Pocket Data

The Case for TPC-MOBILE

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http://odin.cse.buffalo.edu/research/astral

Big Data!

Big Data!

Big Data!

- GB, TB or PB of data!
- Hundreds of thousands of updates per second
- Thousands of nodes computing together!
- “Virtually” infinite resources!

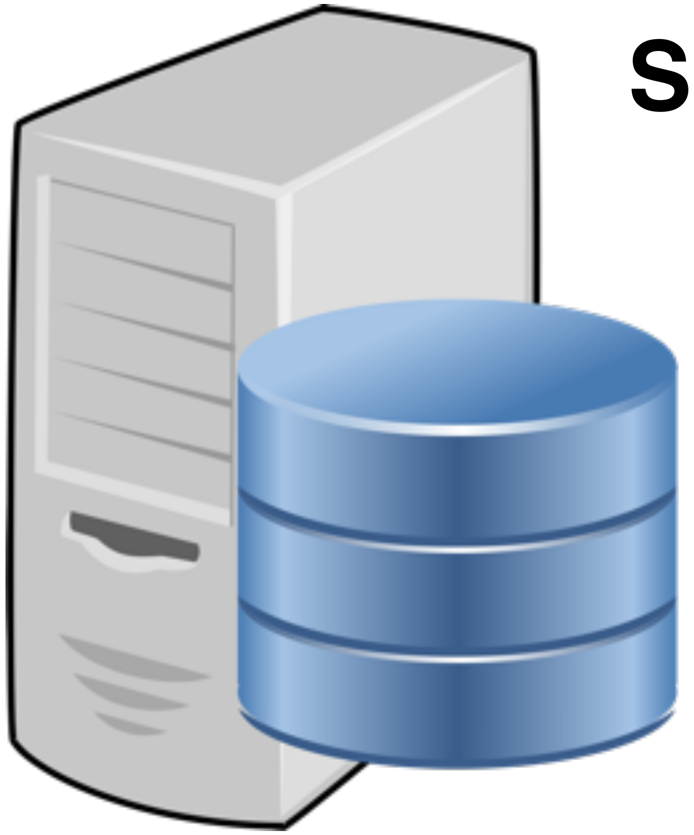
Big Data!

Big Data!

TPC-H

TPC-C

SSB



TPC-E

TPC-DI

YCSB

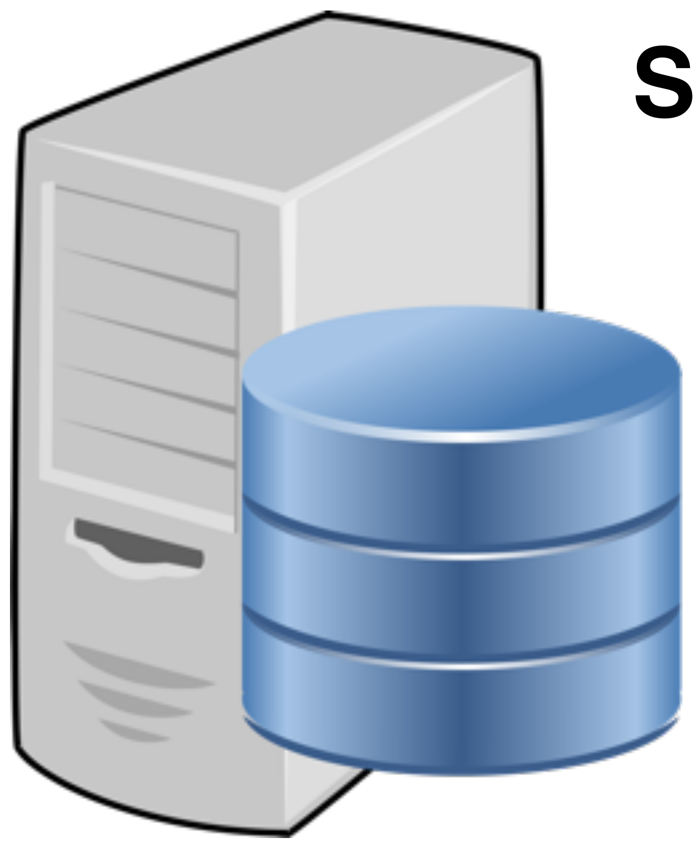
TPC-DS

Big Data!

TPC-H

TPC-C

SSB



TPC-E

TPC-DI

YCSB

TPC-DS

What about other types of databases?

The average smartphone processes almost 180 thousand queries per day

That's about **2 queries per second**

2 Queries per Second

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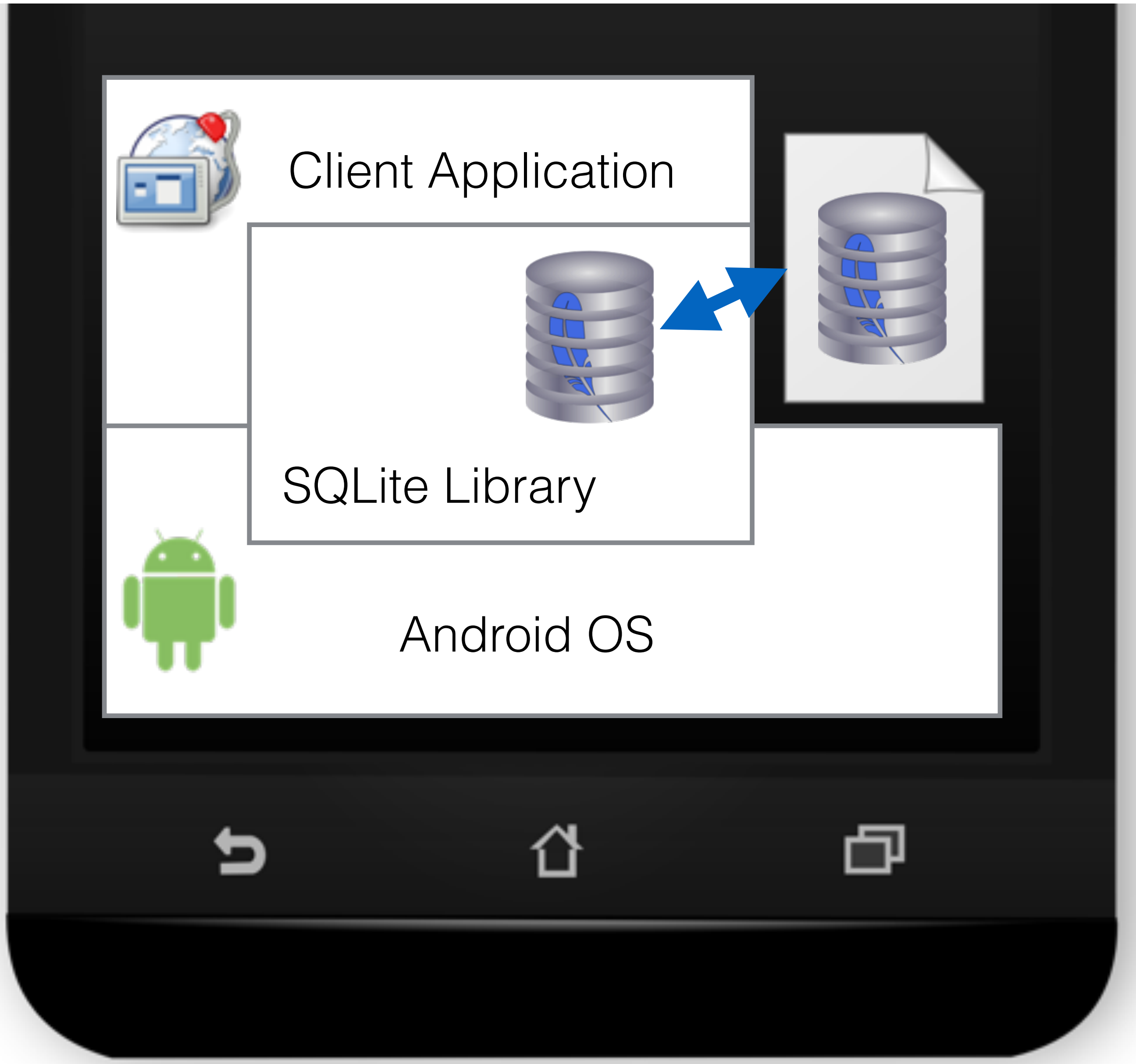
2 Queries per Second

- Is this Big Data? **No!**
- Is this Important? **YES!**
    - **Multi-Tenancy**: The phone is more than just a DB.
    - **Power**: 1-2 days of battery life under ideal circumstances.
    - **It's Everywhere**: Odds are that your phone is running some queries right now!

