Going FaaSter

Cost-Performance optimisations of Serverless on Kubernetes

Erwin van Eyk

The central trade-off in serverless computing

High Performance

"Infinite" scaling

High availability

Low latency

Low Cost

No costs when idle

No operational cost

Granular billing

How can we optimize the performance-cost trade-off?

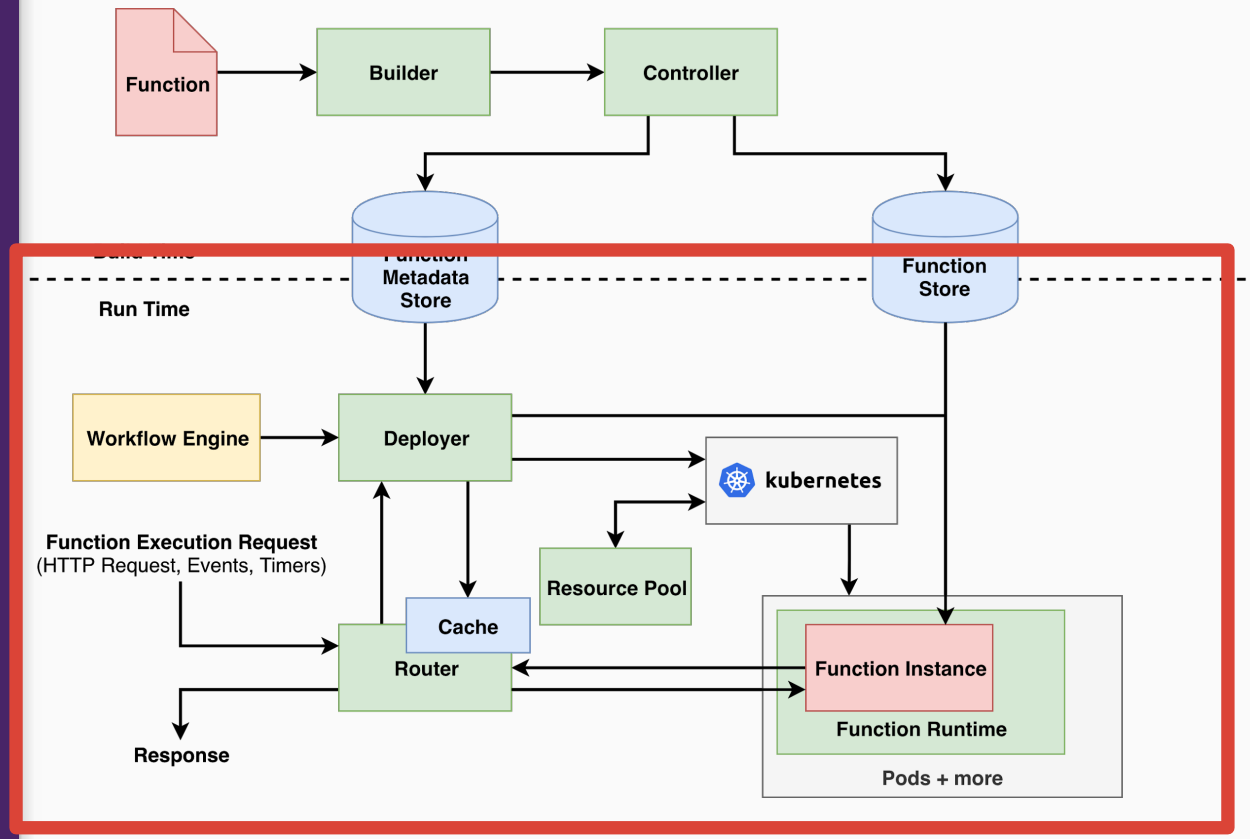
Anatomy of a FaaS platform

Build time

Developer creates, manages the functions

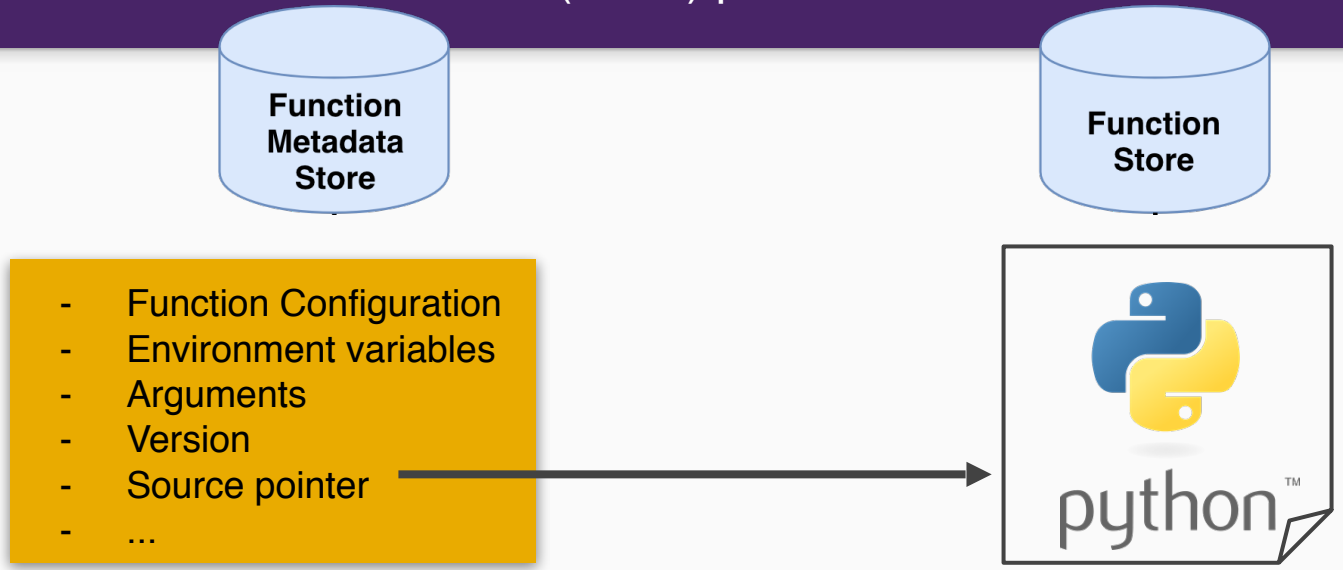
Run time

User and external systems events trigger function executions.

