Request Reconstruction in MirageOS Unikernels

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Motivation

Exploring the potential of combining unikernels with distributed tracing to address the autoscaling problem in microservice applications

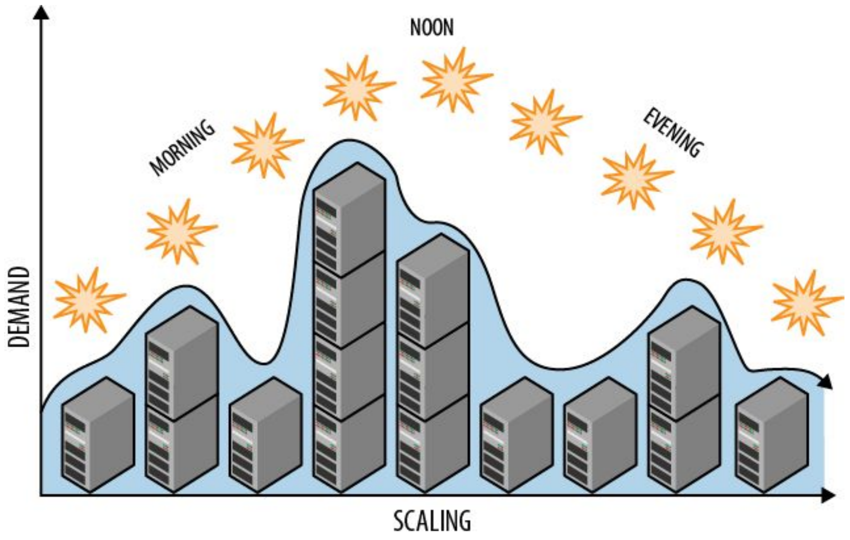
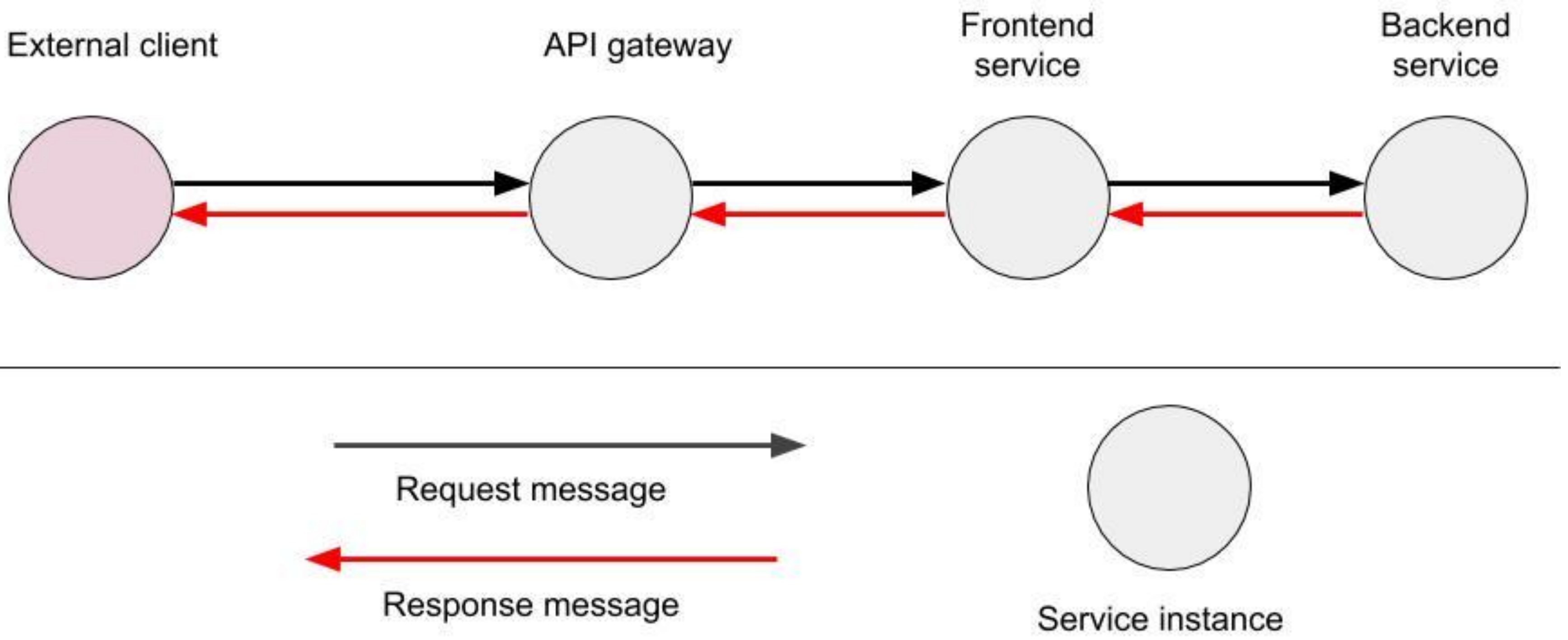
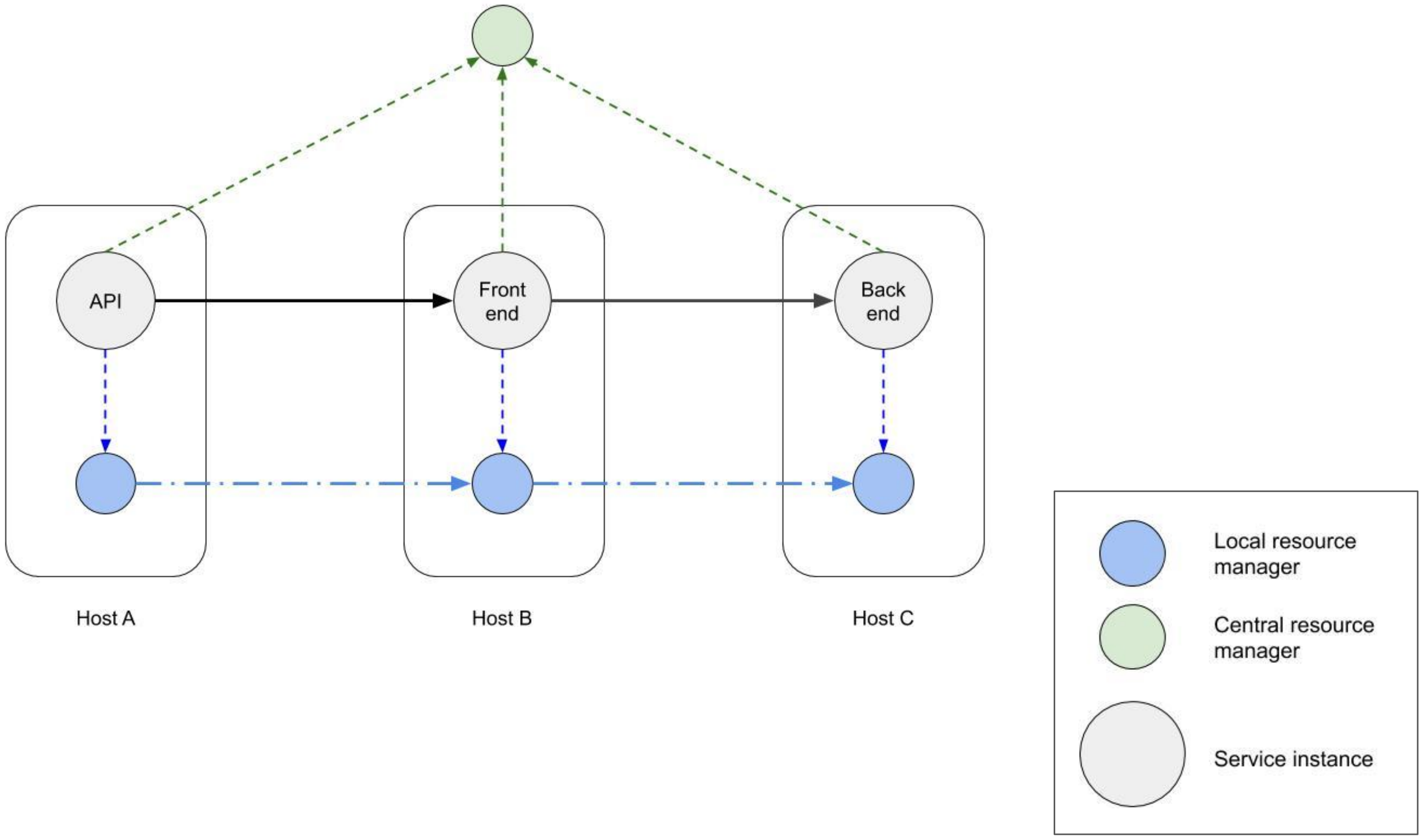