We need to better understand pocket-scale data

SQLite

- **Embedded**: SQLite is a library
- **Un-shared**: SQLite DBs are specific to one client “app”.
- **Lightweight**: Entire SQLite DB is backed to one file.
- **Universal**: SQLite client library is available by default in nearly all major OSes.
- **“Easy”**: Duck Typing, Relaxed SQL Syntax, One Big Lock (file)



How do developers and users use Pocket Scale Data?

PhoneLab

A Smartphone Platform Testbed

~200 UB students, faculty, and staff using instrumented LG Nexus 5 smartphones in exchange for discounted service.

PhoneLab

A Smartphone Platform Testbed

- **Preliminary Trial**: 11 phones for ~1 month (254 phone/days)
- Instrumented SQLite logs **all** statements (~45 mil statements)
  - ~33.5 million `SELECT` statements
  - ~9.4 million `INSERT` statements
  - ~1 million `UPDATE` statements
  - ~1.2 million `DELETE` statements
  - 179 distinct ‘apps’ issuing statements

https://phone-lab.org/experiment/request

- SELECT Complexity
- ORM Effects
- Function Usage
- Read/Write Ratios
- Query Periodicity

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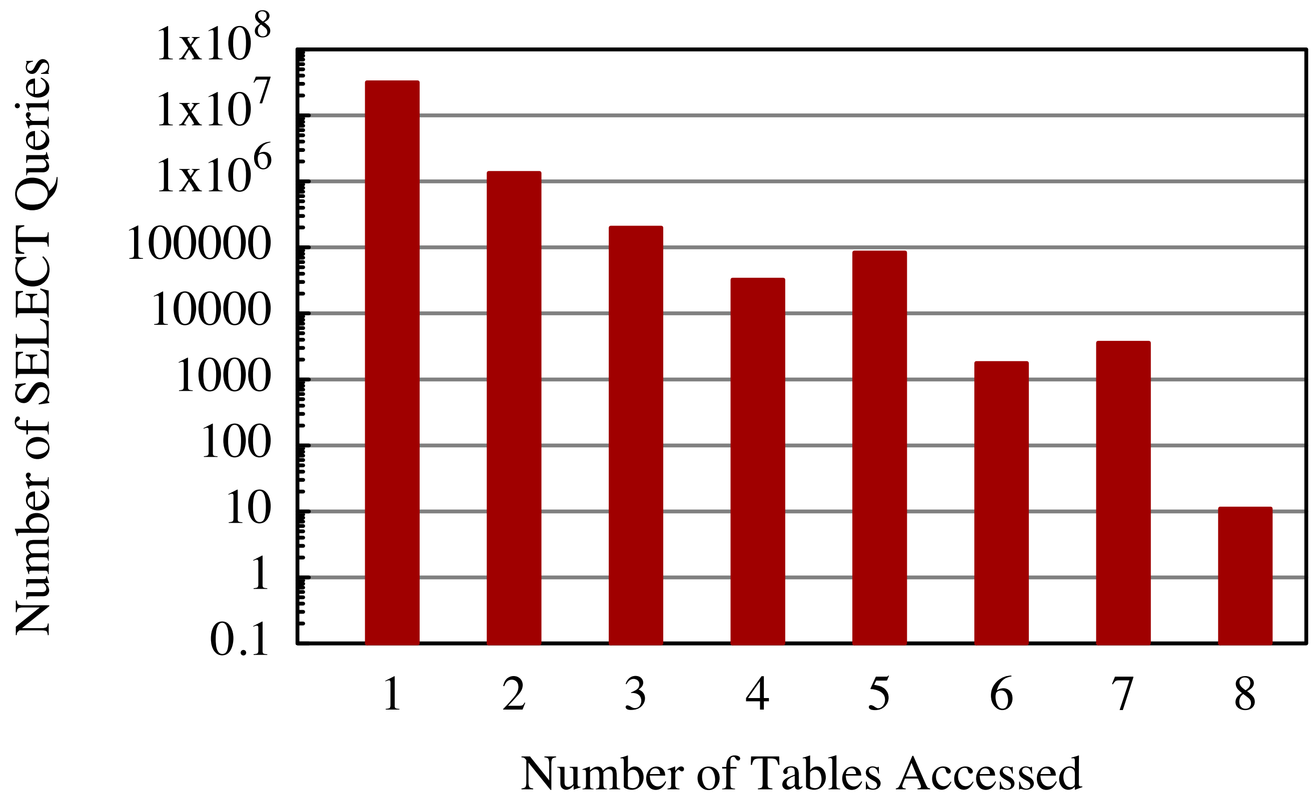
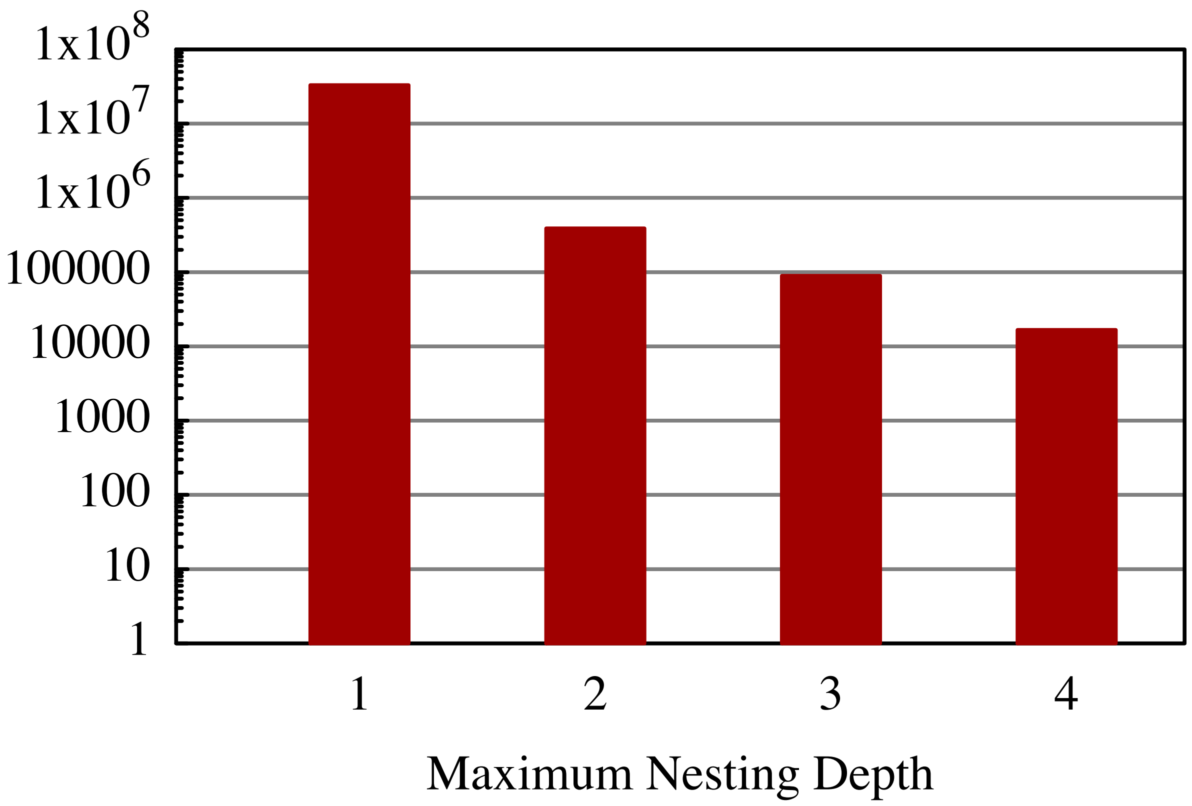
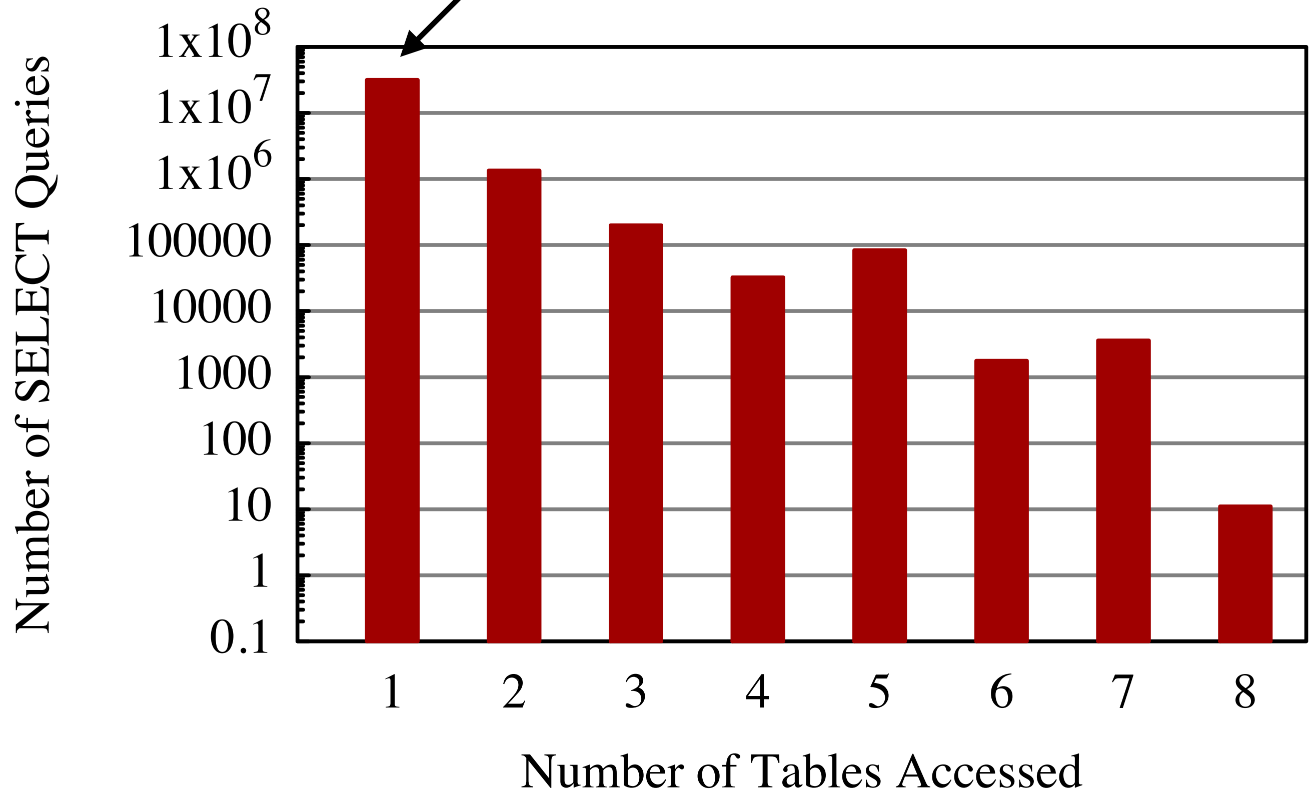
SELECT Complexity

