Performance Benchmarking of FHIR Terminology Operations in ETL Jobs

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MIE 2023
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Motivation

- National initiatives demand data from Healthcare providers for selected use cases
- ETL jobs perform data mapping for these iniatives into standardized formats
  - Syntactic mapping: transfer a datum into a standardized data structure (e.g. from relational data, HL7 v2, … to HL7 FHIR profile, openEHR template, ...)
  - Semantic mappings
    - *Unit conversions (e.g. from internal unit codes to UCUM)*
    - *NLP and other AI methods*
    - Mapping of coded data (e.g. from internal laboratory codes to LOINC)

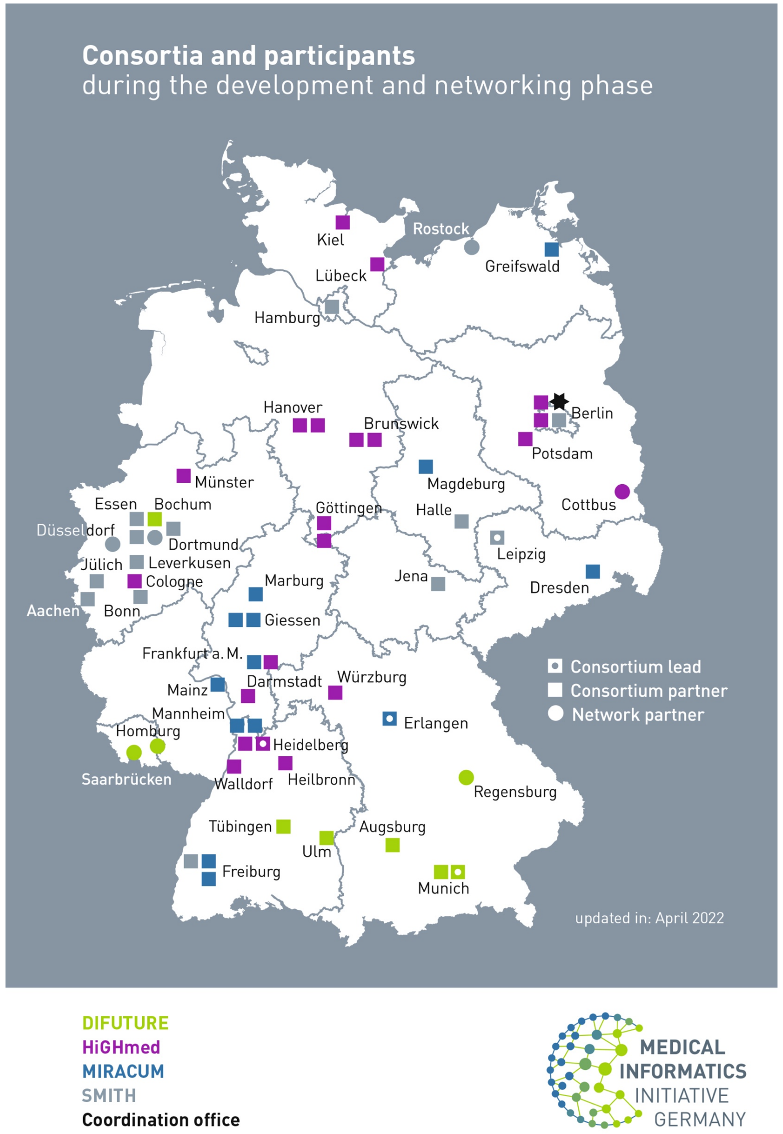


Image: https://www.medizininformatik-initiative.de/en/about-initiative

HL7 FHIR Terminology Module

- Groundwork for terminology servers
- Framework has seen broad use, even outside of HL7 FHIR
- Definition of *resources* for terminological content
- Definition of *operations* between a client system and a server/system providing these resources
  - *Is a code a member of a CodeSystem/ ValueSet?* (CS/$validate-code)
  - *What is the definition of a code in this CodeSystem?* (CS/$lookup)
  - *Map from this code to this code using this ConceptMap* (CS/$translate)
  - …