Image sources: O’Reilly Media, Netflix

Running example



Trace collection and resource management



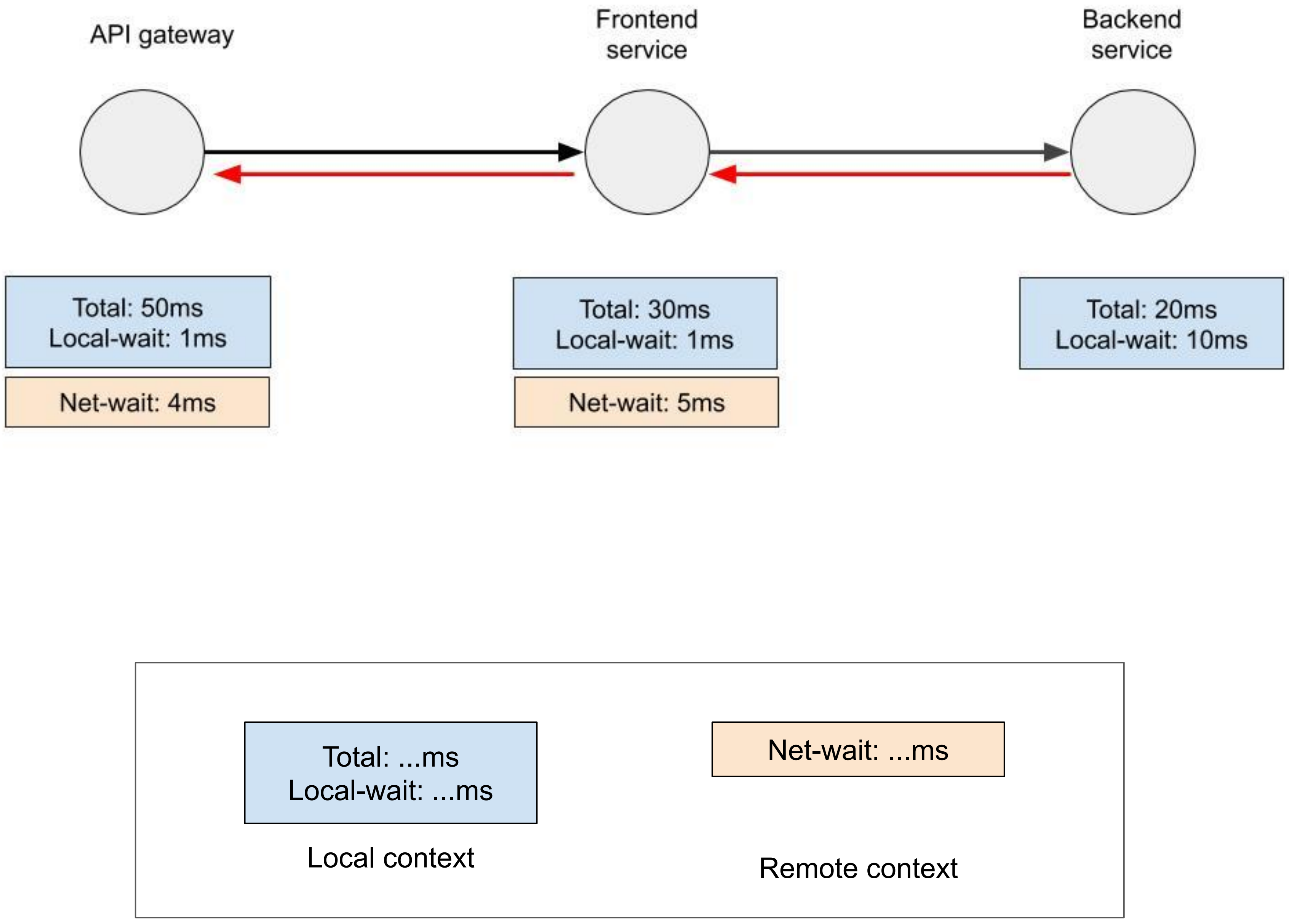
Key ideas

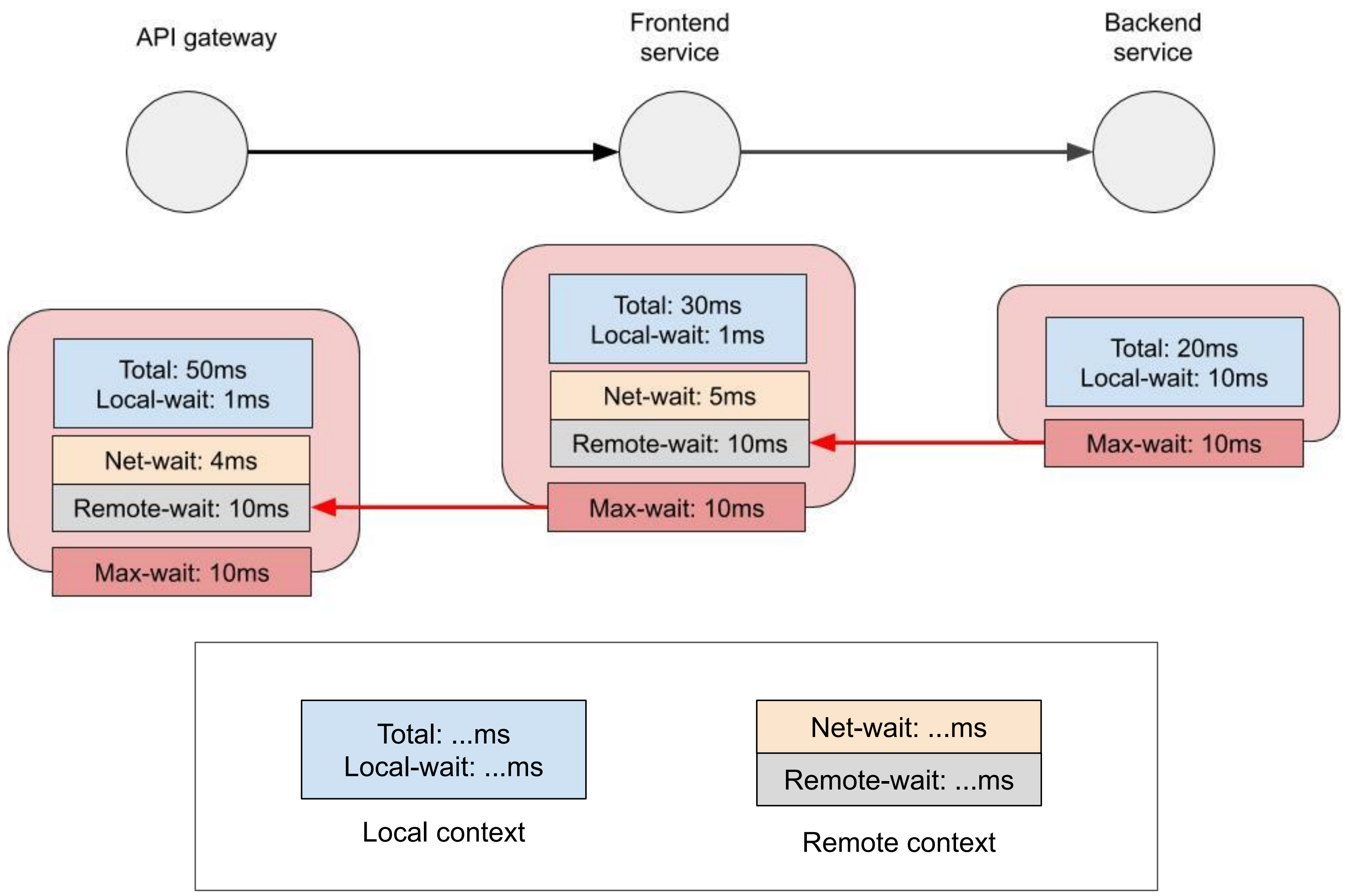
Key ideas in the proposed tracing model:

- Measuring resource waiting times (CPU and Network)
- “Flexible” tracing analysis (application-level & service-level trace analysis)

Generic execution wrappers to instrument Mirage HTTP library (Cohttp)

- Protocol agnostic: can be used to automatically instrument any protocol libraries based on inter-service communication
- Mirage libraries based on Lwt lightweight threads or *promises (futures)*