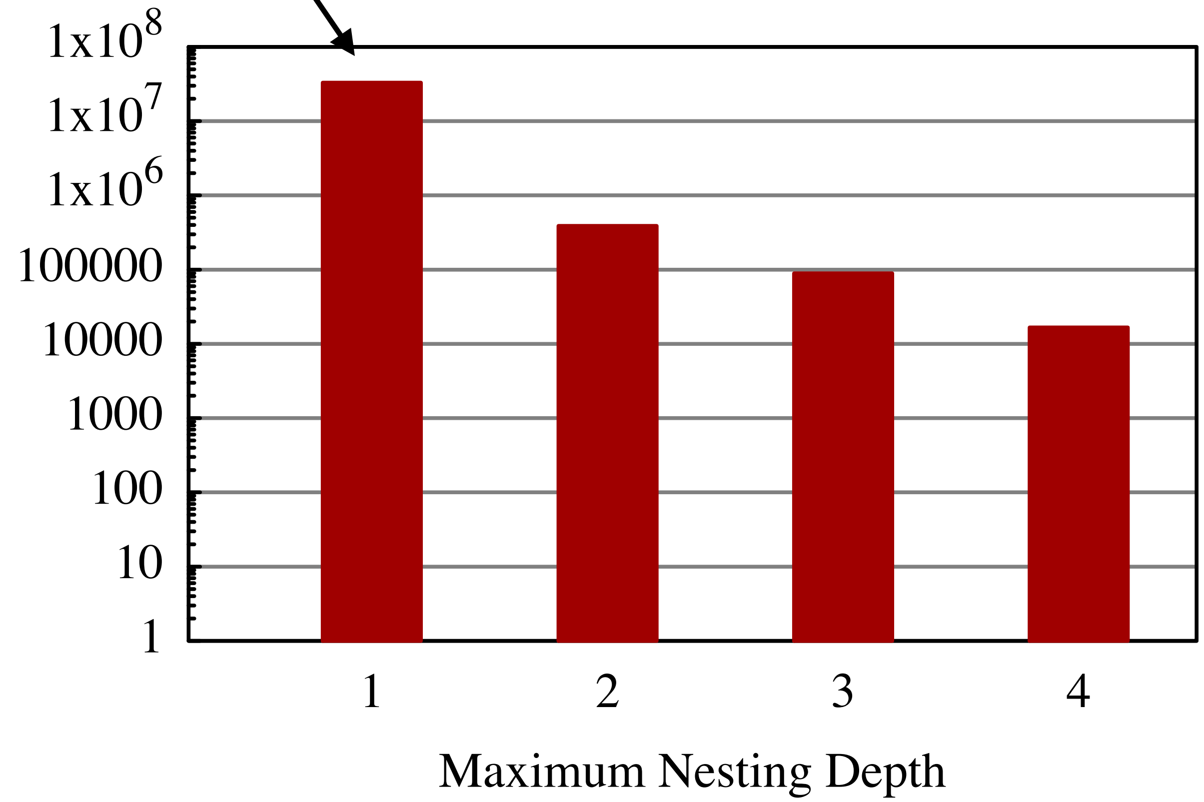




SELECT Complexity

30 million simple "SPA" queries





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