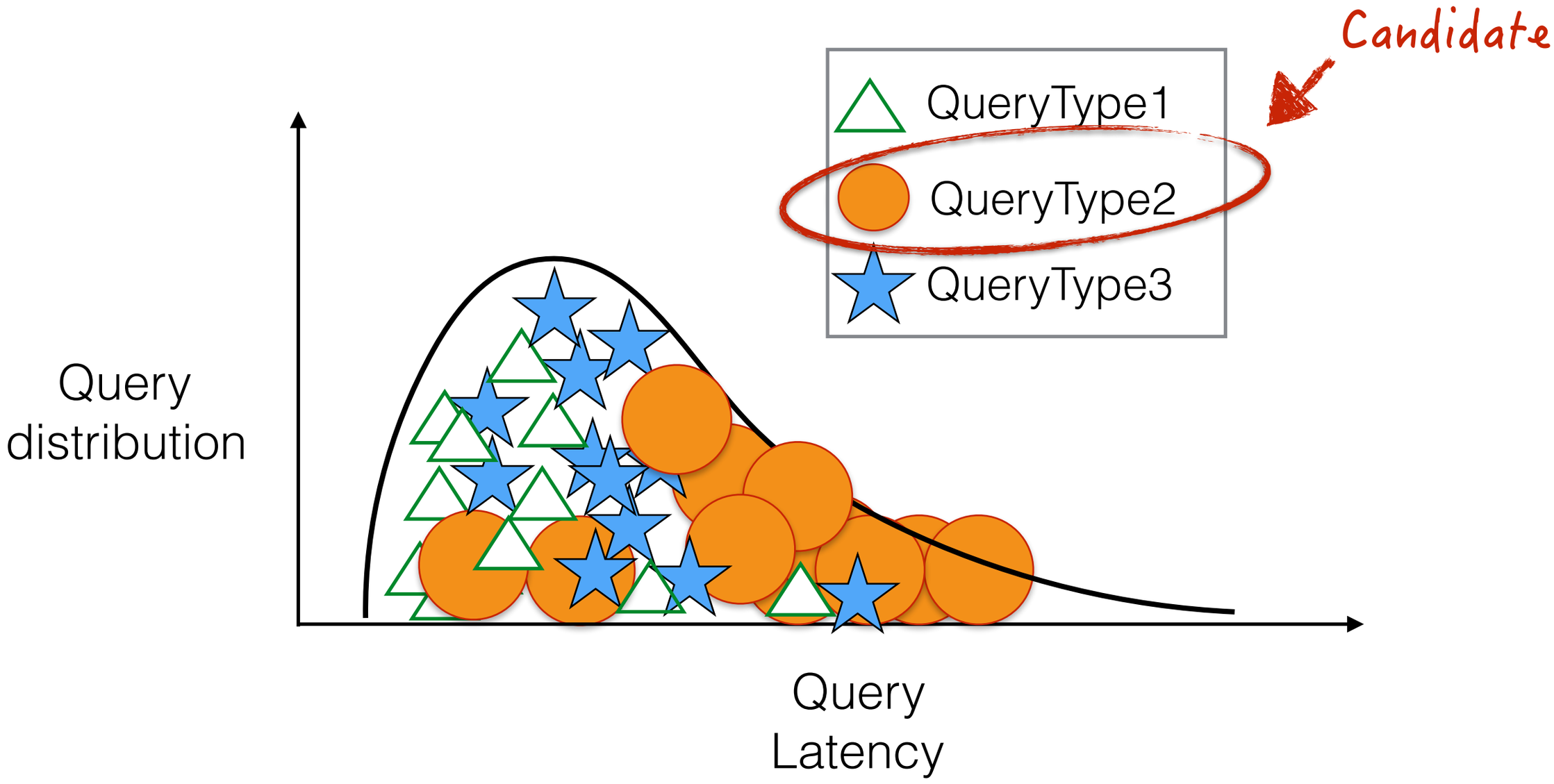
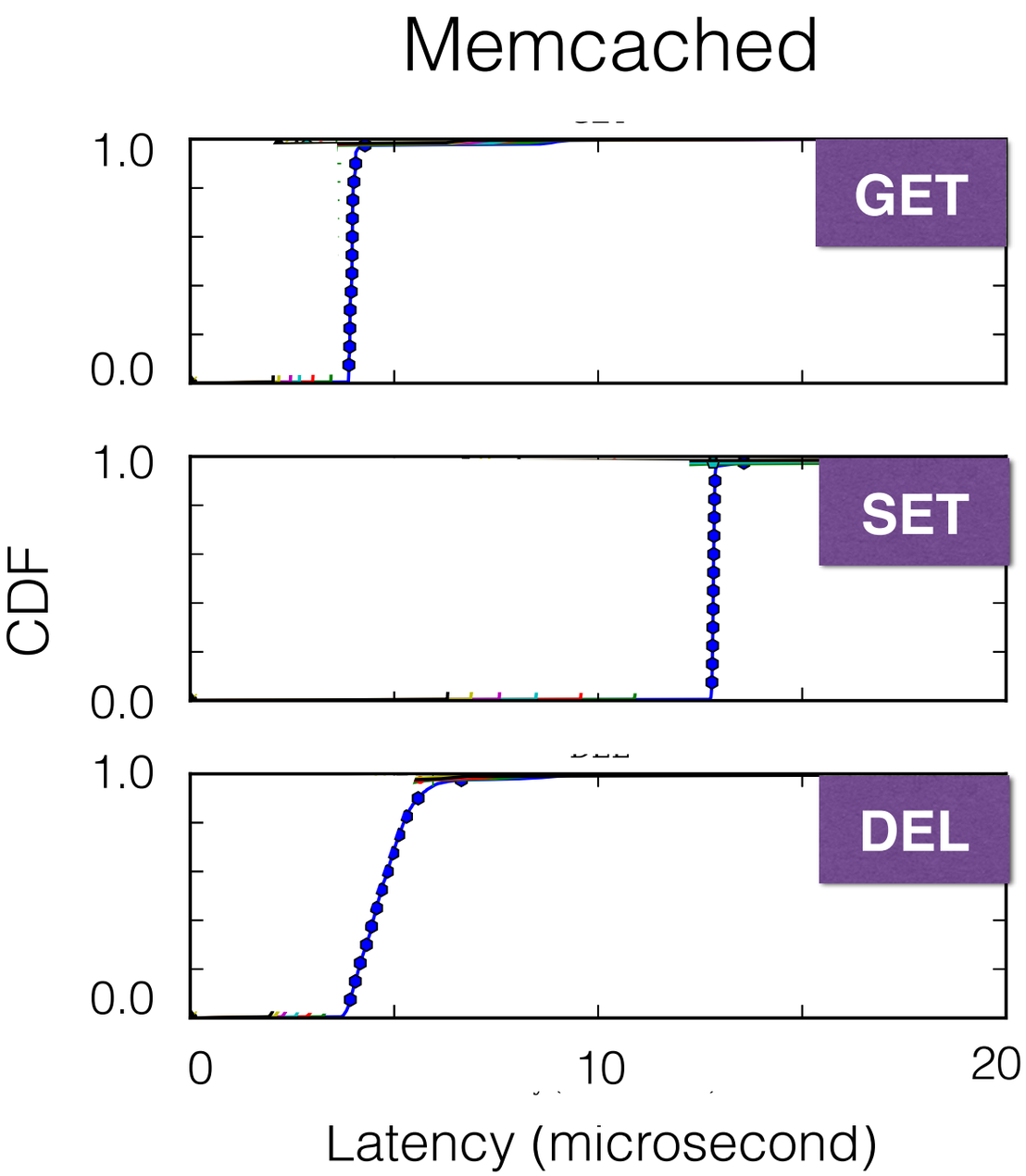


High tail-contribution example in Memcached



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- Latency distributions (CDFs) of different types of requests
- Running with a fixed core frequency

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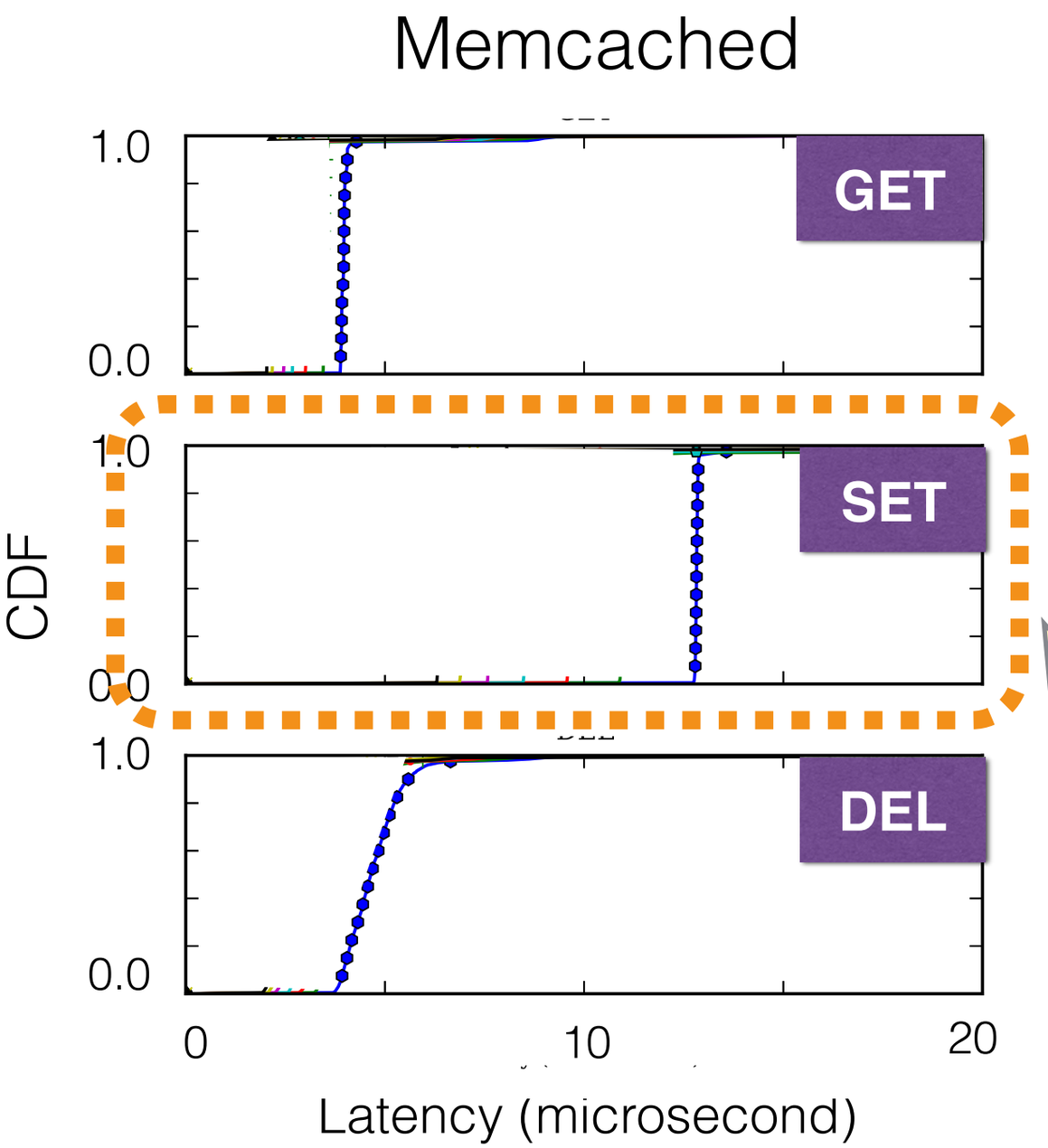

