PostgreSQL
as a Schemaless Database.

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Welcome!

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What's on the menu?

- What is a schemaless database?
- How can you use PostgreSQL to store schemaless data?
- How does do the various schemaless options perform?

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A note on NoSQL.

- Worst. Term. Ever.
- It's true that all modern schemaless databases do not use SQL, but…
- Neither did Postgres before it became Postgre**SQL**. (Remember QUEL?)
- The defining characteristic is the lack of a fixed schema.

Schematic.

- A **schema** is a fixed (although mutable over time) definition of the data.
- Database to schema (unfortunate term) to table to field/column/attribute.
- Individual fields can be optional (NULL).
- Adding new columns requires a schema change.

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Rock-n-Roll!

- Schemaless databases store “documents” rather than rows.
- They have internal structure, but…
- … that structure is per document.
- No fields! No schemas! Make up whatever you like!

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We are not amused.

- Culturally, very different from the glass house data warehouse model.
- Grew out of the need for persistent object storage…
- … and impatience with the (perceived) limitations of relational databases and object-relational managers.

Let us never speak of this again.

- There’s a lot to talk about in schemaless vs traditional relational databases.
- But let’s not.
- Today’s topic: If you want to store schemaless data in PostgreSQL, how can you?
- And what can you expect?

What is schemaless data?

- Schemaless does not mean unstructured.
- Each “document” (=record/row) is a hierarchical structure of arrays and key-value pairs.
- The application knows what to expect in one of these…
- … and how to react if it doesn’t get it.

PostgreSQL has you covered.

- Not one, not two, but three different document types:
  - XML
  - hstore
  - JSON
- Let's see what they've got.

XML

It seemed like a good idea at the time.

XML

- Been around since the mid-1990s.
- Hierarchical structured data based on SGML.
- Underlying technology for SOAP and a lot of other stuff that was really popular for a while.
- Still super-popular in the Java world.

XML, your dad's document language.

- Can specify XML schemas using DTDs.
  - No one does this.
- Can do automatic transformations of XML into other markups using XSLT.
  - Only the masochistic do this.
- Let's not forget the most important use of XML!

Tomcat Configuration Files.

```
    <Server port="8005" shutdown="SHUTDOWN" debug="0">
  <Service name="Tomcat-Standalone">
    <Connector className="org.apache.catalina.connector.http.HttpConnector"
      port="8080" minProcessors="5" maxProcessors="75"
      enableLookups="true" redirectPort="8443"
      acceptCount="10" debug="0" connectionTimeout="60000"/>
    <Engine name="Standalone" defaultHost="localhost" debug="0">
      <Logger className="org.apache.catalina.logger.FileLogger"
        prefix="catalina_log." suffix=".txt"
        timestamp="true"/>
      <Realm className="org.apache.catalina.realm.MemoryRealm" />
      <Host name="localhost" debug="0" appBase="webapps" unpackWARs="true">
        <Valve className="org.apache.catalina.valves.AccessLogValve"
          directory="logs" prefix="localhost_access_log." suffix=".txt"
          pattern="common"/>
        <Logger className="org.apache.catalina.logger.FileLogger"
         directory="logs" prefix="localhost_log." suffix=".txt"
         timestamp="true"/>
        <Context path="/examples" docBase="examples" debug="0"
         reloadable="true">
          <Logger className="org.apache.catalina.logger.FileLogger"
           prefix="localhost_examples_log." suffix=".txt"
           timestamp="true"/>
         </Context>
      </Host>
    </Engine>
  </Service>
</Server>
```

XML Support in PostgreSQL.

- Built-in type.
- Can handle documents up to 2 gigabytes.
- A healthy selection of XML operators.
  - xpath in particular.
- Very convenient XML export functions.
- Great for external XML requirements.

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XML Indexing.

- There isn't any.
- Unless you build it yourself with an expression index.
- Functionality is great.
- Performance is… we'll talk about this later.

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hstore

The hidden gem of contrib/

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hstore

- A key/value storage type specific to PostgreSQL.
- Maps string keys to string values.
- Contrib module; not part of the PostgreSQL core.

hstore functions

- Lots and lots and lots of hstore functions.
  - h->”a” (get value for key a).
  - h?”a” (does h contain key a?).
  - h@>”a->2” (does key a contain 2?).
- Many others.

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hstore indexing.

- Can create GiST and GIN indexes over hstore values.
- Indexes the whole hierarchy, not just one key.
- Accelerates @>, ?, ?& and ?| operators.
- Can also build expression indexes.

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JSON

All the *cool* kids are doing it.

JSON

- JavaScript Object Notation.
- JavaScript's data structure declaration format, turned into a protocol.
- Dictionaries, arrays, primitive types.
- Originally designed to just be passed into `eval()` in JavaScript.
  - Please don't do this.

JSON, the new hotness

- The de facto standard API data format for REST web services.
- Very comfortable for Python and Ruby programmers.
- MongoDB's native data storage type.

JSON? Yeah, we got that.

- JSON type in core as of 9.2.
- Validates JSON going in.
- And… not much else right now.
  - array_to_json, row_to_json.
- Lots more coming in 9.3 (offer subject to committer approval).

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JSON Indexing.

- Expression indexing.
- Can also treat as a text string for strict comparison…
    - … which is kind of a weird idea and I'm not sure why you'd do that.
- But the coolest part of JSON in core is!

