DATA 2019 Paper #21

Distributed and scalable platform for collaborative analysis of massive time series data sets

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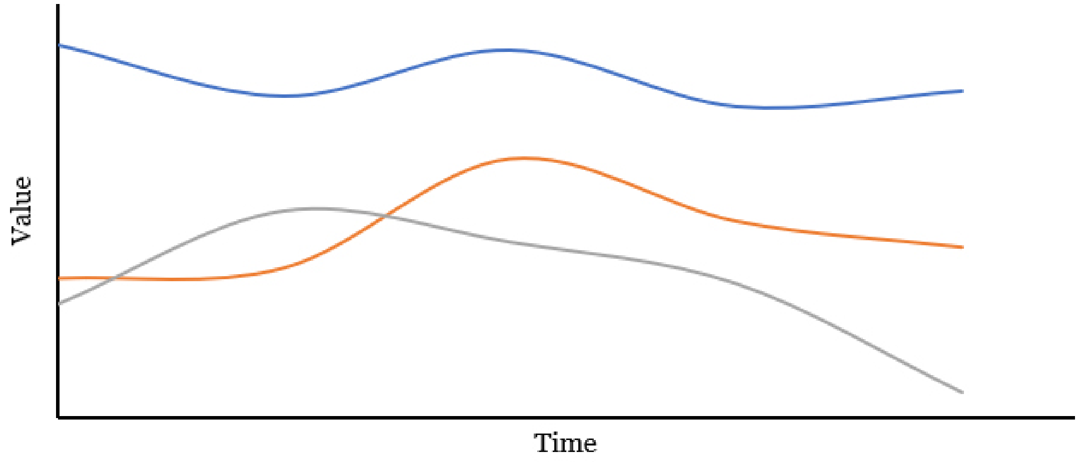
Fundo Europeu de Desenvolvimento Regional

Introduction

- metrification of devices;
  - e.g. wearable gadgets, real-time IoT sensors, Smart Home devices
- annual data acquisition rate:
  - 2016 – 1.2 zb/y;
  - 2021 – 3.3 zb/y;
- requirements for digital data processing and storage are increasing exponentially;
- Volume, Variety and Velocity;
- <u>Value</u> and <u>Veracity</u>.

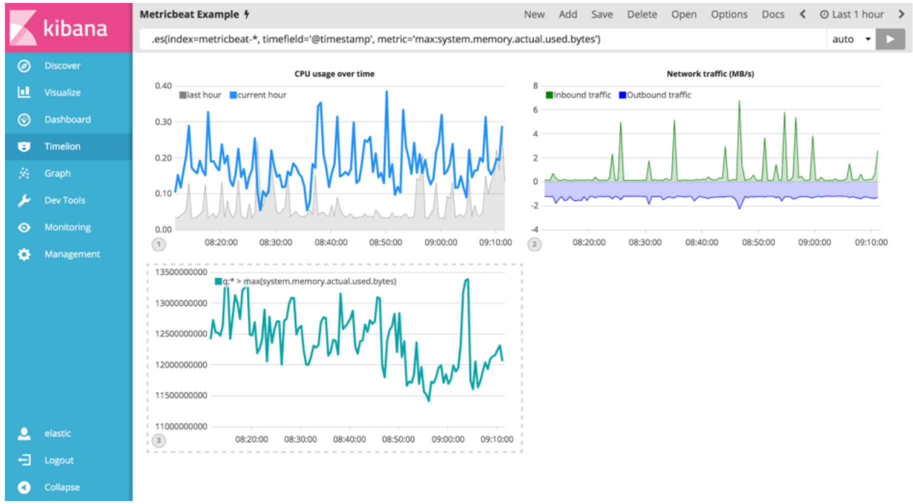
Introduction Time series analysis



- some metrics only have meaning when observed as a pattern over time;
- **time series** can be found in almost every aspect of human life;
- most domains produce massive amounts of series data;
- analysis is more agile when within a software solution.

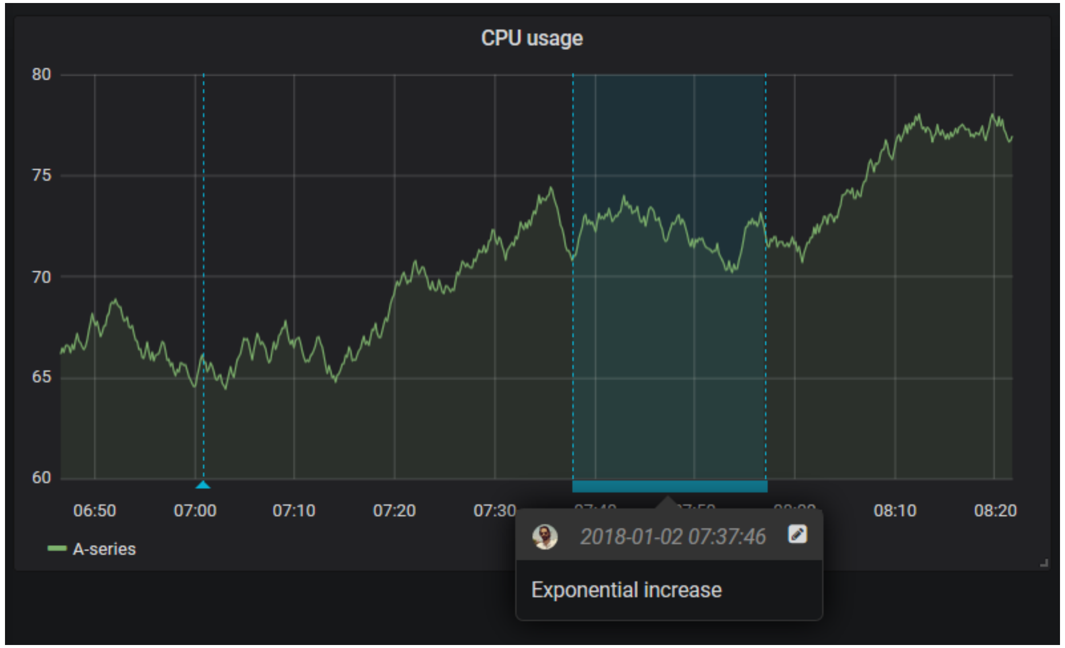
Introduction Time series visualization

- can be a very challenging task:
  - data sets commonly have high cardinality and complexity;
- comparative visualization tasks:
  - dashboard applications like Timelion, Grafana and Freeboard
- most analysis applications are built as web applications.



Introduction **Annotation**

- realistic analysis tasks involve collaboration and knowledge-sharing between human curators;
- **annotations** facilitate knowledge-building and decision-making in analysis processes.