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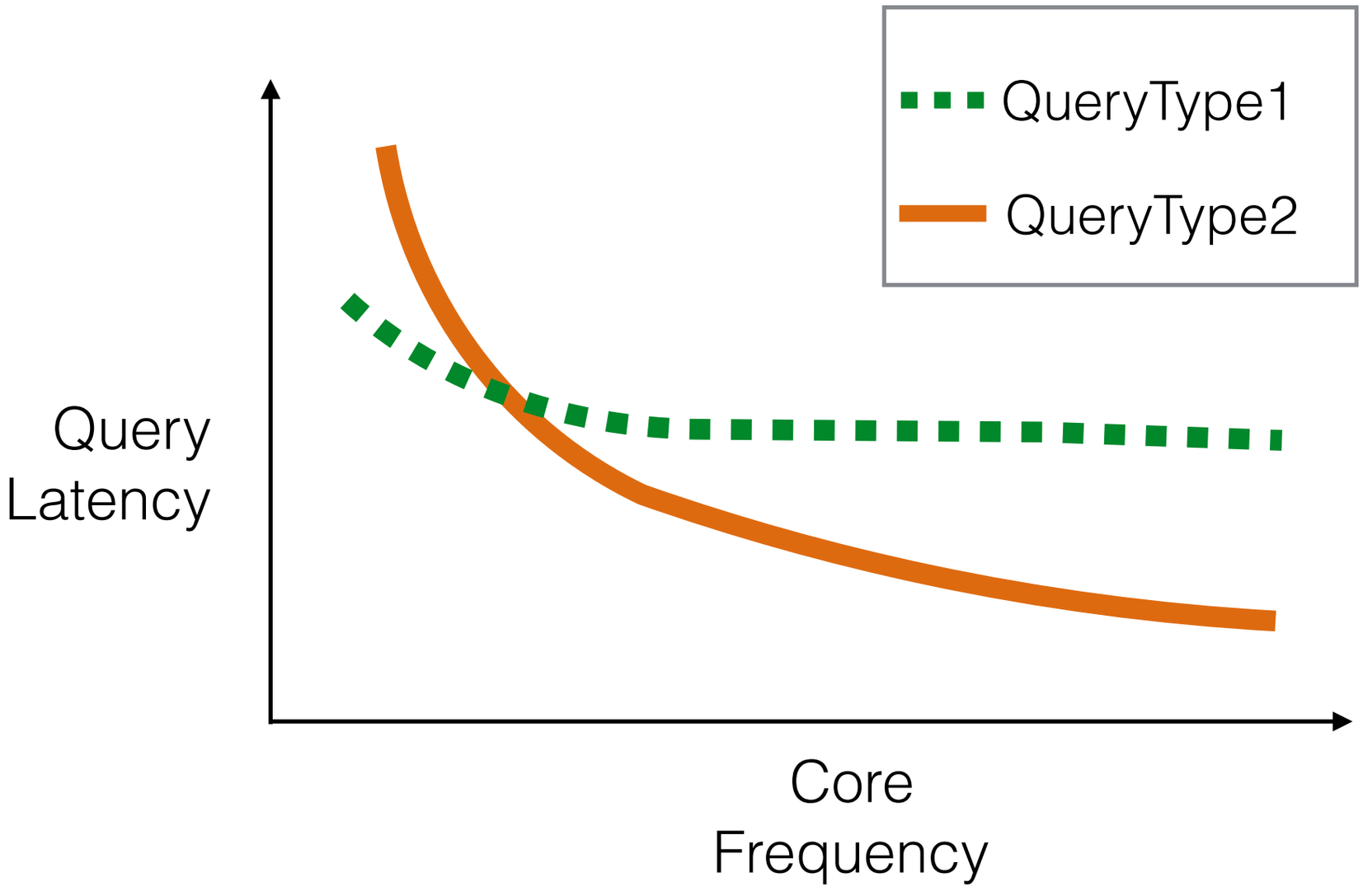
Observation

- **SETs** have **2-3x longer tail latency**

How much can we boost?

Characteristic 2: **High boost-ability**



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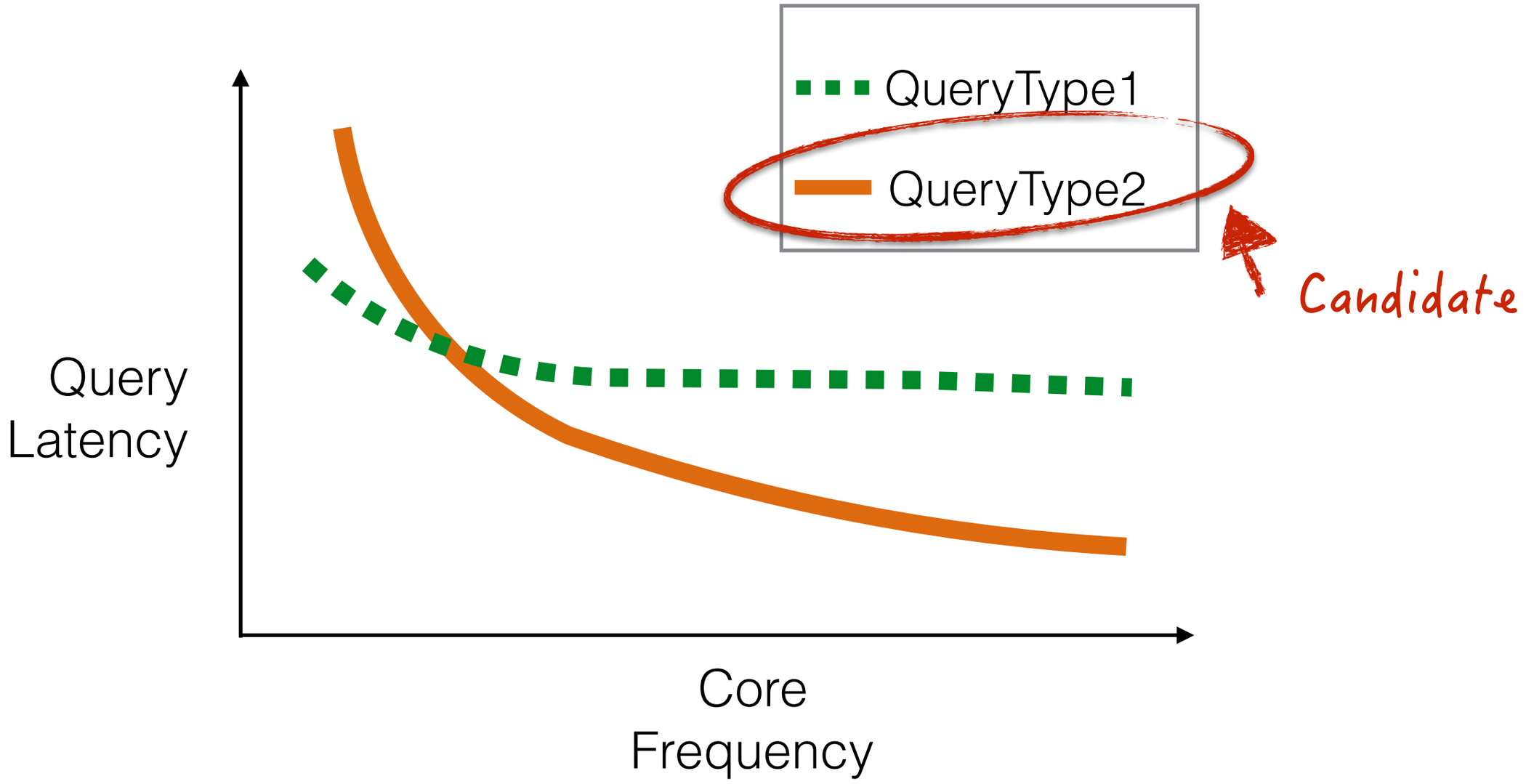

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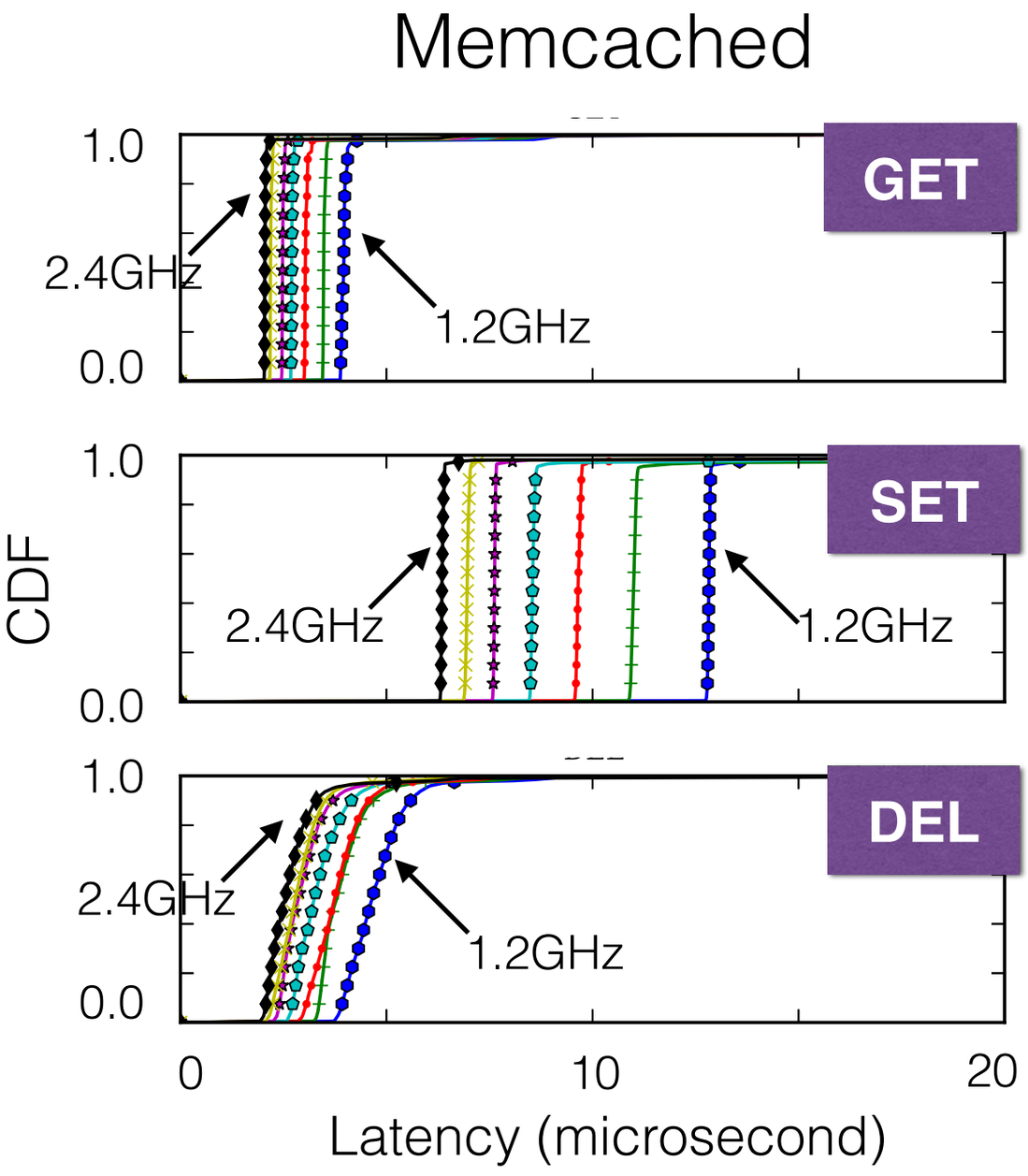

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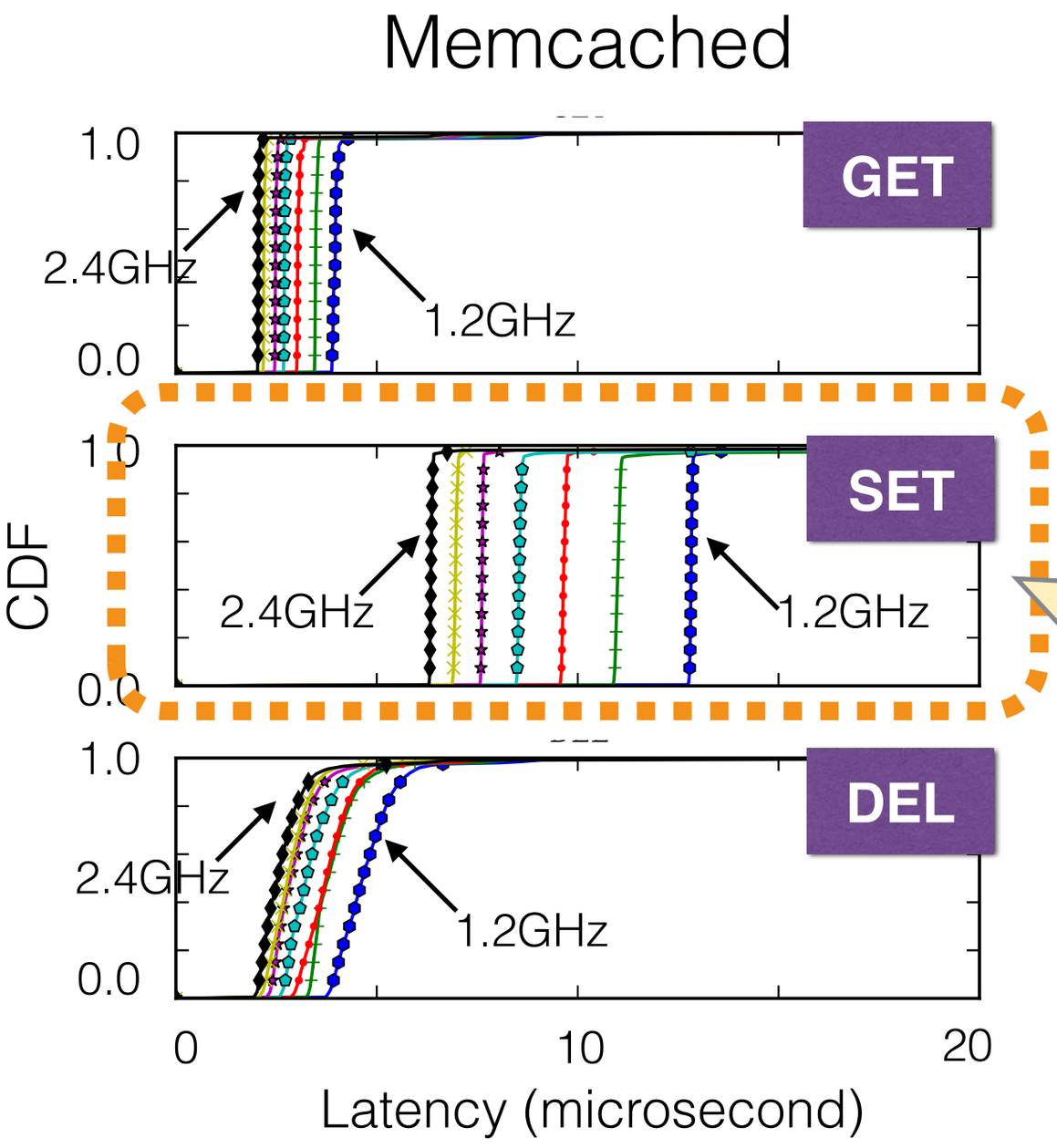