API gateway
Frontend service
Backend service
Total: 50ms
Local-wait: 1ms
Net-wait: 4ms
Total: 30ms
Local-wait: 1ms
Net-wait: 5ms
Total: 20ms
Local-wait: 10ms
Total: ...ms
Local-wait: ...ms
Local context
Net-wait: ...ms
Remote context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Remote-wait: 10ms
Max-wait: 10ms
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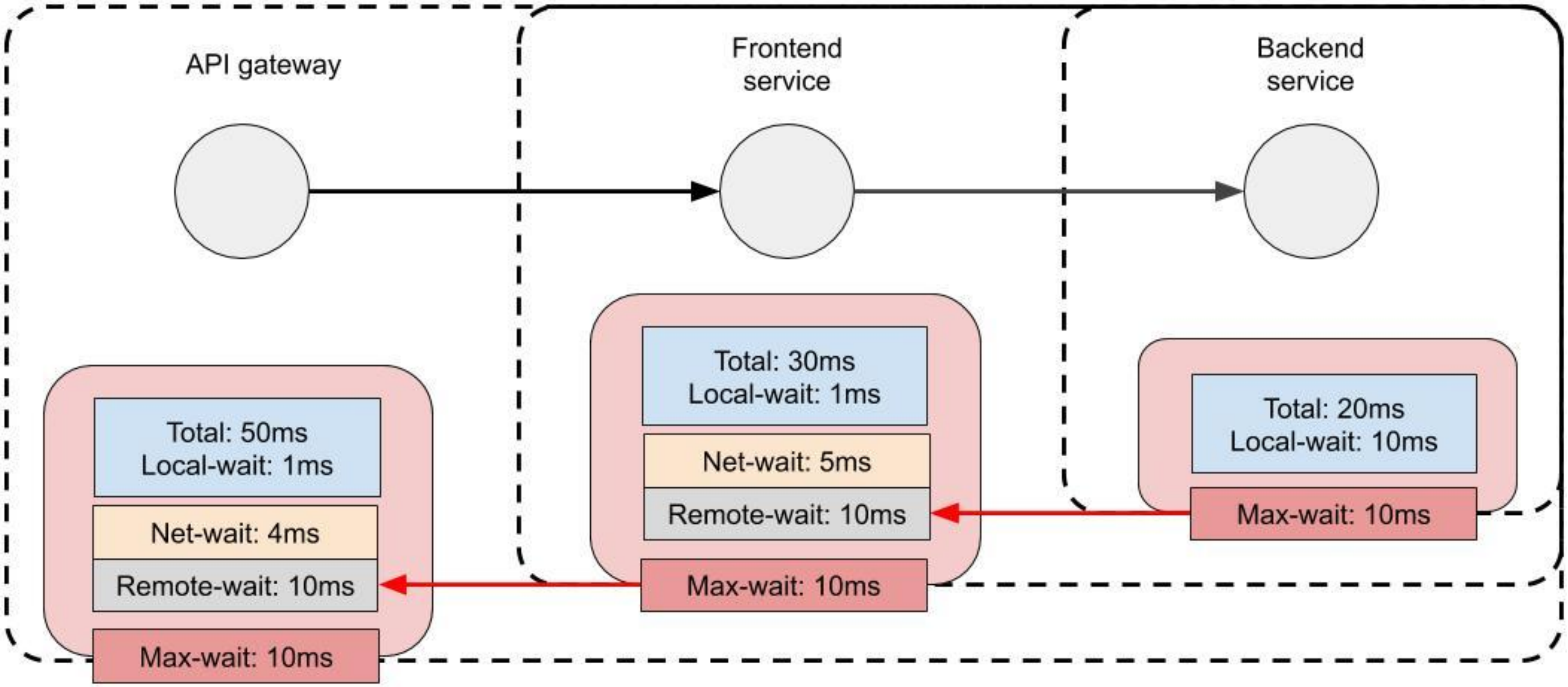
Net-wait: ...ms
Remote-wait: ...ms
Remote context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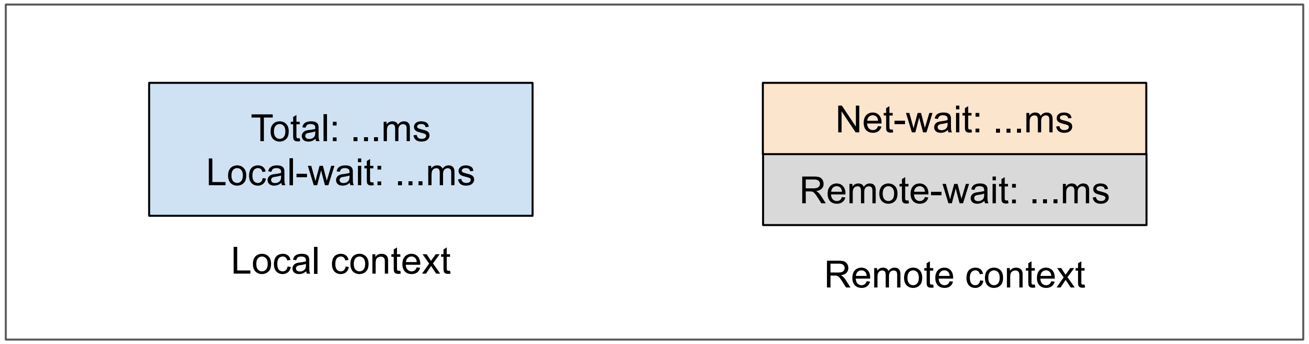
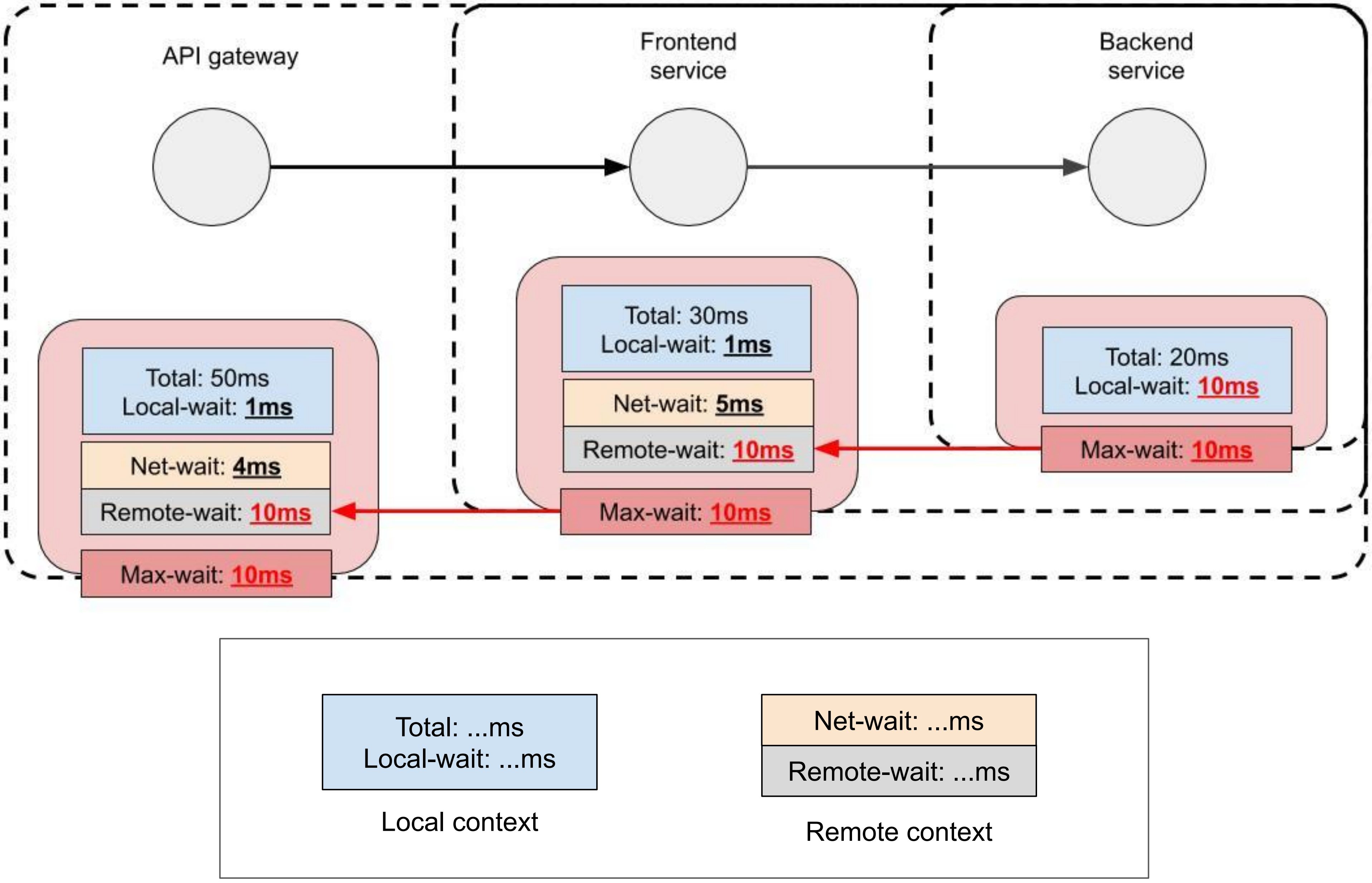