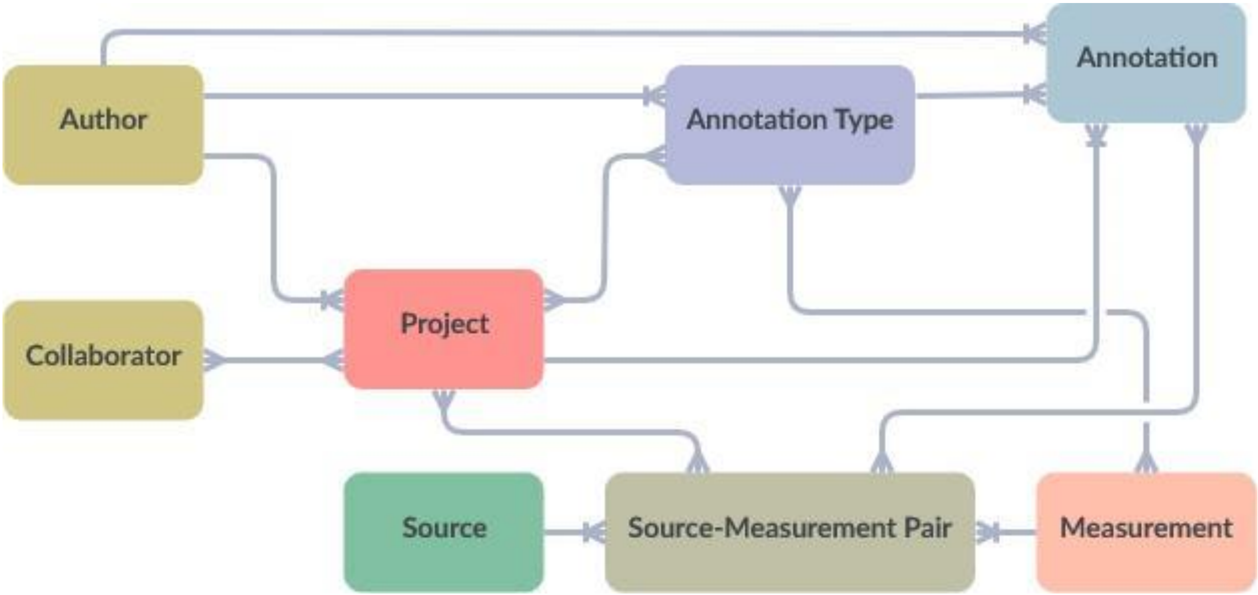


Proposal

- data-intensive architecture and web application for collaborative time series analysis;
- use most appropriate open-source tools for querying, storing and displaying time series and annotations;
- distributed architecture to handle high quantities of concurrent usage:
  - E+C for annotations, users and the knowledge base;
  - E+L for series.
- prototype tested with HVAC data set from 1000 boilers over 1.3 years.

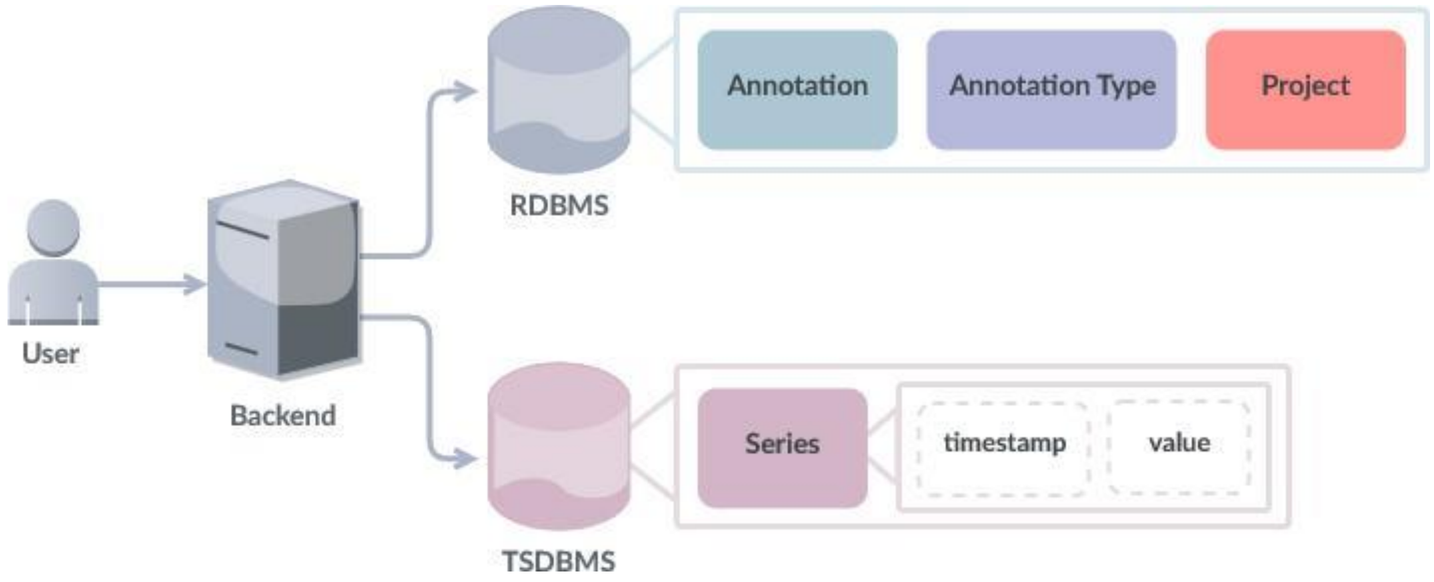
Proposal **Data model**

- time series has a **measurement** and a data **source**;
- annotations have a parent **type**, a point or ranged segment of time, and a set of affected series;
- **projects** restrict a set of collaborators to a segment of time, a set of series, and an annotation scope.