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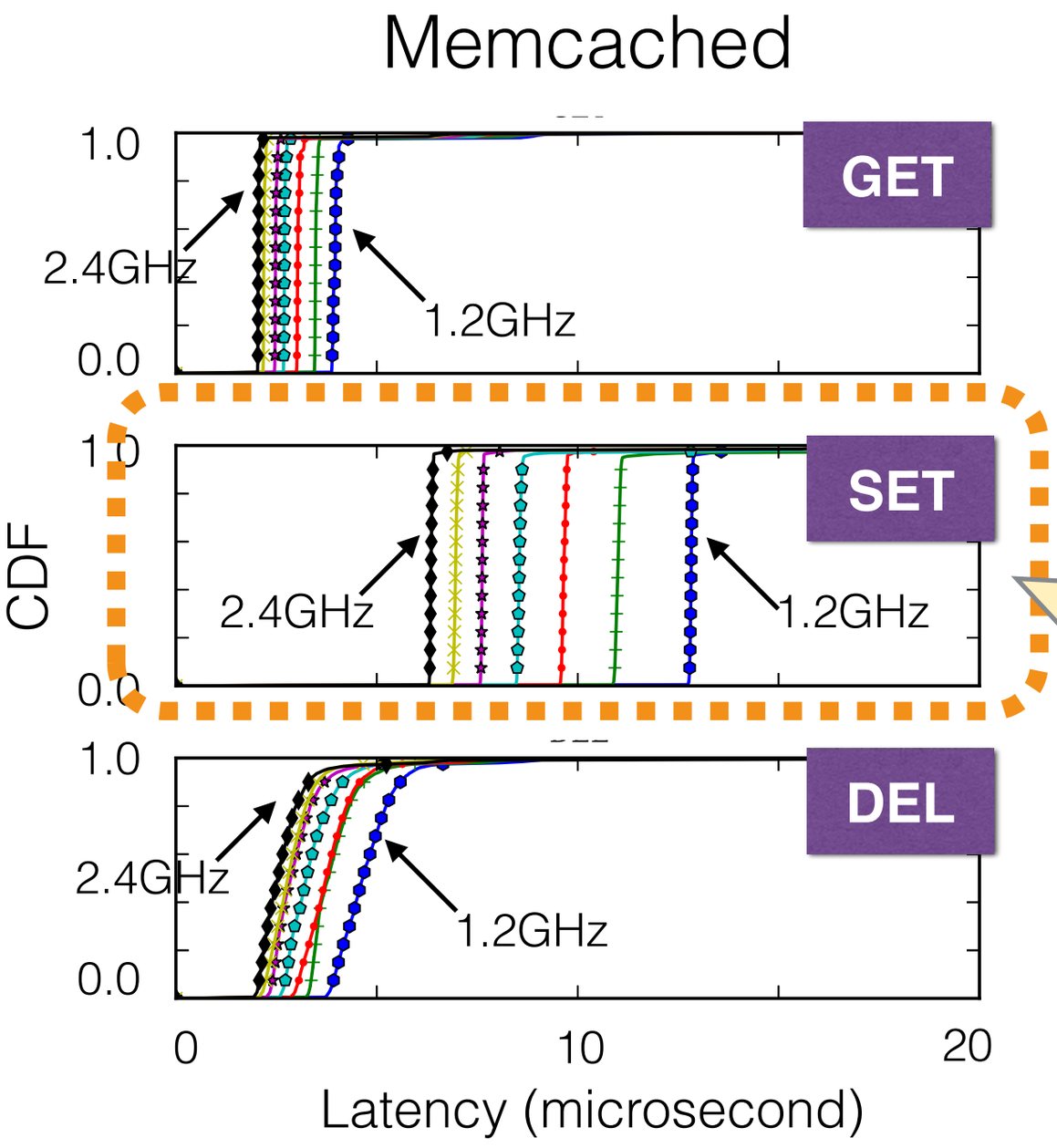

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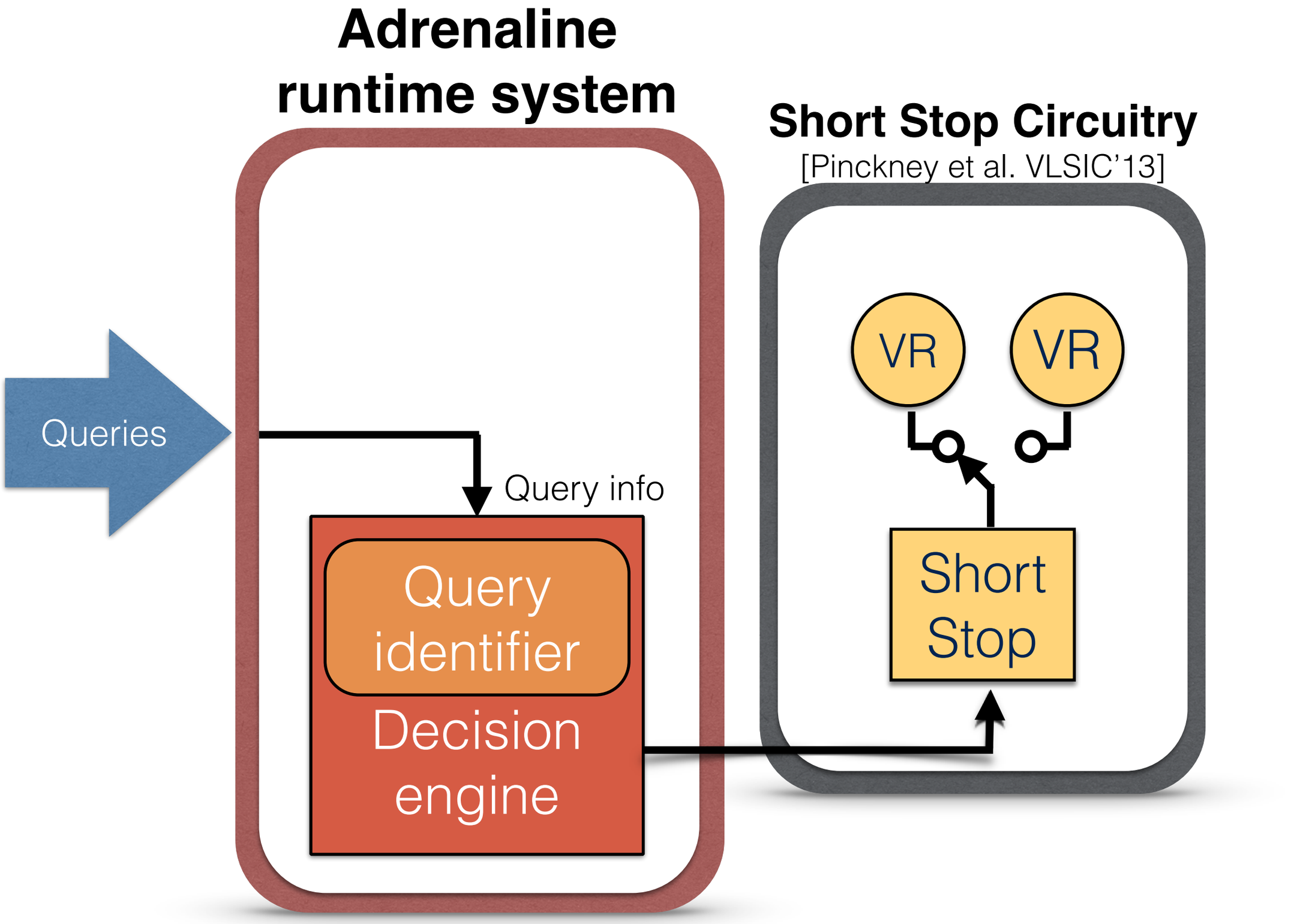
SET requests are good candidates for boosting

Query-level boosting with Adrenaline

- ✓ Pinpoint queries that are highly likely to contribute to the tail
- ✓ Quickly boost the core via ultra-fast switching circuitry

Adrenaline Design

Design of Adrenaline



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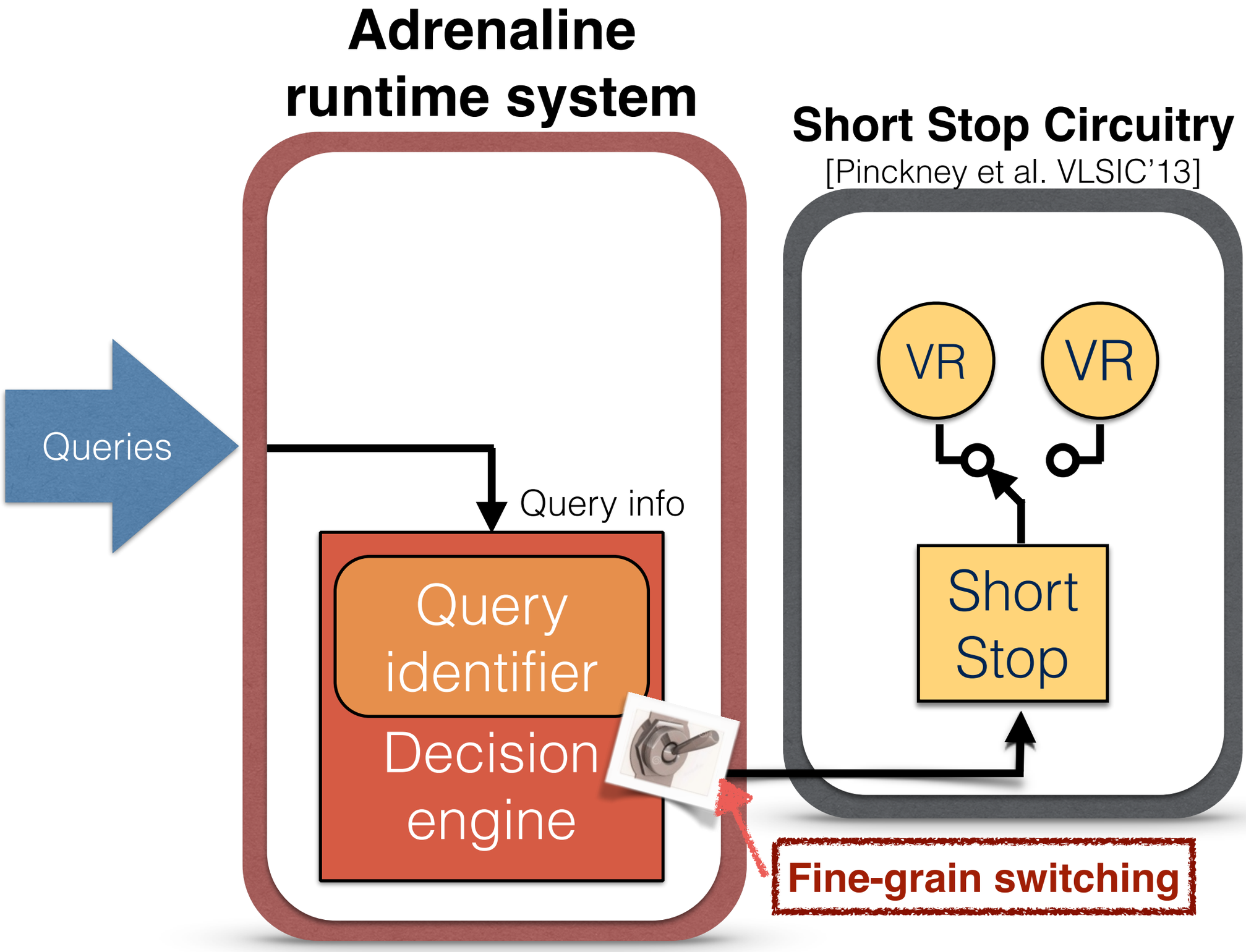