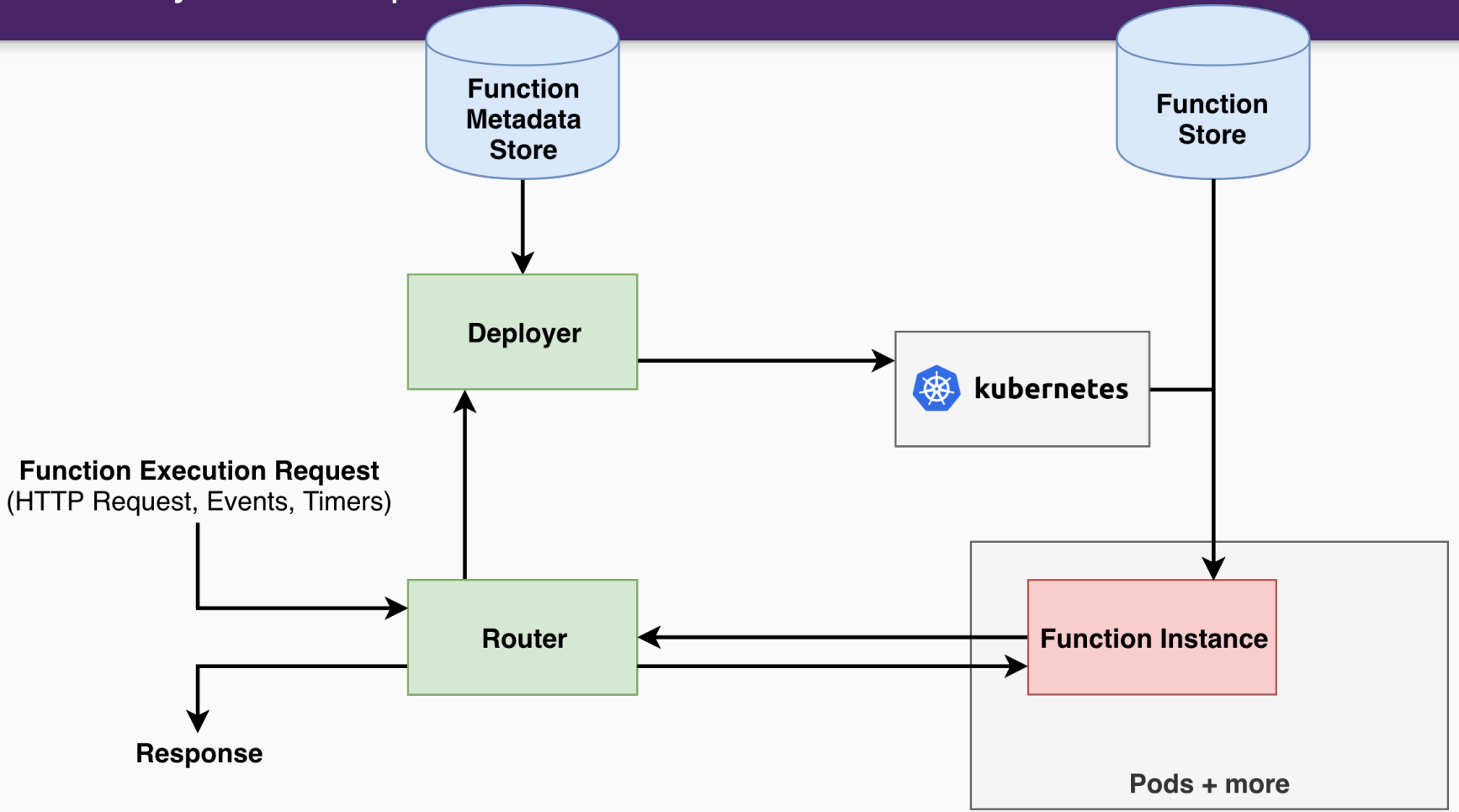


van Eyk, E., Iosup, A., Seif, S., & Thömmes, M. (2017, December). The SPEC cloud group's research vision on FaaS and serverless architectures. In Proceedings of the 2nd International Workshop on Serverless Computing (pp. 1-4). ACM.

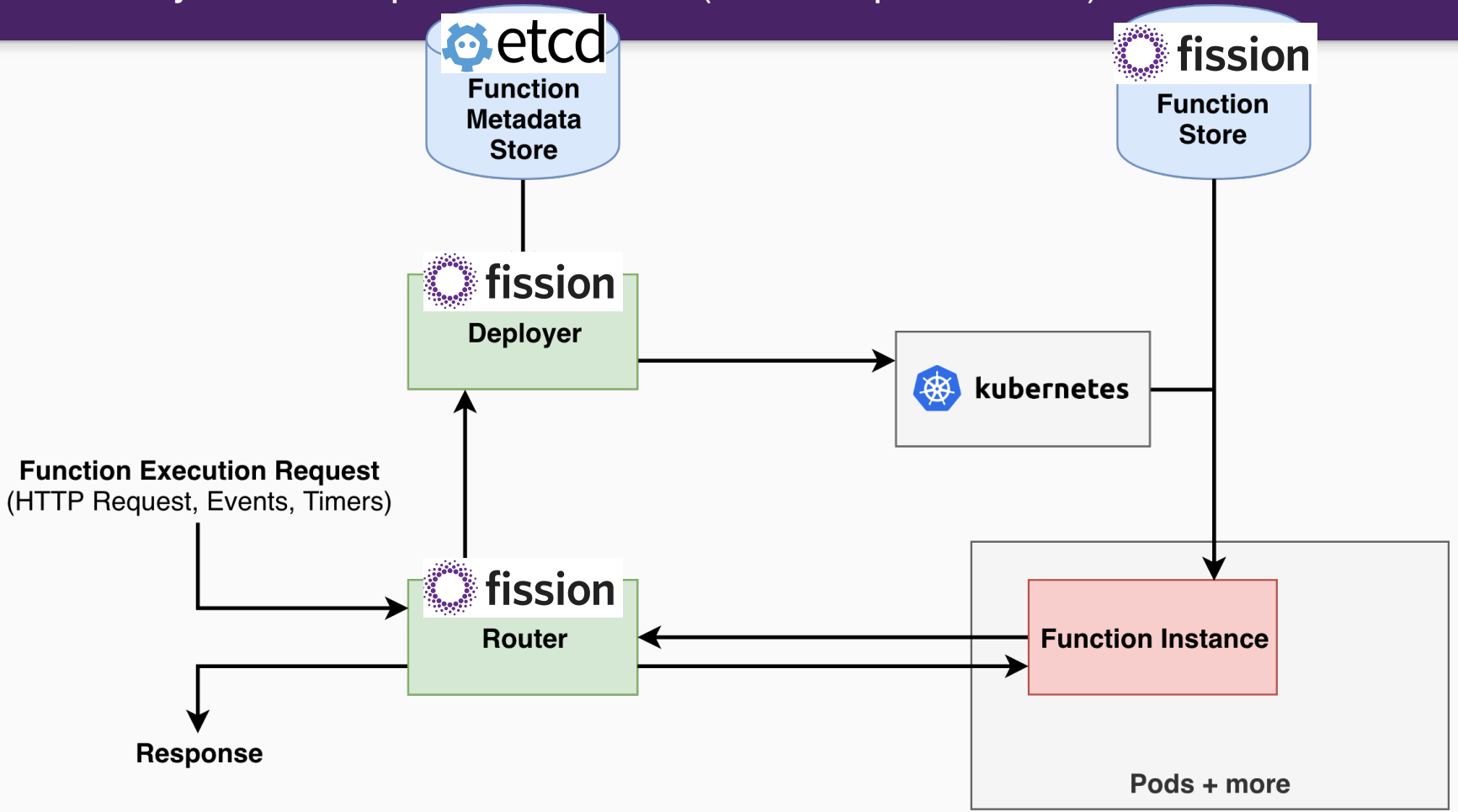
Anatomy of a Functions-as-a-Service (FaaS) platform