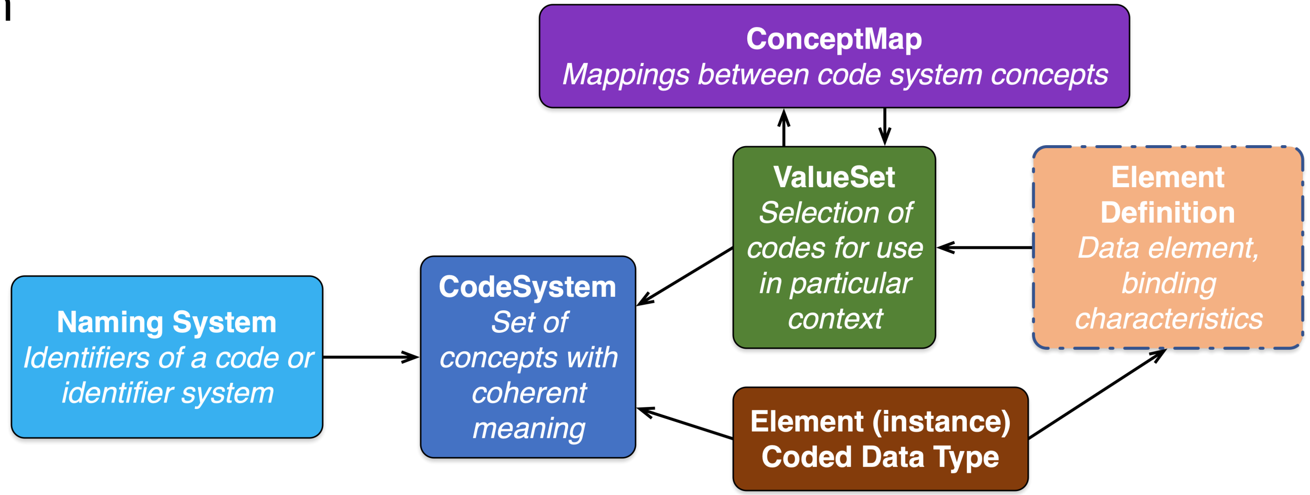
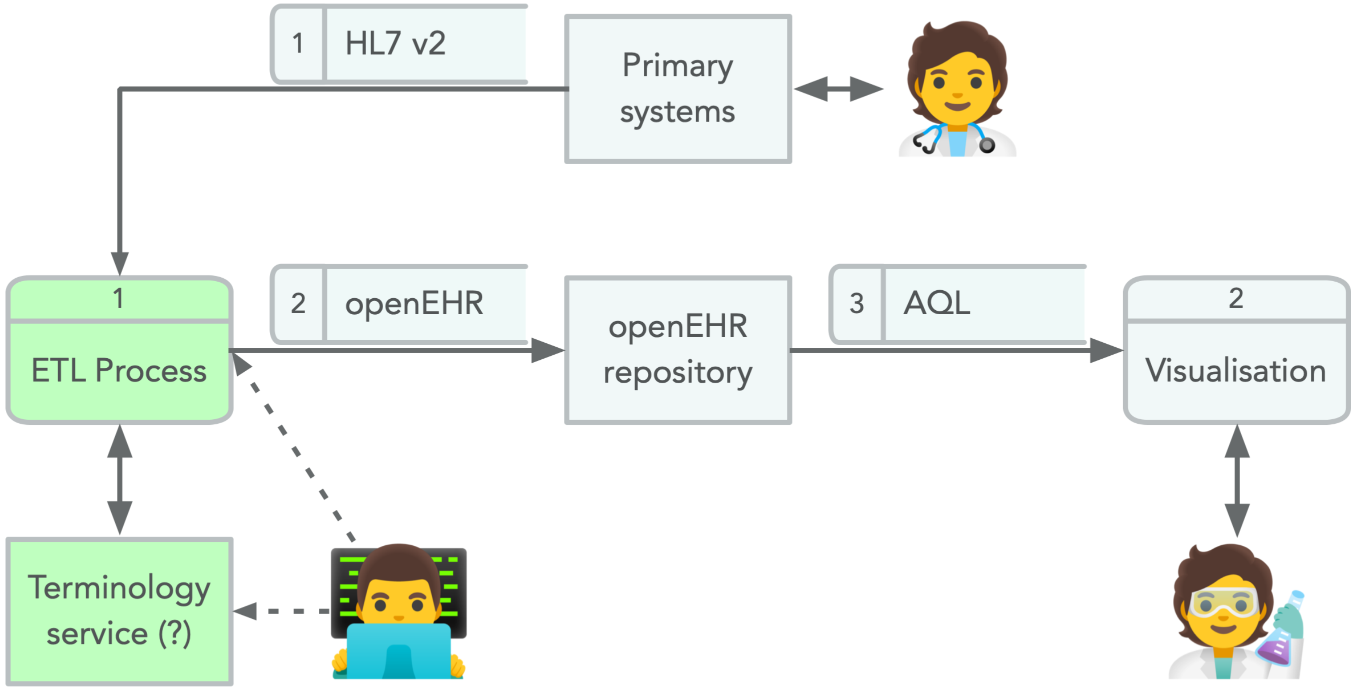

ConceptMap
Mappings between code system concepts
ValueSet
Selection of codes for use in particular context
Element Definition
Data element, binding characteristics
Naming System
Identifiers of a code or identifier system
CodeSystem
Set of concepts with coherent meaning
Element (instance)
Coded Data Type

Image: https://www.hl7.org/fhir/terminology-module.html [simplified]

Benchmarking FHIR Terminology

- Use Case: ETL job for a partner in the Use Case *Infection Control* of the *HiGHmed* consortium of the MI-I
- We have access to a high-performance terminology server (locally), but…
  - Dependency on server during all phases of development and deployment
  - Performance impact/bottleneck of continuous HTTP requests to the server?
  - Importance of caching?