PL/V8!

- The V8 JavaScript engine from Google is available as an embedded language.
- JavaScript deals with JSON very well, as you'd expect.
- Not part of core or contrib; needs to be built and installed separately.

PL/V8 ProTips

- Use the static V8 engine that comes with PL/V8.
- Function is compiled by V8 on first use.
- Now that we got rid of SQL injection attacks, we now have JSON injection attacks.
- PL invocation overhead is non-trivial.

Schemaless Strategies

- Create single-field tables with only a hierarchical type.
- Wrap up the (very simple) SQL to provide an object API.
- Create indexes to taste
- Maybe extract fields if you need to JOIN.
- Profit!

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```
CREATE OR REPLACE FUNCTION
   get_json_key(structure JSON, key TEXT) RETURNS TEXT
   AS $get_json_key$
   var js_object = structure;
   if (typeof ej != 'object')
      return NULL;
   return JSON.stringify(js_object[key]);
$get_json_key$
    IMMUTABLE STRICT LANGUAGE plv8;
```

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```
CREATE TABLE blog {
   post json
}

CREATE INDEX post_pk_idx ON
   blog((get_json_key(post, ‘post_id’)::BIGINT));

CREATE INDEX post_date_idx ON
   blog((get_json_key(post, ‘post_date’)::TIMESTAMPTZ));
```

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But but but…

- PostgreSQL was not designed to be a schemaless database.
- Wouldn’t it be better to use a bespoke database designed for this kind of data?
- Well, let’s find out!

Some Numbers.

When all else fails, measure.

Schemaless Shootout!

- A very basic document structure:
  - id, name, company, address1, address2, city, state, postal code.
  - address2 and company are optional (NULL in relational version).
  - id 64-bit integer, all others text.
- 1,780,000 records, average 63 bytes each.

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The Competitors!

- Traditional relational schema.
- hstore (GiST and GIN indexes).
- XML
- JSON
    - One column per table for these.
- MongoDB

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Timing Harness.

- Scripts written in Python.
- psycopg2 2.4.6 for PostgreSQL interface.
- pymongo 2.4.2 for MongoDB interface.

The Test Track.

- This laptop.
- OS X 10.7.5.
- 2.8GHz Intel Core i7.
- 7200 RPM disk.
- 8GB (never comes close to using a fraction of it).

Indexing Philosophy

- For relational, index on primary key.
- For hstore, index using GiST and GIN (and none).
- For JSON and XML, expression index on primary key.
- For MongoDB, index on primary key.
- Indexes created before records loaded.

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Your Methodology Sucks.

- Documents are not particularly large.
- No deep hierarchies.
- Hot cache.
- Only one index.
- No joins.
- No updates.

The Sophisticated Database Tuning Philosophy.

- None.
- Stock PostgreSQL 9.2.2, from source.
  - No changes to postgresql.conf
- Stock MongoDB 2.2, from MacPorts.
  - Fire it up, let it go.

First Test: Bulk Load

- Scripts read a CSV file, parse it into the appropriate format, INSERT it into the database.
- We measure total load time, including parsing time.
- (COPY will be much much much faster.)
  - mongoimport too, most likely.

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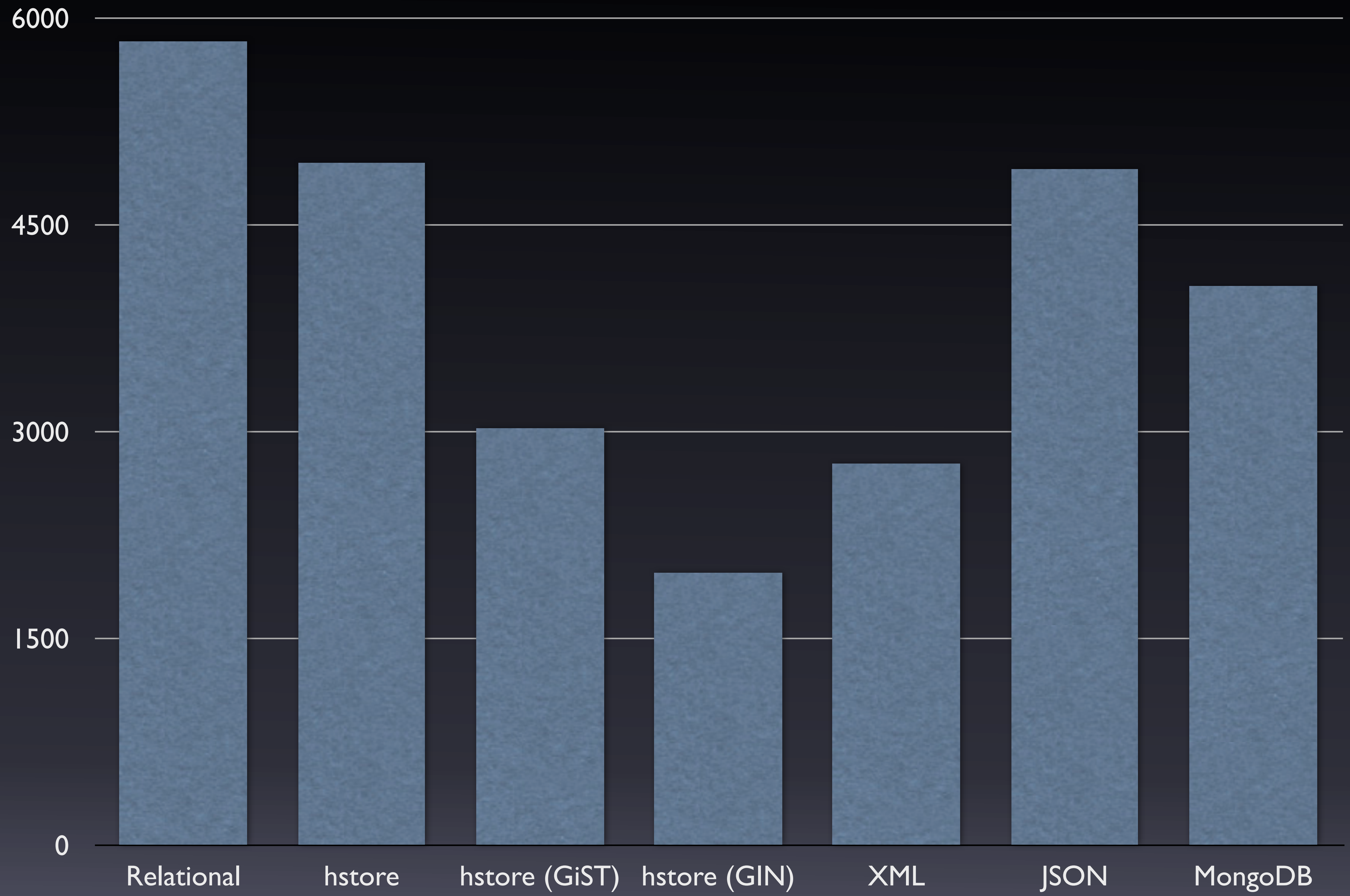
Records/Second