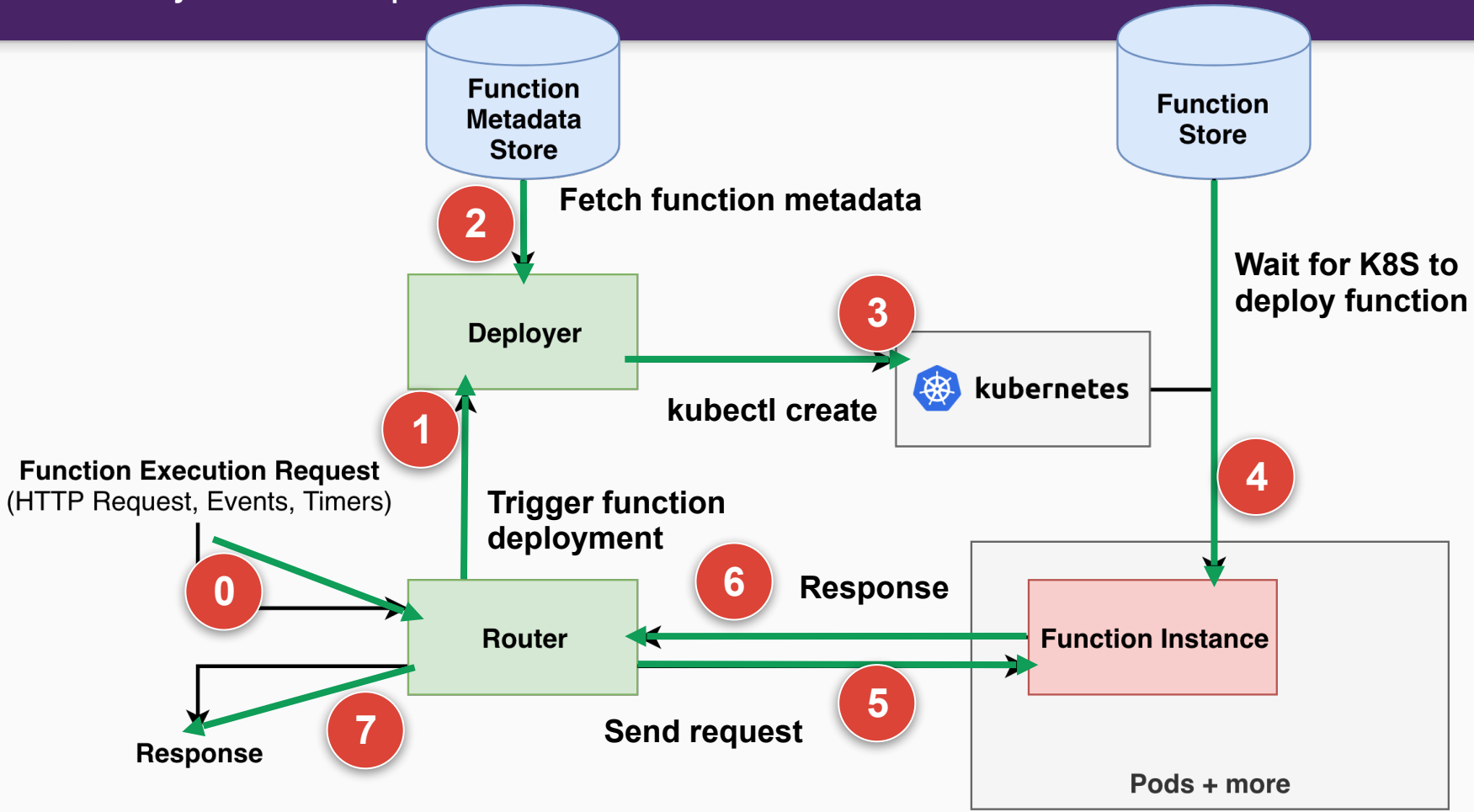
Anatomy of a FaaS platform



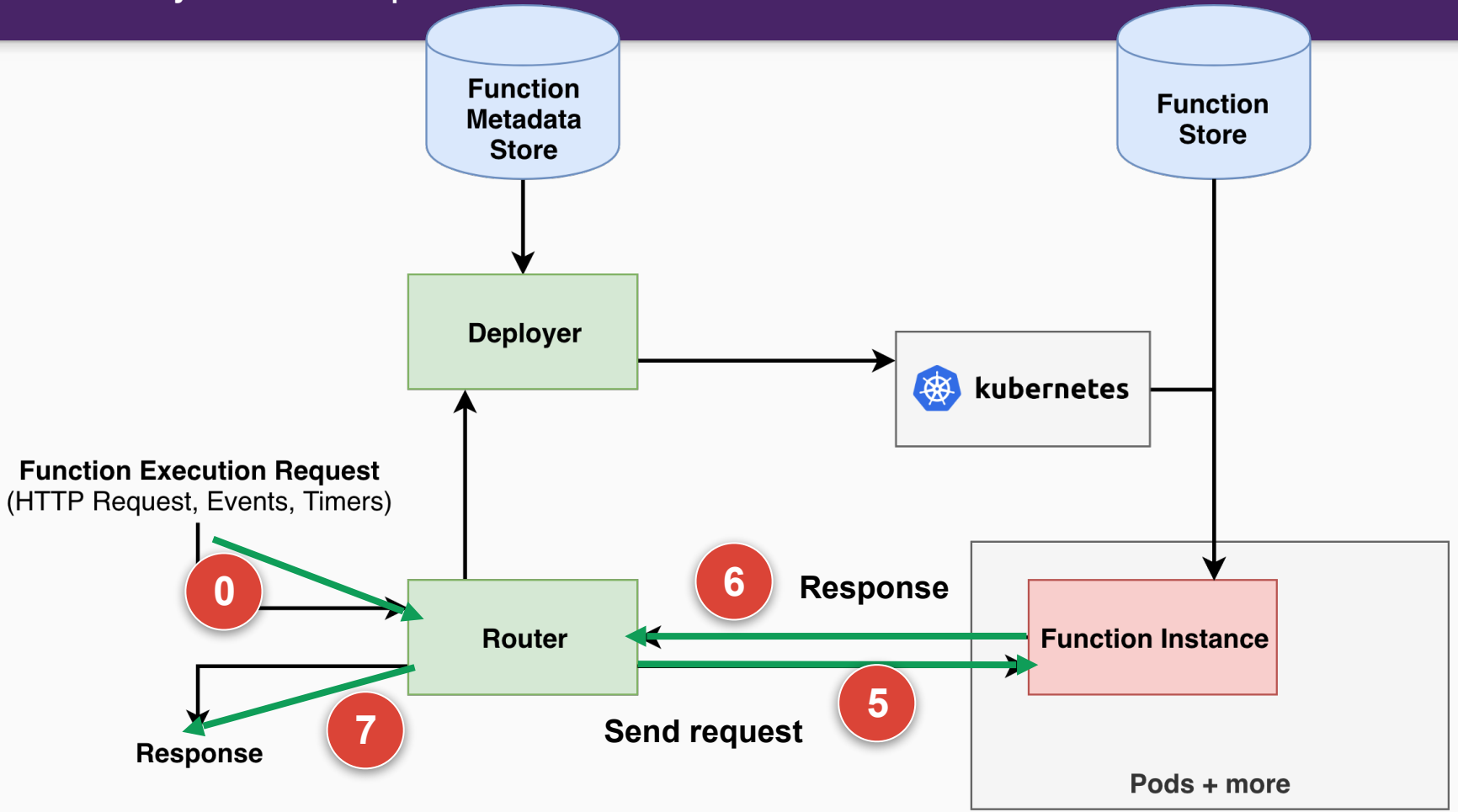
Anatomy of a FaaS platform: Fission (without optimizations)



Anatomy of a FaaS platform: cold start



Anatomy of a FaaS platform: warm execution

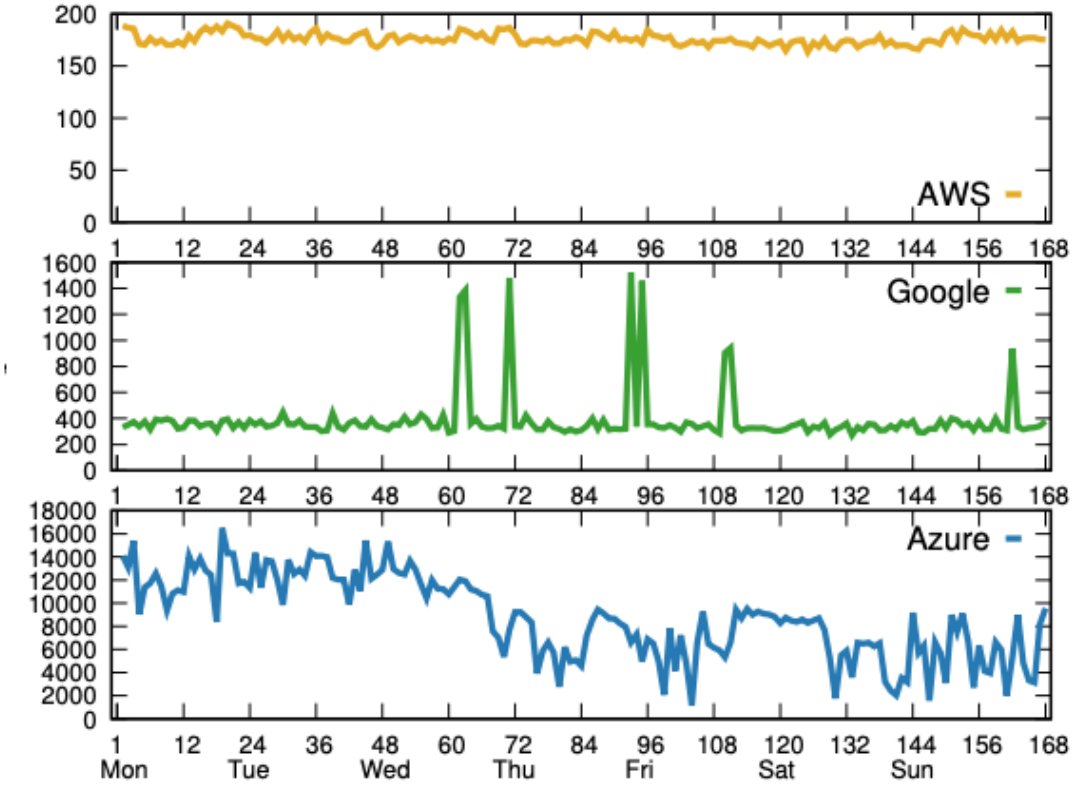


Cold Start

Warm Execution

Cold starts matter!