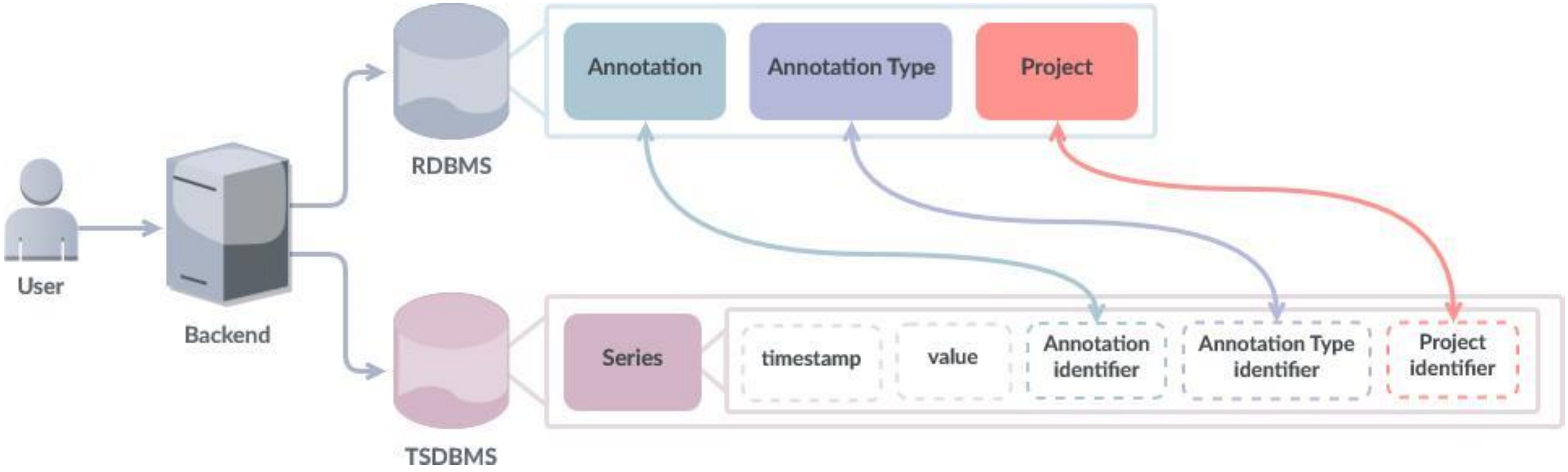
Proposal Data management

- polyglot persistence model:
  - time series are stored in InfluxDB, ontology is stored in PostgreSQL;
  - central backend enforces data access logic and conceals the real location of the data.