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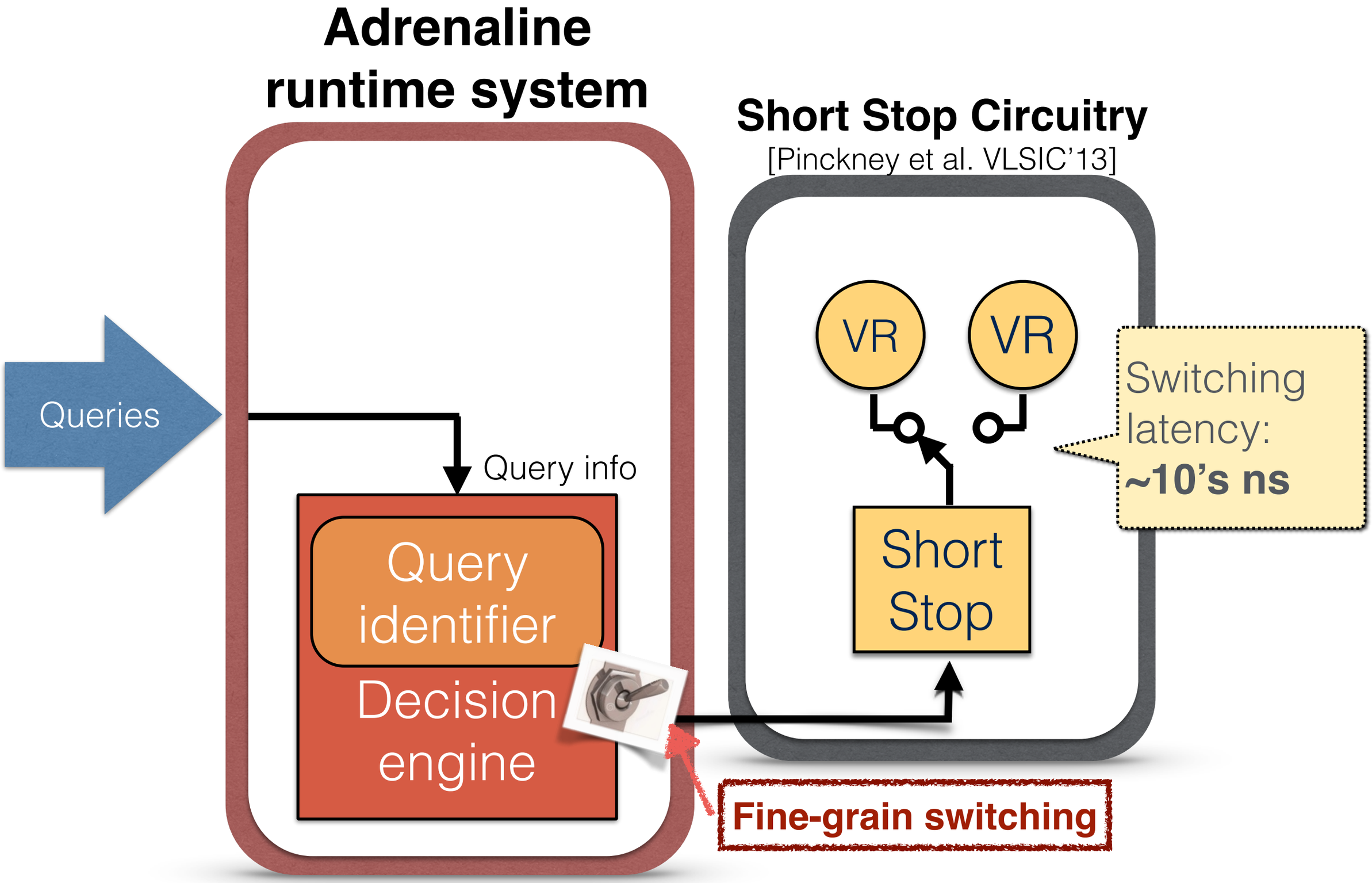

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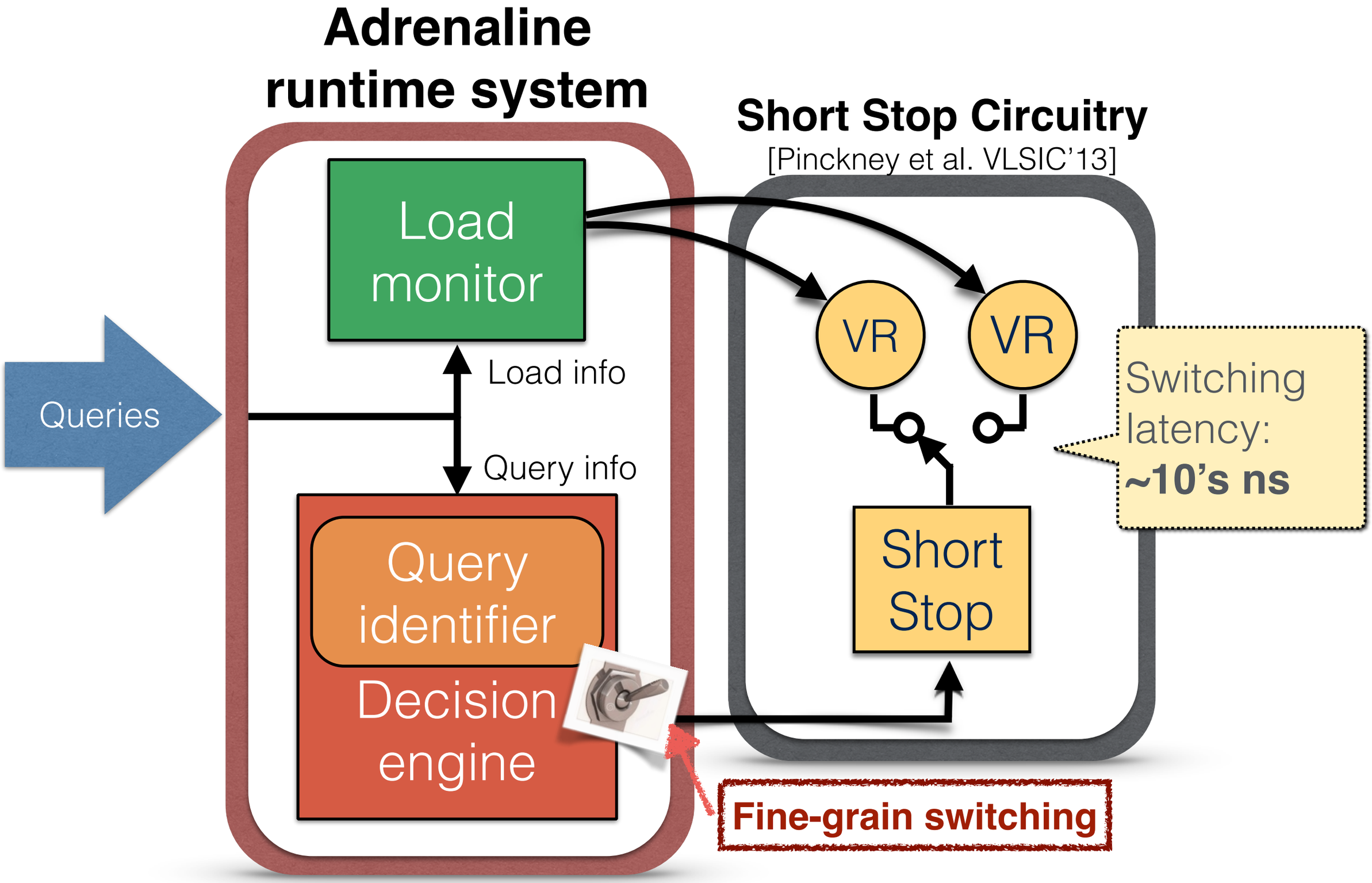

Boosting based on the query-level indicators

Query identifier

Rapidly identifying query types

- ➡ Candidate vs. non-candidate type
- ➡ Needs to be simple to achieve low overhead

Decision engine

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Decision engine

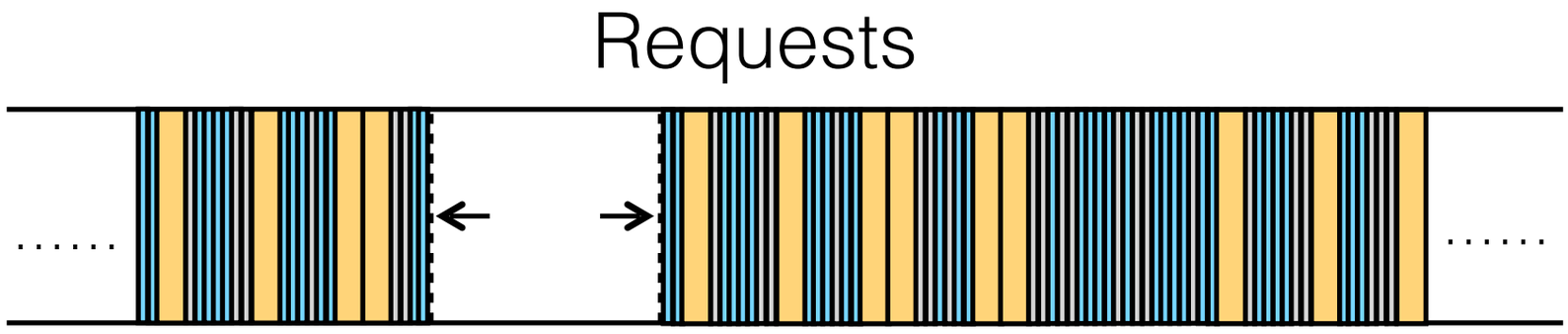
Candidate type:

- ➡ Boost this query as soon as possible

Non-candidate type:

- ➡ Boost when query runtime exceeds half of QoS target

Adrenaline: a closer look



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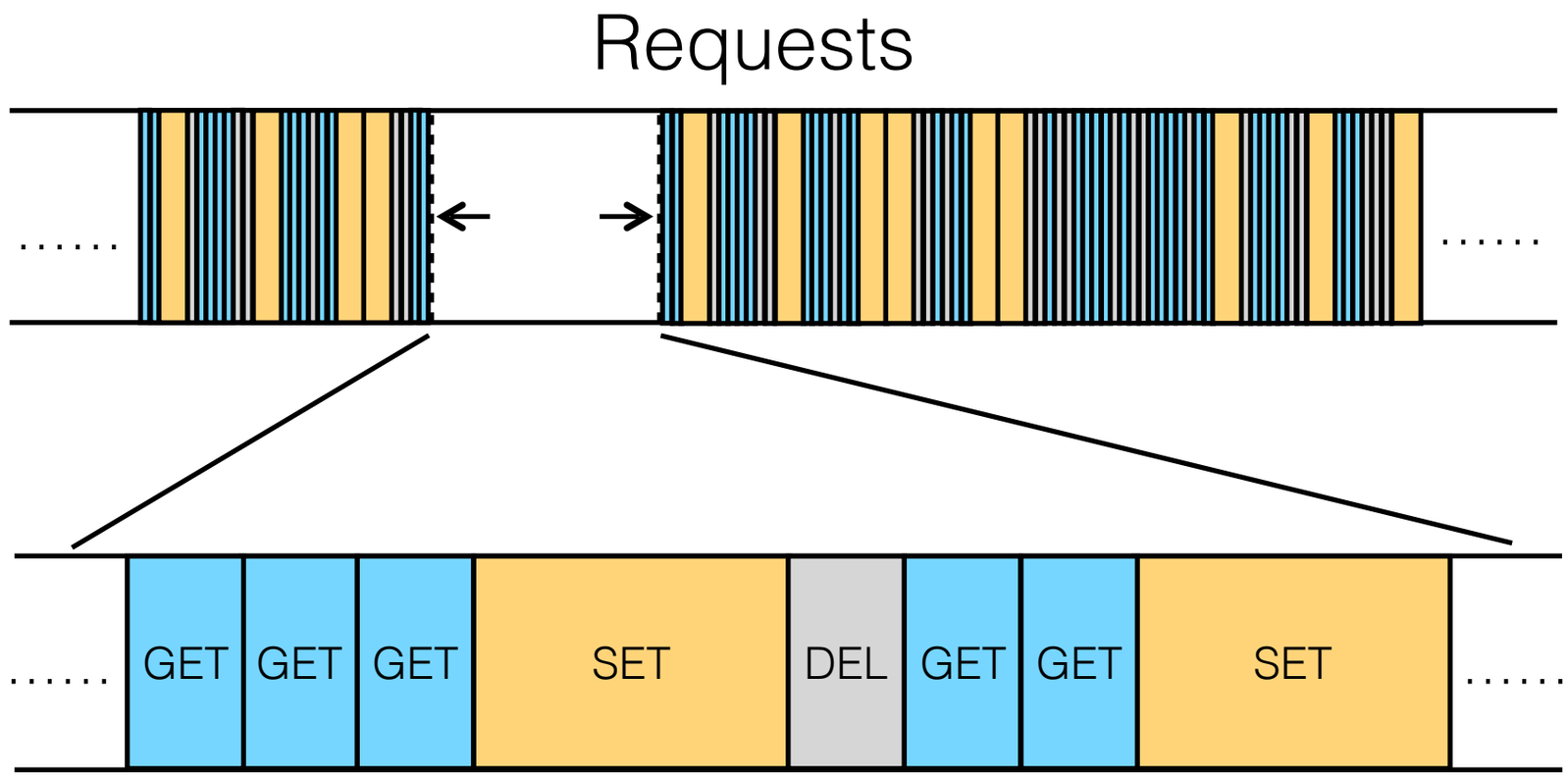