Total: ...ms
Local-wait: ...ms
Local context
Net-wait: ...ms
Remote-wait: ...ms
Remote context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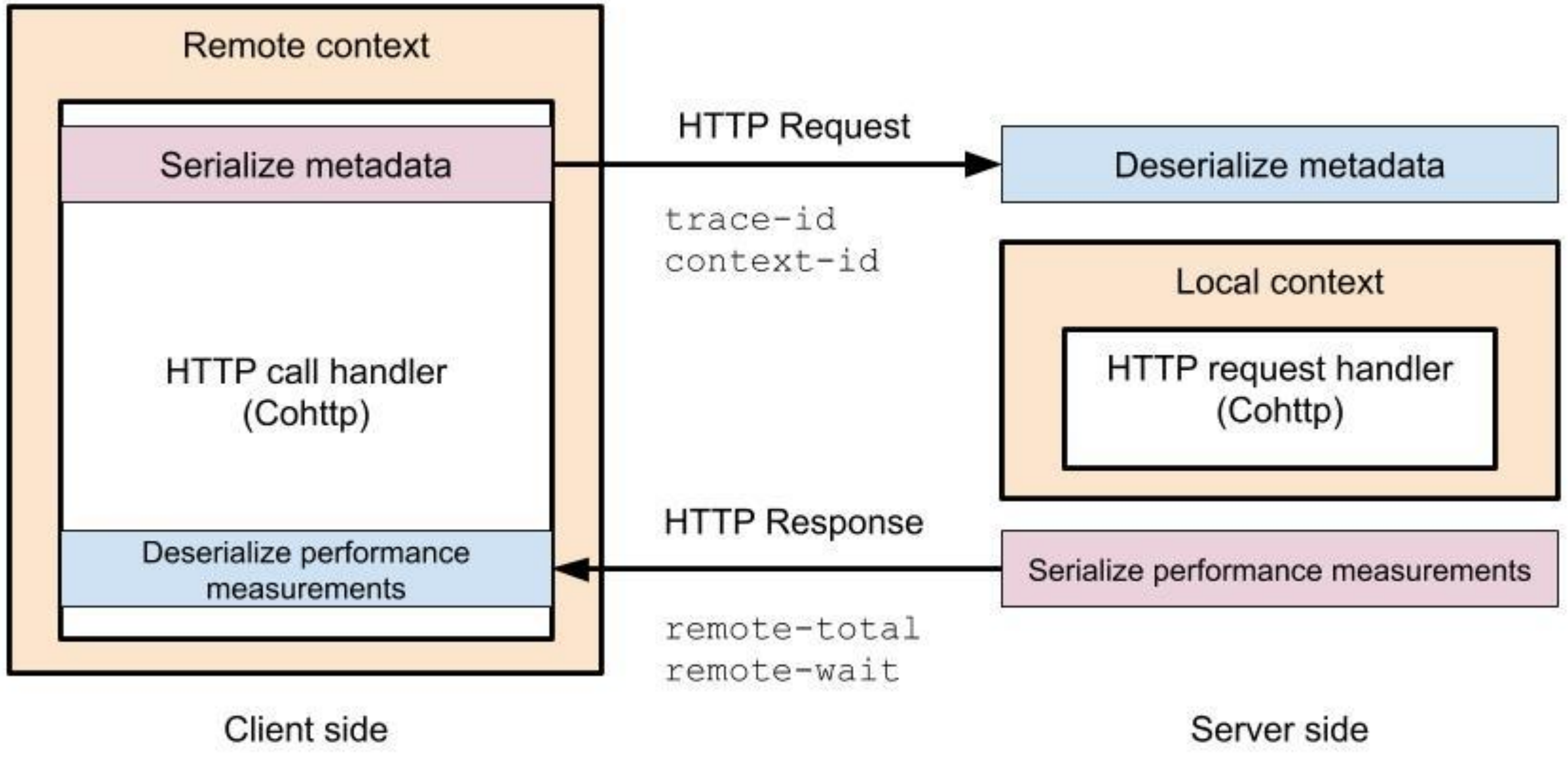
Local context
Net-wait: ...ms
Remote-wait: ...ms
Remote context