Observations.

- No attempt made to speed up PostgreSQL.
  - Synchronous commit, checkpoint tuning, etc.
- GIN indexes are really slow to build.
- The XML xpath function is probably the culprit for its load time.

Next Test: Disk Footprint.

- Final disk footprint once data is loaded.
- For PostgreSQL, reported database sizes from the `pg_*_size` functions.
- For MongoDB, reported by `db.stats()`.

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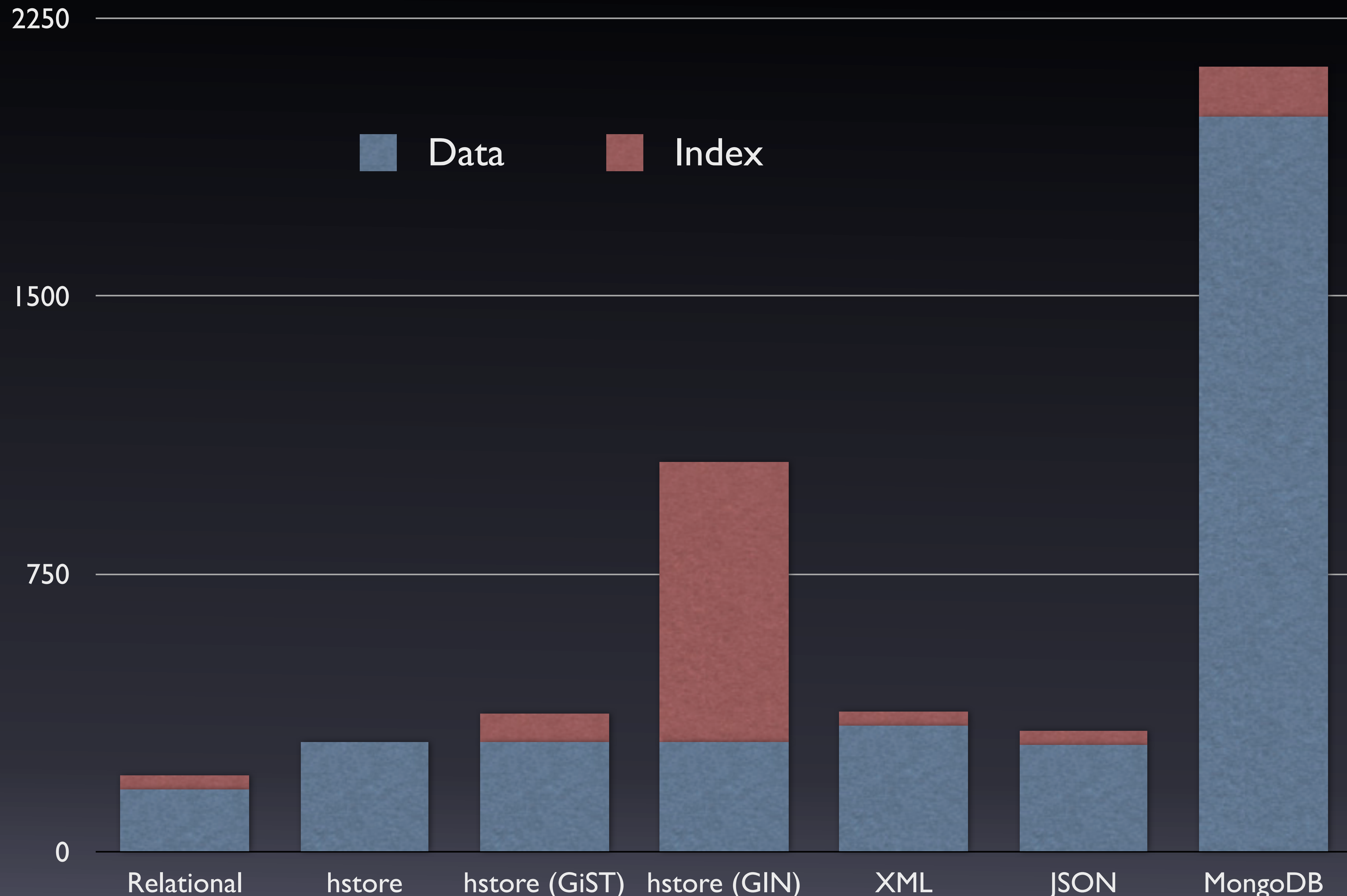
Disk Footprint in Megabytes



Observations.