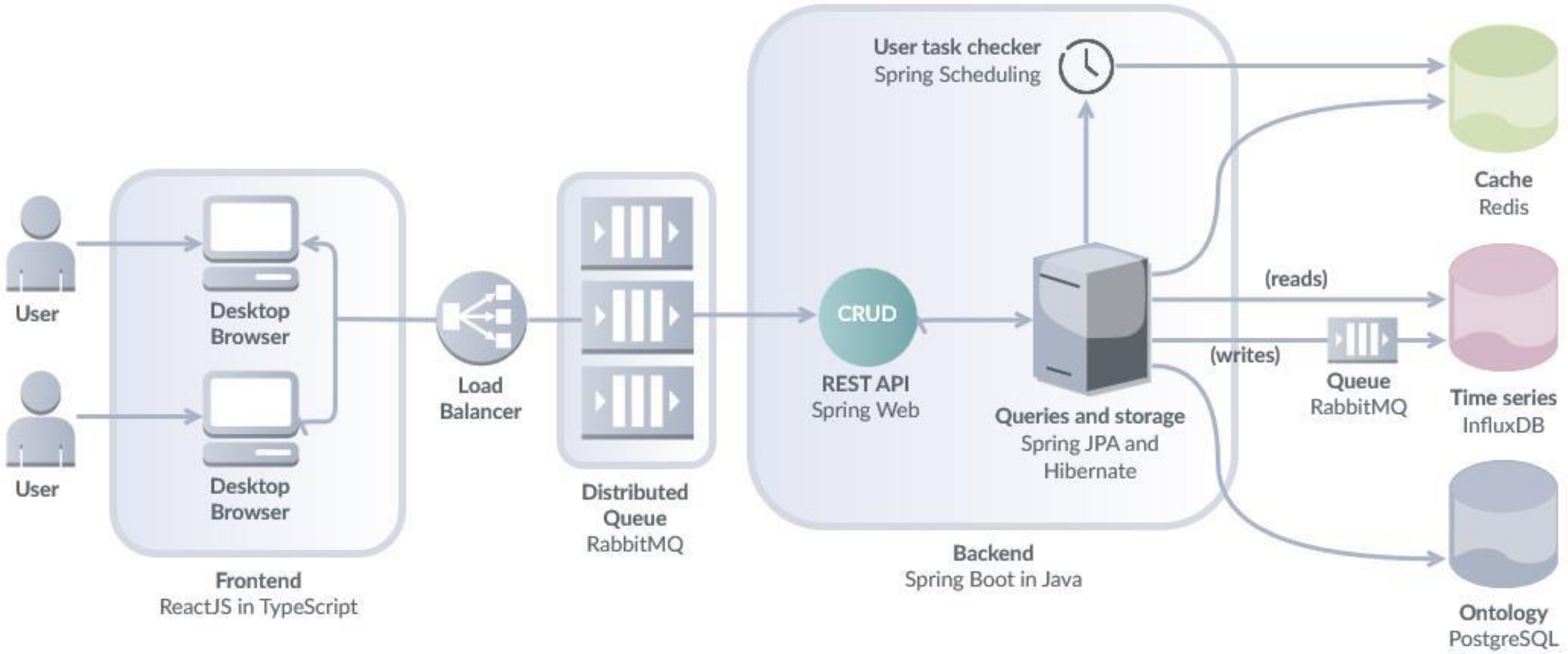


Proposal Data management

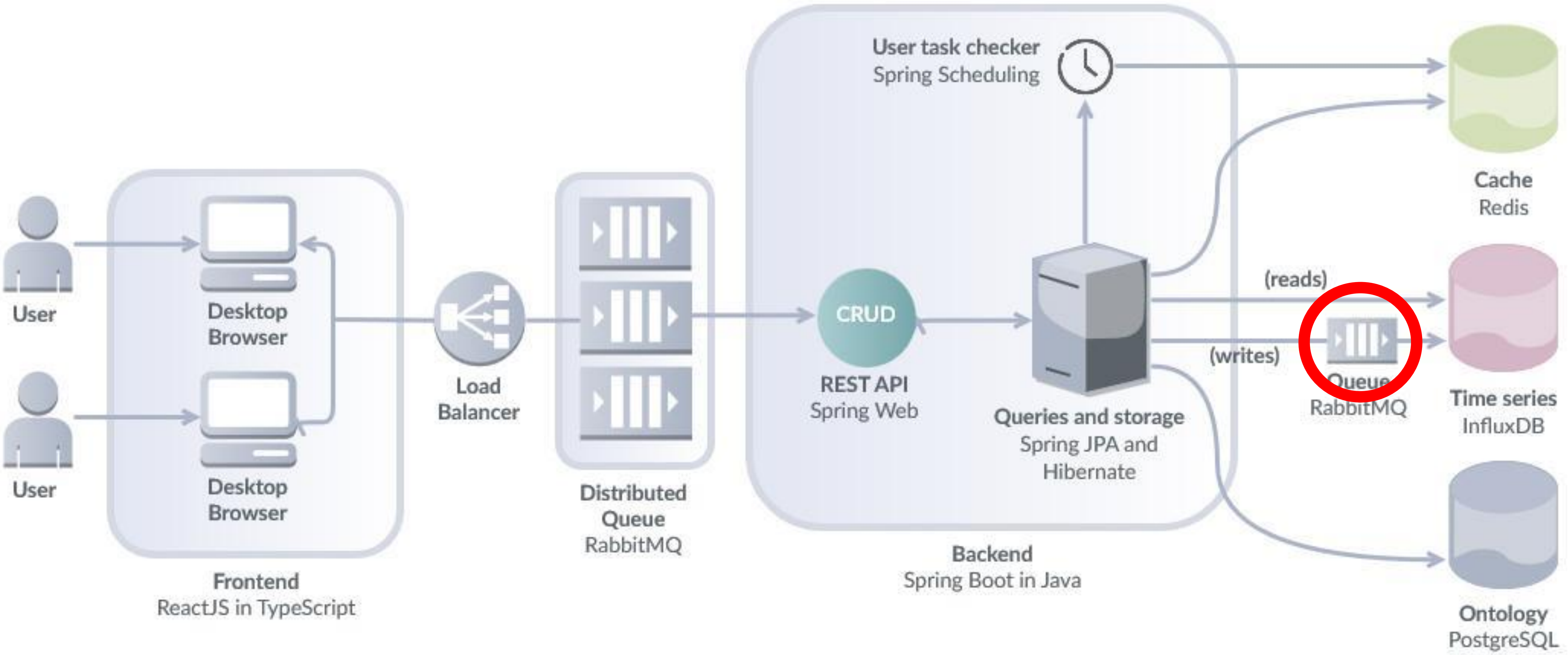
- overall traffic workload is distributed, but querying simultaneous data types can lead to bottlenecks;
- links are added on each data point and propagated to the TSDBMS on ontology updates.