Emoji: Google Noto Color Emoji, OFL

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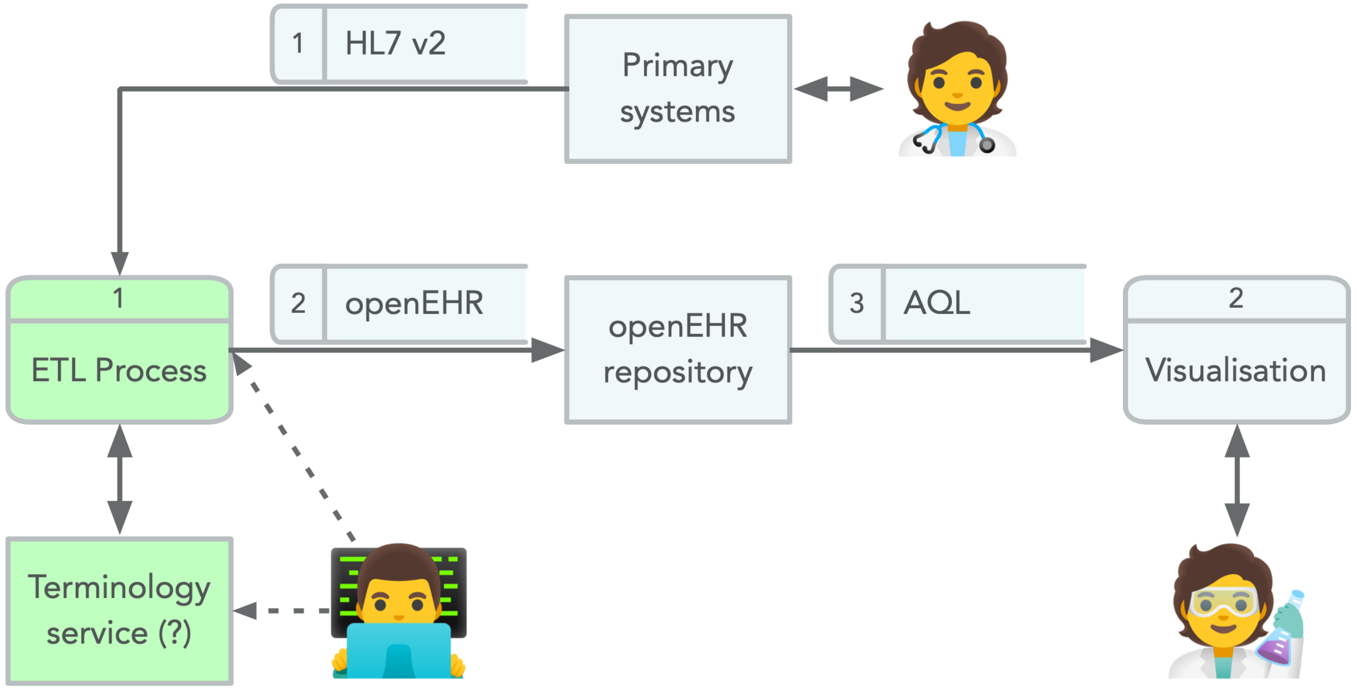

How do I integrate terminology services into my ETL job without incurring a significant bottleneck?

Emoji: Google Noto Color Emoji, OFL

Benchmarking setup

- measurement of ops/s for two operations
  - *CodeSystem/$lookup*
  - *ConceptMap/$translate*
- Multiple implementations of the same functionality benchmarked one after the other
- Several different approaches to caching
- Generation of test dataset from real-world resources
  - $ops/s_{input} \gg ops/s_{operations}$

https://github.com/openjdk/jmh

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- JMH: *Java Microbenchmarking Harness*
- Industry-standard setup for generating reliable benchmarks
- JMH greatly simplifies benchmarking setup, but *caveat emptor*!

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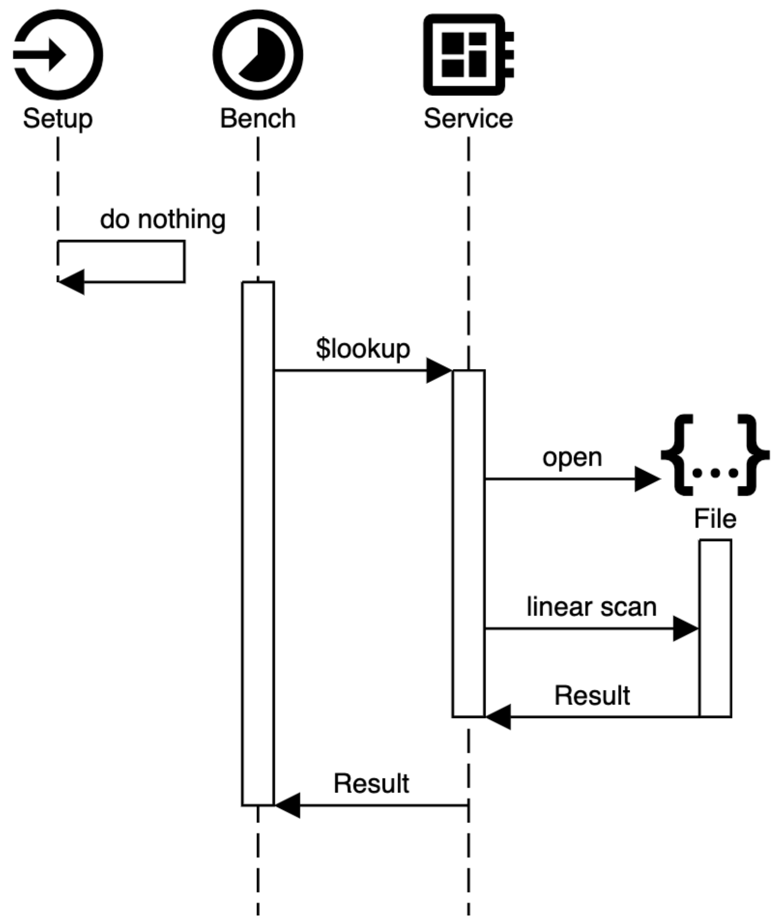
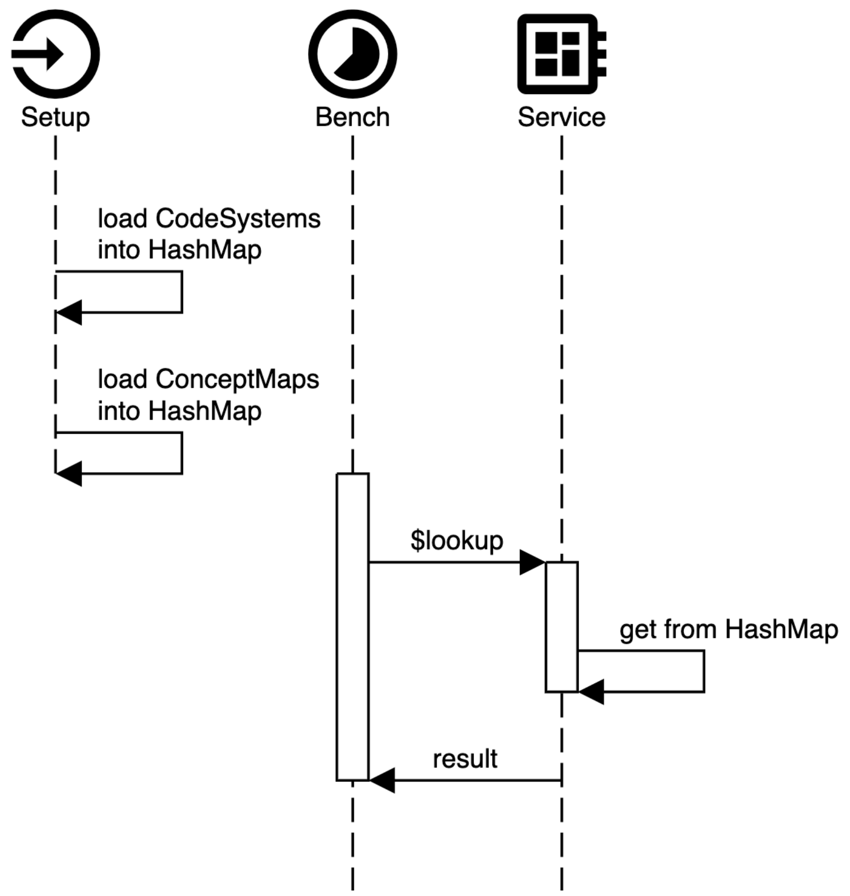
Implementations