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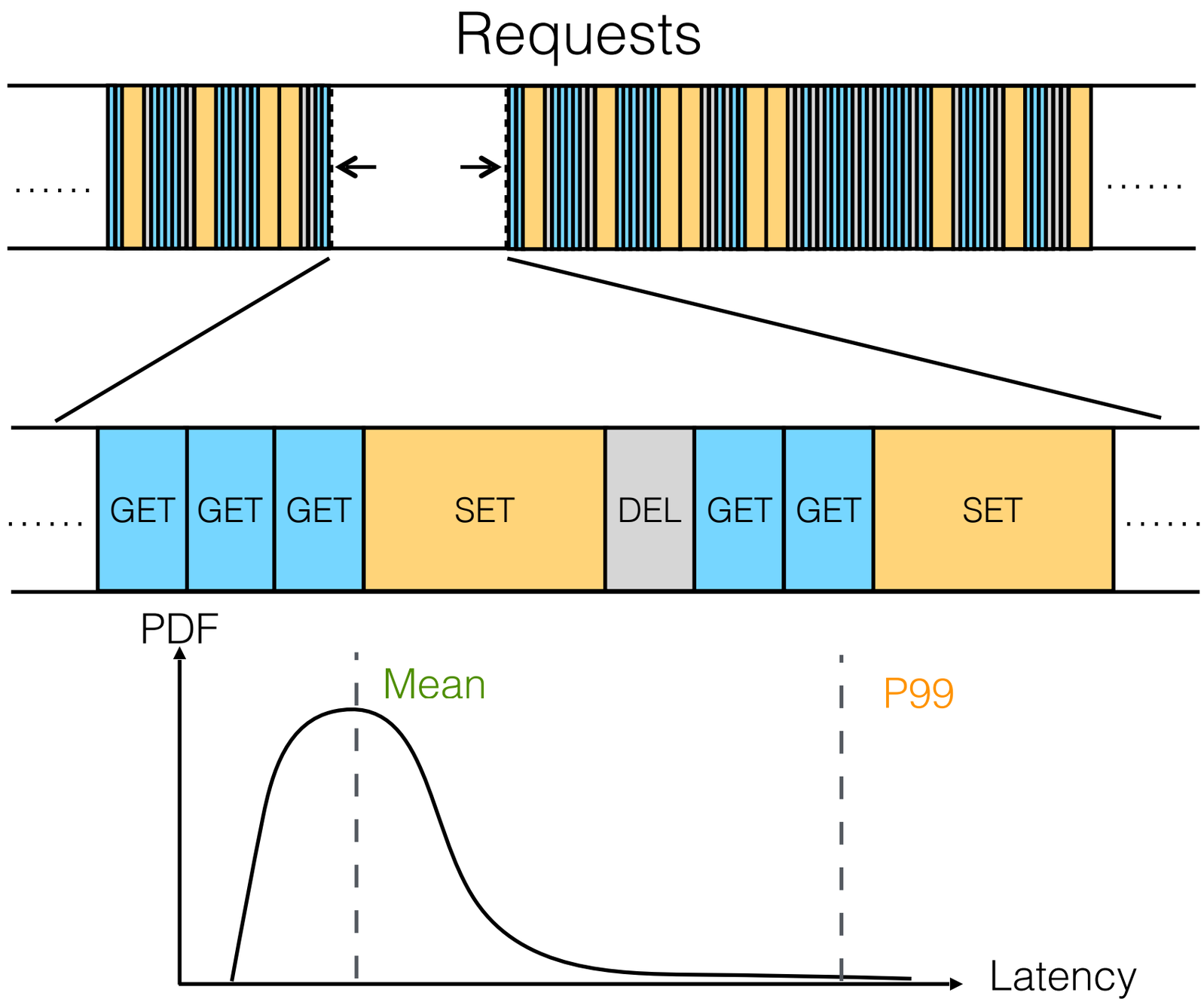
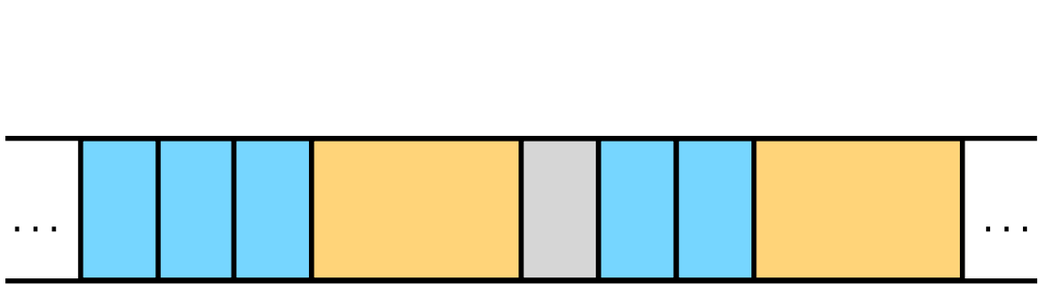
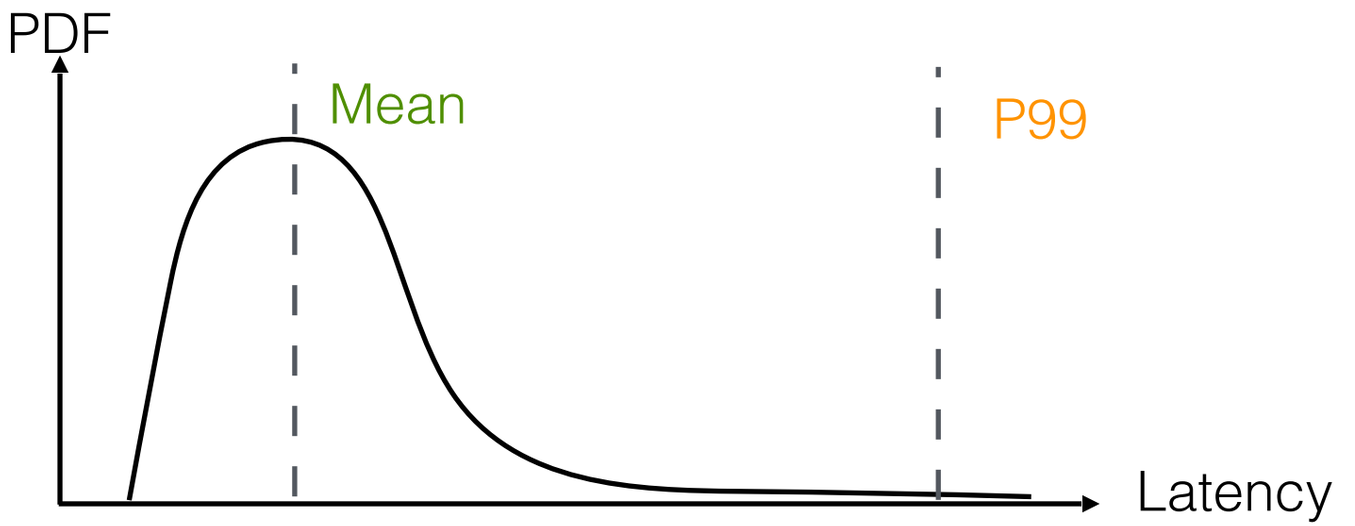


Coarse-grain solution shifts entire distribution





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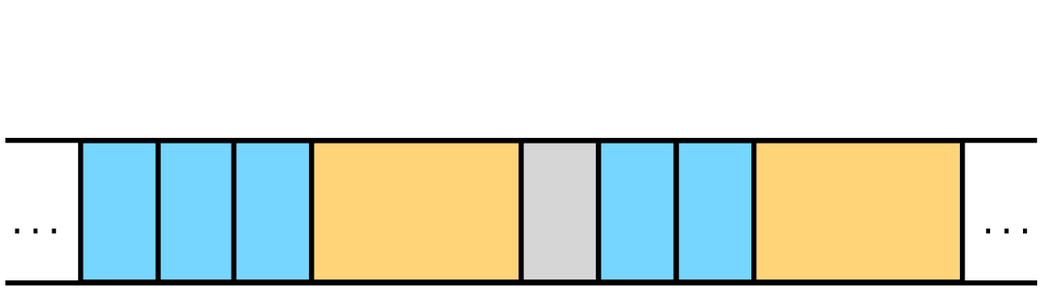
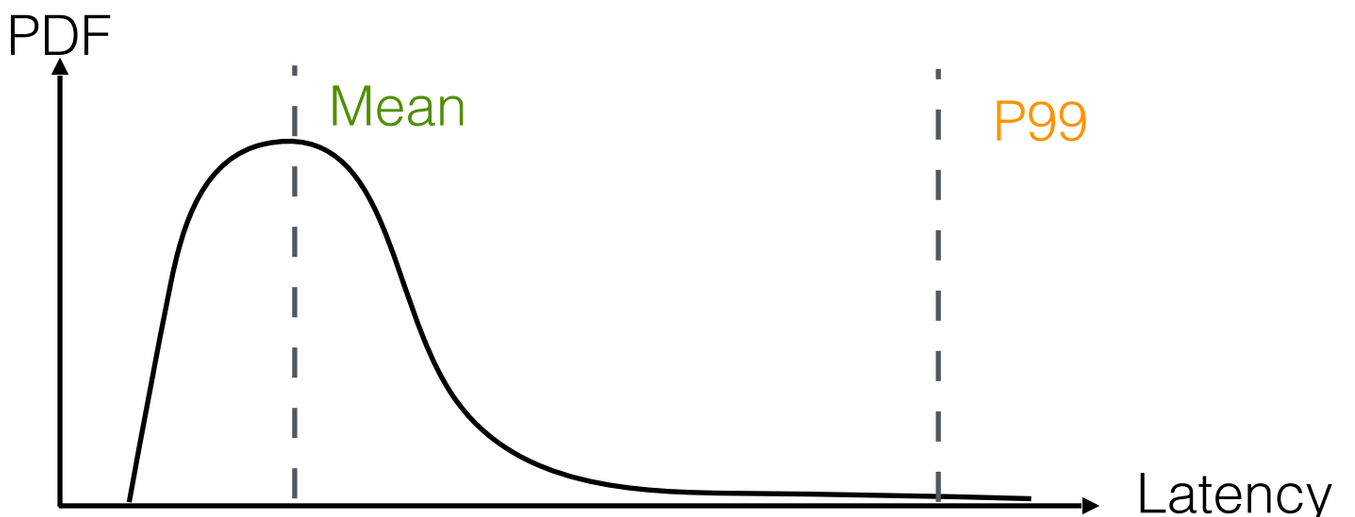
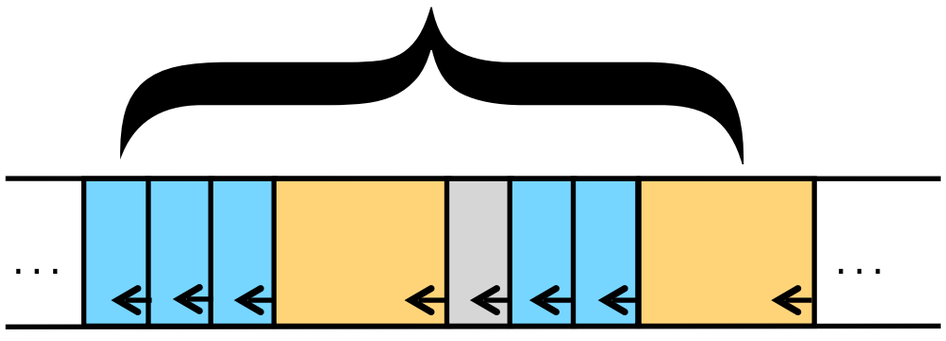




Coarse-grain solutions boost every query in that time interval



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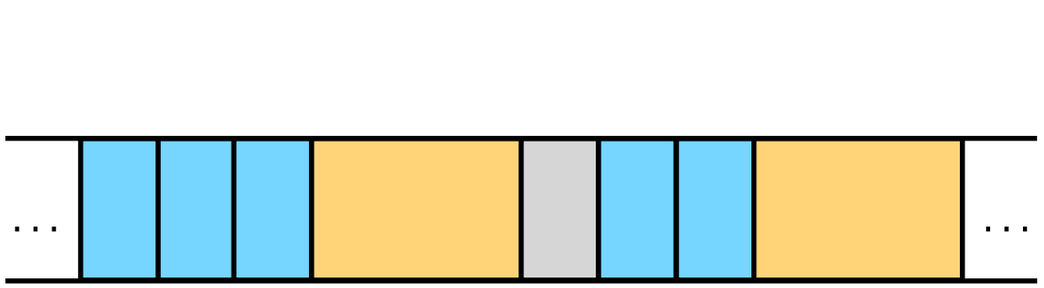