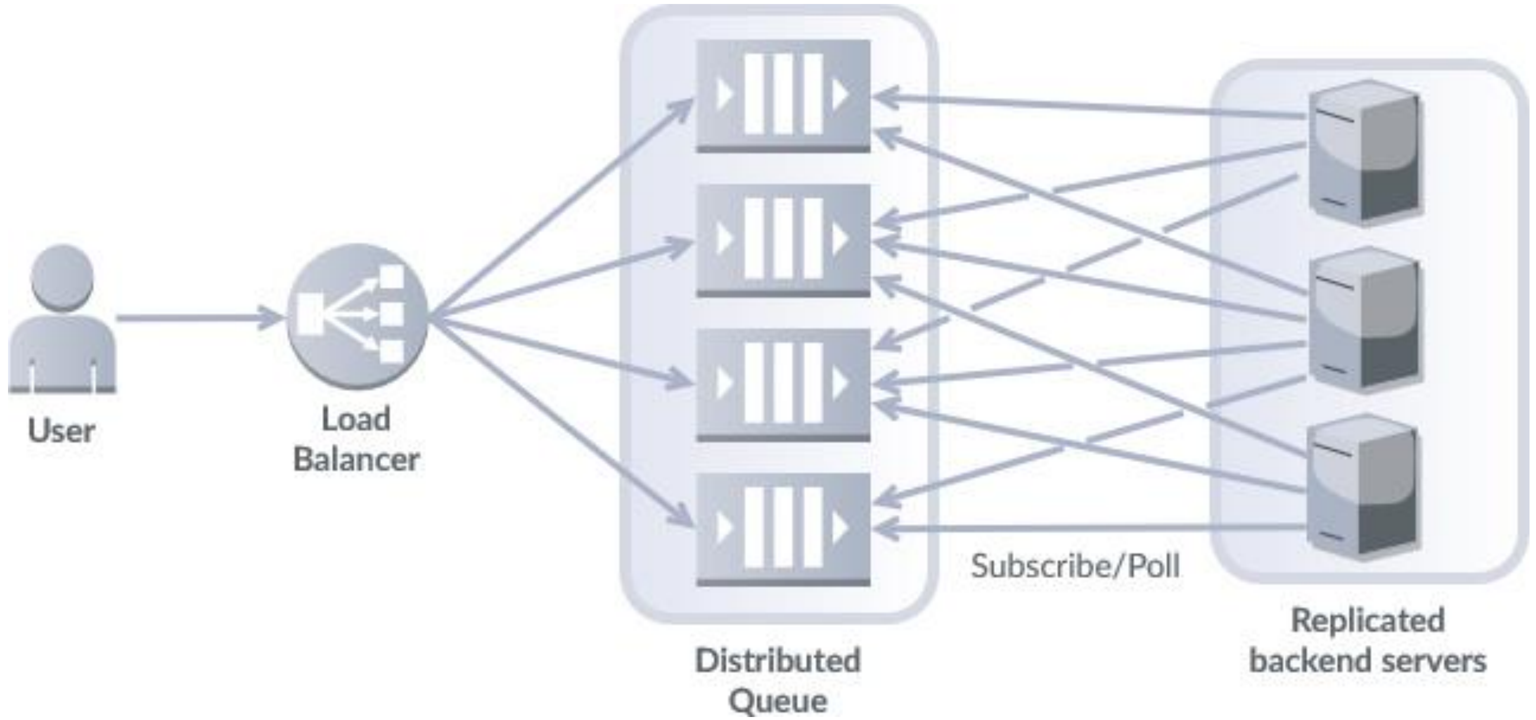
Proposal Architecture



Proposal Architecture

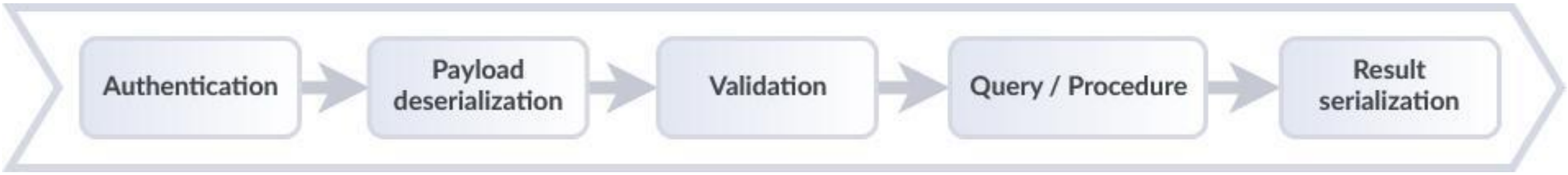


Proposal Architecture



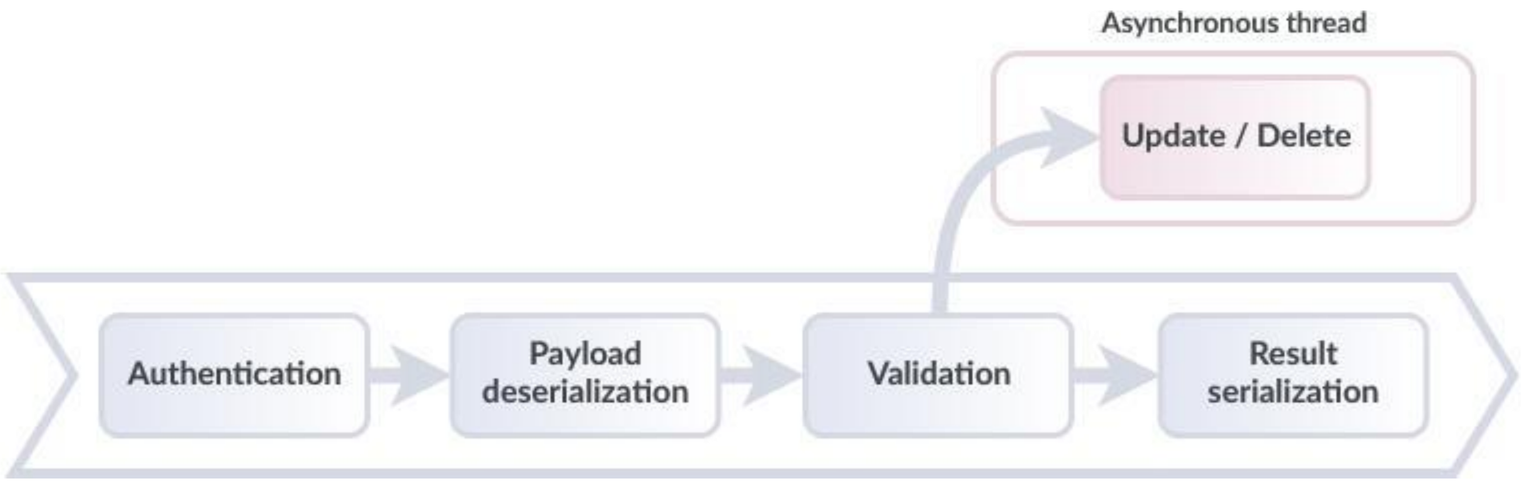
Proposal Architecture

- the backend opens processing pipelines for each request;
- authentication:
  - auth. session tokens are JWTs with an expiration date.
- validation stage checks for invalid contents or constraint violations



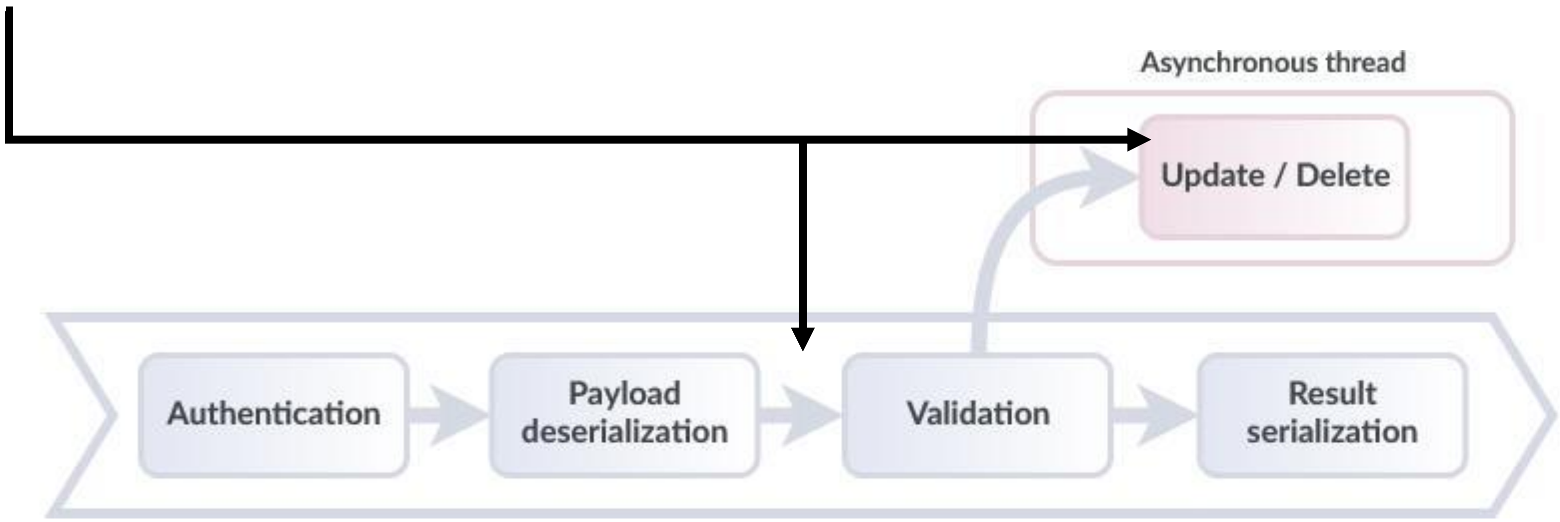
Proposal Architecture

- updates, deletions and rollbacks are made asynchronously:
  - user receives a simulated snapshot with proposed changes;
  - validation stage ensures that the update will likely be committed;
  - **caveat:** unexpected errors cannot be sent to the user.