Coldstart latency (in ms) over 168 hours



180 ms

500 ms

3600 ms

Wang, Liang, et al. "Peeking Behind the Curtains of Serverless Platforms." 2018 USENIX ATC, 2018.

How do FaaS platforms improve their performance?

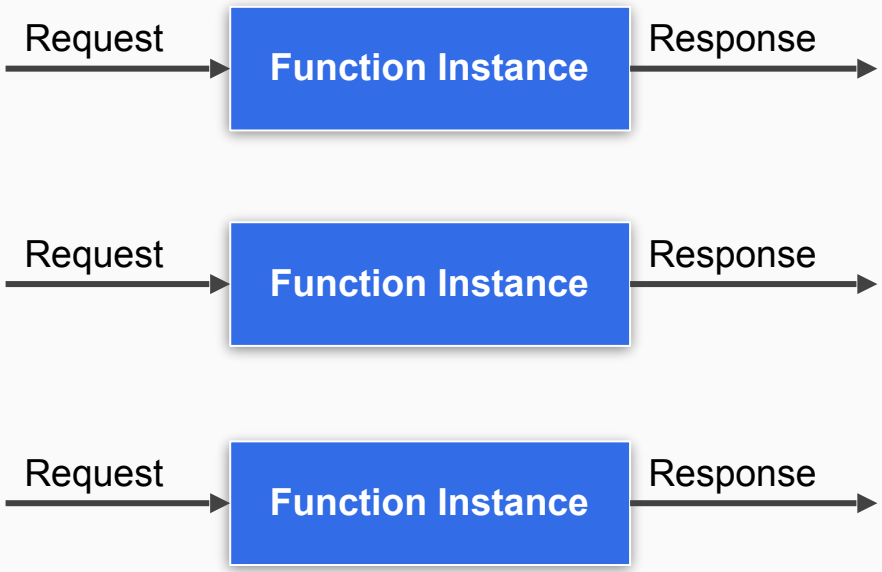
And, at what cost?

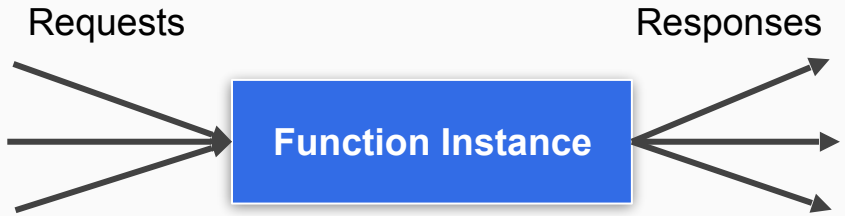
1. Function resource reusing
2. Function runtime pooling
3. Function prefetching
4. Function prewarming

Optimization 1

Function Resource Reusing

Function Isolation vs. Function Reuse





Full Isolation

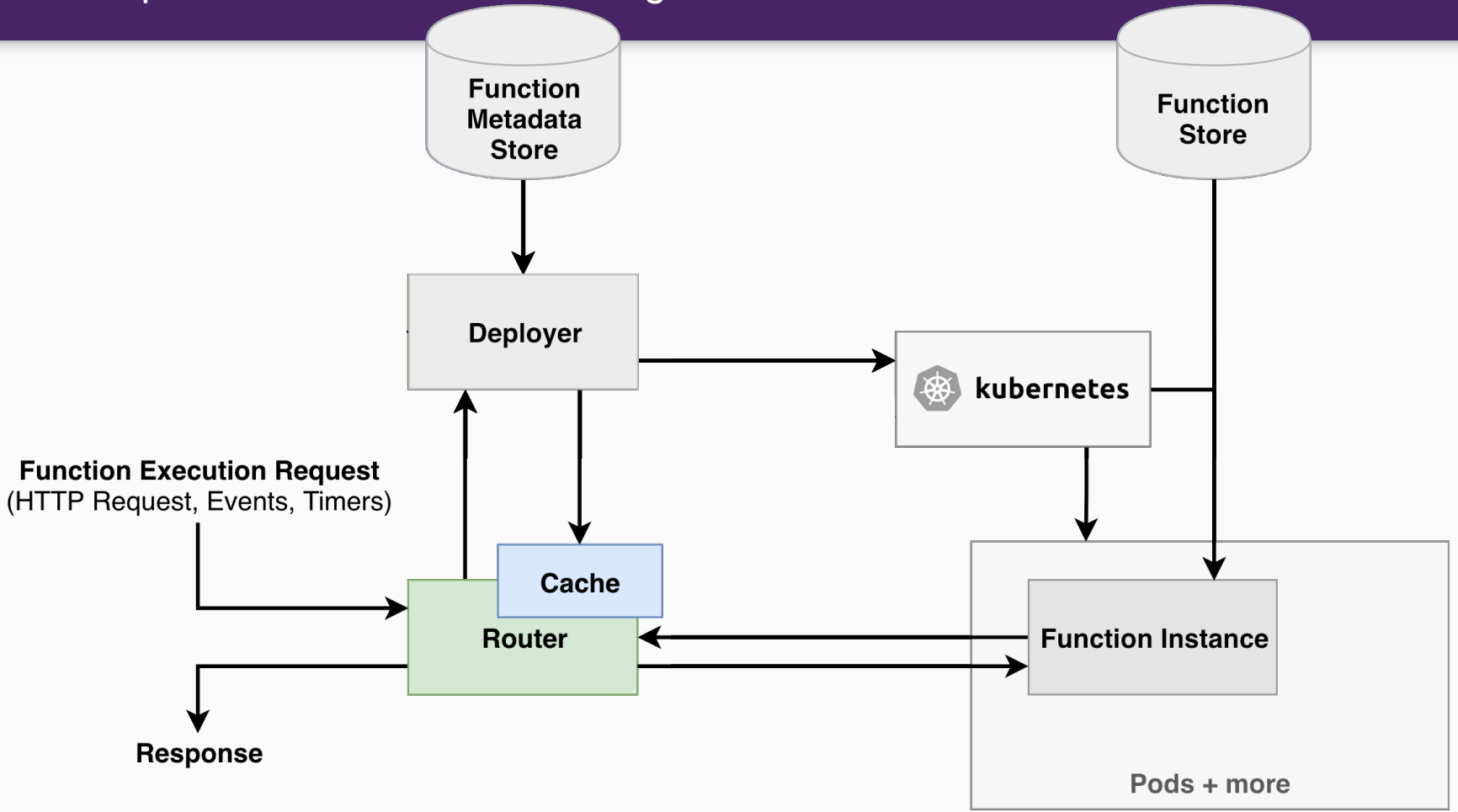
Full resource reuse

Function resource reusing in practice

- Why performance isolation:
  - Performance variability

- In practice: all FaaS platforms reuse resources
  - Per-user binpacking
  - Functions are isolated
  - Function executions share resources

FaaS platform with function reusing



Trade-off: how long to keep functions alive?