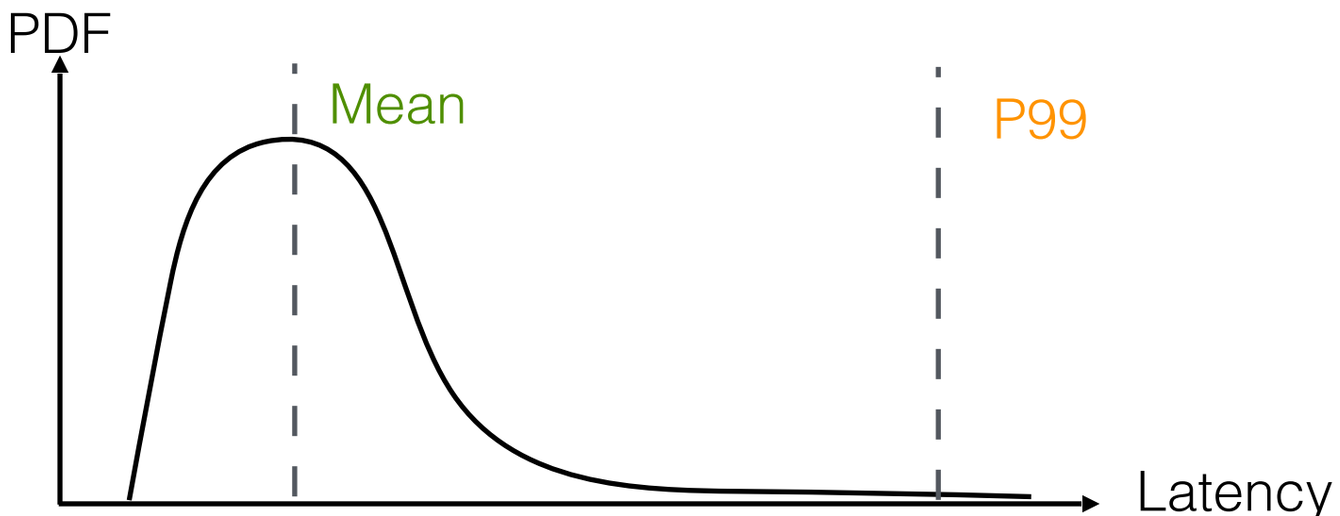

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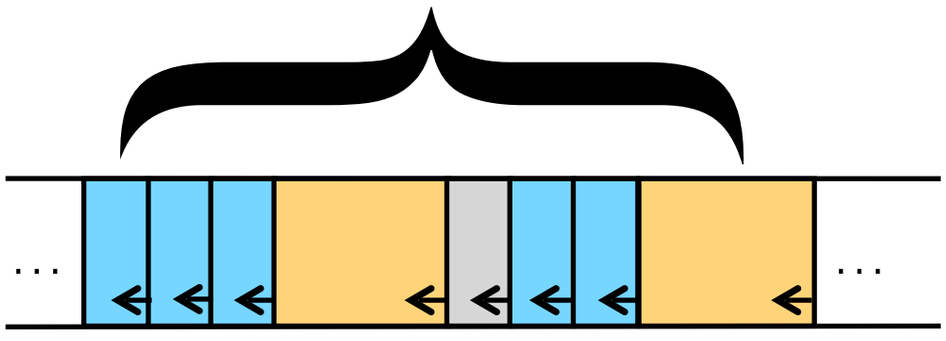
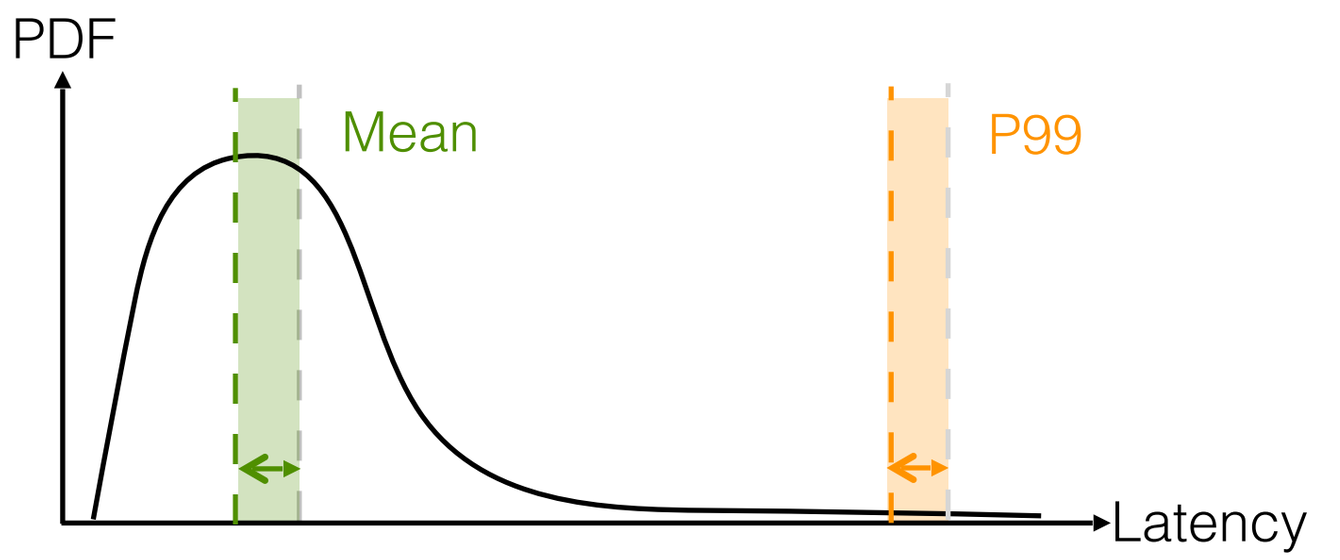
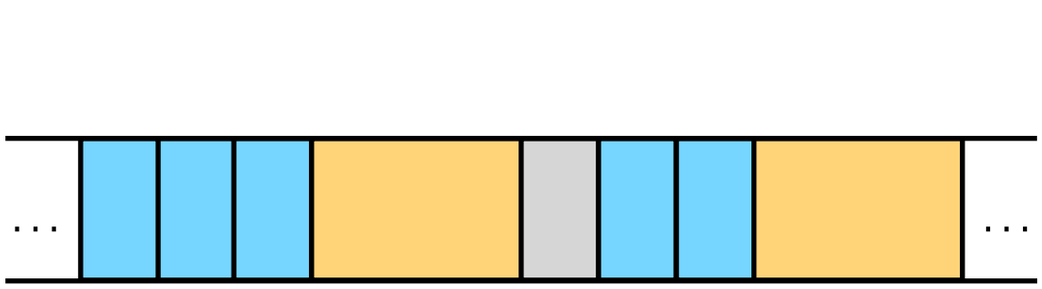
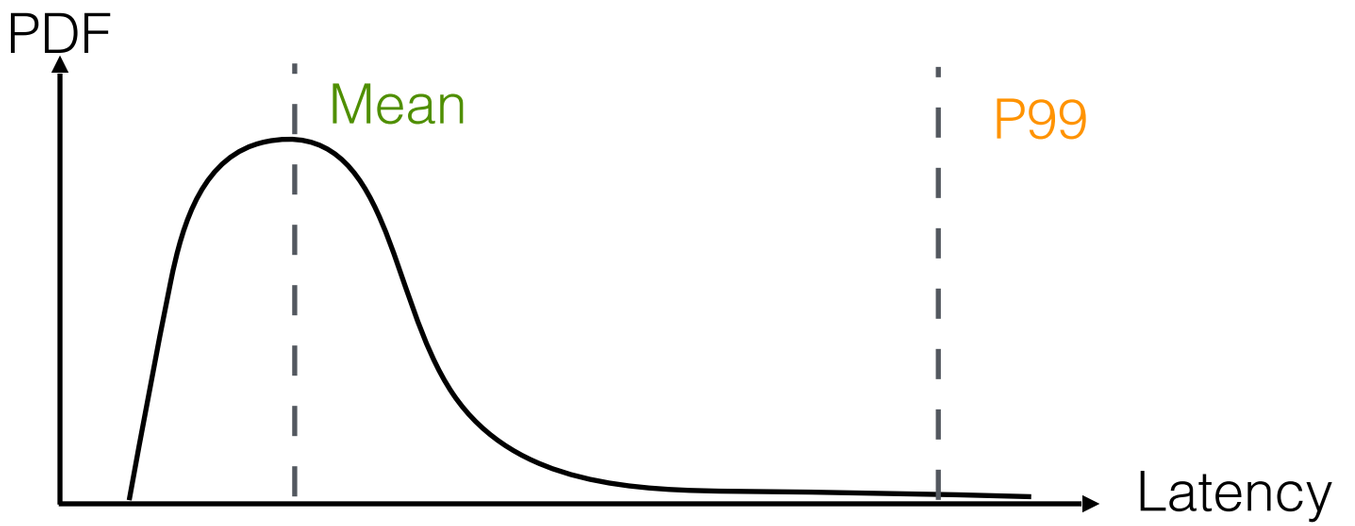




Adrenaline targets the tail





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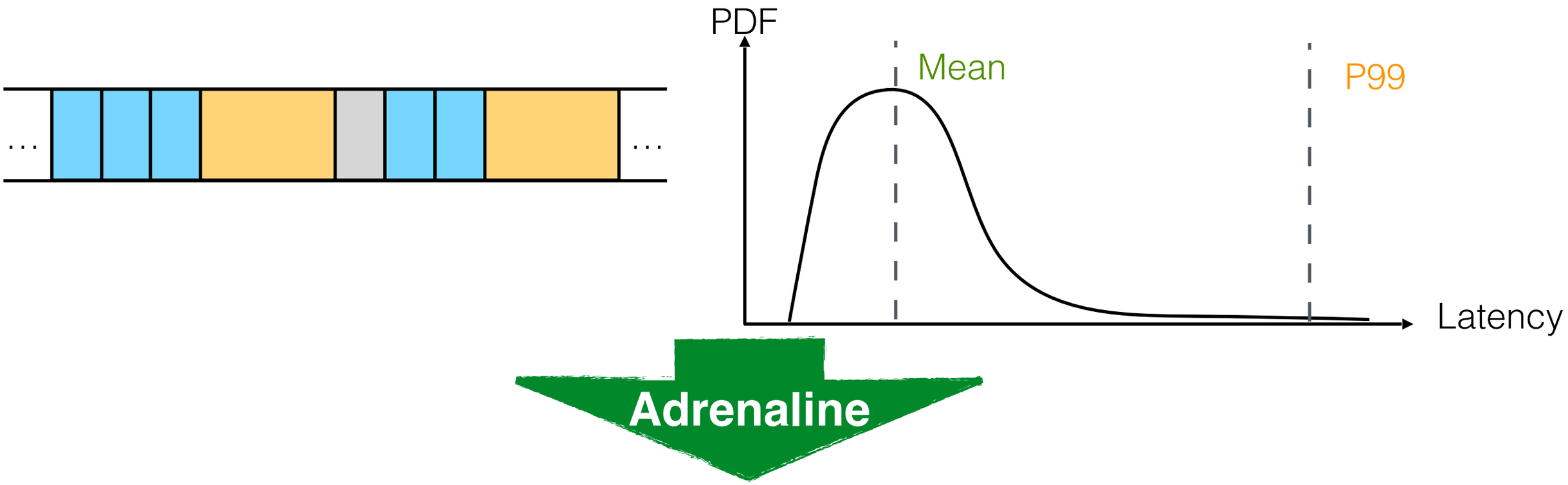
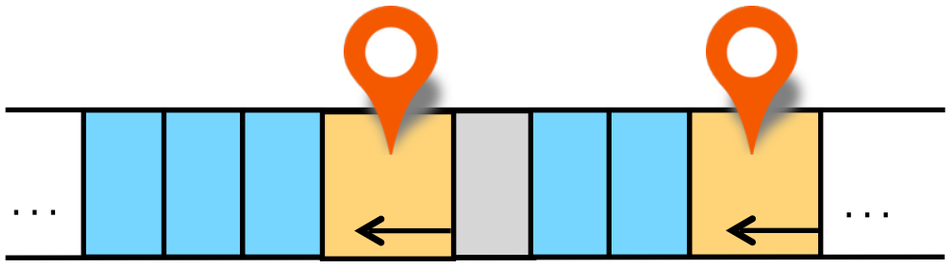


