CausalRPC

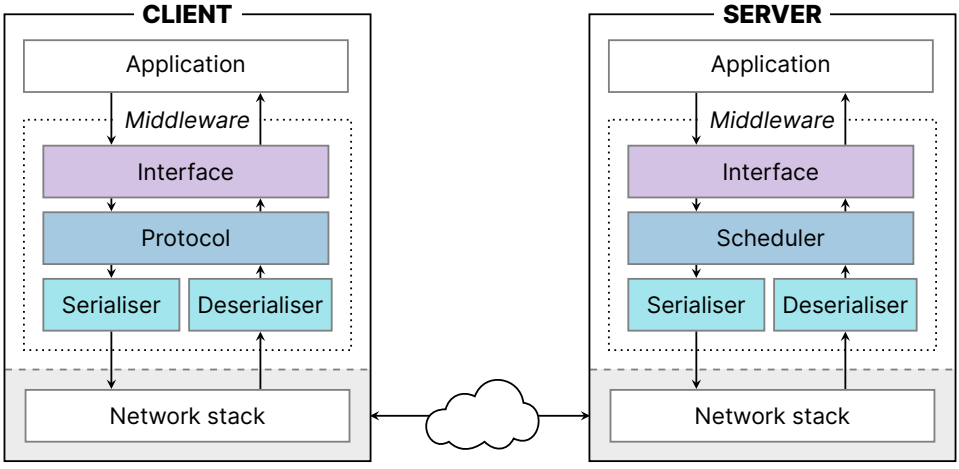
Distributed computation over Irmin

Craig Ferguson (@CraigFe)

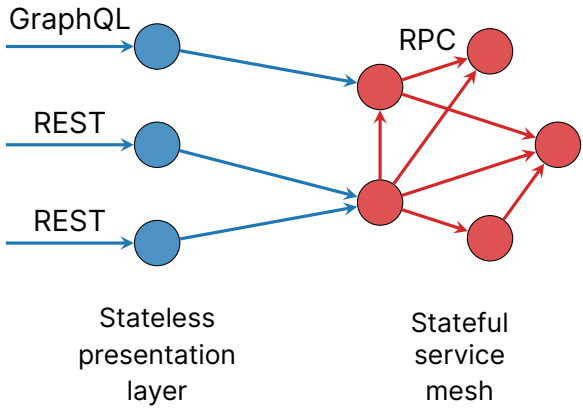
Friday 23rd August

Remote Procedure Call (RPC)

Remote computation at the level of individual function calls.



Trendy microservice architectures



Use RPC for remote access to a resource (storage, private network etc.).

Two birds and one cannonball

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Problem: consistency under race conditions

- breaks RPC abstraction
- results in additional round-trips to server

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Idea: middleware that understands state

- application explains the underlying state to the middleware
- middleware resolves conflicts and constructs a trace as it goes

Introducing Irmin

- Distributed, immutable Merkle trees with push/pull sync – just like Git!
- Pure OCaml; unikernel-compatible.
- Parameterised on:
  - Storage backend (Memory, FS, Git repo, Redis, ...)
  - User-defined mergable contents (leaves of the tree)

Aside: why *three*-way merge?

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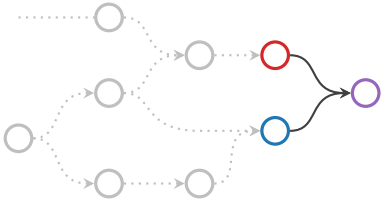
Two-way CRDT[1] merge



state → state → state

[1] M. Shapiro et al. *Conflict-Free Replicated Data Types*, 2011.

Aside: why *three*-way merge?

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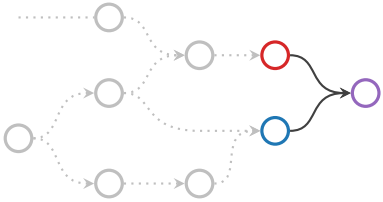

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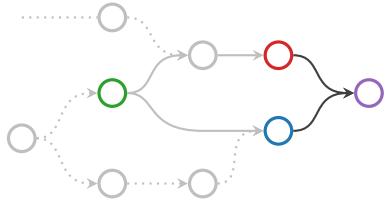
Three-way Irmin merge



lca : state → state → state → state

Lowest common ancestor allows the merge operation to reason about *intent*.