- To reuse functions we have to keep them alive.
- Keep-alive in practice:
  - AWS: ~6 hours
  - Google: ~6 hours
  - Azure: 1-4 days

Long keep-alive

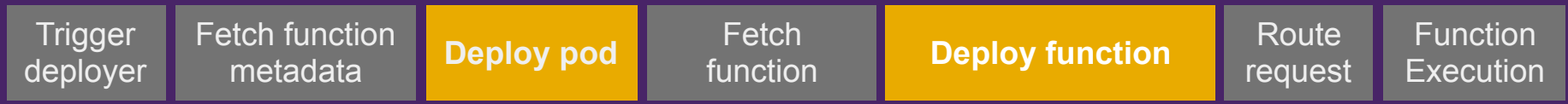
More warm executions

short keep-alives

Less idle resources

Optimization 2

Function Runtime Pooling



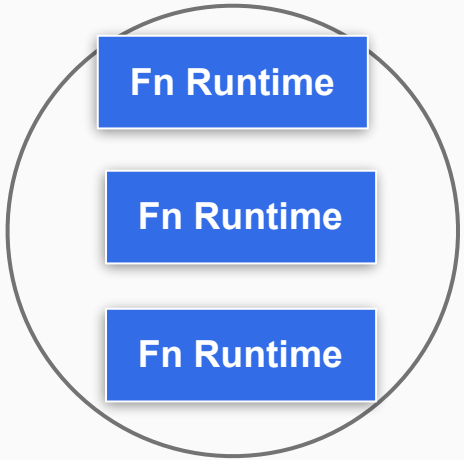
Function Instance = Runtime + Function

- Insight: function instances consist out of two parts
  - **Function-specific code**: user-provided business logic.
  - **Runtime:** operational logic, monitoring, health checks...
- Divide the deployment process into 2 stages:
  - Deploy the runtime → unspecialized runtime or stem cell
  - Deploy the function to the runtime → specialized function

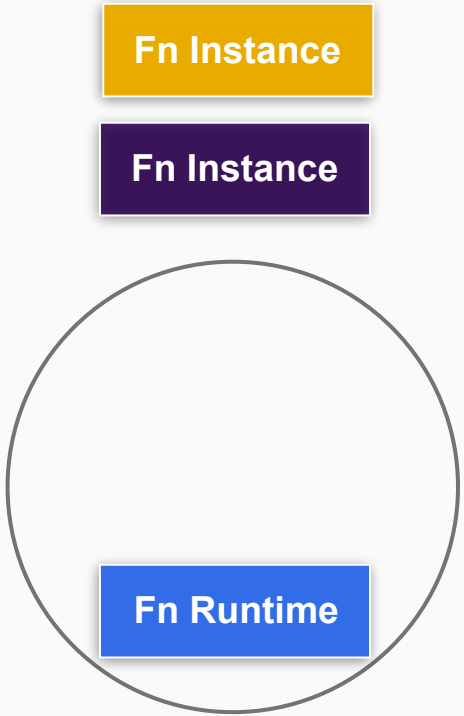
Runtime deployment **Function deployment**

Resource Pooling

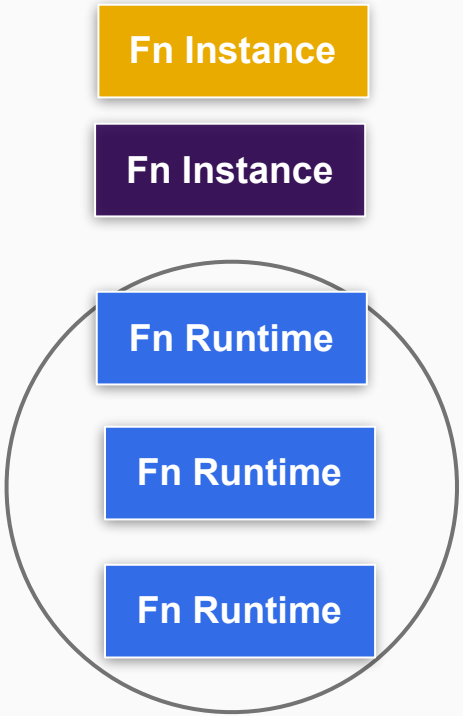
- Common in many domains (e.g. thread pools)



Pool of 3 function runtimes

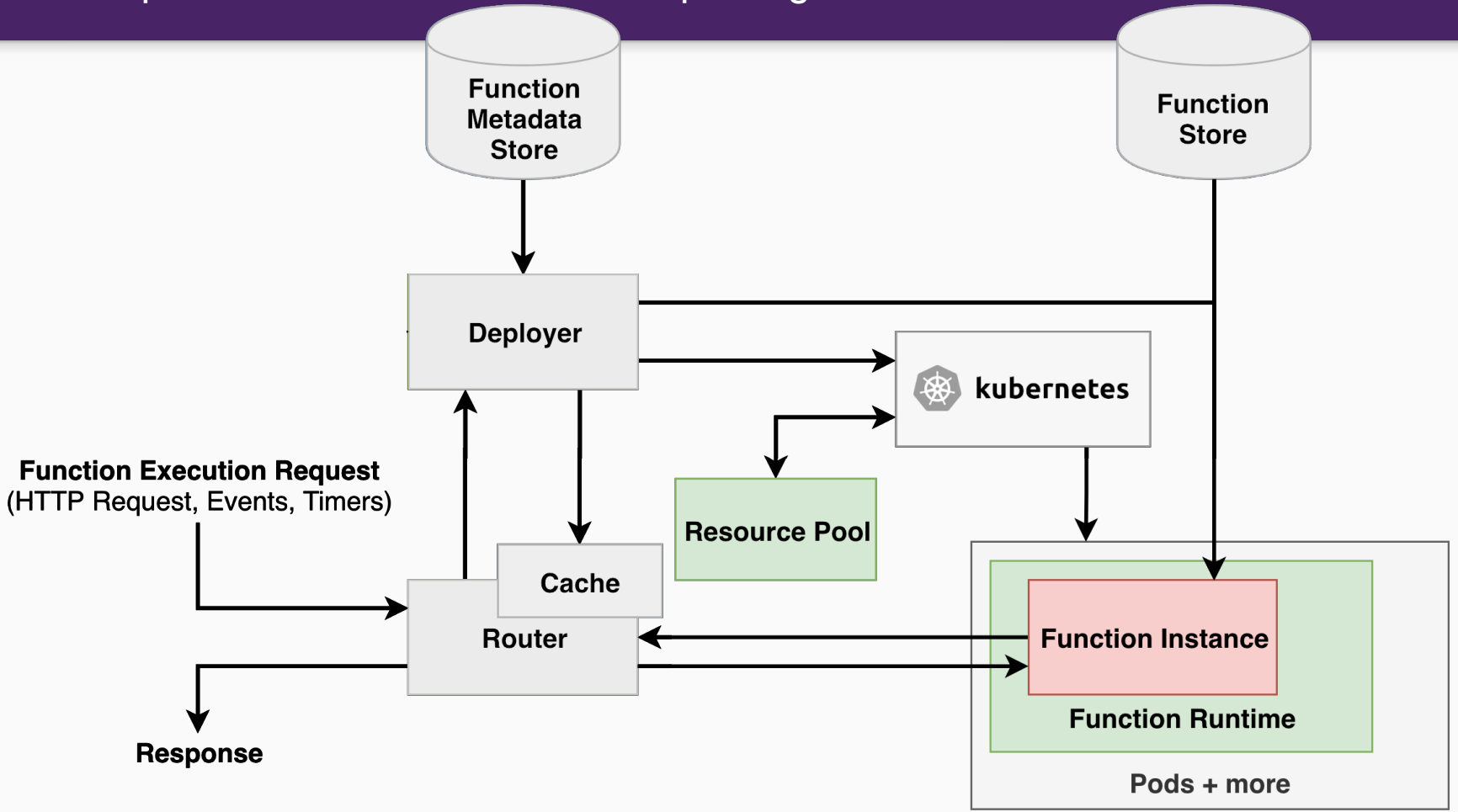


2 function runtimes → function instances



Pool rebalancing

FaaS platform with function runtime pooling



Trade-off: how big should the pool?

Large pool

Handle high concurrency

Increases resource overhead

Minimal pool

Fast pool exhaustion

Minimize pool; less idle resources

Performance — **Minimize cost**

Optimization 3

Function Prefetching

Trigger deployer	Fetch function metadata	Deploy pod	**Fetch function**	Deploy function	Route request	Function Execution

Function prefetching

Fetch function sources proactively and place them near resources to reduce function transfer latency

- Software flow has a big impact on cold start durations
  - Function sources (10s of MBs) have to be retrieved and transferred to the resources
- Especially important for geo-distributed and edge use cases
  - AWS Lambda@edge
  - Cloudflare

Abad, Cristina L. et al. "Package-Aware Scheduling of FaaS Functions." Companion of the 2018 ACM/SPEC International Conference on Performance Engineering. ACM, 2018.