File



RAM HashMap



Icons: Material Design Icons via https://pictogrammers.github.io/@mdi/font/6.9.96

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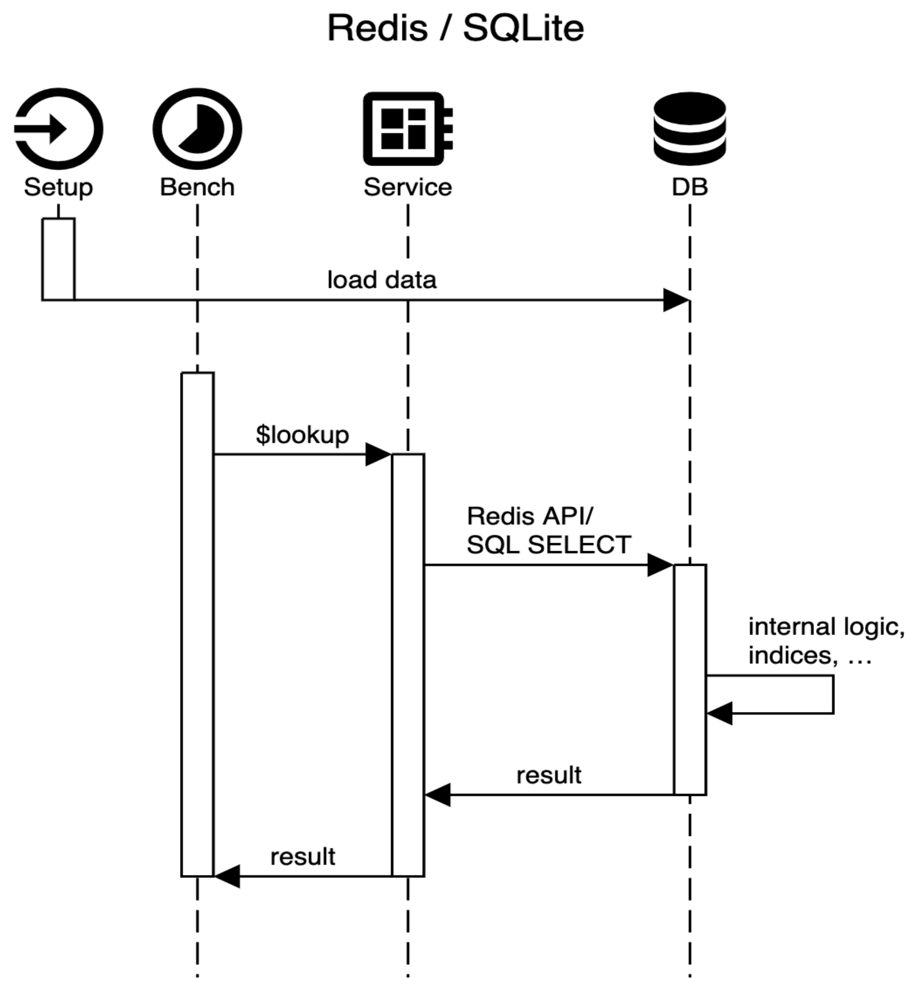