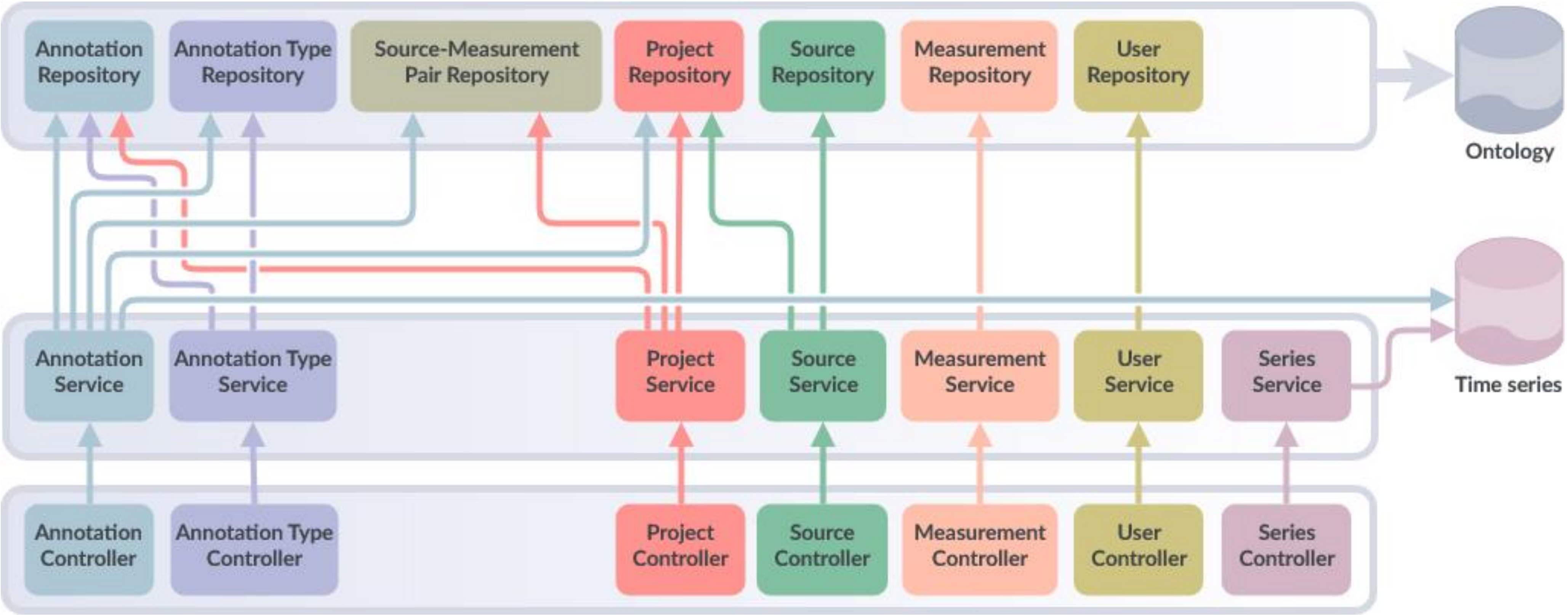
Proposal Architecture

- users make changes based on the observed data;
- if two users update the same record at the same time -> **race condition!!!**;
- optimistic-locking: last-modified dates checksum



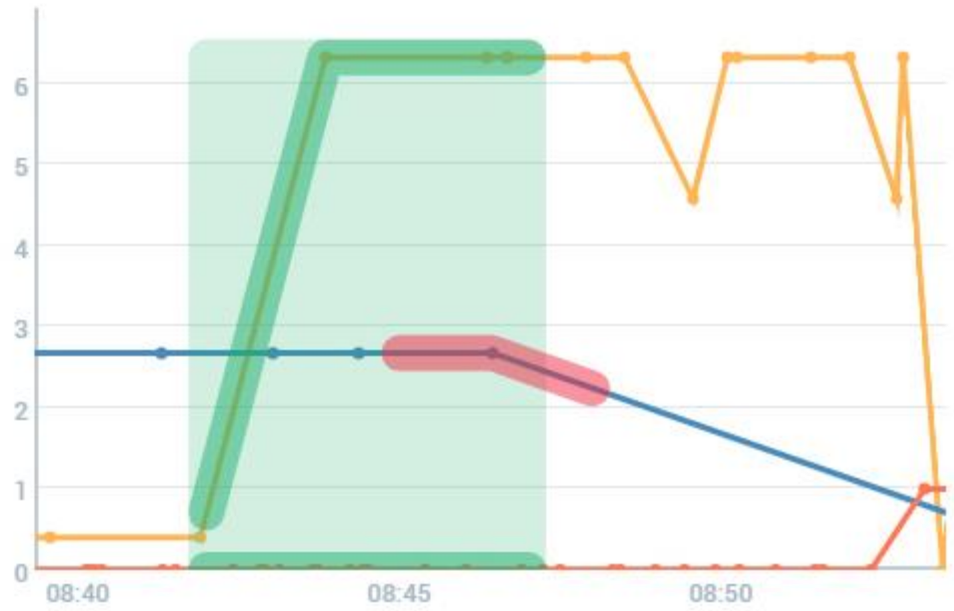
Proposal Architecture

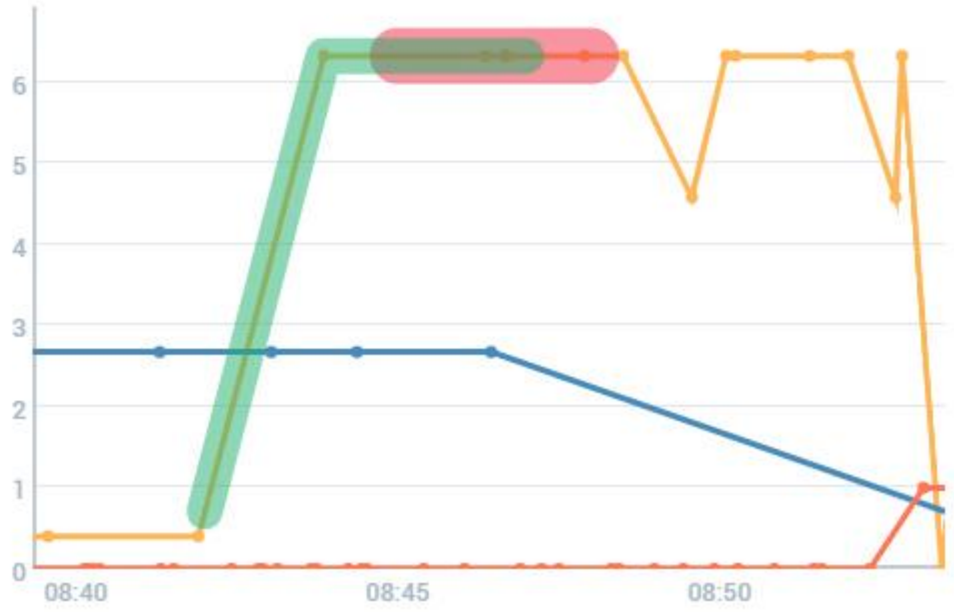
- Spring JPA provides abstraction layers for PostgreSQL queries (hot-swap)



Proposal Annotations

- snakes: arcs traced over series' curves;
- paint over existing points, interpolate when in-between;
- intersection handling (nesting).