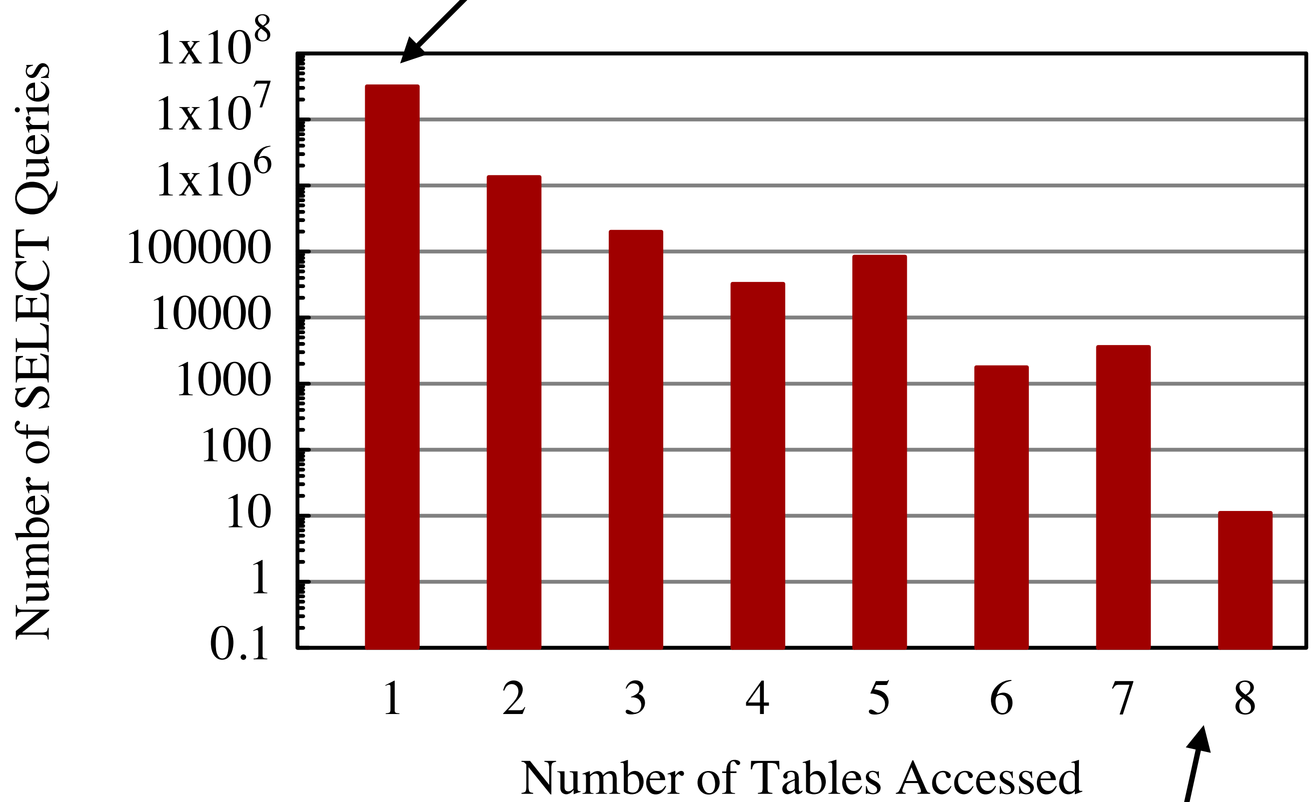
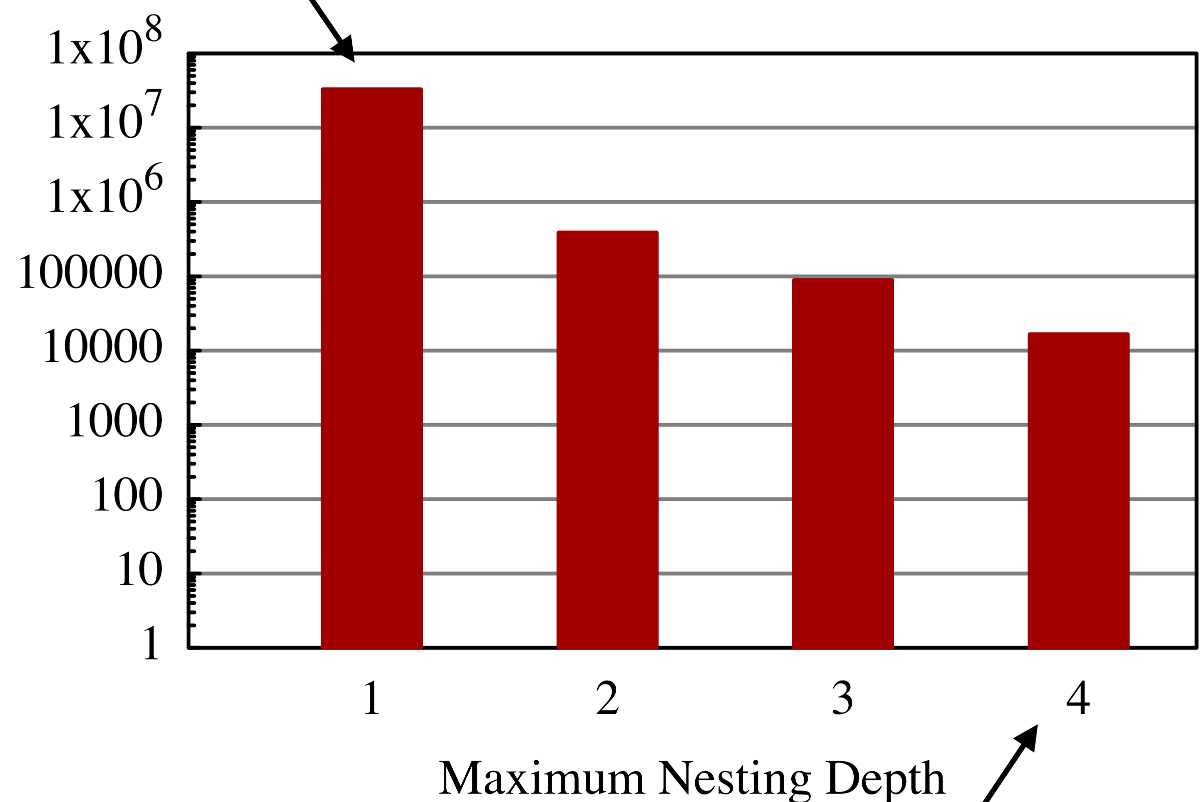
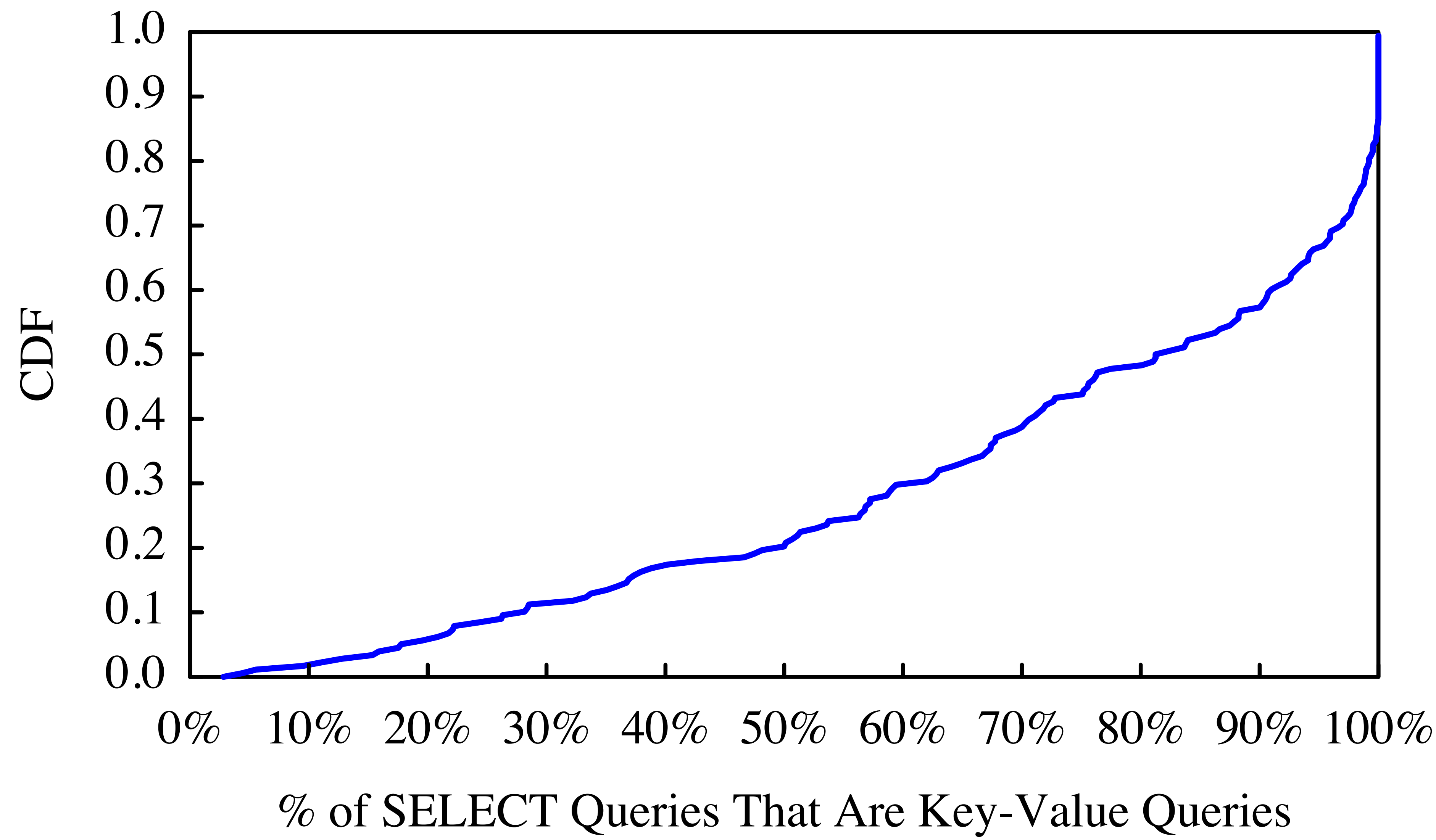