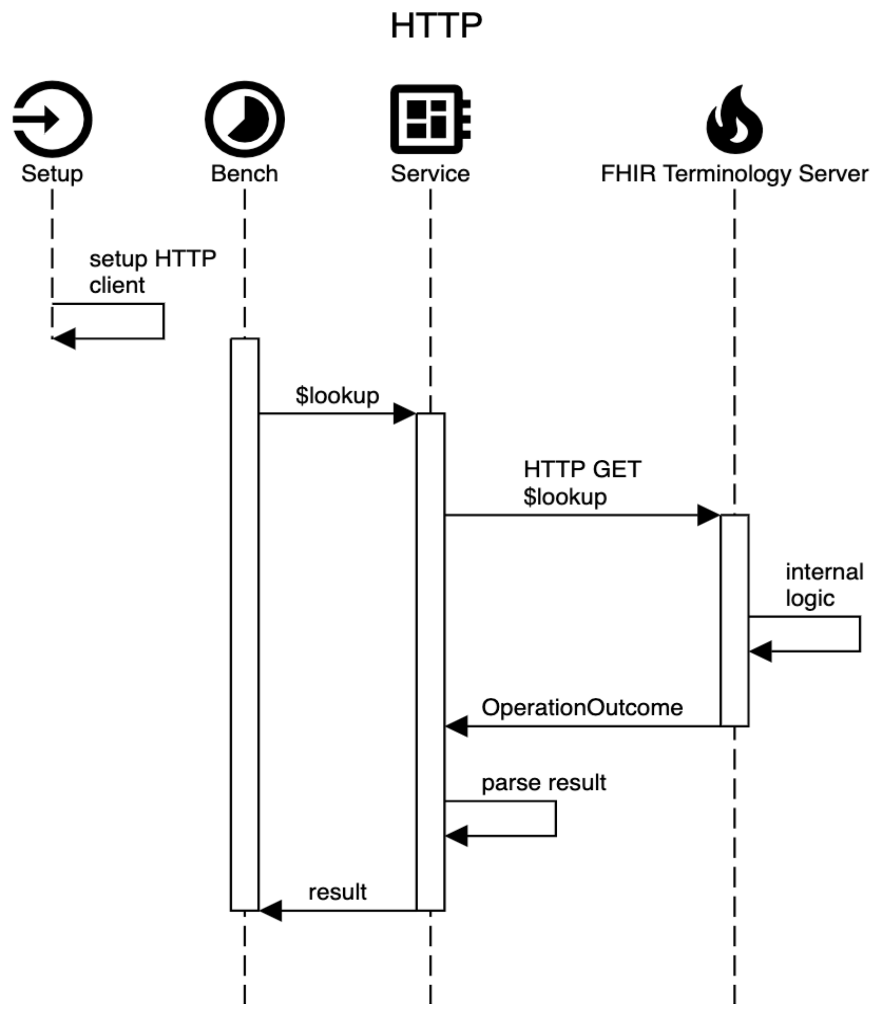

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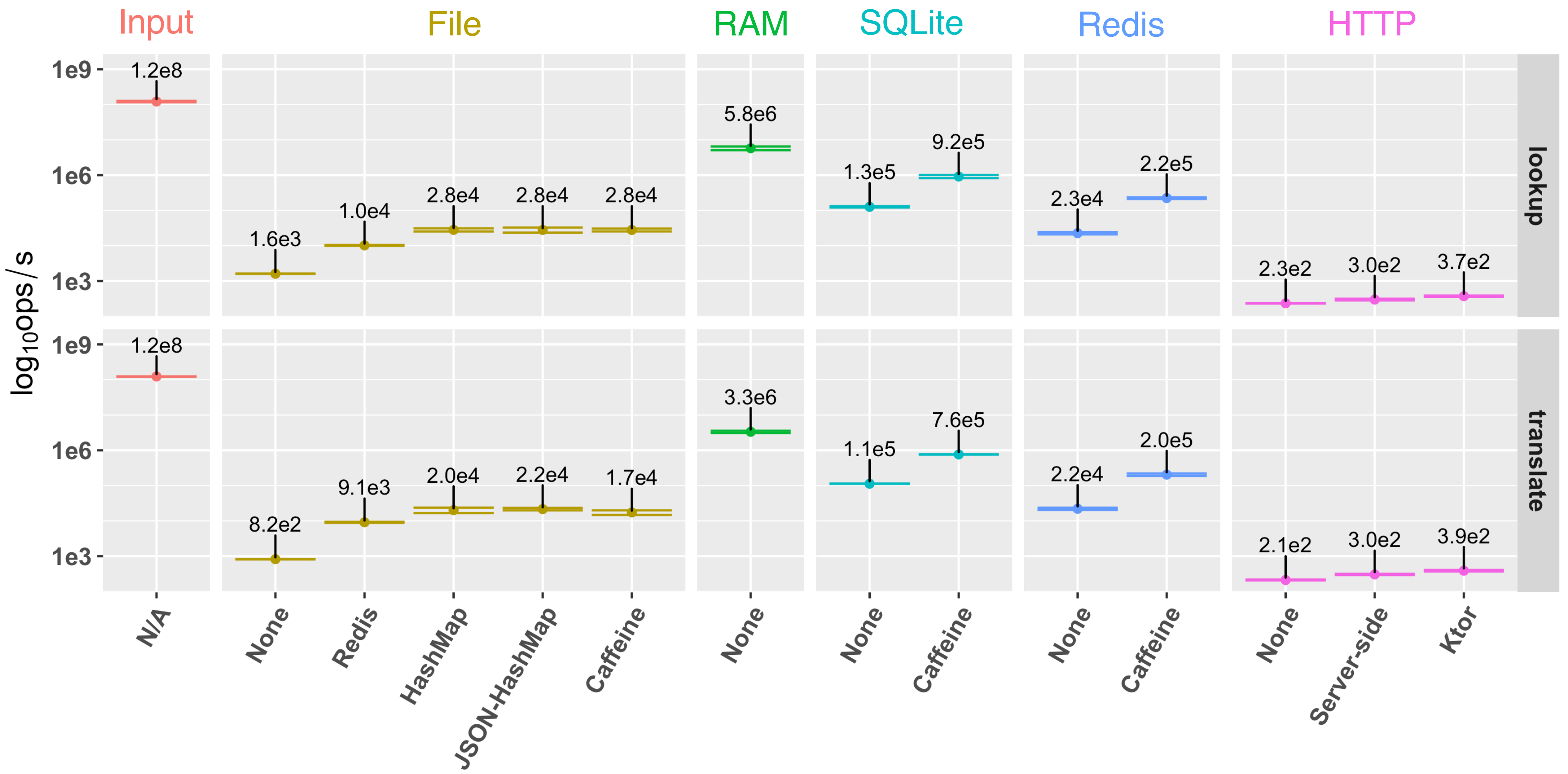
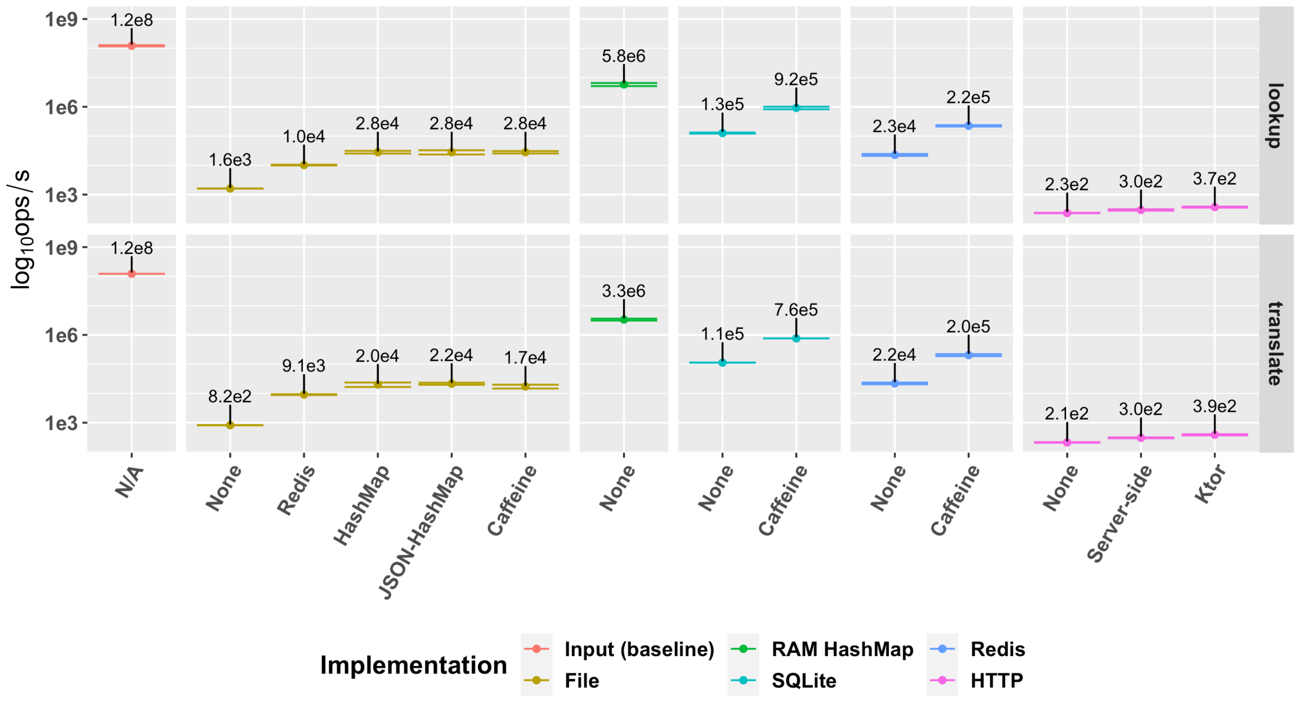
Results