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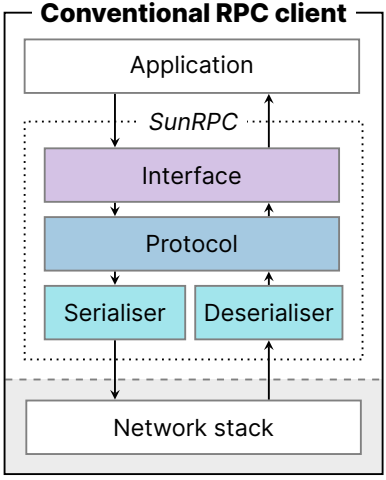
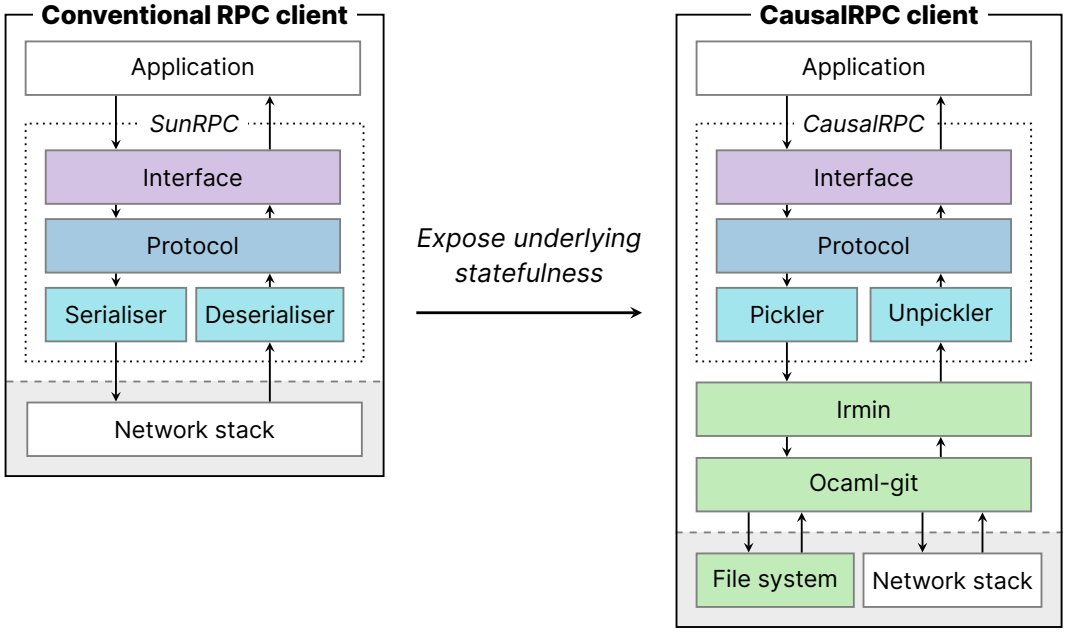
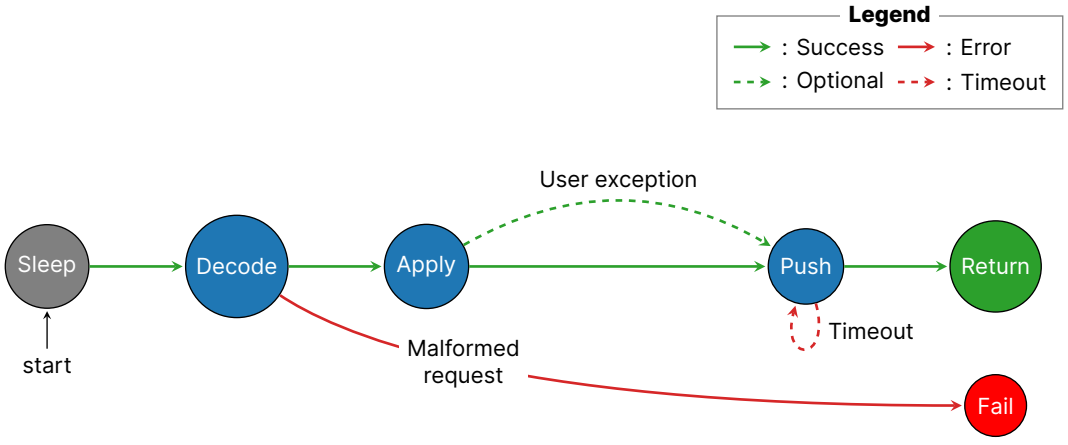
State-aware RPC



State-aware RPC



The life of an RPC thread



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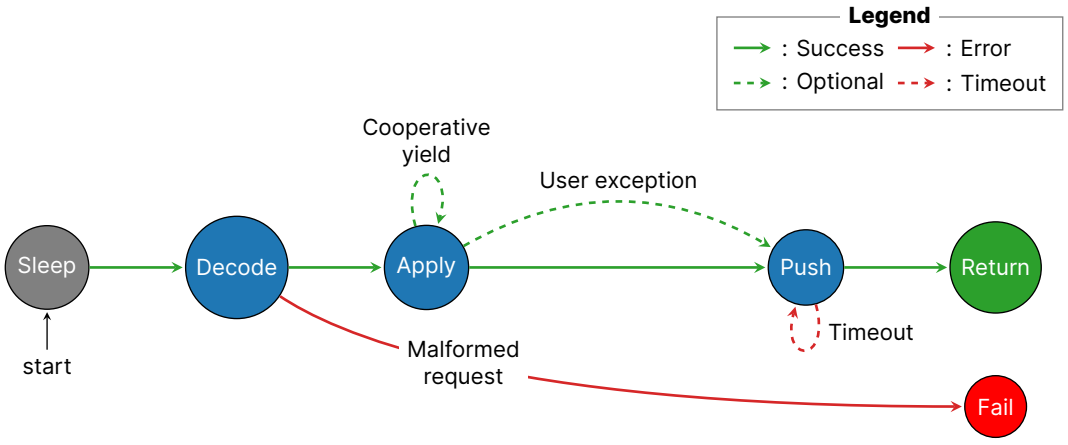

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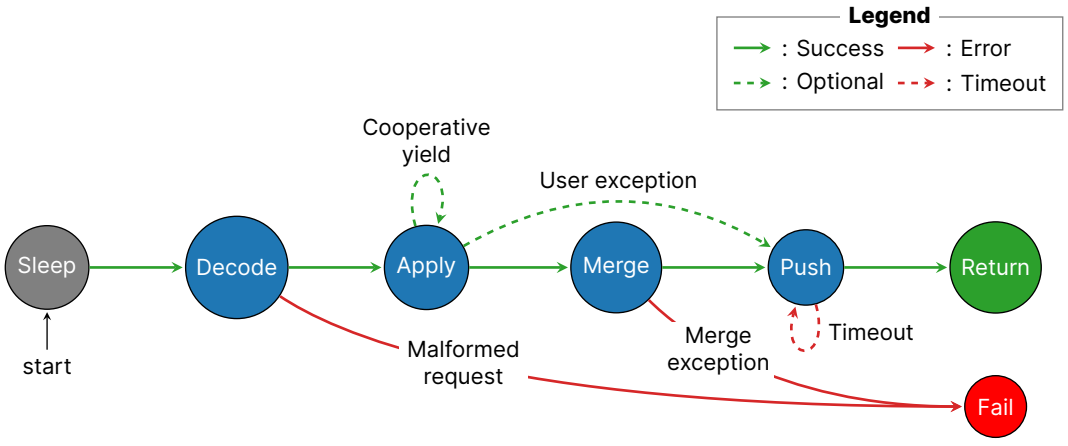