Adrenaline focuses on boosting candidate requests



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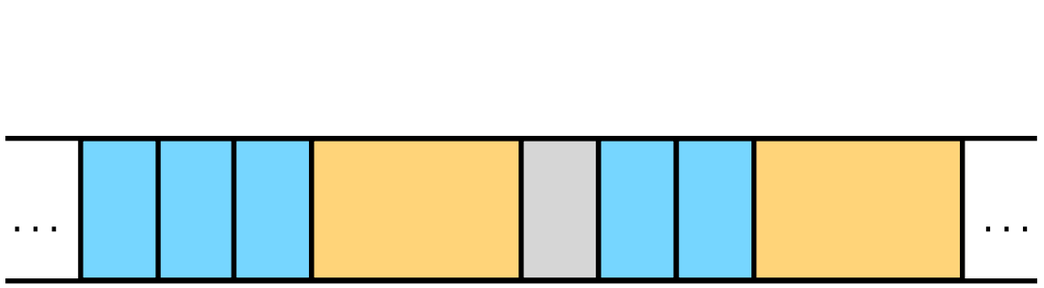
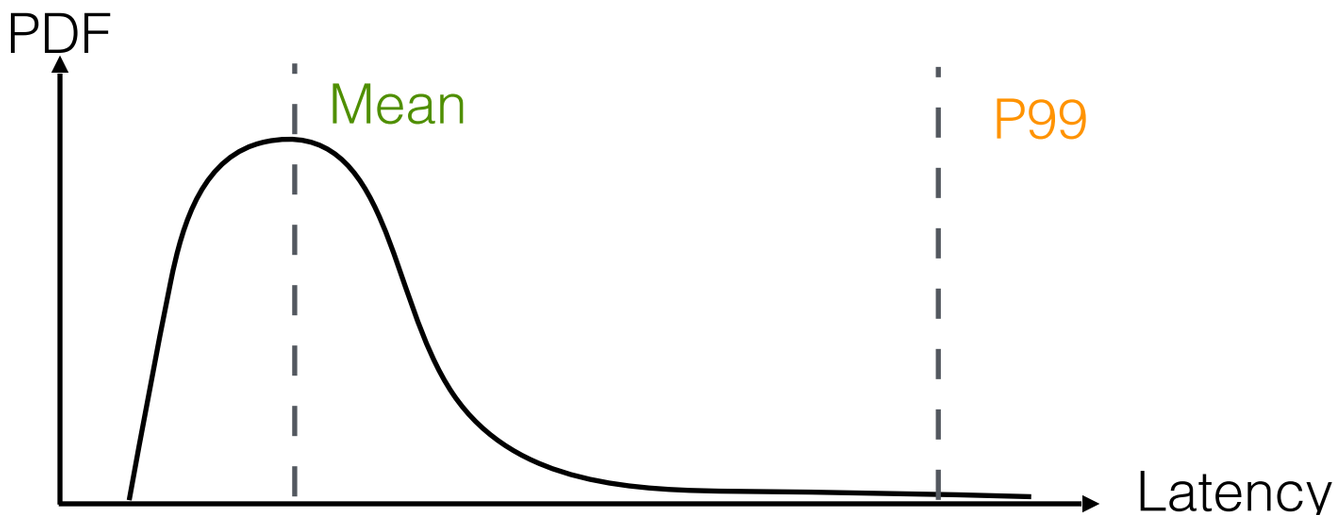
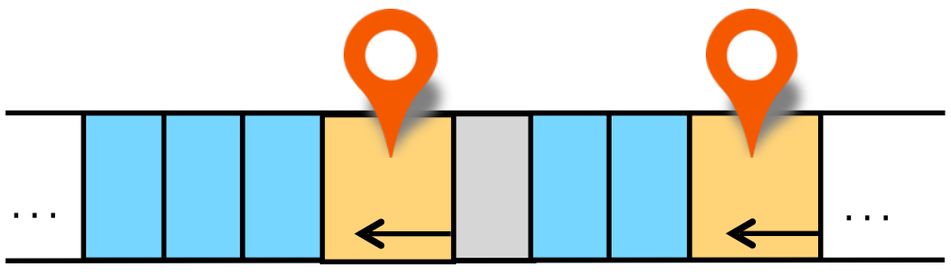
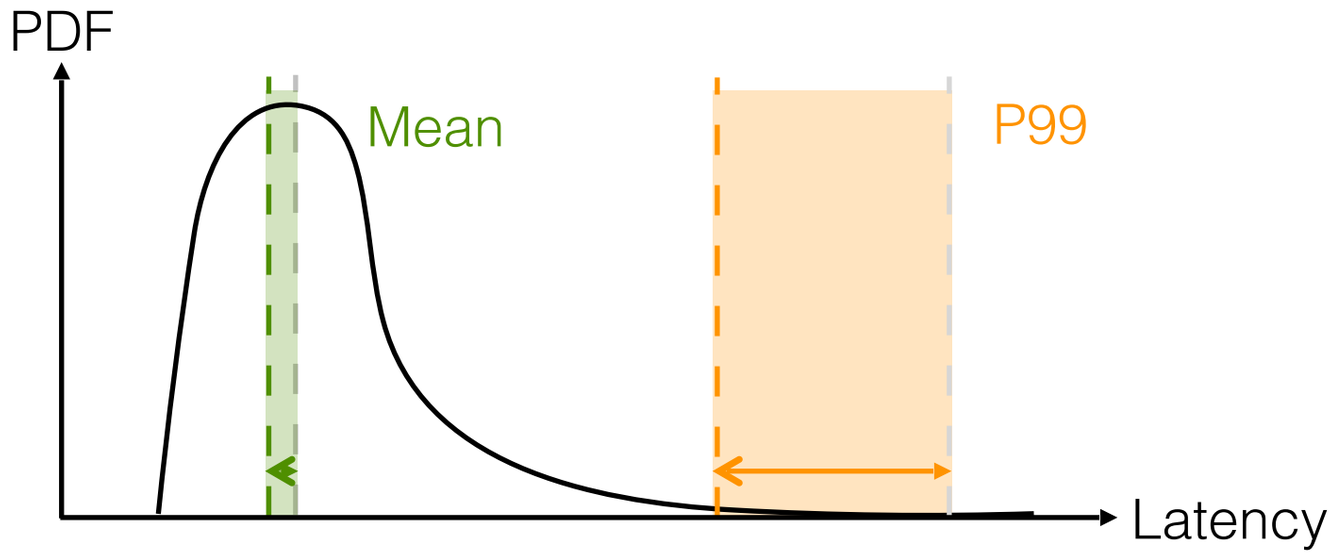




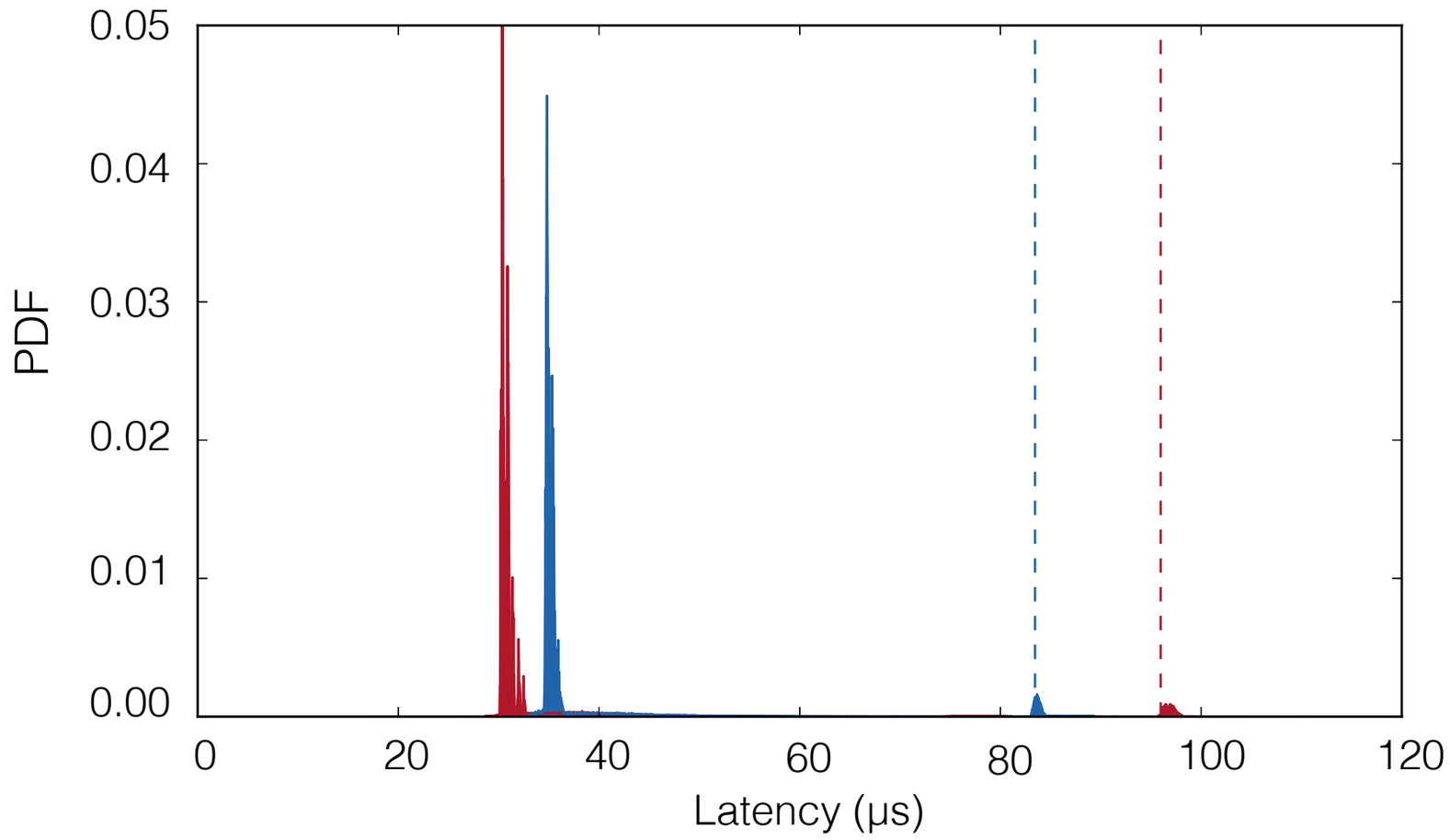
Adrenaline

Adrenaline focuses on boosting candidate requests



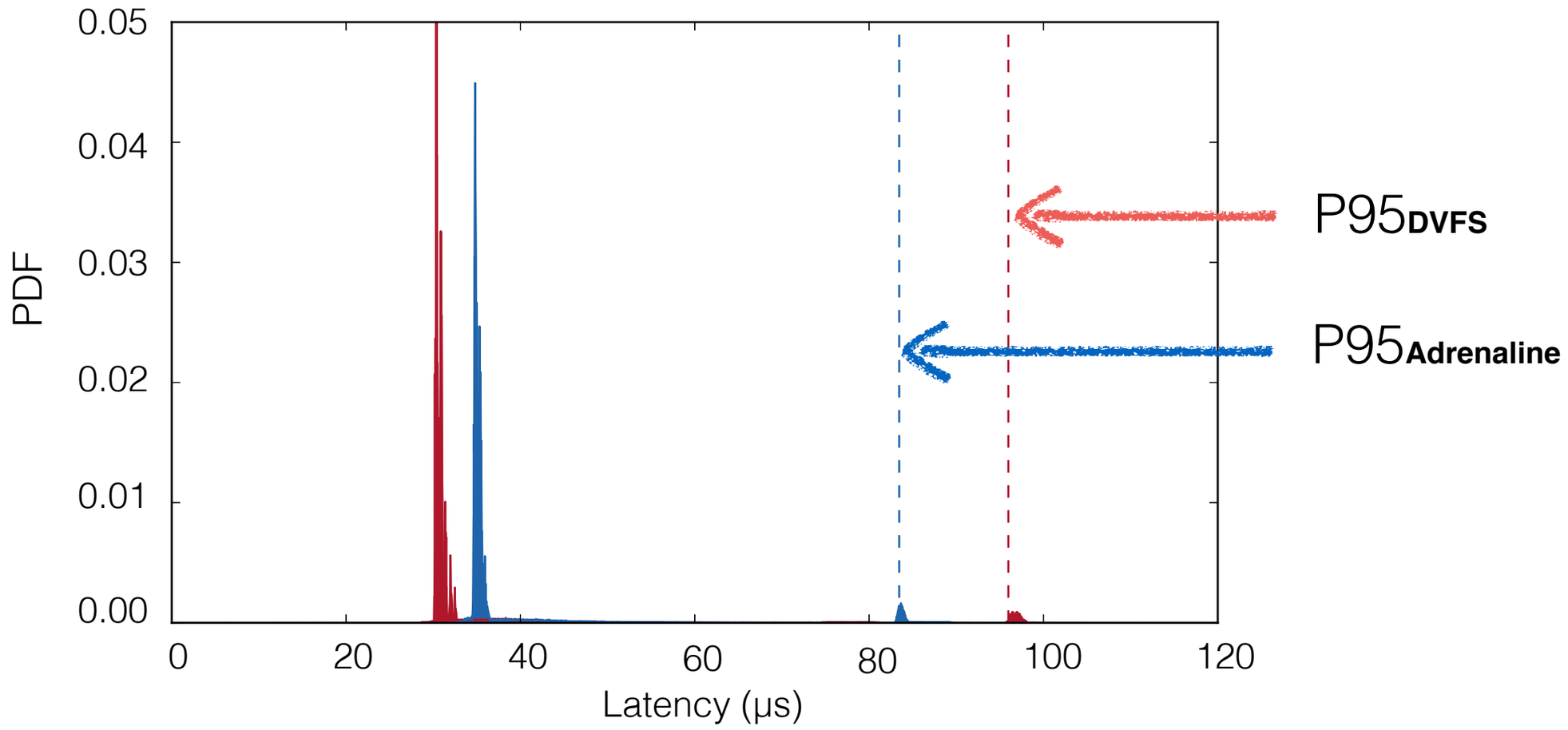


Measured latency distributions



- Compared to coarse-grain DVFS, Adrenaline…

Measured latency distributions



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  - ✓reduces the tail latency significantly, achieving superior QoS

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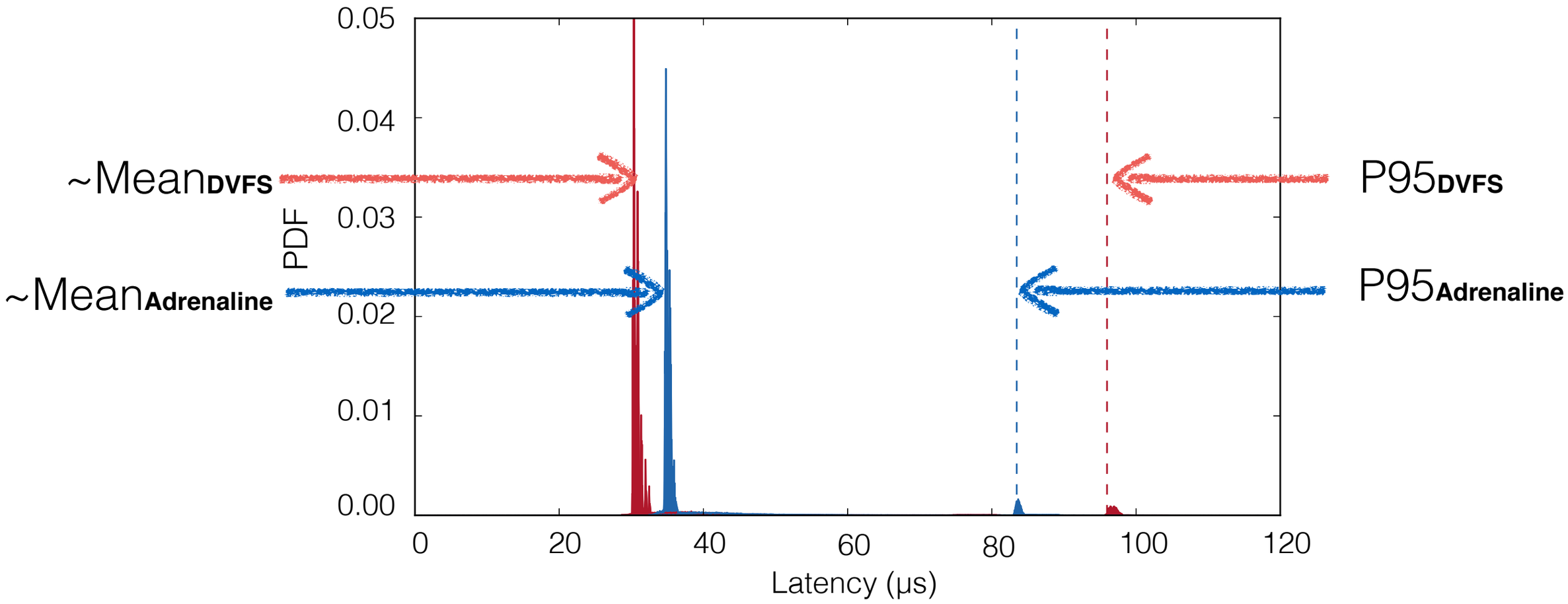