- GIN indexes are really big on disk.
- PostgreSQL's relational data storage is very efficient.
  - None of these records are TOAST-able.
- MongoDB certain likes its disk space.
  - padding factor was 1, so it wasn't that.

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Next Test: Query on Primary Key

- For a sample of 100 documents, query a single document based on the primary key.
- Results not fetched.
- For PostgreSQL, time of `.execute()` method from Python.
- For MongoDB, time of `.fetch()` method.

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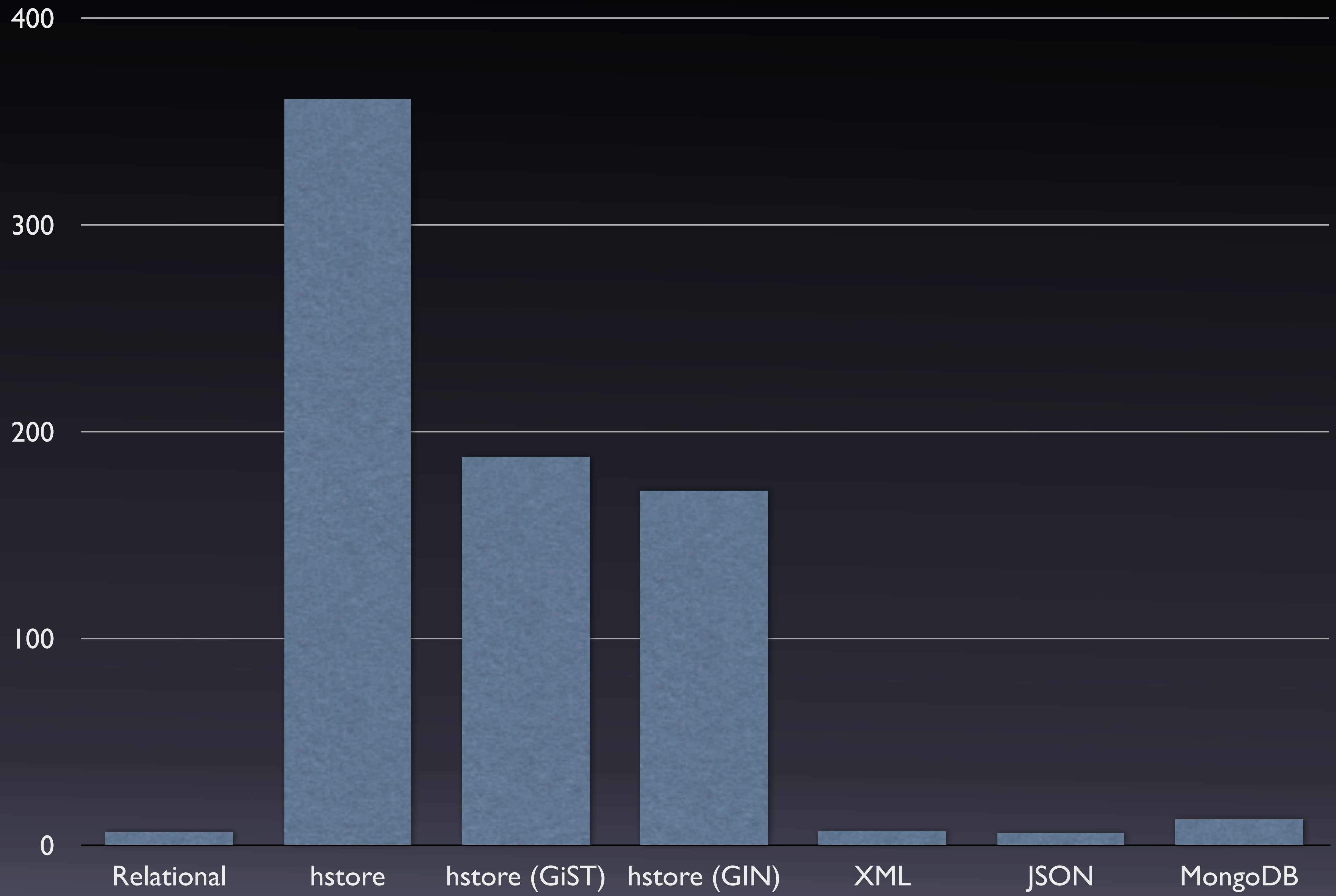
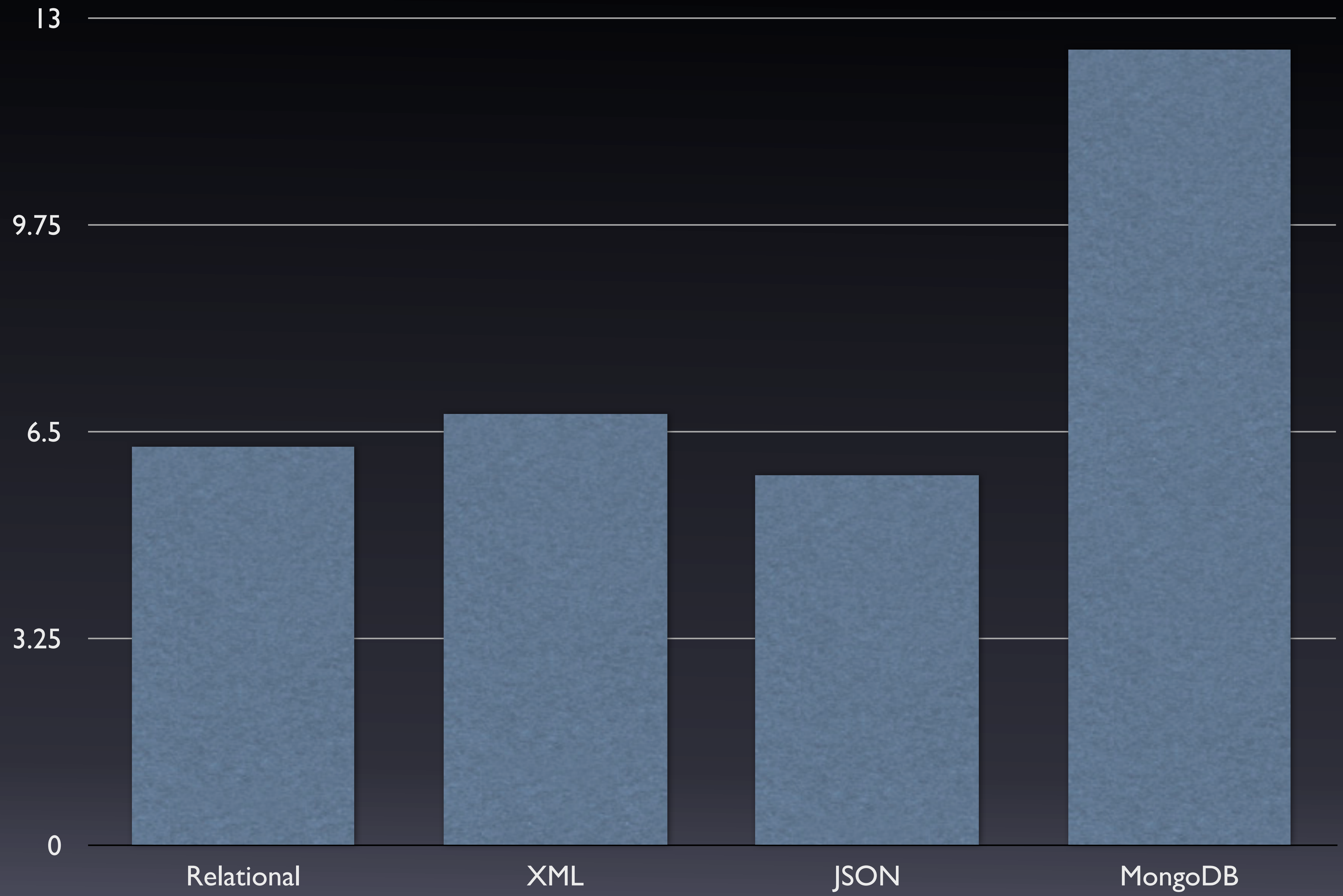
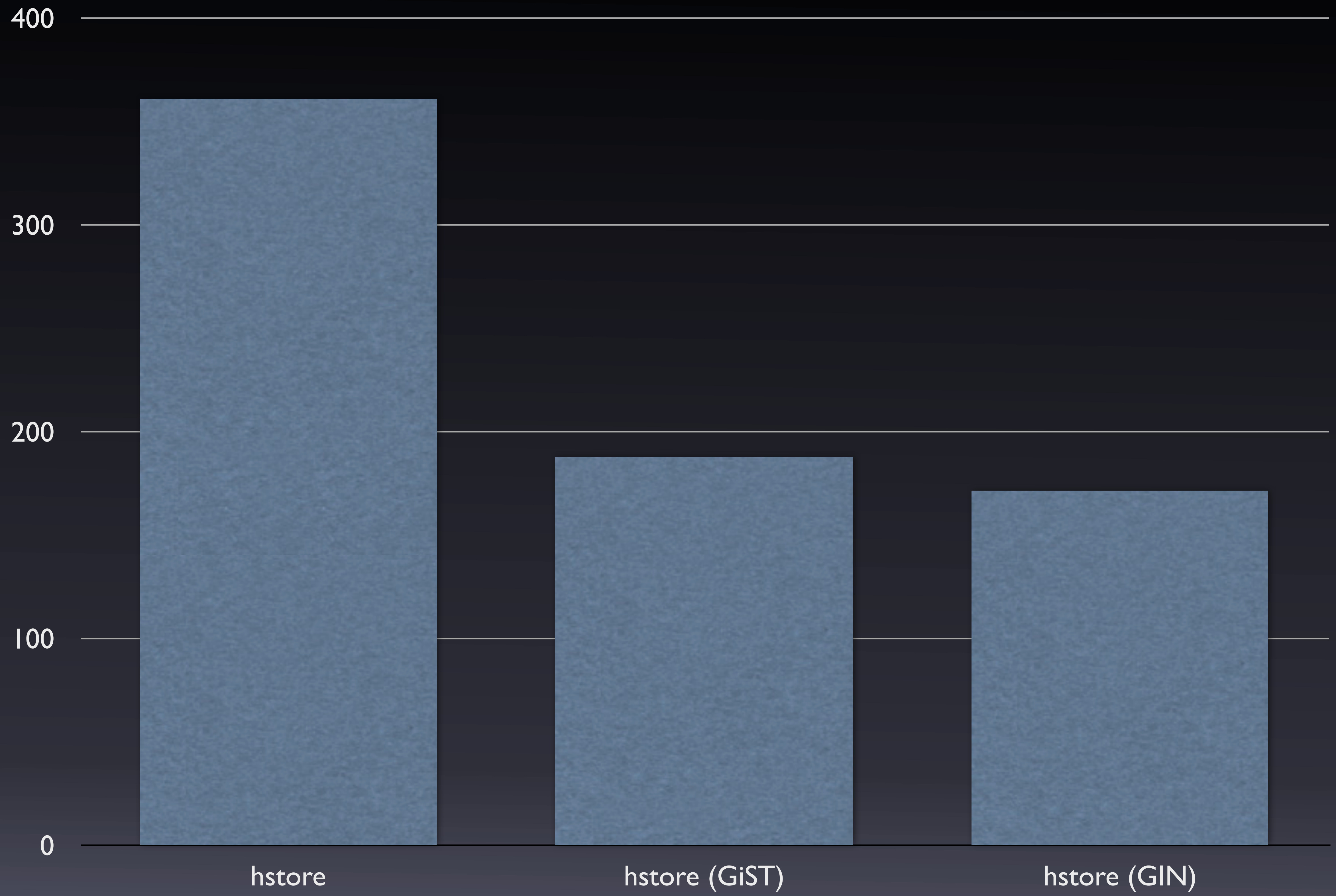
Fetch Time in Milliseconds