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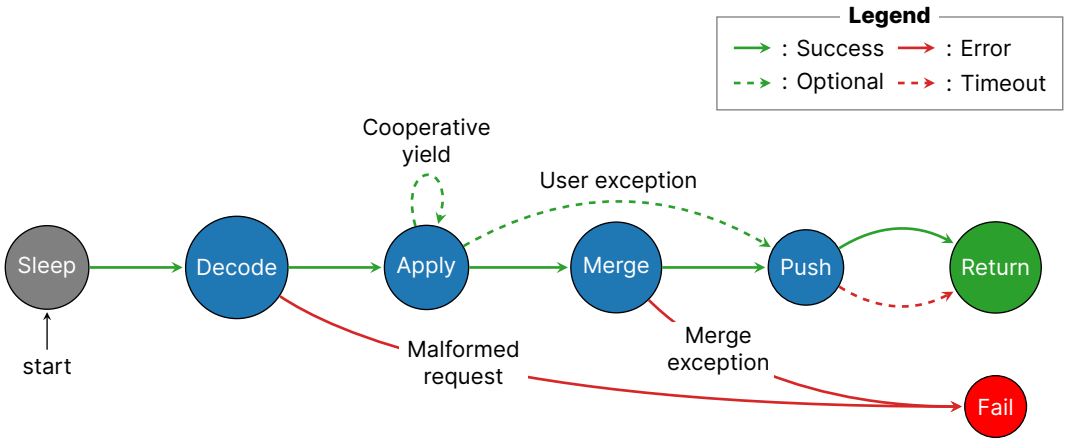
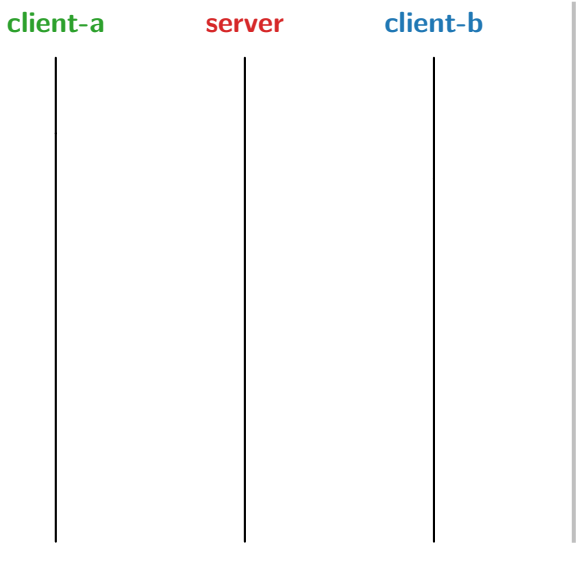
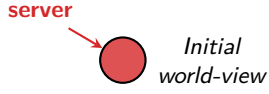


Mergeable filesystems

Mergeable filesystems





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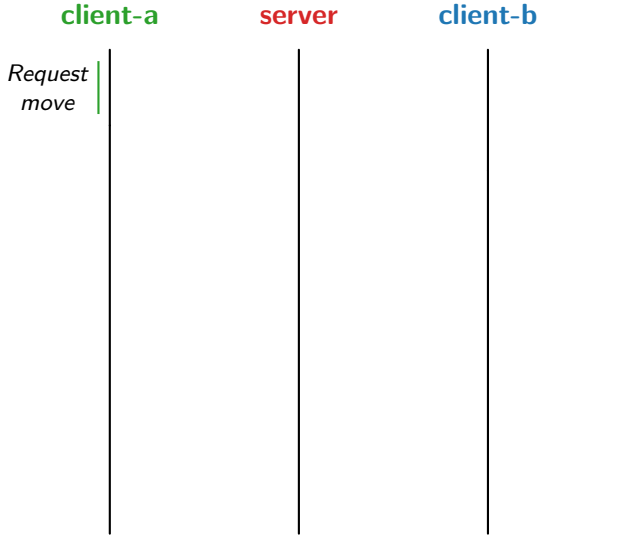

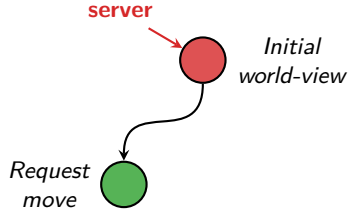

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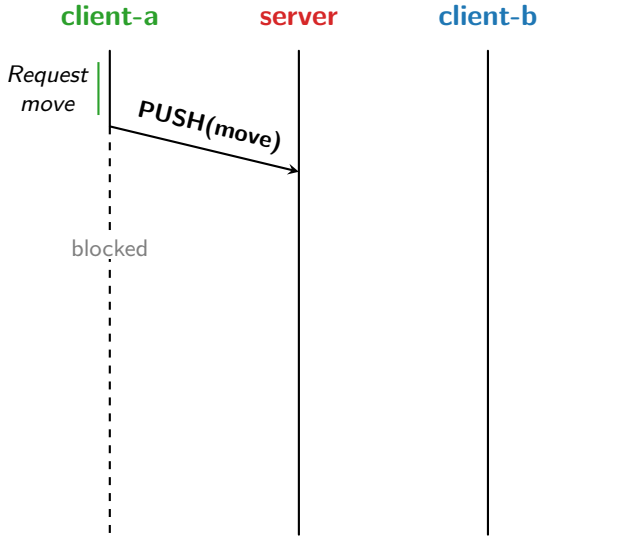