- Compared to coarse-grain DVFS, Adrenaline…
  - ✓reduces the tail latency significantly, achieving superior QoS
  - ✓trades the mean latency for energy saving

Evaluation

Evaluation methodology

- Measure request latency distributions on a real system
  - Intel Ivy Bridge + 136 GB RAM
  - Analyze Adrenaline & coarse-grain DVFS in BigHouse
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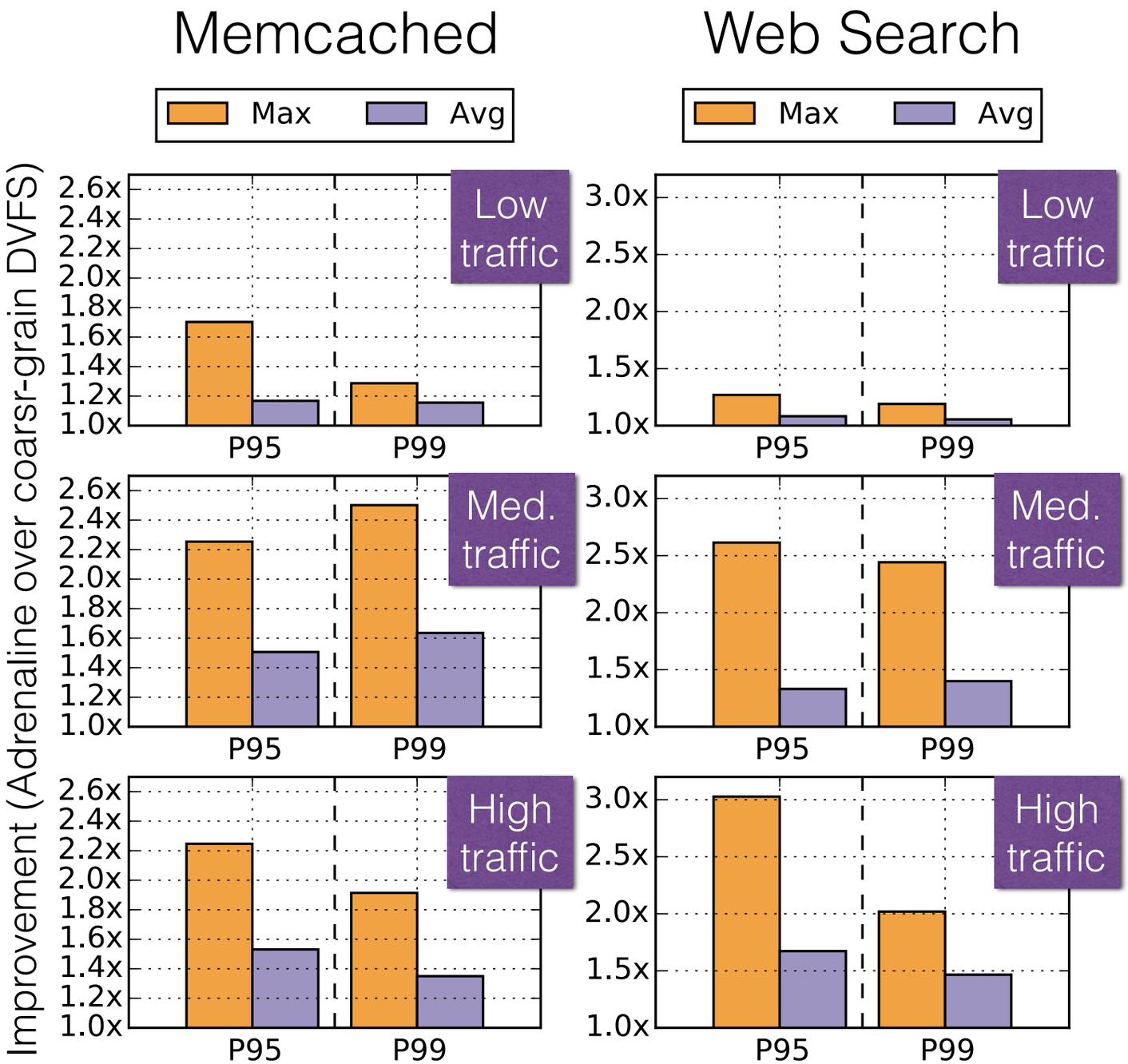
- We generate various workload compositions using Facebook's published result [Atikoglu et al. SIGMETRIC'12]

Rein in the tail with Adrenaline



Optimizing for tail latency:

- Same energy budget
- Memcached:
  - Max: up to 2.5x
  - Avg: up to 1.6x
- Websearch
  - Max: up to 3x
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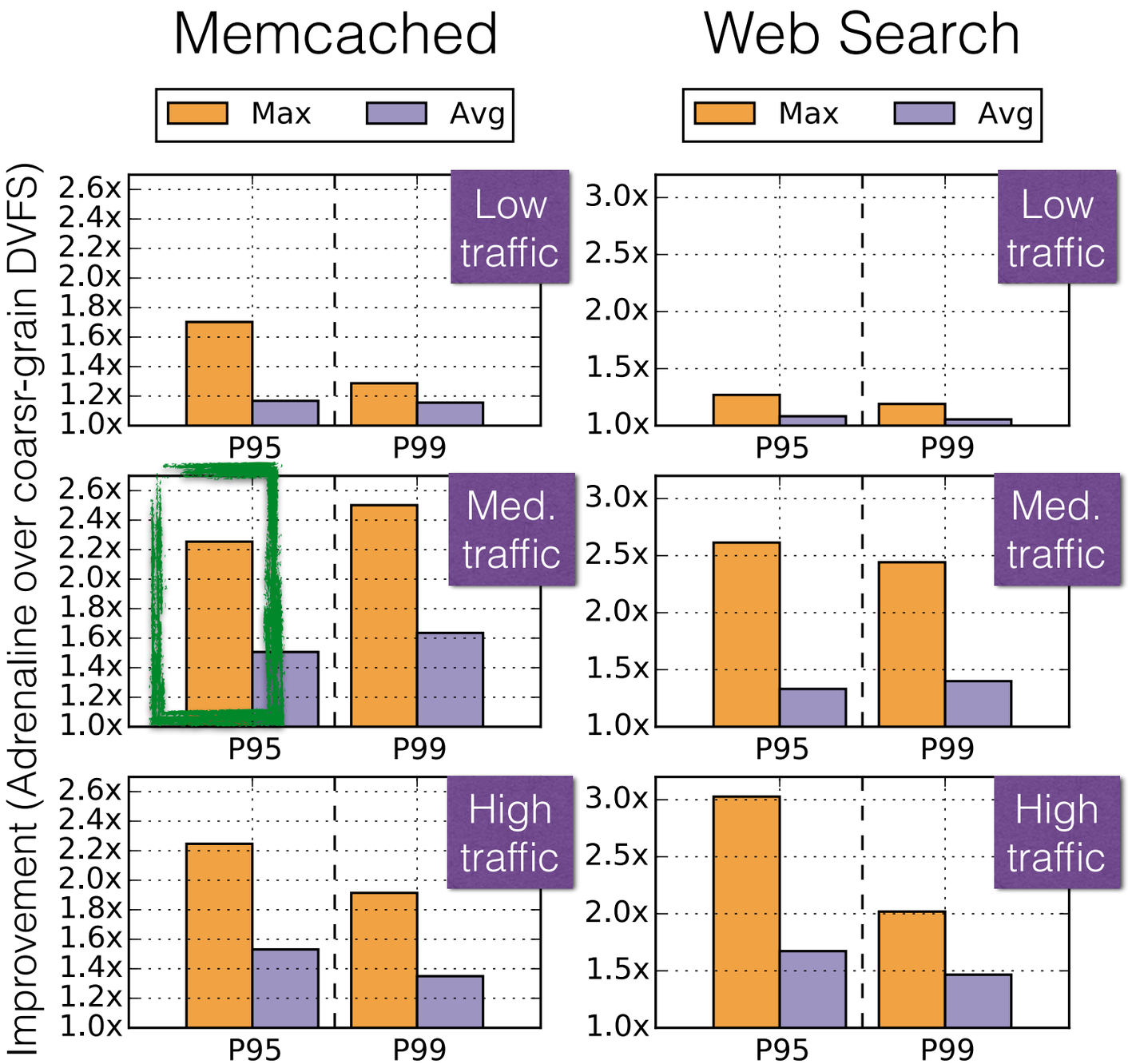

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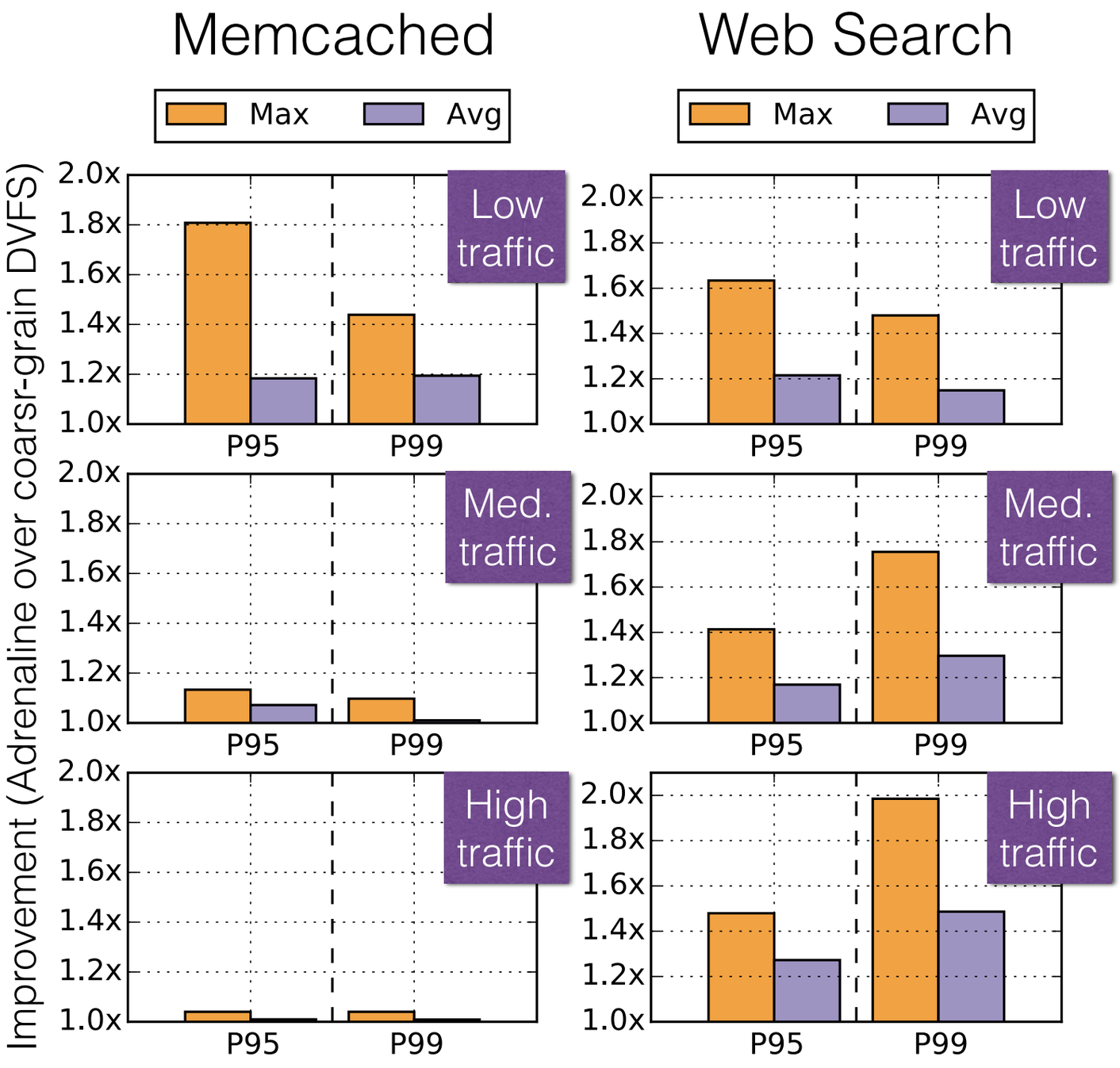

Optimizing for energy

- Same tail latency target
- Memcached:
  - Max: up to 1.8x
  - Avg: up to 1.2x
- Websearch
  - Max: up to 2x
  - Avg: up to 1.5x

Conclusion

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- User-facing services requires responsiveness and energy efficiency

- Pinpointing and boosting for tail queries gives the best of both worlds

- Adrenaline outperforms coarse-grain DVFS
  - ✓ Up to 3x tail latency improvement
  - ✓ Up to 2x energy saving improvement

?