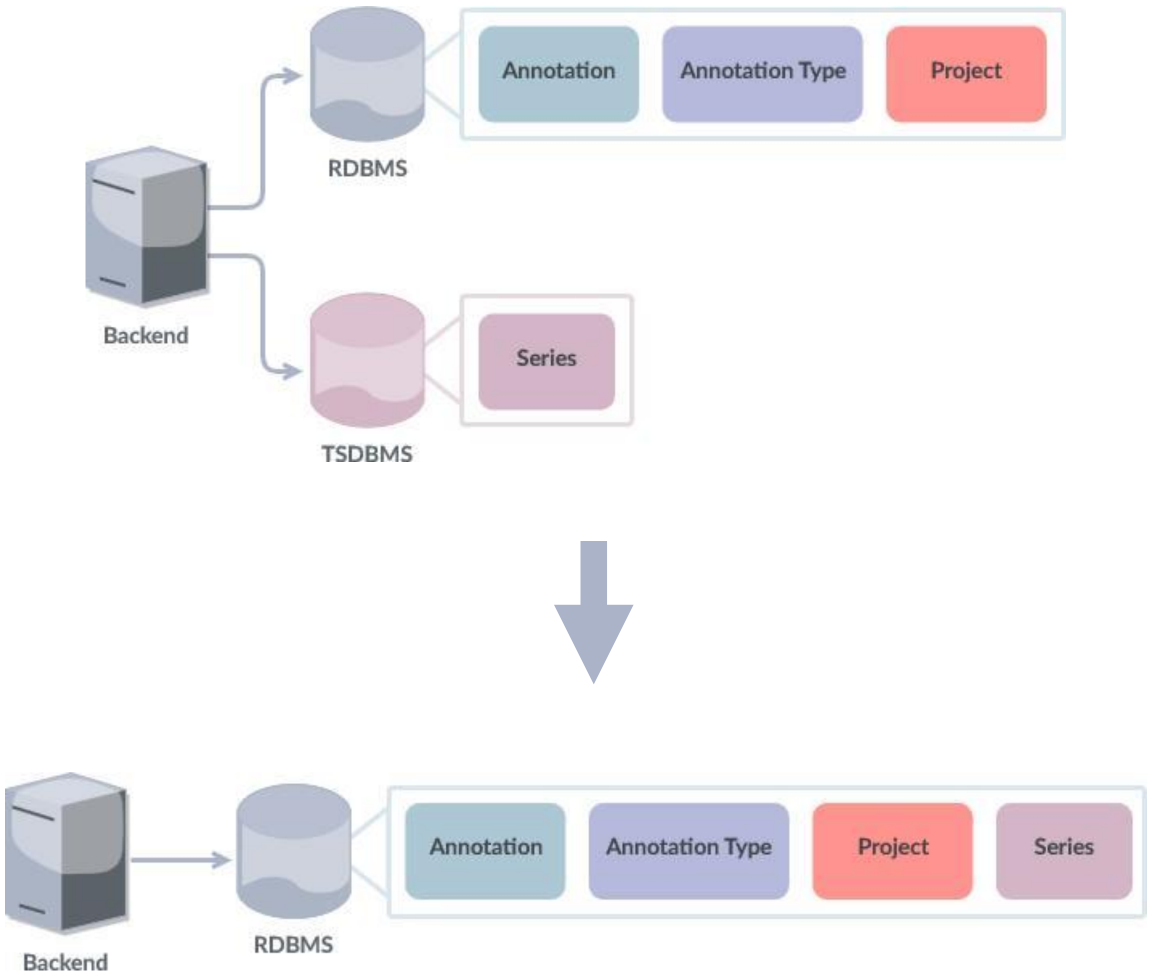




DEMO

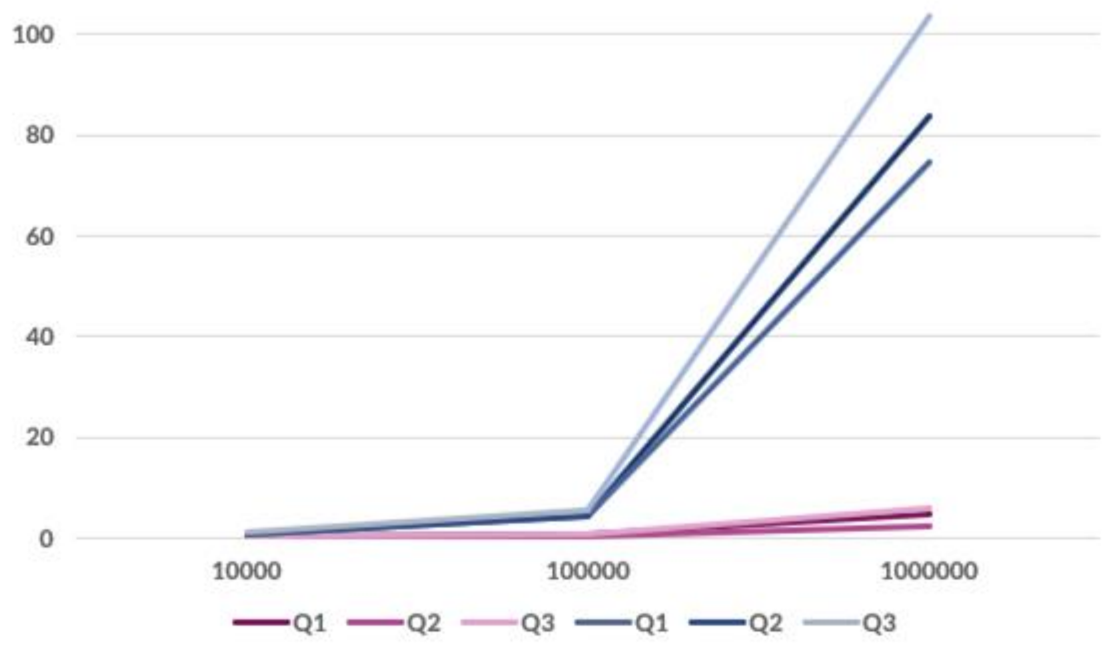
Evaluation **Time series in PostgreSQL**

- as granularity increases, Consistency is harder to attain;
- put all data in a single ACID-compliant RDBMS:
  - linking logic is built-in through the relational model;
  - better Consistency handling.
- benchmark read-write performance