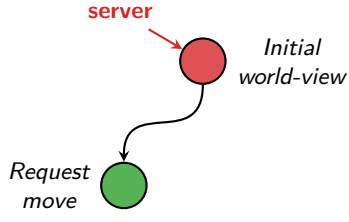

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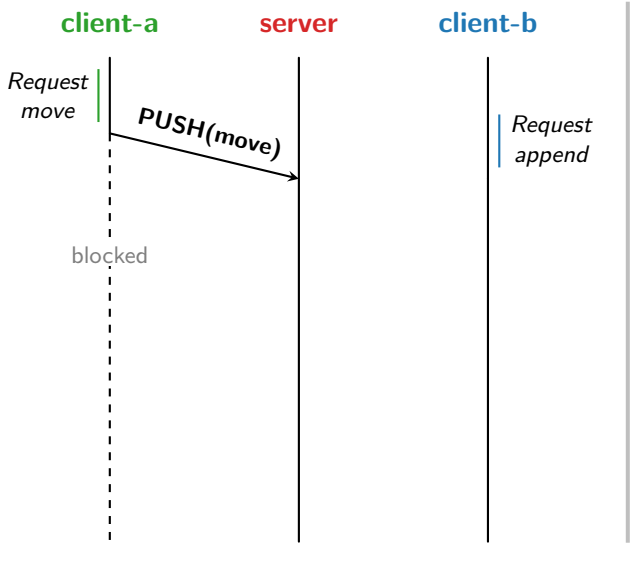

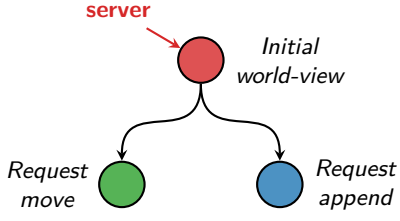

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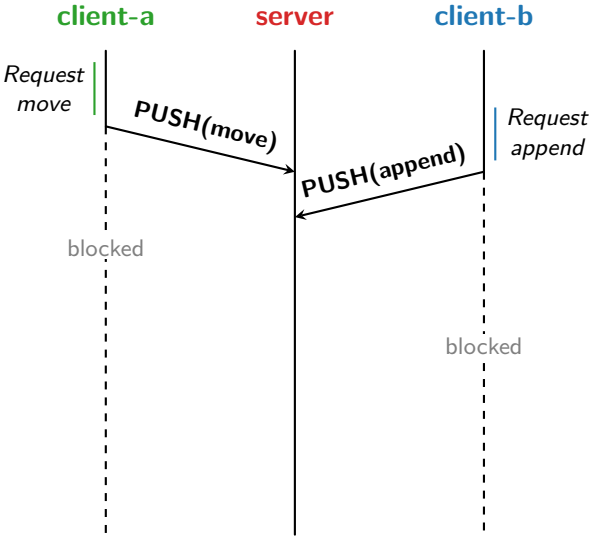

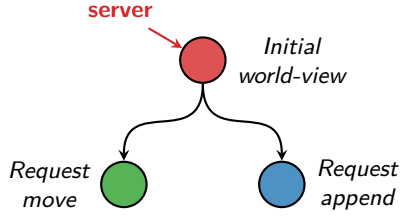

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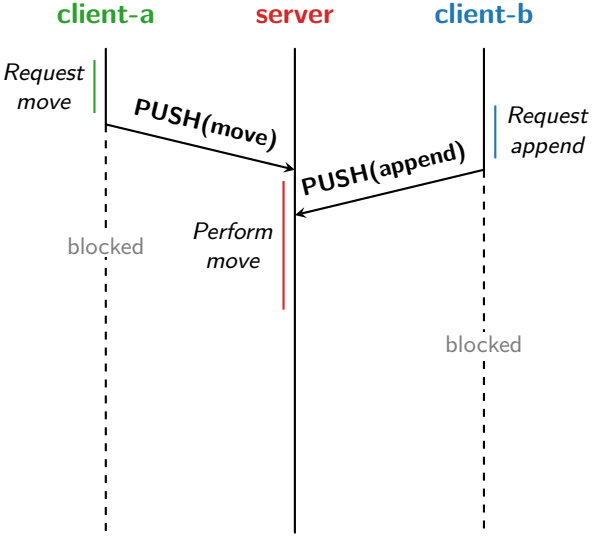

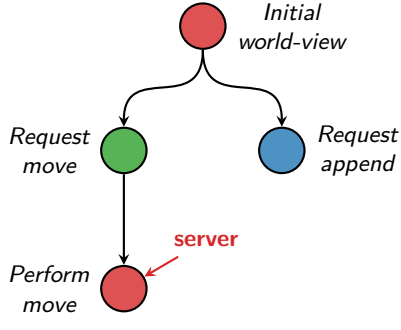

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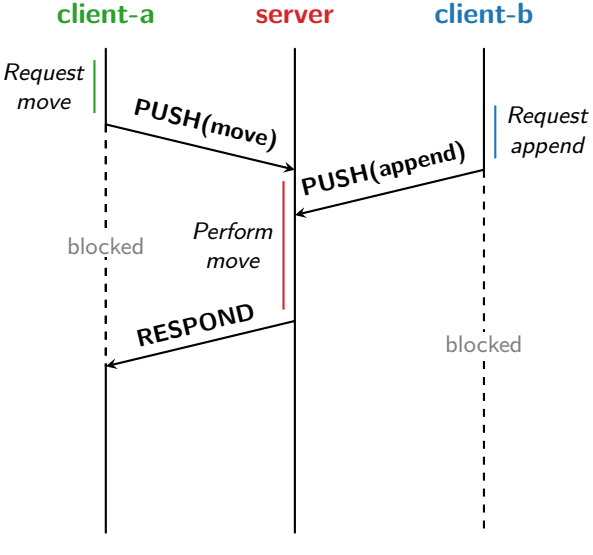