Prefetching

Remote Storage

Cluster-level

Rack/Machine-level

Function-level

Prefetching

Higher latency
Less storage costs

Remote Storage

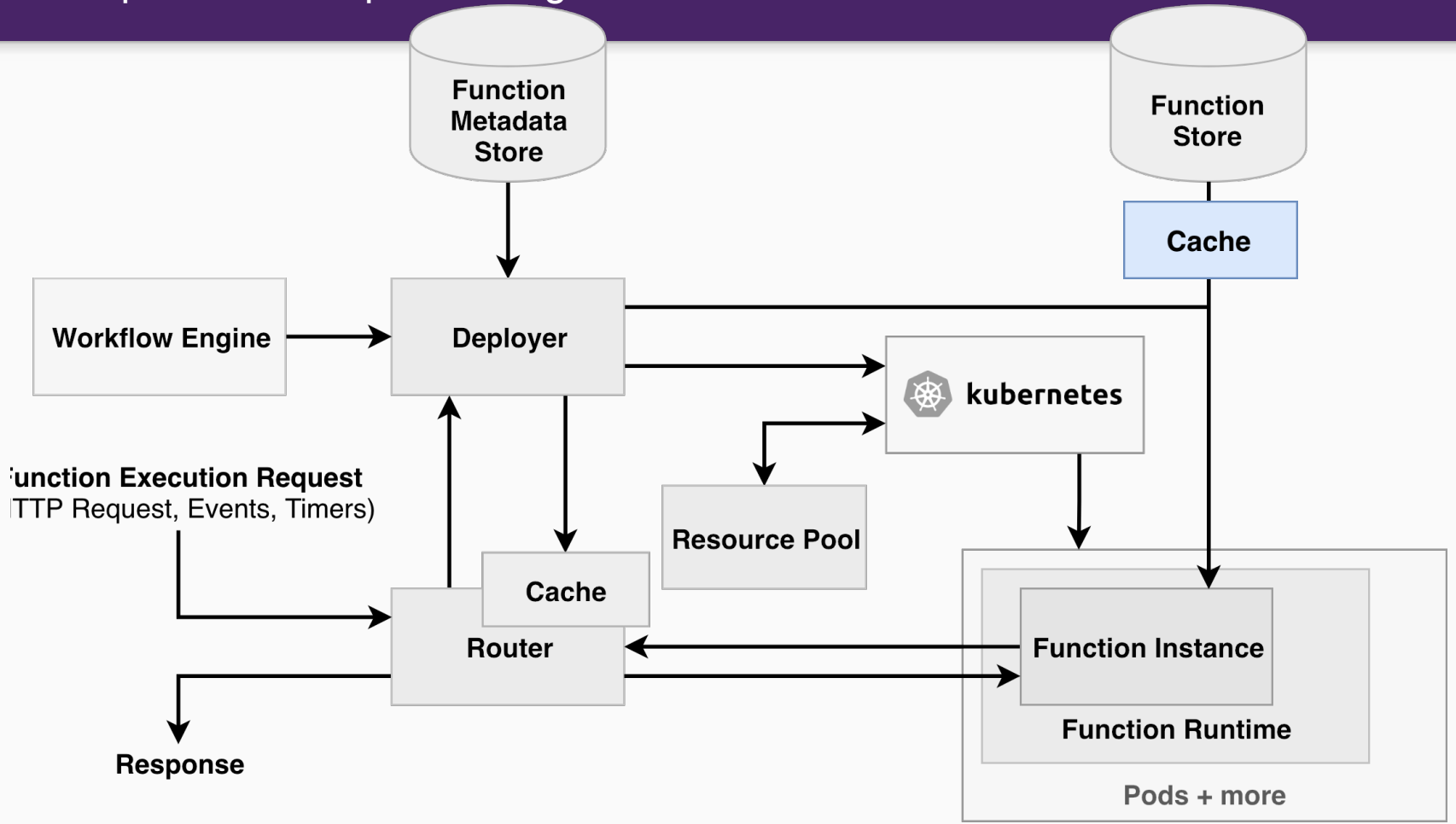
Cluster-level

Rack/Machine-level

Lower latency
More storage costs

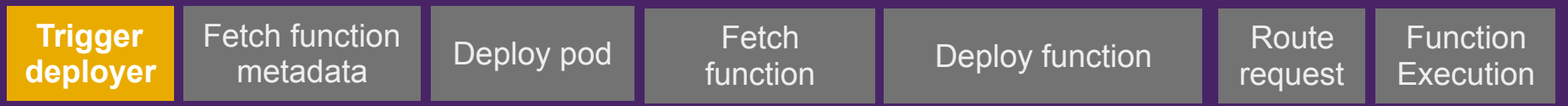
Function-level

FaaS platform with prefetching



Optimization 4

Function Prewarming



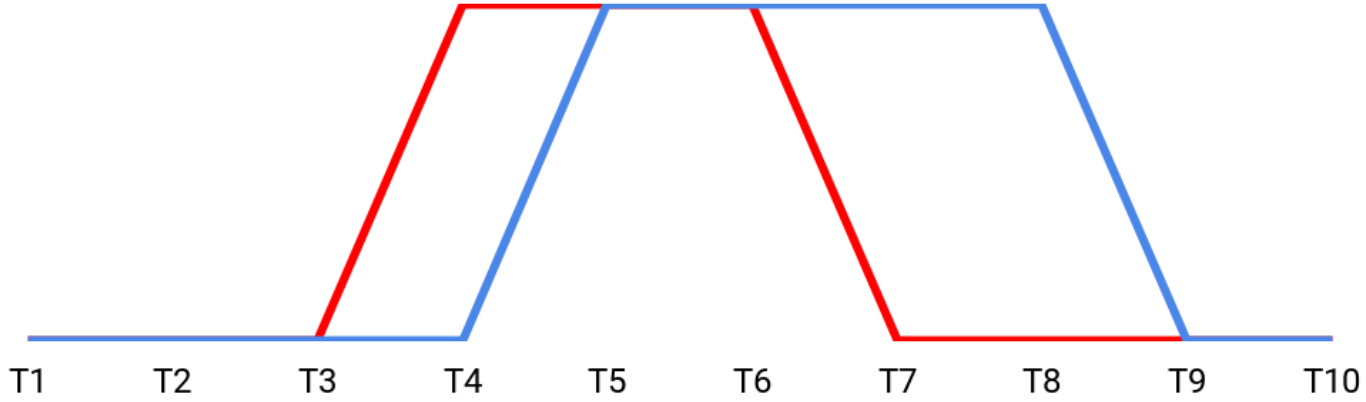
Function prewarming

Anticipate function executions by deploying functions predictively.

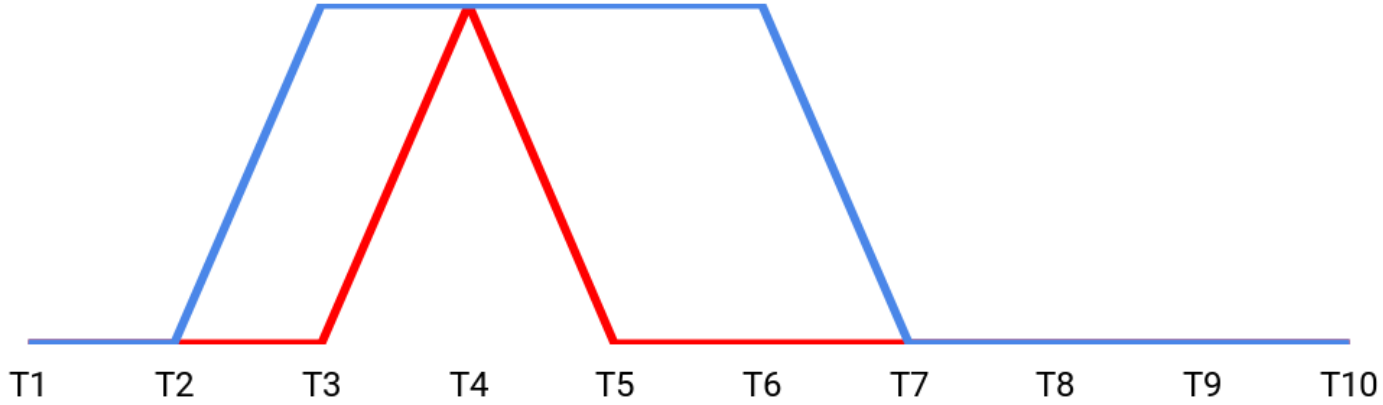
- Prewarming or predictive scheduling in other domains:
  - CPU branch predictor
  - Proactive autoscalers
  - Predictive caches

van Eyk, Erwin, et al. "A SPEC RG CLOUD Group's Vision on the Performance Challenges of FaaS Cloud Architectures." Companion of the 2018 ACM/SPEC International Conference on Performance Engineering. ACM, 2018.