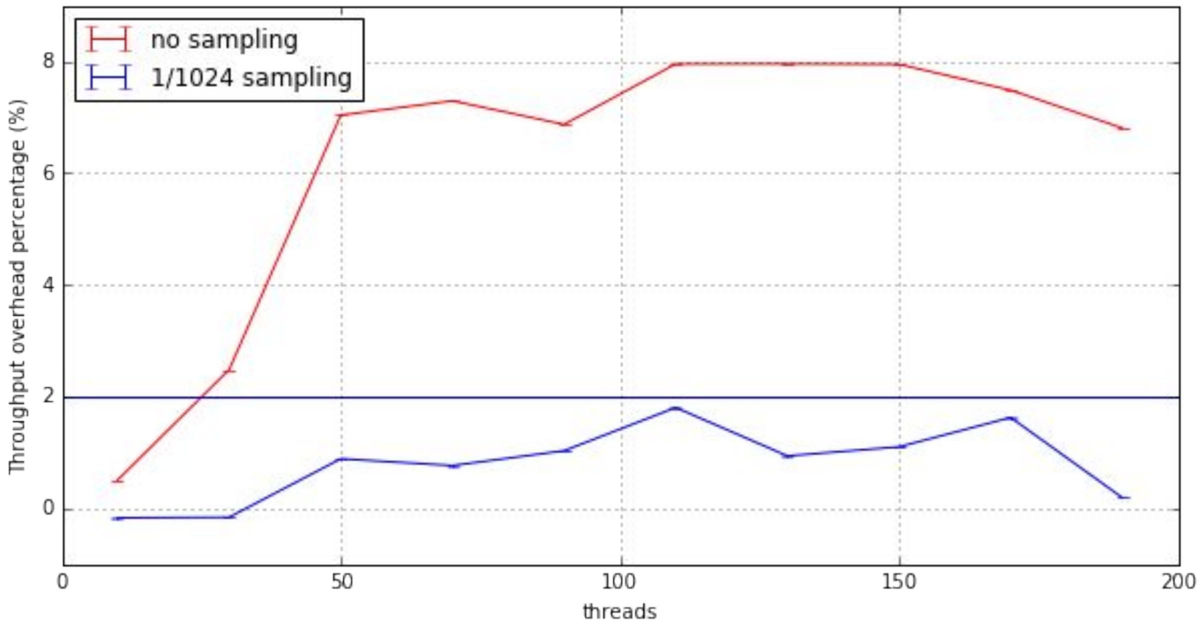
Execution wrappers and Cohttp library instrumentation



Overhead evaluation

For 100 explicit context switch points (also known as *yield points*)

- 8% overhead with no sampling
- Less than 2% under a sampling rate of 1/1024



Summary and conclusions

A tracing model based on hierarchical aggregation of resource waiting times suitable for further research on microservices autoscaling policies

- The tracing model can be extended for other lightweight virtualization options (e.g. containers)

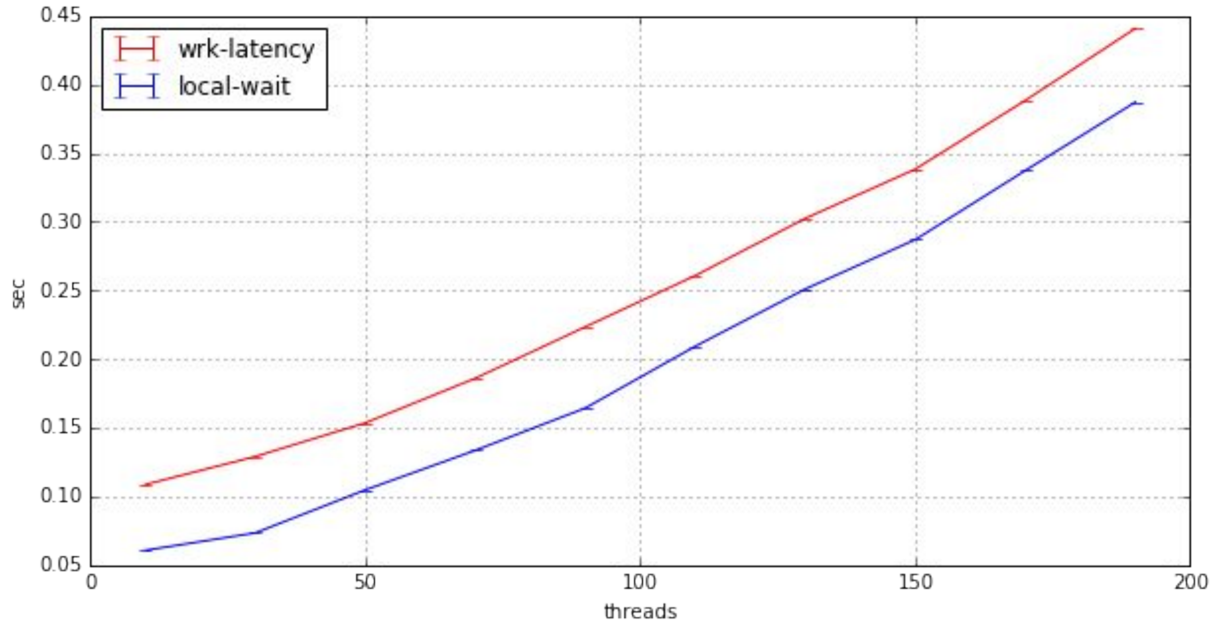
The single-threaded architecture of Mirage unikernels introduce various issues that need to be addressed in future work

- A CPU bottleneck can lead to an indistinguishable artificial network bottleneck
- Instrumenting the TCP stack can be useless, and packet-timestamping is required