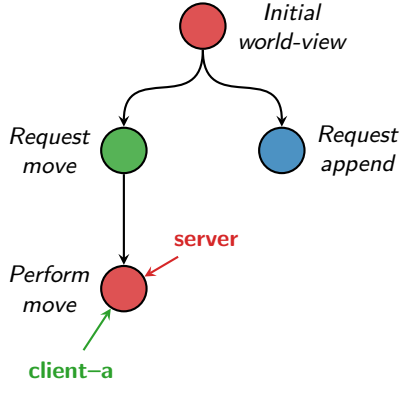

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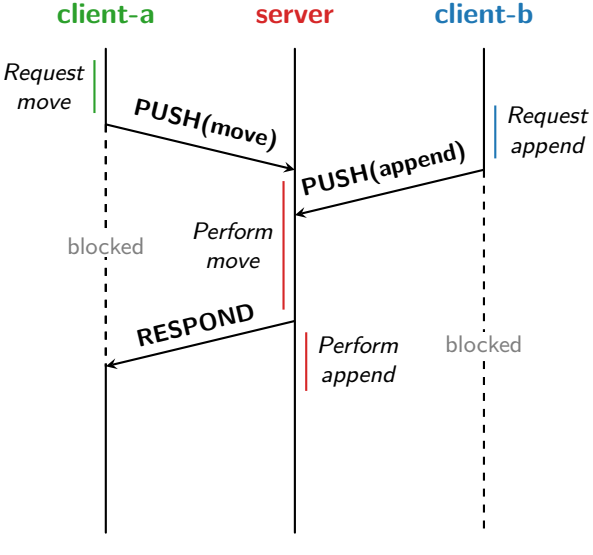

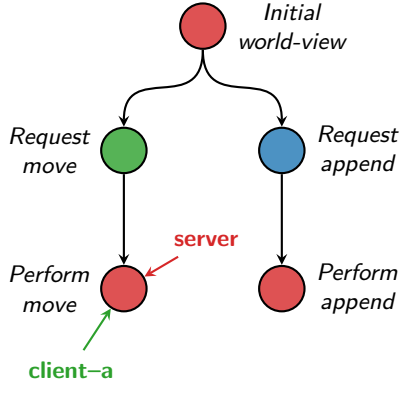

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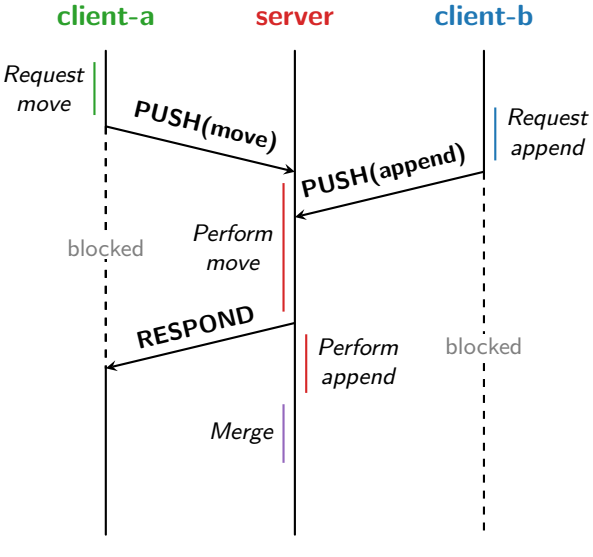

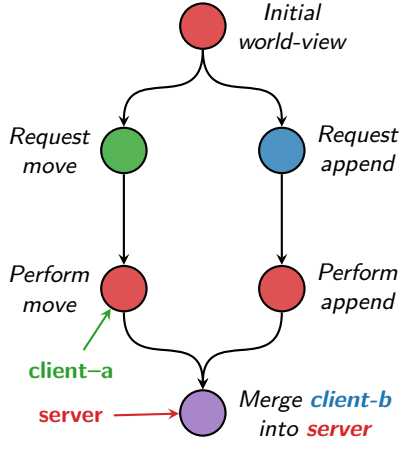

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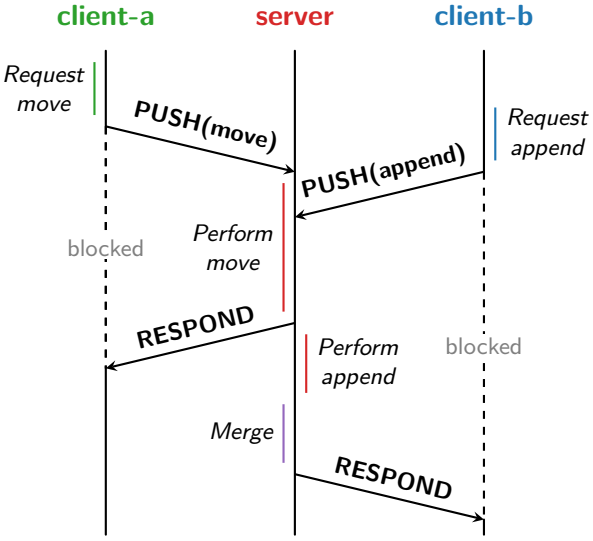