Input
File
RAM
SQLite
Redis
HTTP
log10ops/s
1e9
1e6
1e3
lookup
translate
1.2e8
1.6e3
1.0e4
2.8e4
2.8e4
2.8e4
5.8e6
1.3e5
9.2e5
2.3e4
2.2e5
2.3e2
3.0e2
3.7e2
1.2e8
8.2e2
9.1e3
2.0e4
2.2e4
1.7e4
3.3e6
1.1e5
7.6e5
2.2e4
2.0e5
2.1e2
3.0e2
3.9e2
N/A
None
Redis
HashMap
JSON-HashMap
Caffeine
None
None
Caffeine
None
Caffeine
None
Server-side
Ktor

Results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2.8e4
5.8e6
1.3e5
9.2e5
2.3e4
2.2e5
2.3e2
3.0e2
3.7e2
1.2e8
8.2e2
9.1e3
2.0e4
2.2e4
1.7e4
3.3e6
1.1e5
7.6e5
2.2e4
2.0e5
2.1e2
3.0e2
3.9e2
N/A
None
Redis
HashMap
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Caffeine
None
None
Caffeine
None
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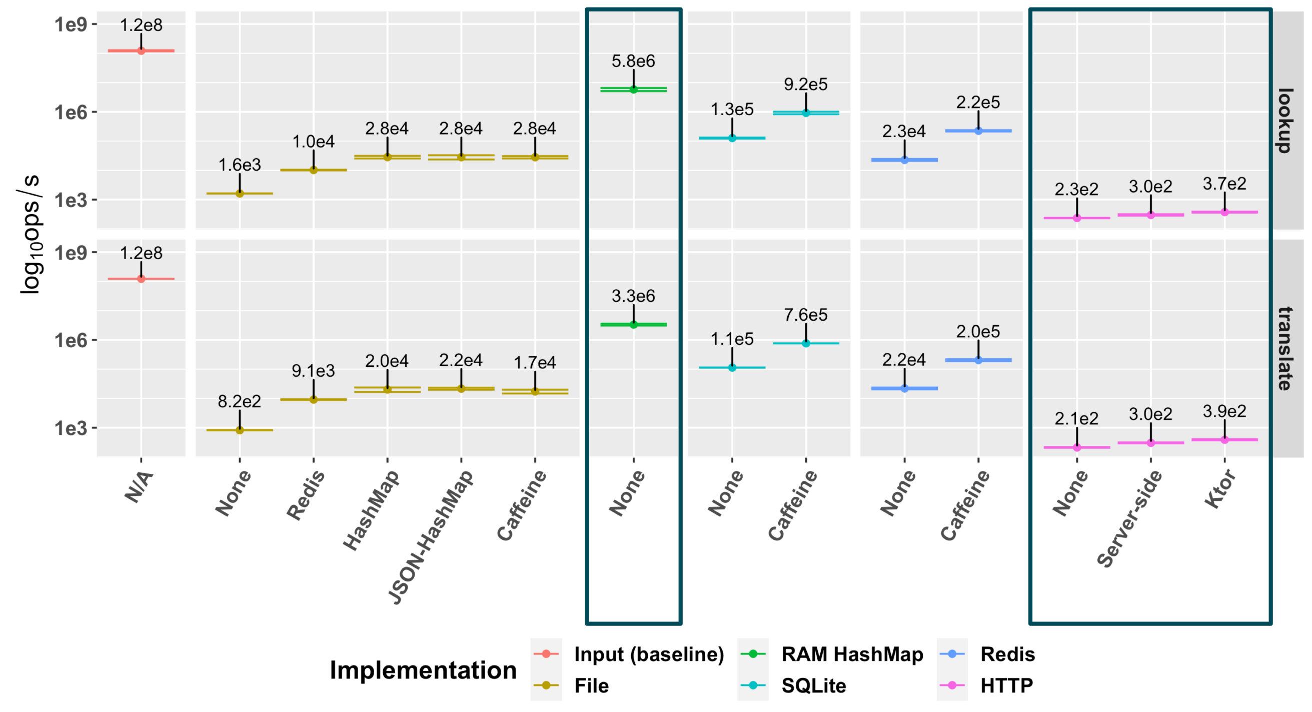
Server-side
Ktor
Implementation
Input (baseline)
File
RAM HashMap
SQLite
Redis
HTTP