Infrequent, but extremely complex queries

SELECT Complexity
(by app)



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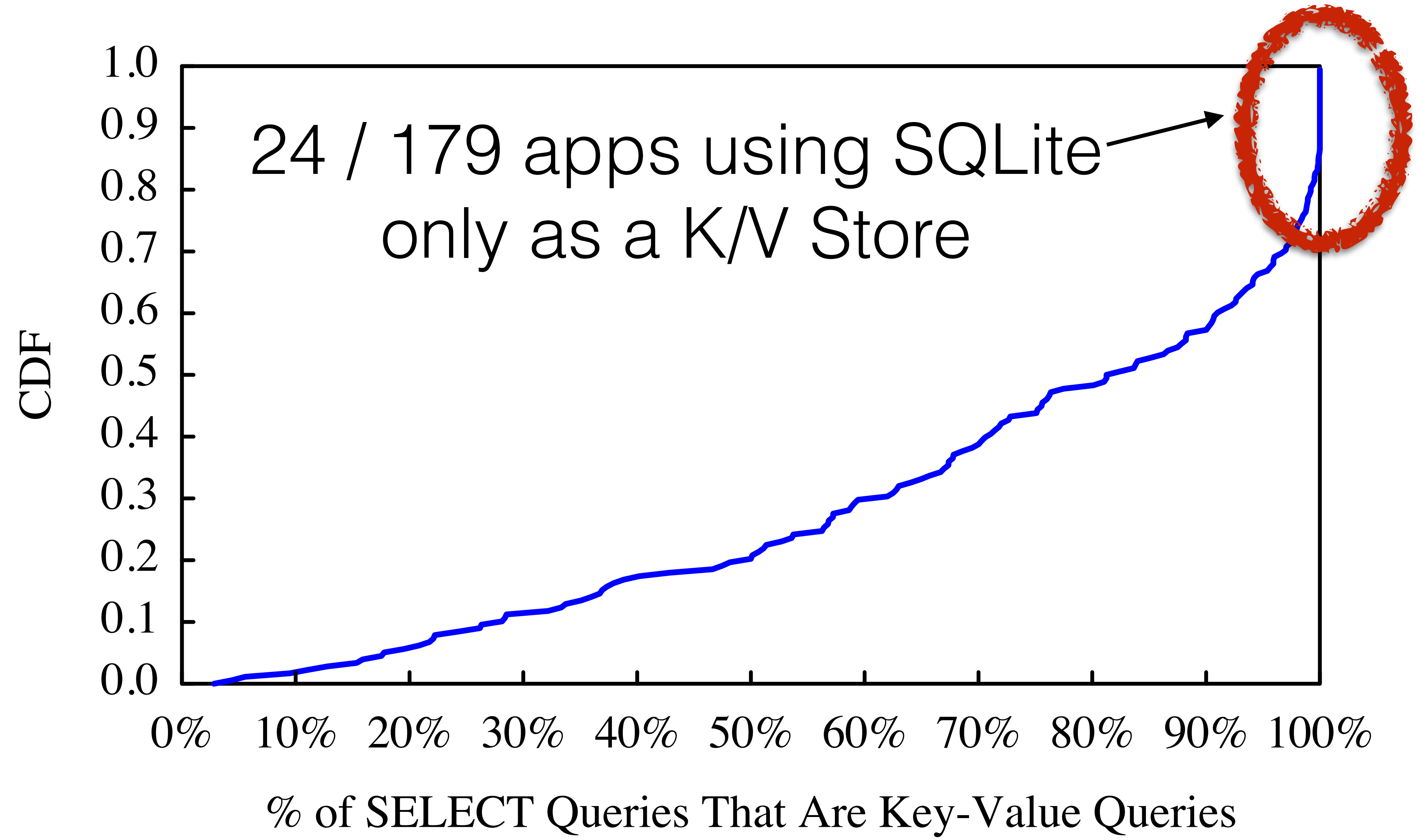


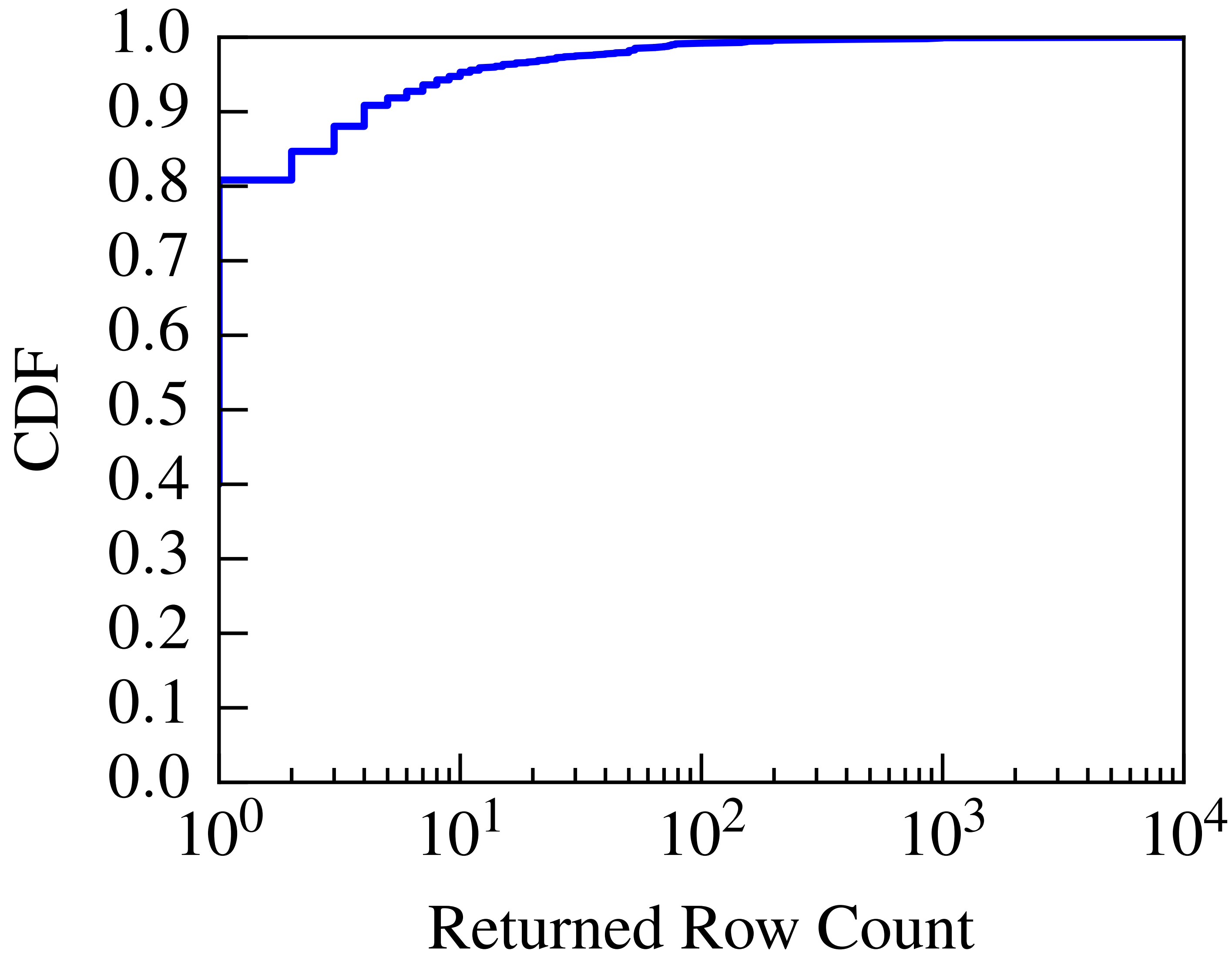
SELECT Complexity

```
INSERT OR REPLACE INTO
    properties(property_key,property_value)
    VALUES (?,?);

SELECT property_value
    FROM properties
    WHERE property_key=?;
```