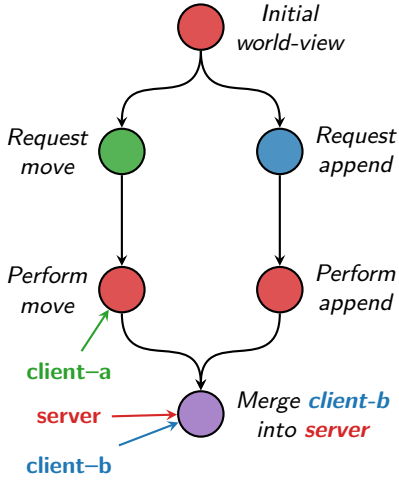

Mergeable filesystems: trace output

```
$ git log
```

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```
$ git log

* server Initialised Filesystem store
|\
* | clientA Request <move>: /tmp/sharedFile -> /log/sharedFile
* | server (client--a) Perform <move> for clientA
| * clientB Request <append>: /tmp/sharedFile
| * server  Perform <append> operation for clientB
|/
*   server (server, client--b) Merge client--b into server
```

Why OCaml?

Portability – Inherits the Mirage mindset towards platform-independence.

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Type-safety – Strict interface definition using an embedded DSL.

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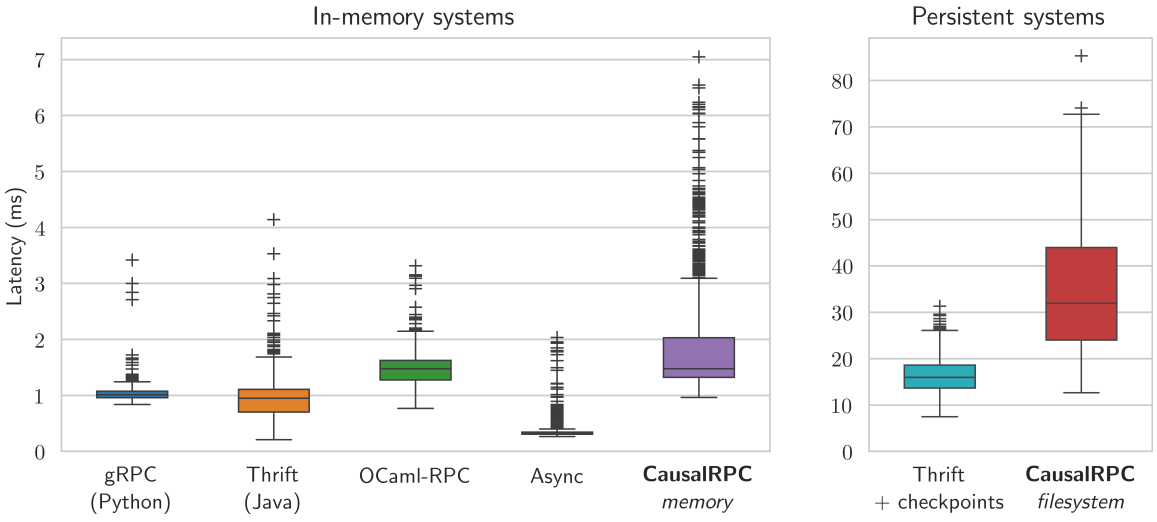
Type-safety – Strict interface definition using an embedded DSL.

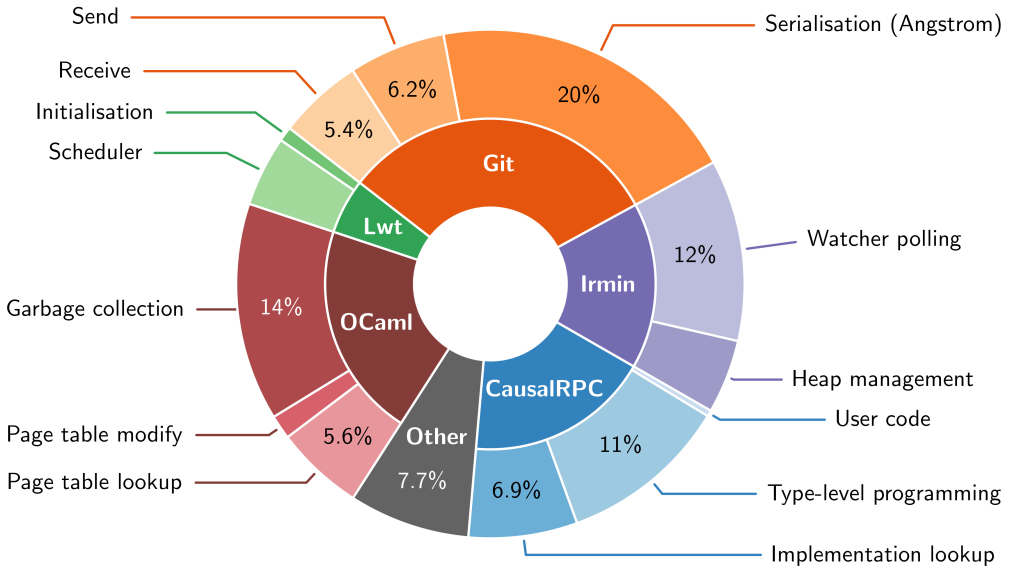
Coolness-factor (!!!) – Protocol design in OCaml is really fun.

Performance: latency



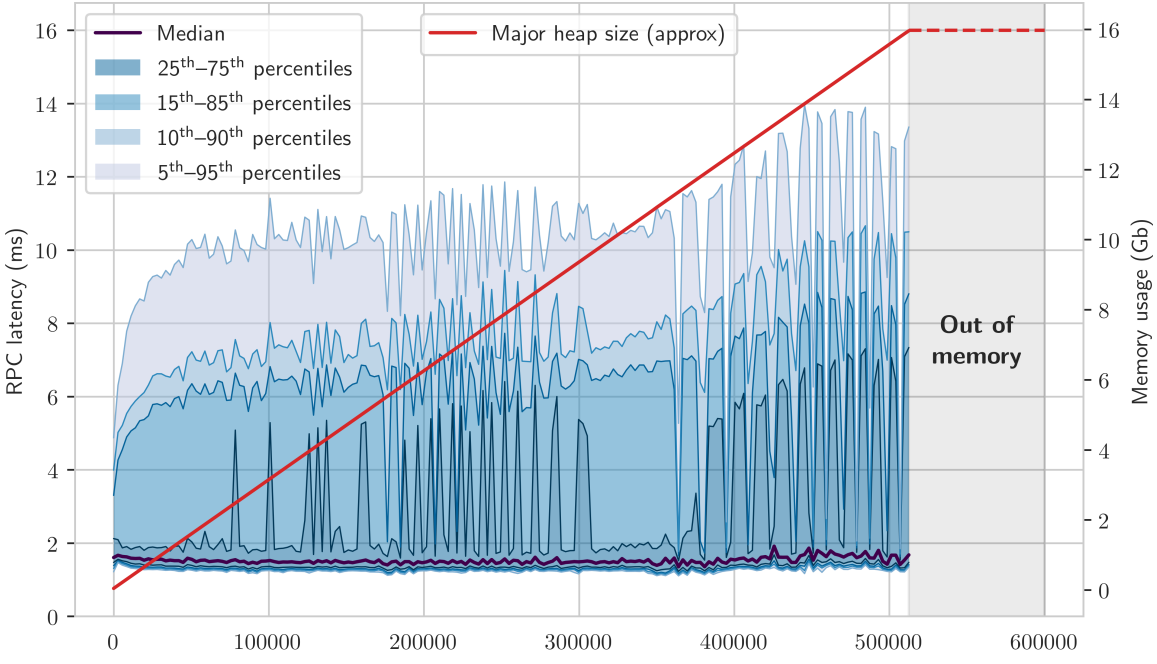