Fetch Time in Milliseconds (<100ms)



Fetch Time in Milliseconds (>100ms)



Observations.

- B-tree indexes kick ass.
  - GiST and GIN not even in same league for simple key retrieval.
- Difference between relational, XML and JSON is not statistically significant.
- Wait, I thought MongoDB was supposed to be super-performant. Huh.

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Next Test: Query on Name

- For a sample of 100 names, query all documents with that name.
- Results not fetched.
- Required a full-table scan (except for hstore with GiST and GIN indexes).
- Same timing methodology.

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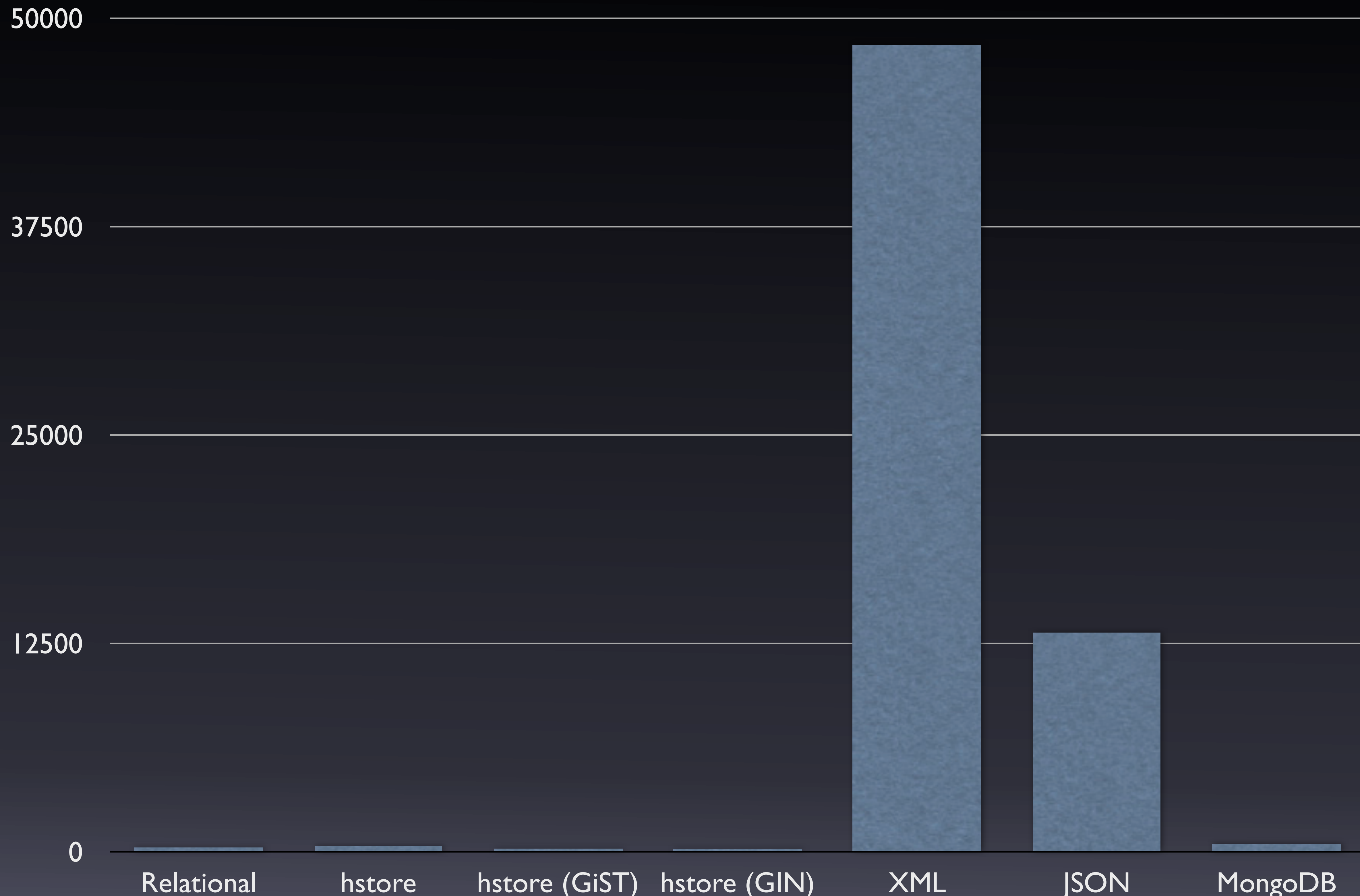
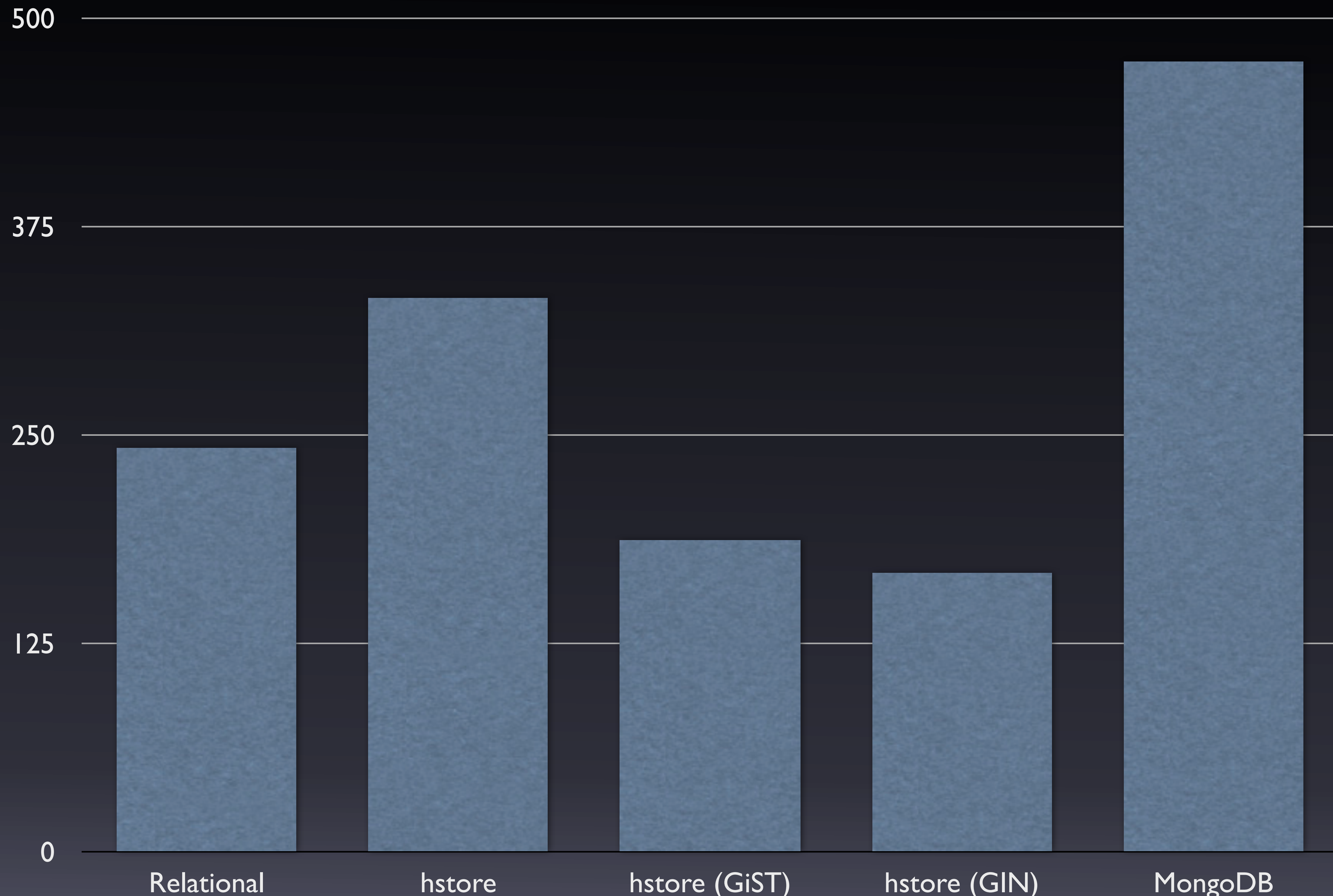
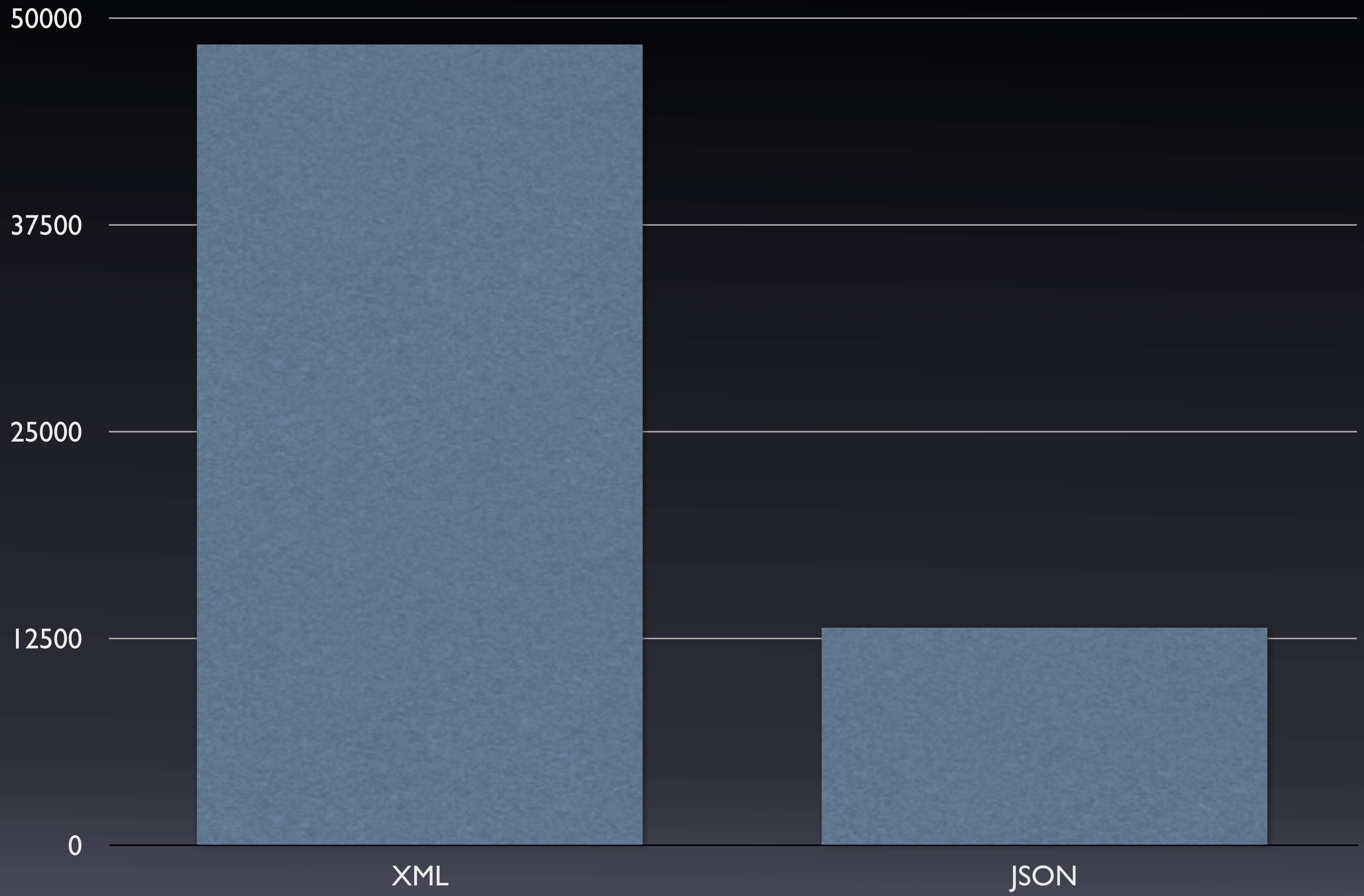
Fetch Time in Milliseconds