(These are actual real queries from the trace)

SELECT Complexity



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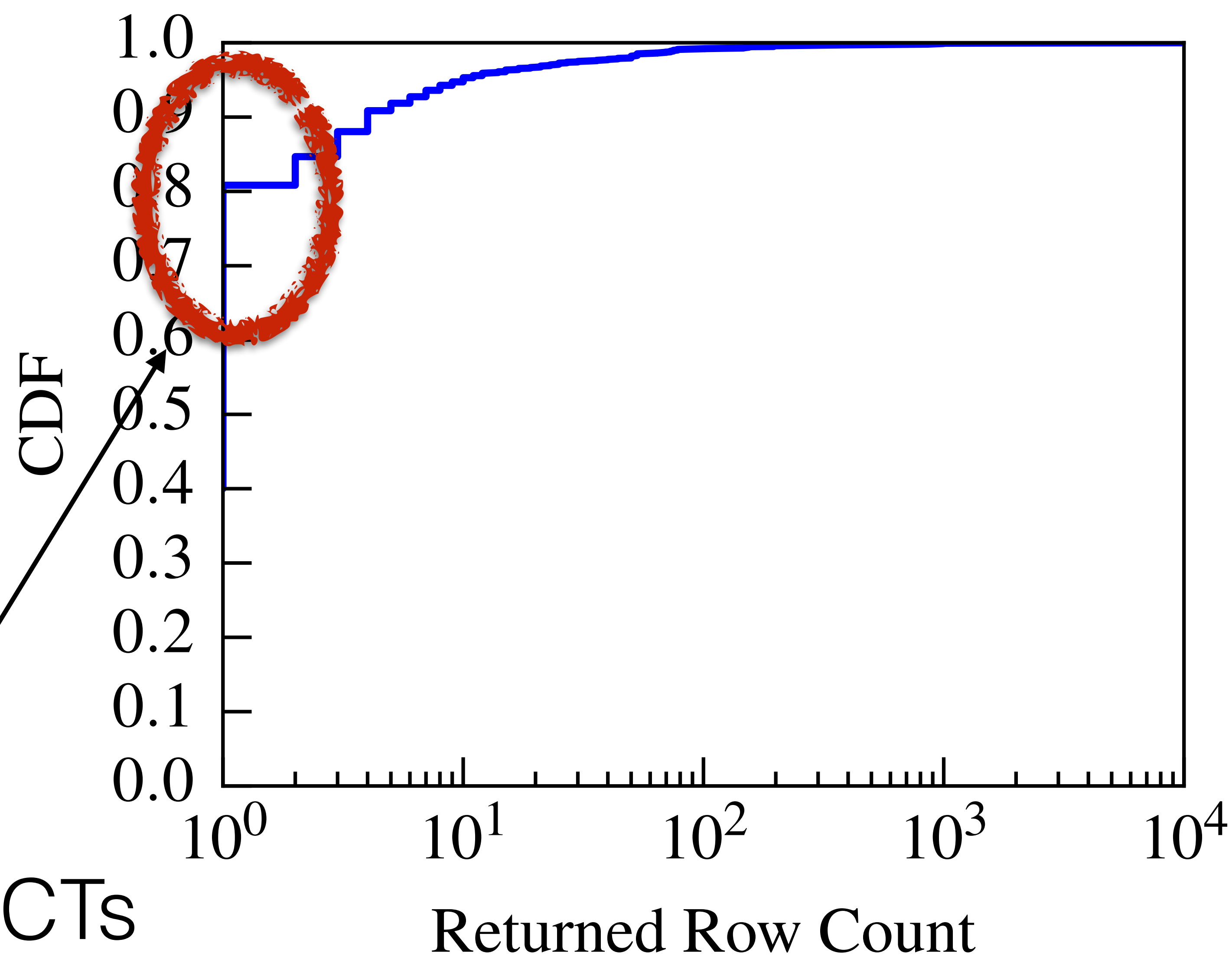
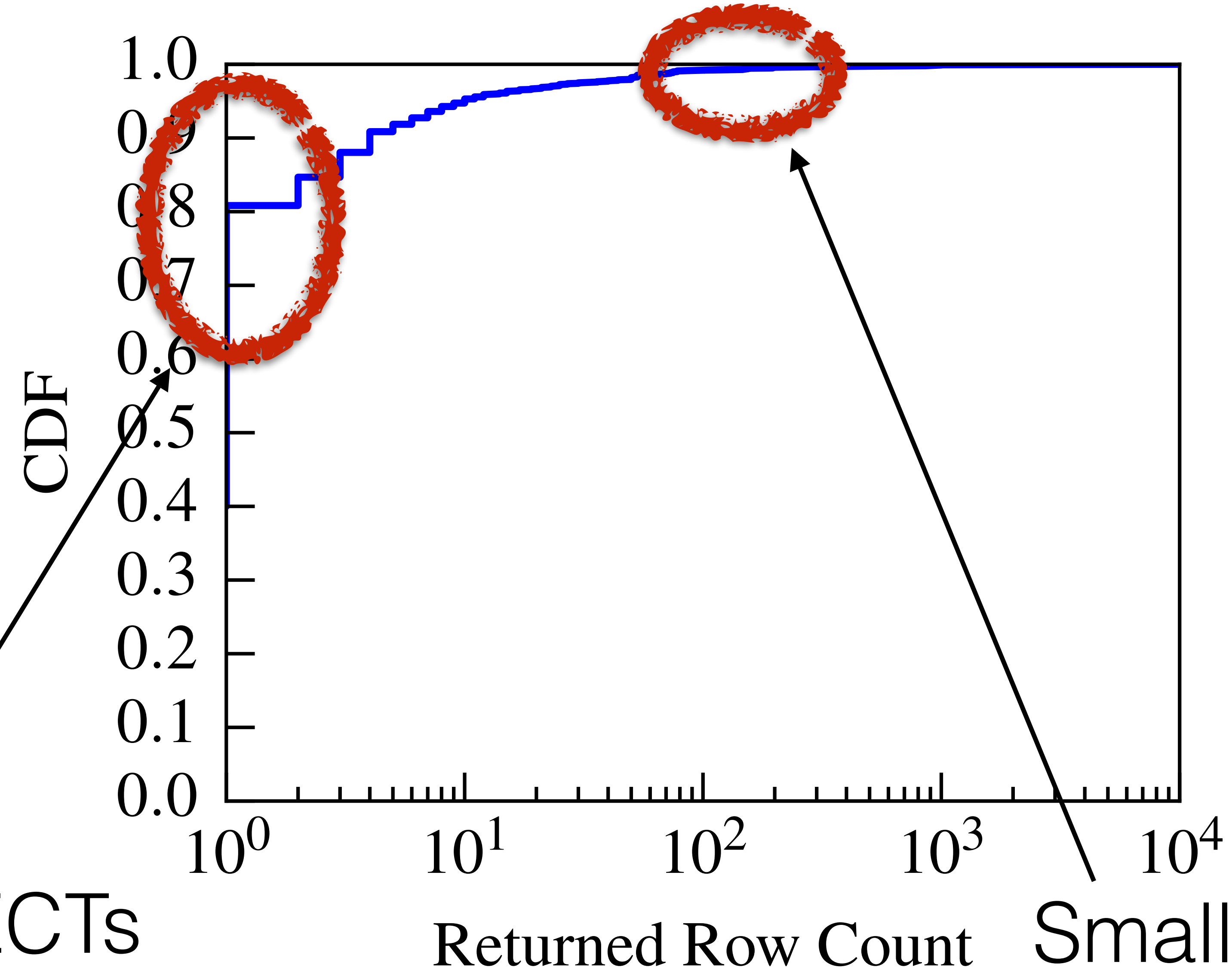