Measured over 1000 RPCs for a single client-server pair over a Docker bridge network.

Server run-time cost profile from first packet receipt to final packet send:



Source: *gprof and a huge amount of patience.*

Performance: memory-usage



Generalisation to work clusters

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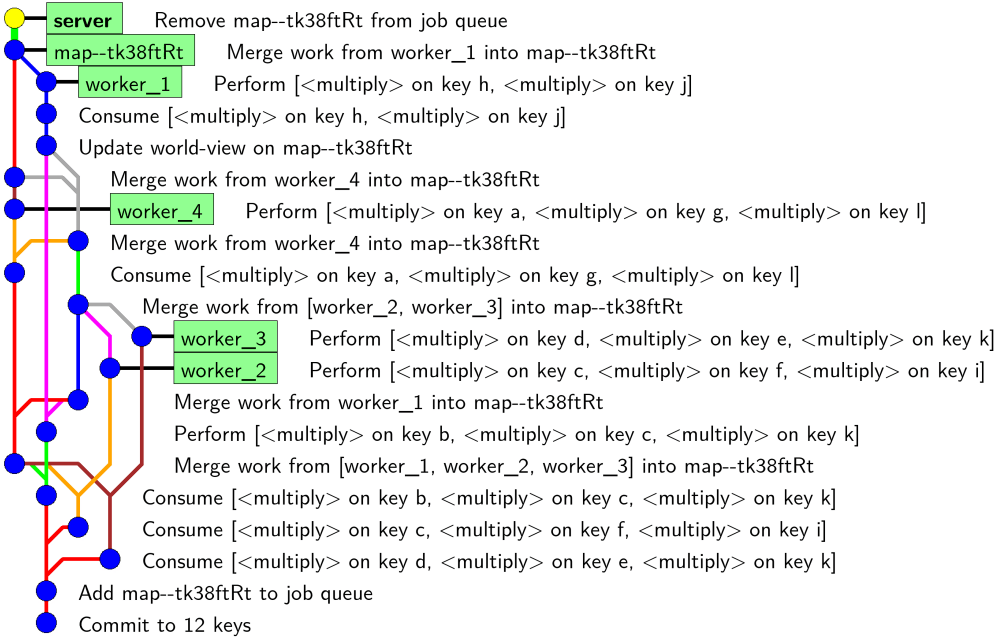

Work cluster scalability

Compare cluster performance to Amdahl's law prediction:

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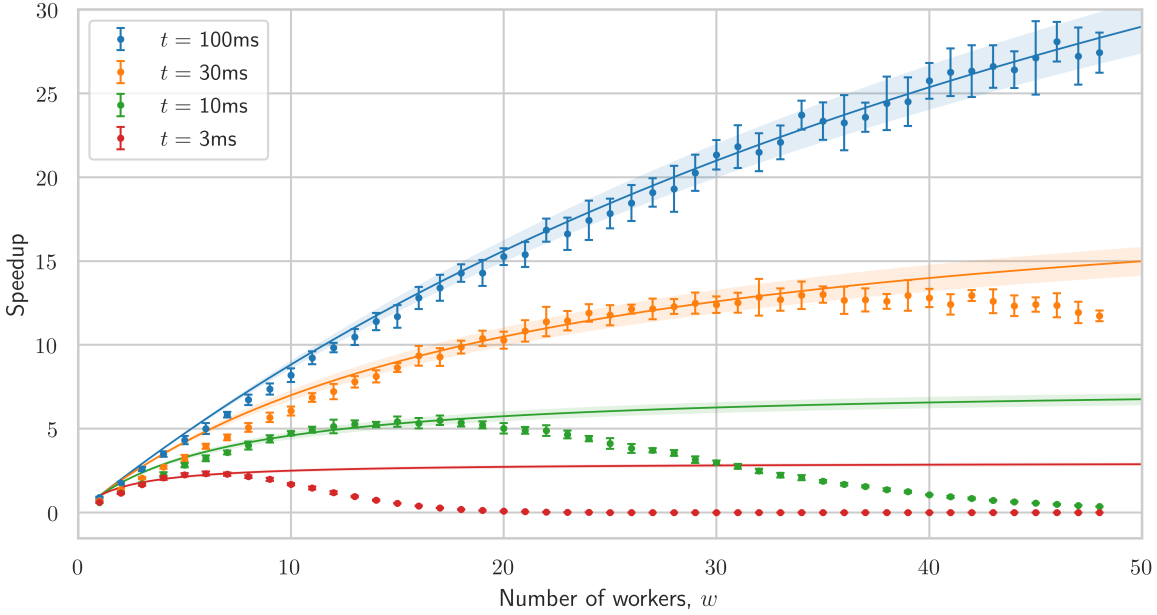
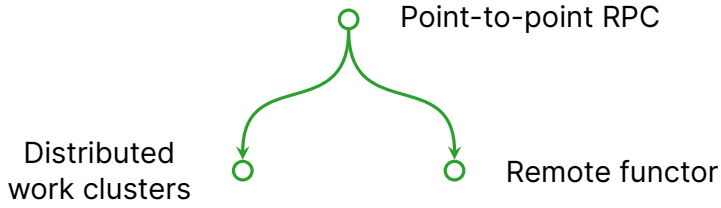
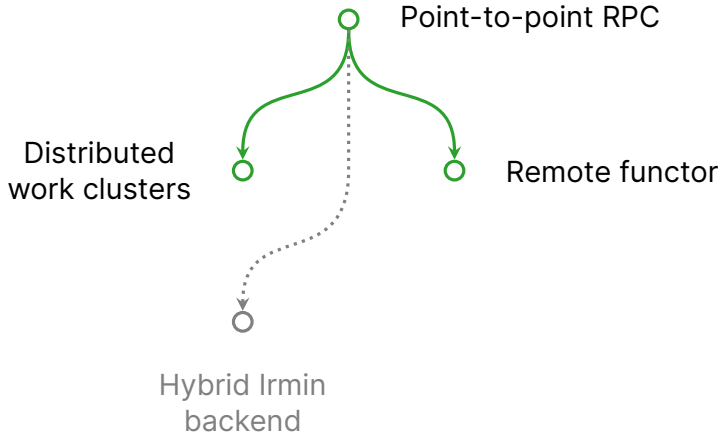


What next?


Point-to-point RPC
Distributed
work clusters
Remote functor

What next?


Point-to-point RPC
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Hybrid Irmin
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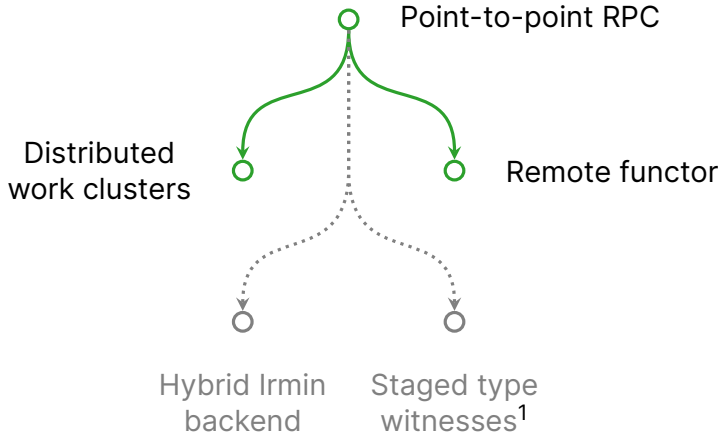

[1] N. Krishnaswami and J. Yallop. *A Typed, Algebraic Approach to Parsing*, 2019.