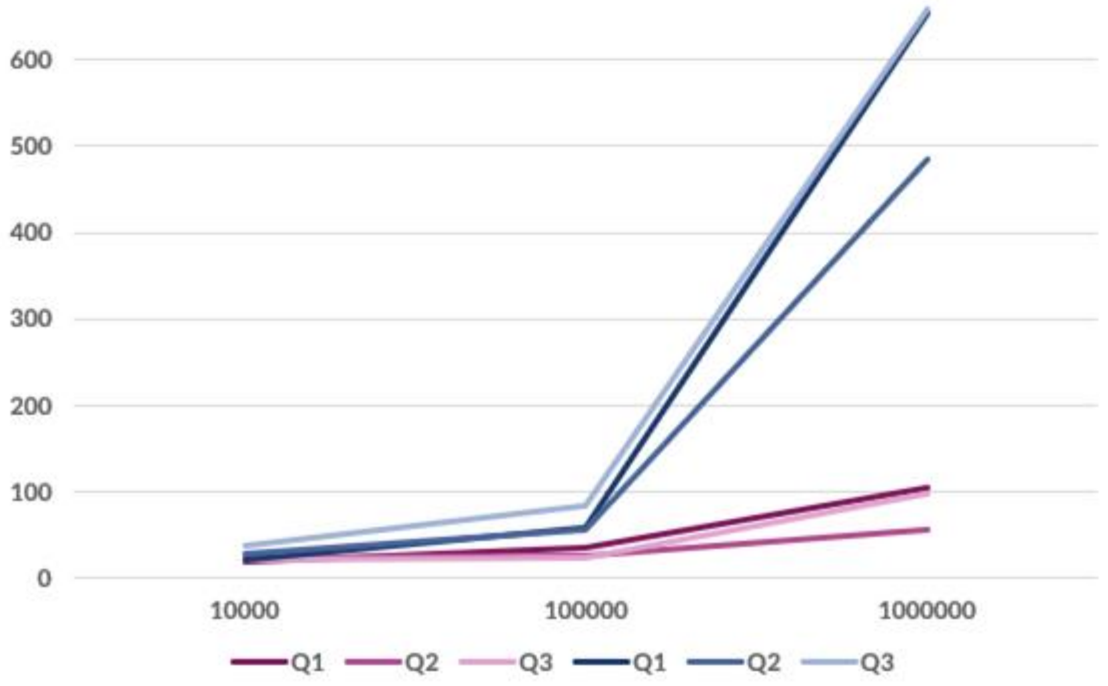


Evaluation Time series in PostgreSQL

READ PERFORMANCE



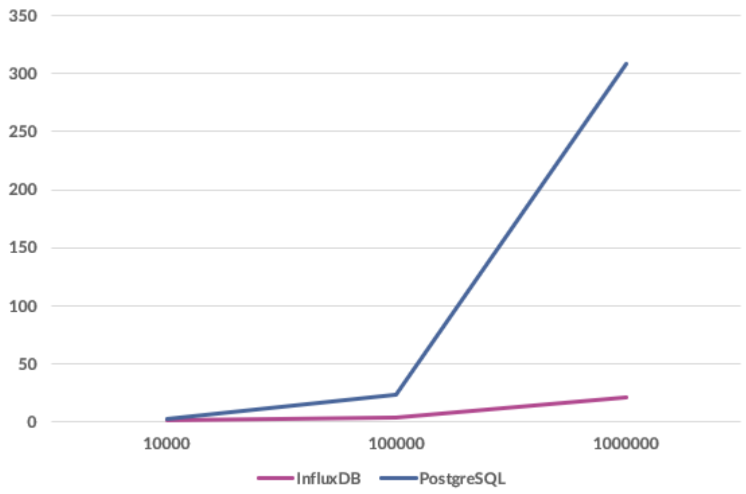
CPU (%)



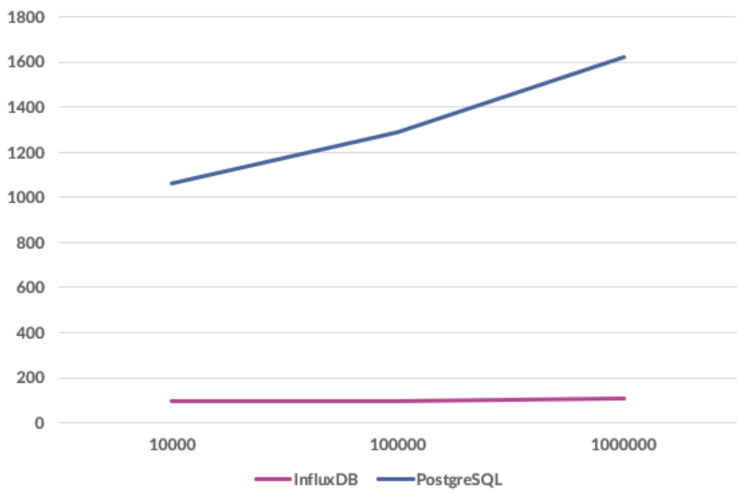
Request time (ms)

Evaluation Time series in PostgreSQL

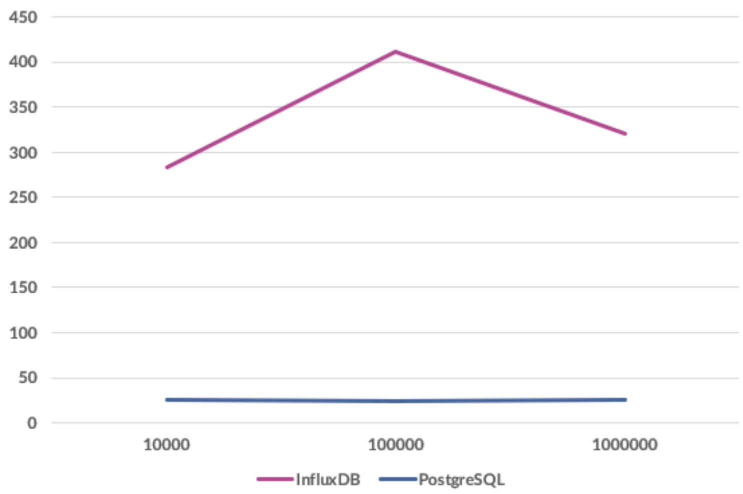
WRITE PERFORMANCE



Write time (seconds)



Disk usage (MB)



RAM usage (MB)

Conclusion

- improved collaboration workflow:
  - enhanced model for building smaller scopes of analysis;
  - better visualization for comparison of data;
  - stronger annotation readability and flexibility of expression;
  - scalable architecture that adjusts to data set size and traffic amount;
  - linearizability and strongly validated contributions;
- the open REST API enables extensibility: more input and output modules can be added.

END

https://www.edduarte.com/time-series-analysis-platform/