Without prewarming



With prewarming



Predicting function executions is hard...

Active field of research (autoscaling, predictive caches…)

Common approaches

1. Runtime analysis
   - Rule-based
   - Pattern recognition and machine learning
   - Artificial intelligence
2. Exploit additional information of functions
   - Dependency knowledge in function compositions
   - Interval triggers

... and involves a trade-off.

Optimistic prewarming

Low threshold

Misprediction: resources wasted

Pessimistic prewarming

High threshold

Misprediction: no prewarm

More performance due to prewarming

Less costs due to less mispredicted prewarming

Optimistic prewarming: ping hack

... and involves a trade-off.

Optimistic prewarming

Low threshold

Misprediction: resources wasted

Pessimistic prewarming

High threshold

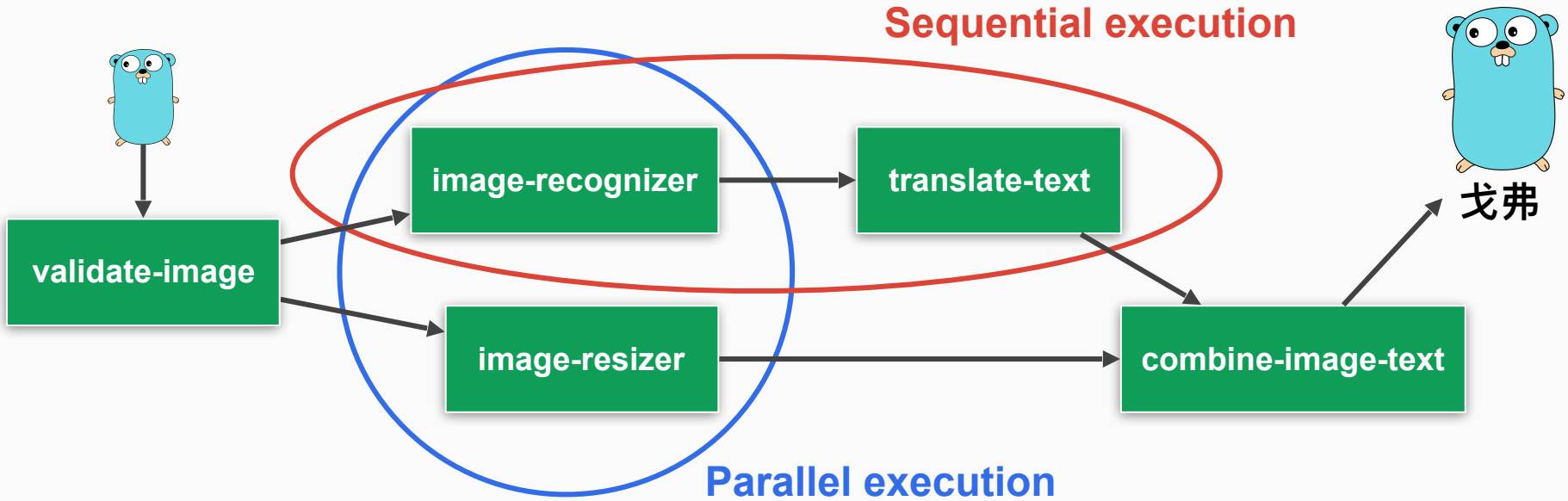
Misprediction: no prewarm

More performance due to prewarming

Less costs due to less mispredicted prewarming

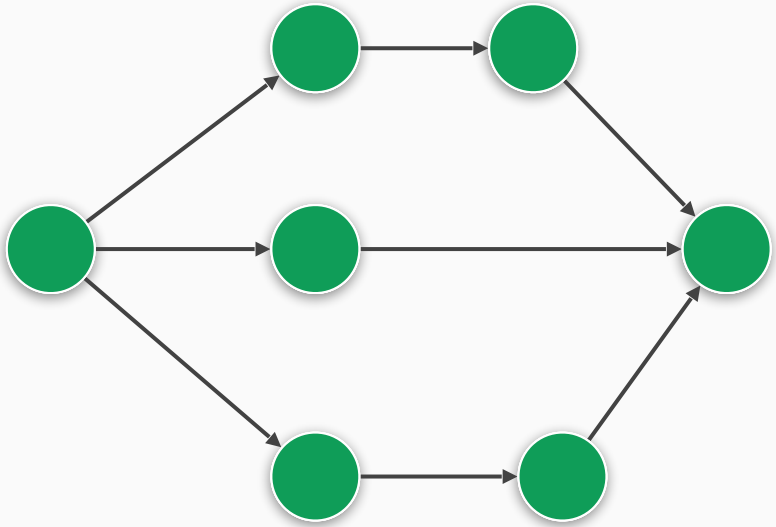
Function composition...

- Connect existing functions into complex function compositions
- Workflow engine takes care of the plumbing and provides fully monitorable, fault-tolerant function compositions with low overhead.



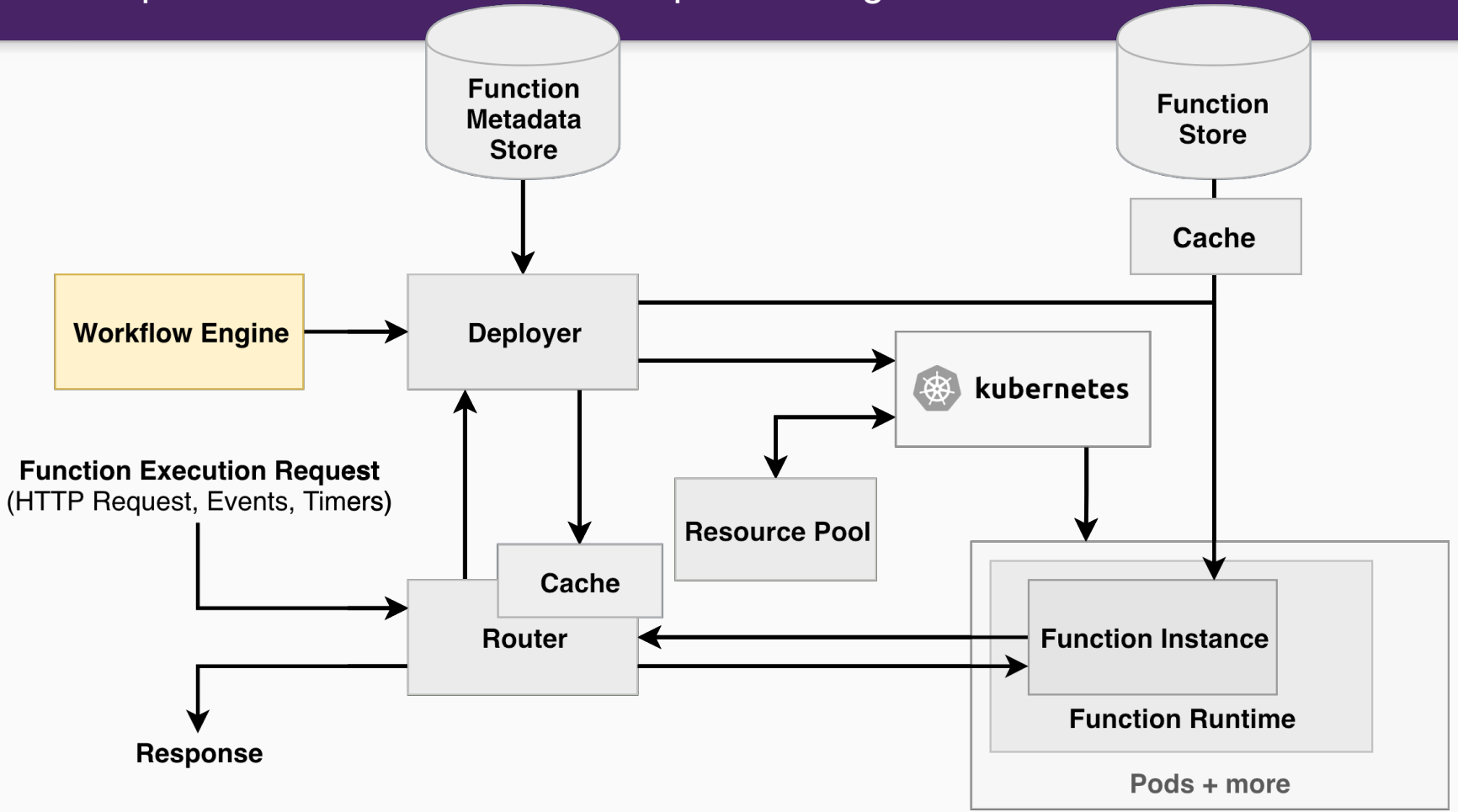
...with prewarming

Fission Workflows supports **horizon-based prewarming**



- Finished
- Started
- Prewarmed
- Not started

FaaS platform with workflow-based prewarming



Conclusion

Four techniques key to performance in serverless:

1. Function resource reusing
2. Function runtime pooling
3. Function prefetching
4. Function prewarming

Each makes a trade-off between performance and cost.