Results



- HTTP is the slowest, while RAM is the fastest

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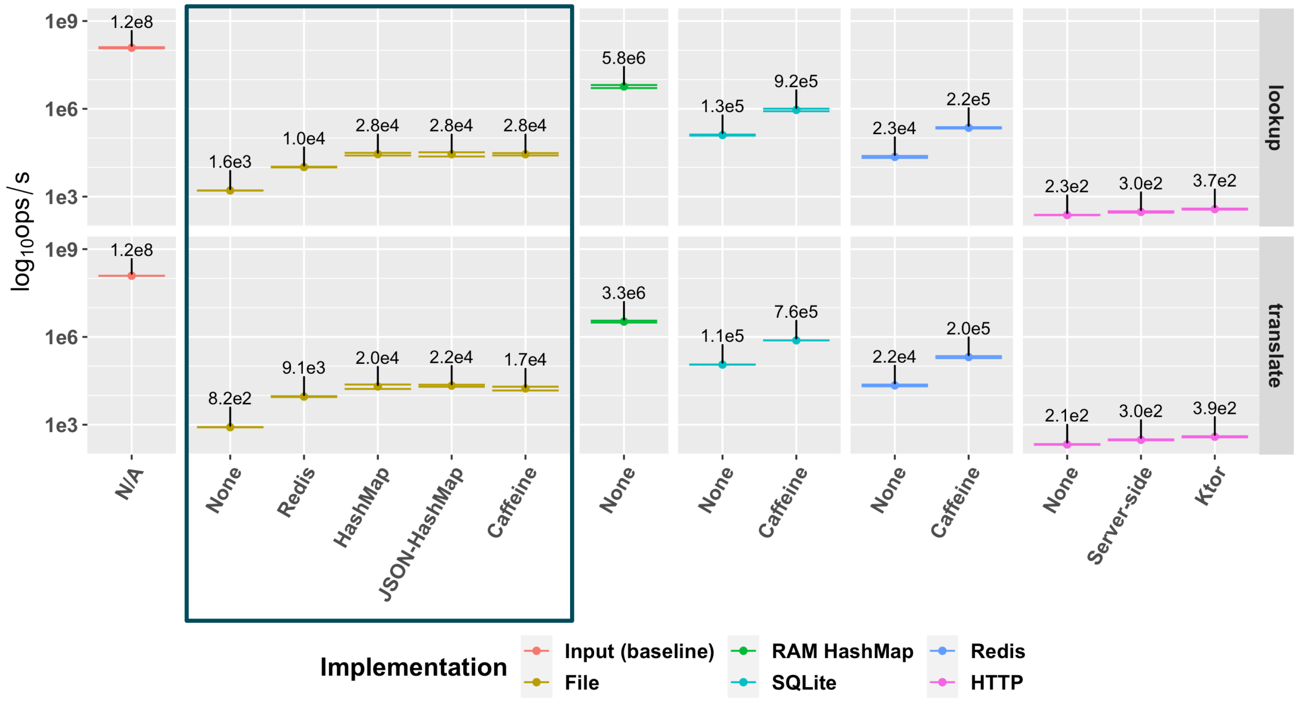

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- Caching is very beneficial for all operations
  - Implementation of the cache is not as important