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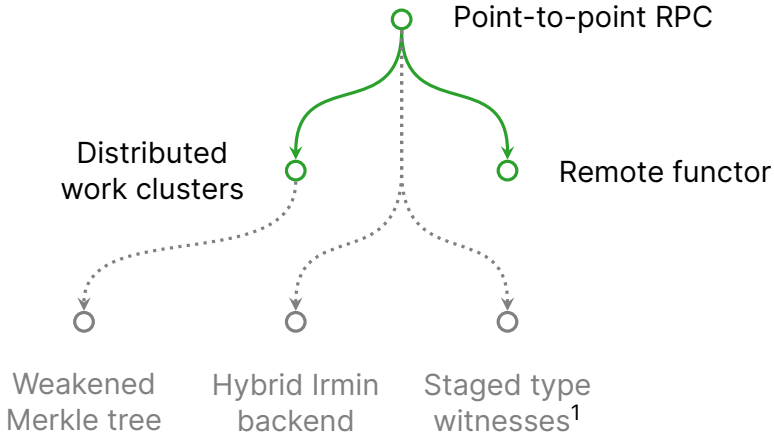

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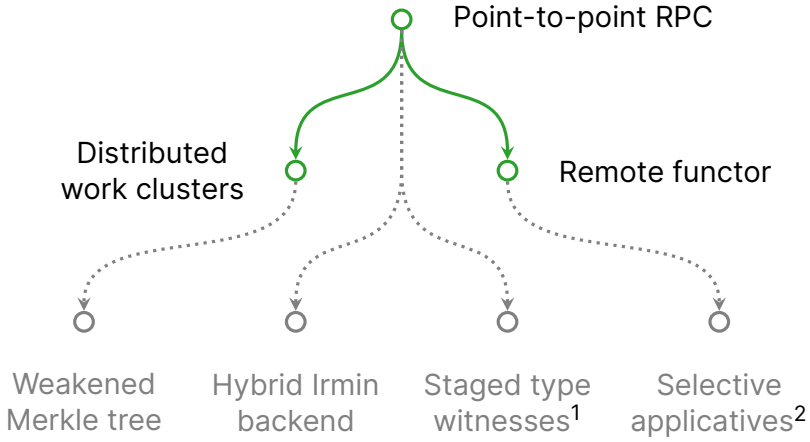

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[2] A. Mokhov et al. *Selective Applicative Functors*, 2019.

Take-away lessons

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2. Improve semantics by squashing the stack; use OCaml to maintain abstraction and flexibility.
3. Consider non-linear log structures in your programs; *casual* logs make it easy to reason about intent.

Thanks For Listening

Related work

(Much) more detail in the full dissertation:

`https://craigfe.io/out/causalrpc.pdf`

mergeable types

- Conflict-free replicated datatypes. [M. Shapiro et al. 2011]
- Mergeable types. [B Farinier et al. 2015]

embedded DSLs for RPC

- Pickler combinators. [A. Kennedy. 2004]

patterns for remote execution

- Remote functors. [A. Gill et al. 2015]
- Selective applicative functors. [A. Mokhov et al. 2019]

Work cluster performance