Fetch Time in Milliseconds (<500ms)



Fetch Time in Milliseconds (>500ms)



Observations.

- GiST and GIN accelerate every field, not just the "primary" key.
- Wow, executing the accessor function on each XML and JSON field is slow.
- MongoDB's **grotesquely bloated** disk footprint hurts it here.
    - Not that there's anything wrong with that.

Now that we know this, what do we know?

Some Conclusions.

- PostgreSQL does pretty well as a schemaless database.
- Build indexes using expressions on commonly-queried fields…
  - … or use GiST and hstore if you want full flexibility.
- GIN might well be worth it for other cases.

Some Conclusions, 2.

- Avoid doing full-table scans if you need to use an accessor function.
  - Although hstore's are not bad compared to xpath or a PL.
- Seriously consider hstore if you have the flexibility.
  - It's really fast.

Flame Bait!

- MongoDB doesn't seem to be more performant than PostgreSQL.
- And you still get all of PostgreSQL's goodies.
- Larger documents will probably continue to favor PostgreSQL.
- As will larger tables.

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Fire Extinguisher.

- You can find workloads that "prove" any data storage technology is the right answer.
  - dBase II included.
- Be very realistic about your workload and data model, now and in the future.
- Test, and test fairly with real-world data in real-world volumes.

The Future is Now!

- Many more JSON functions in PostgreSQL 9.3, now in beta.
- Better, faster support for indexing.
    - No GIST or GIN indexes yet, sadly.

mongres!

- Direct Mongo wire-protocol support in PostgreSQL.
- Uses PostgresSQL's custom background process feature.
- Prototype, but check it out.

Thank you!

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