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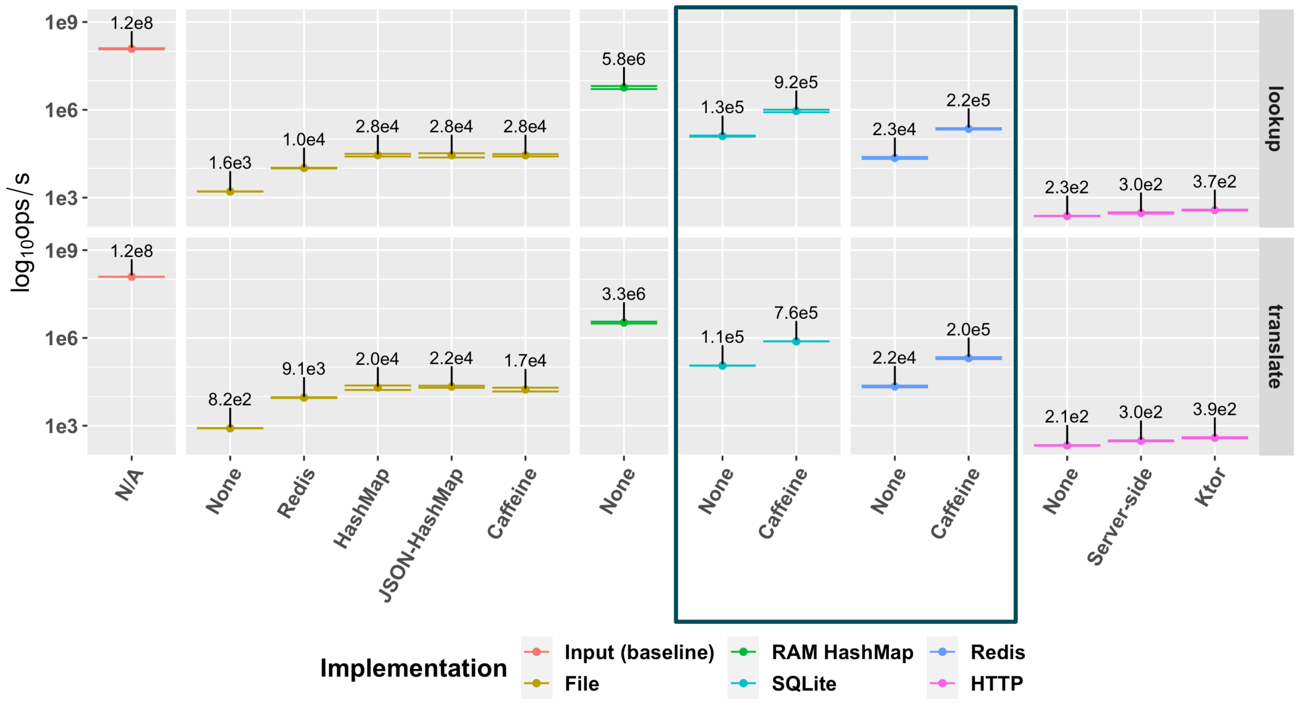

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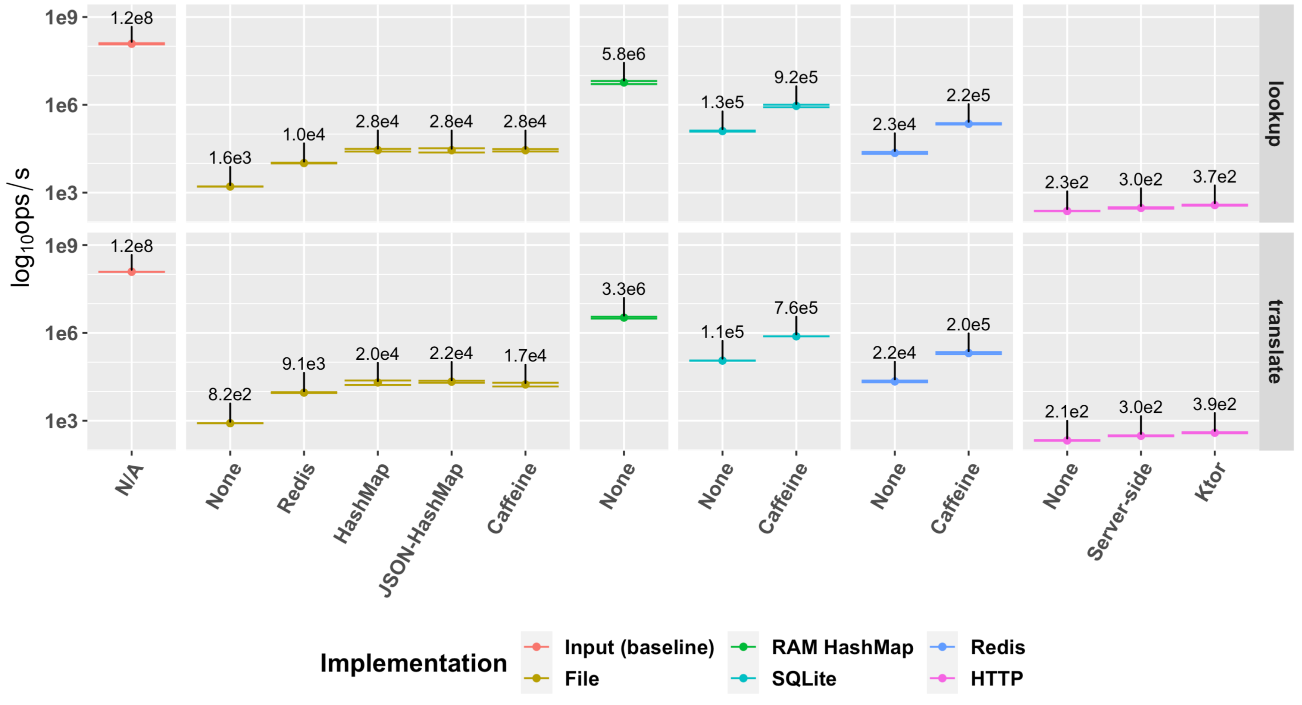

- HTTP is the slowest, while RAM is the fastest
- Caching is very beneficial for all operations
  - Implementation of the cache is not as important
- Network operations may hurt performance (Redis vs SQLite)
- *$translate* is more involved than *$lookup*, but pattern is similar

Discussion

- Obvious limitations of this study
- Caching is important!
- Local solutions will often perform better than querying a FHIR TS across the Internet
  - Need for national and supranational provision of relevant resources for local deployment
  - Rolling your own solution is not trivial!
- Requirements and circumstances of the individual deployment must be taken into account when incorporating local terminology operations
  - Maybe even perform your own benchmarks on your own hardware
  - Consider hybrid approaches: delegate complex operations and implement simple ops yourself

Contact

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