80% of SELECTs return one row

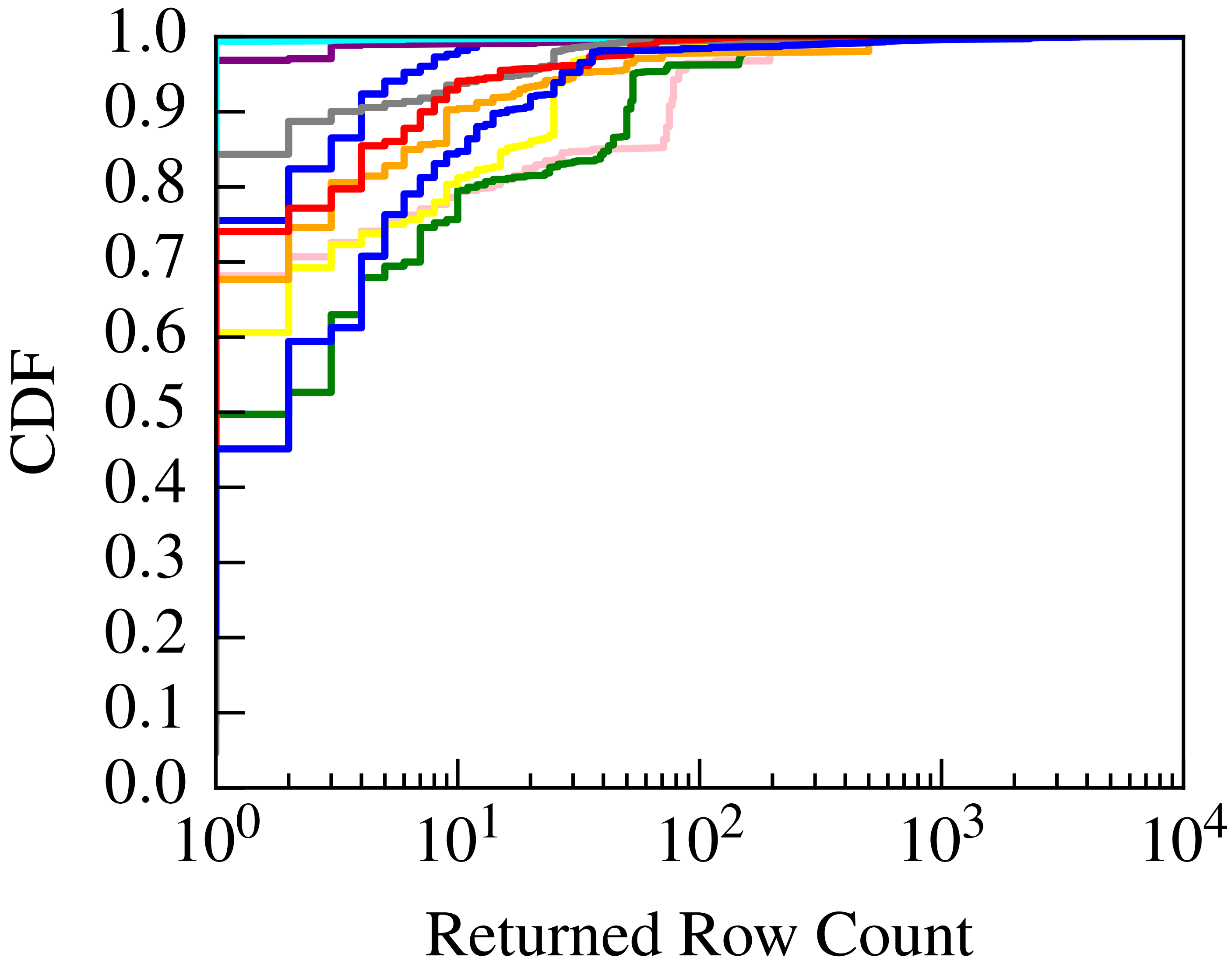
SELECT Complexity



80% of SELECTs return one row

Small % of SELECTs return 100s of rows

SELECT Complexity
(by app)