Serverless: Pay not just for what you use - pay for what you need.

Thanks!

fission — http://fission.io + https://github.com/fission

fission workflows — http://fission.io/workflows

Slack — http://slack.fission.io/

Twitter — @fissionio

Erwin van Eyk
Software Engineer @ Platform9 Systems
Chair @ SPEC CLOUD RG Serverless
Researcher @ AtLarge Research

@erwinvaneyk
erwin@platform9.com
https://erwinvaneyk.nl

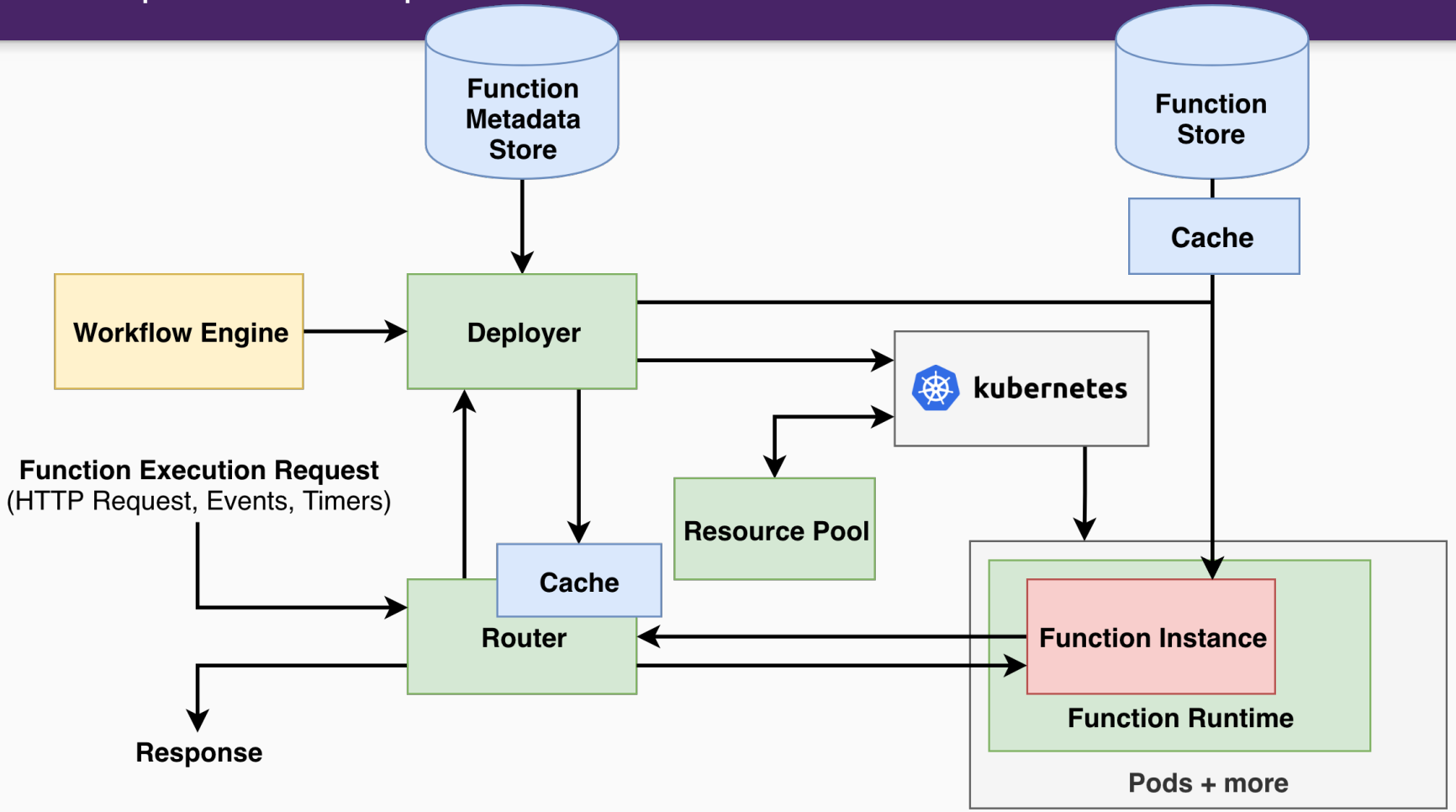
Additional Slides

What is next?

- Function and execution scheduling
- Workload-based predictions
- Comprehensive Benchmarks
- Performance Overhead Reductions
- Explicit Performance vs. Cost trade-offs

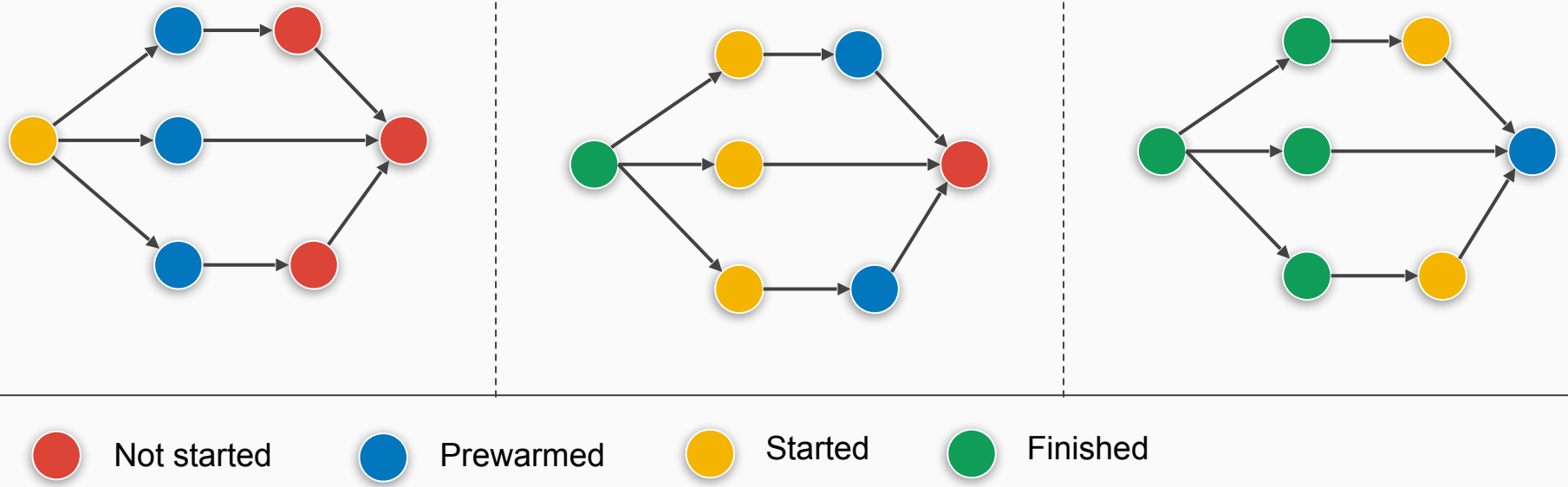
van Eyk, Erwin, et al. "A SPEC RG CLOUD Group's Vision on the Performance Challenges of FaaS Cloud Architectures." Companion of the 2018 ACM/SPEC International Conference on Performance Engineering. ACM, 2018.

FaaS platform with optimizations



Function composition… (pdf version)

Fission Workflows supports initial **horizon-based prewarming**



Function composition… (pdf version)