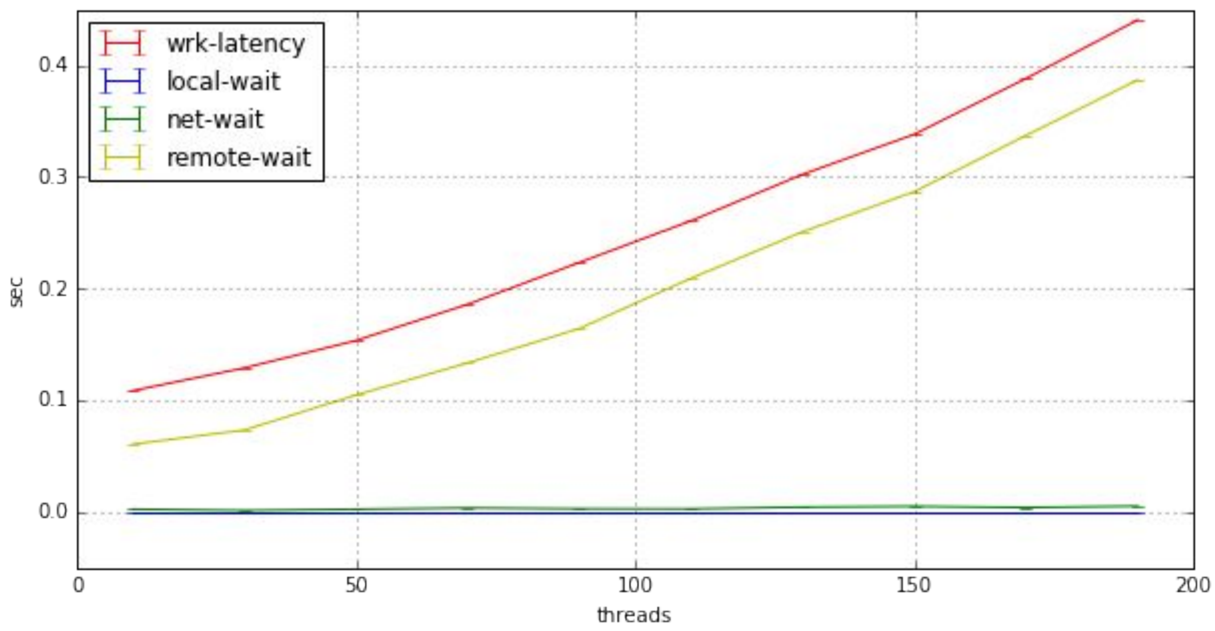
Backup slides

CPU bottleneck

Backend service

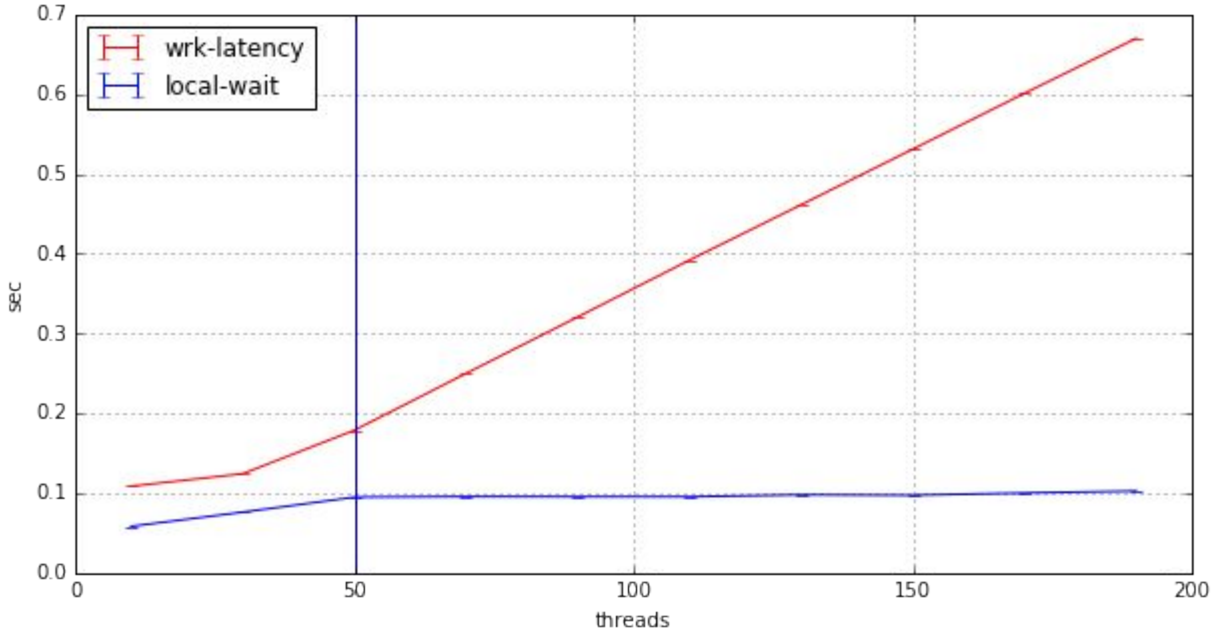


Frontend service

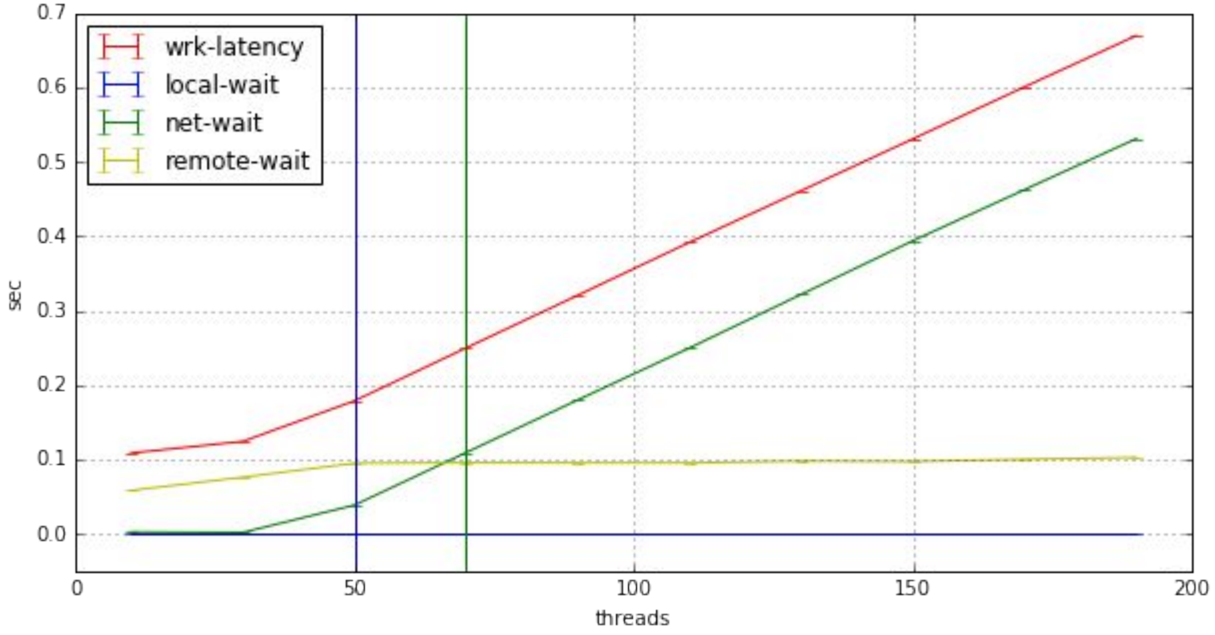


Net bottleneck

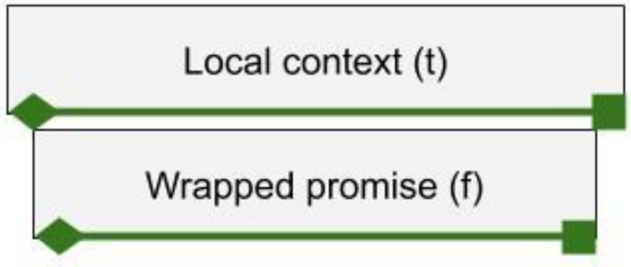
Backend service



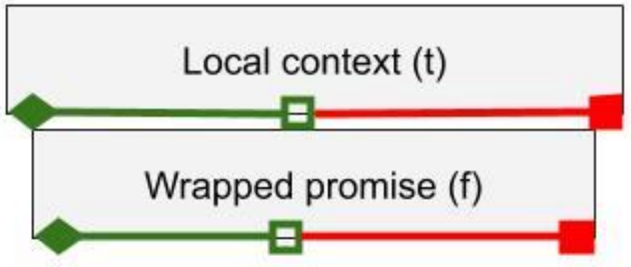
Frontend service



Implementation of local context wrapper

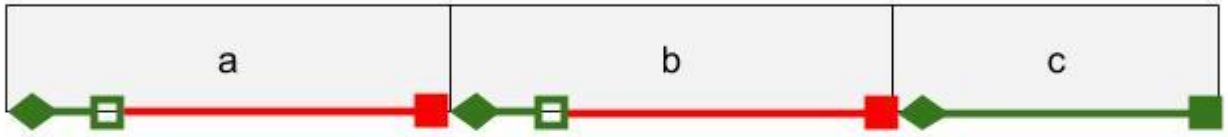


Immediately resolving promise



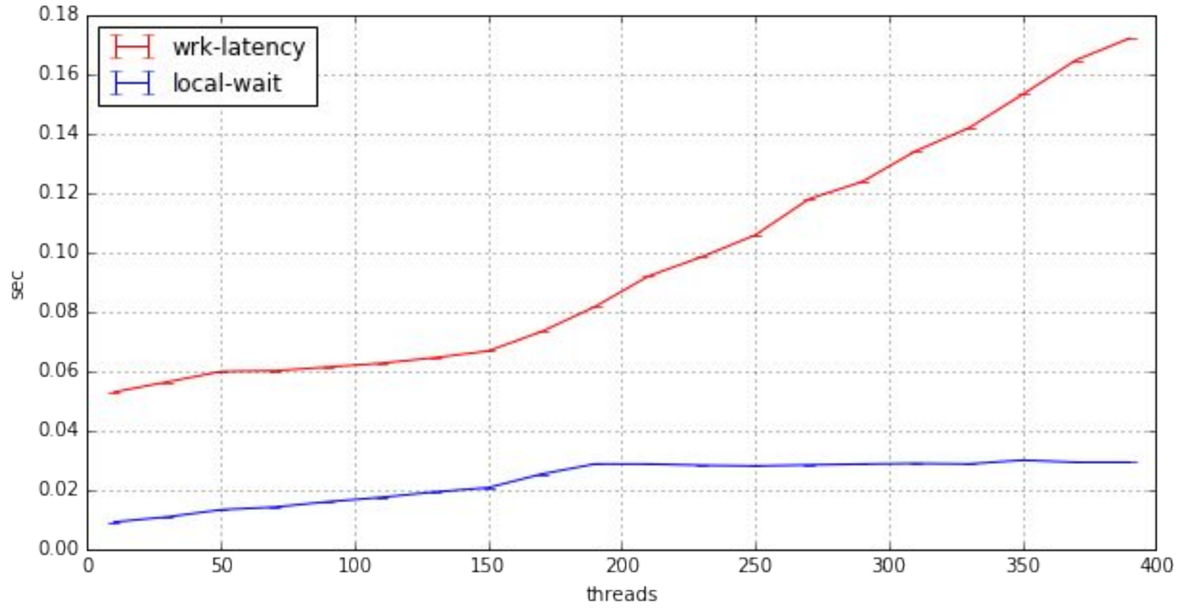
Asynchronous promise

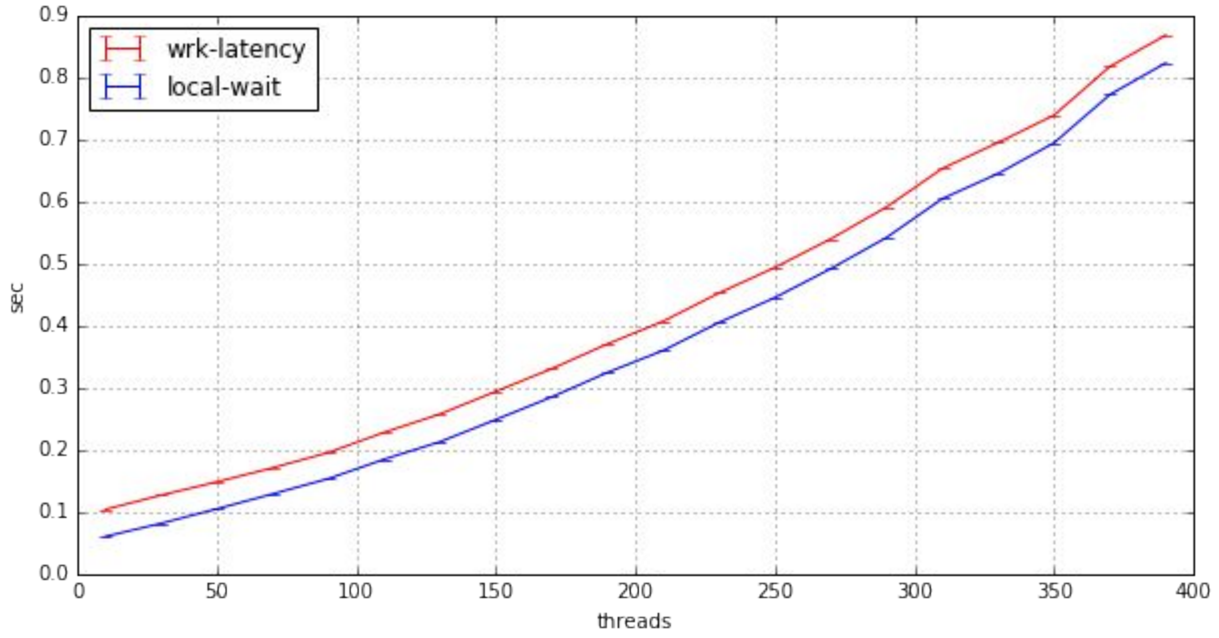
```
let t = Lwt.with_context (fun () -> f)
```



```
let t = Lwt.with_context (fun () -> a >>= b >>= c)
```

Avoiding an artificial network bottleneck (above) by increasing the number of context switches (below)


wrk-latency
local-wait
sec
threads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