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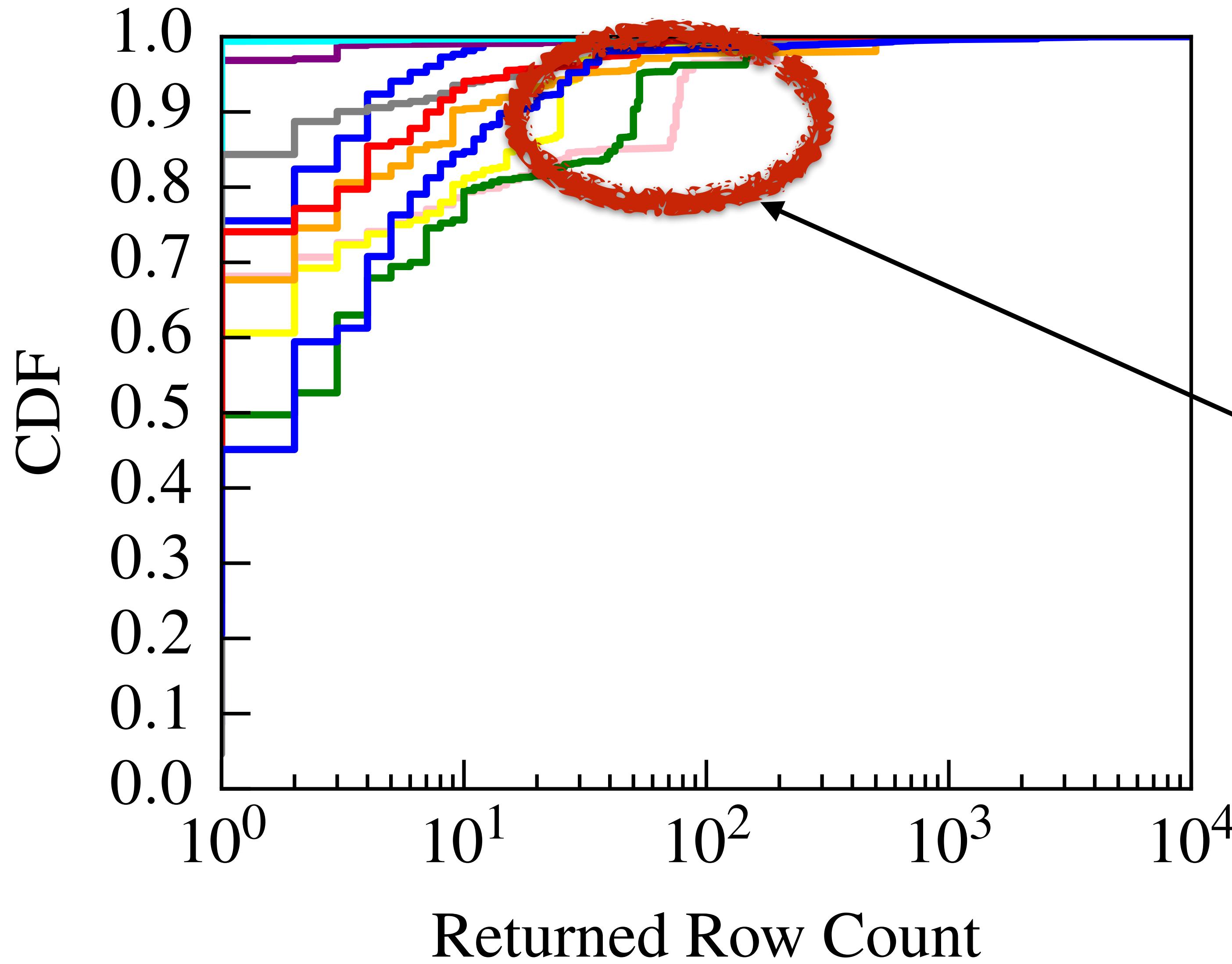
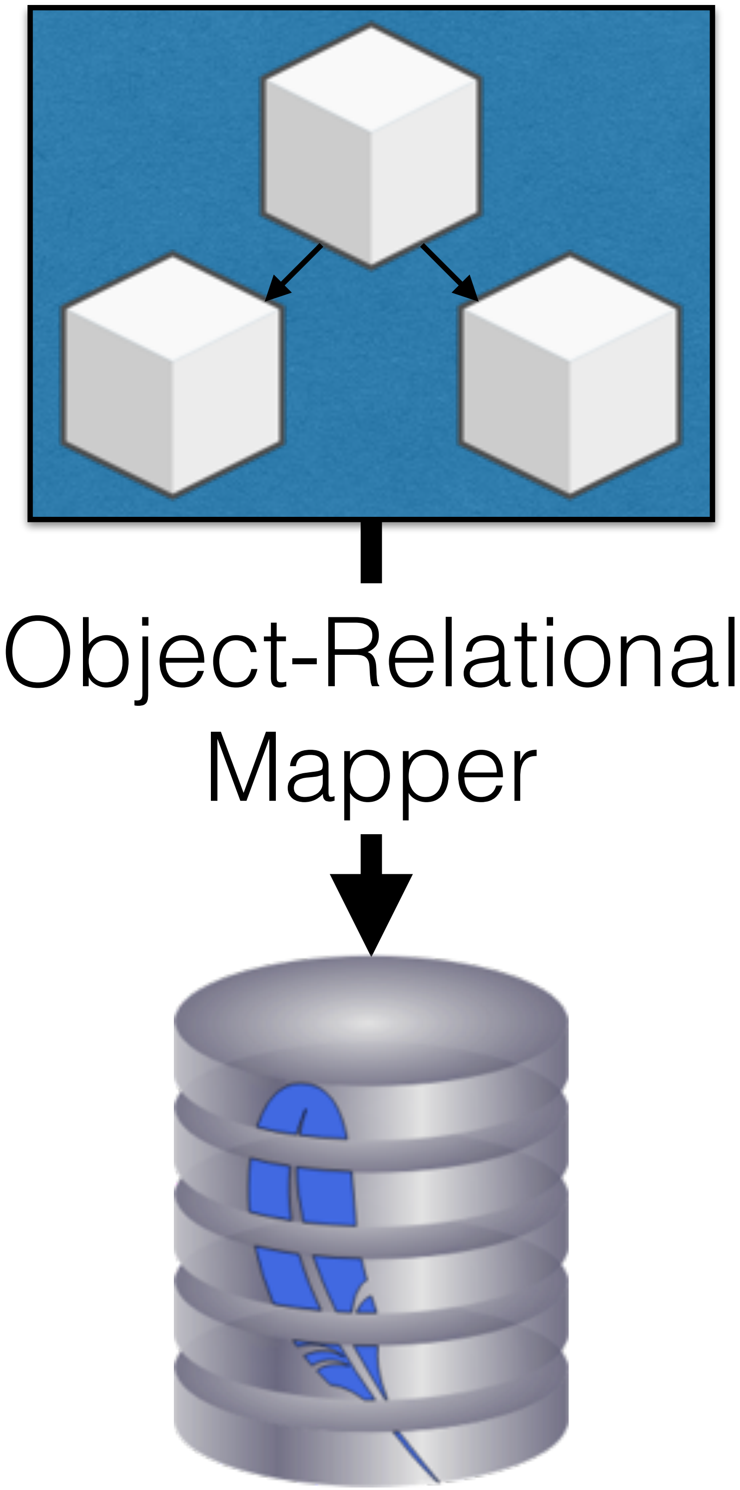
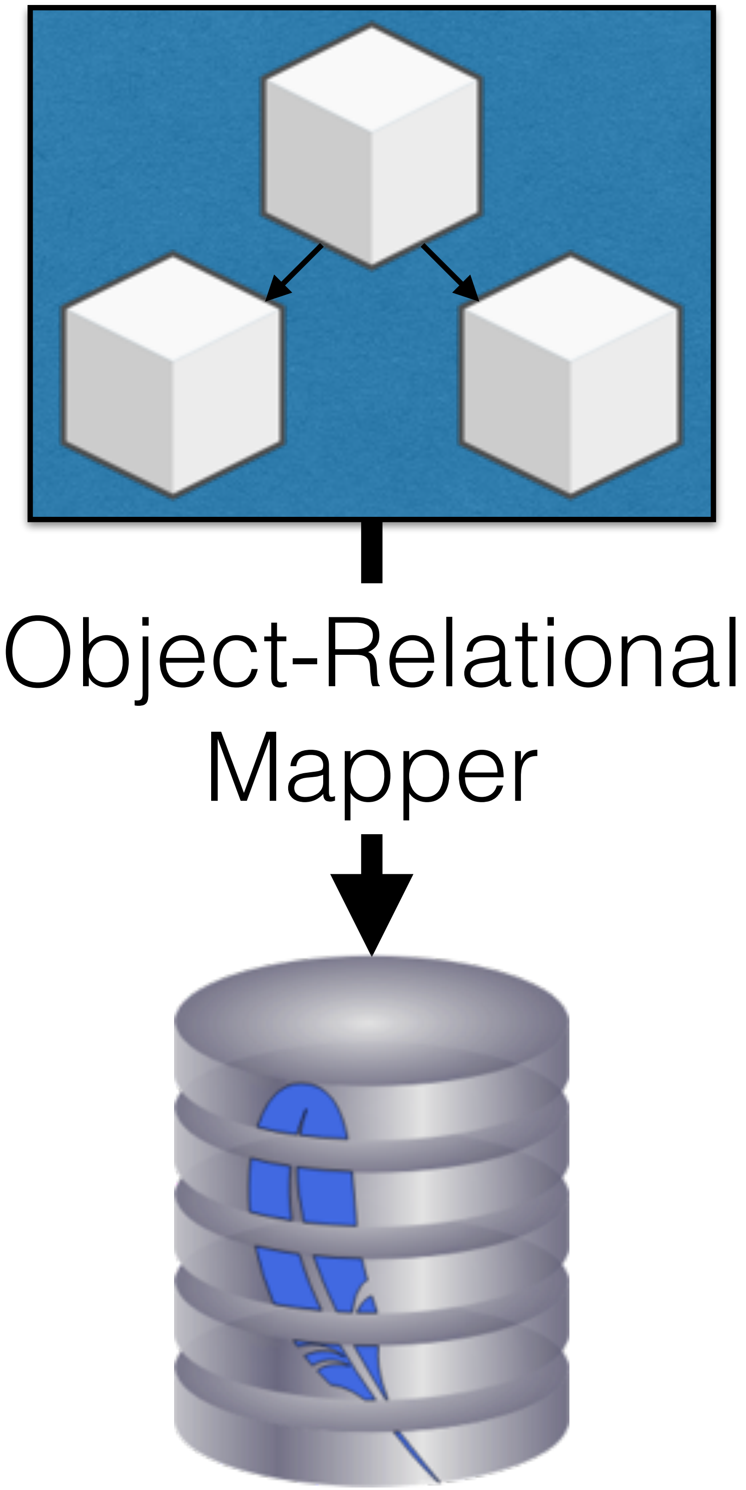


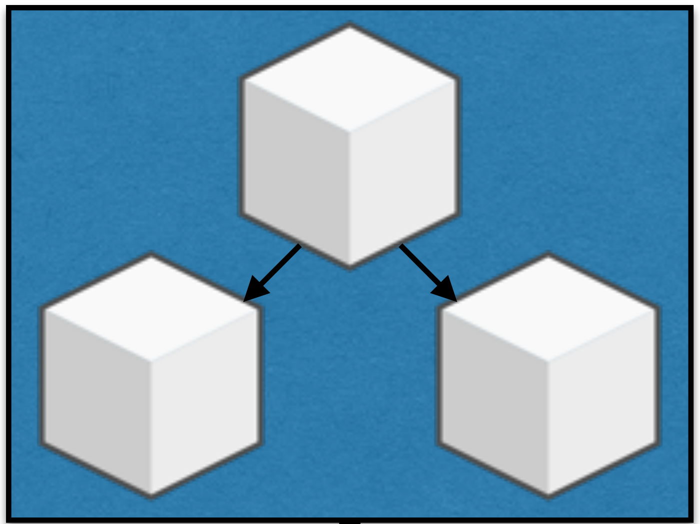
Google+, GMail, Facebook, Contacts

- SELECT Complexity
- ORM Effects
- Function Usage
- Read/Write Ratios
- Query Periodicity

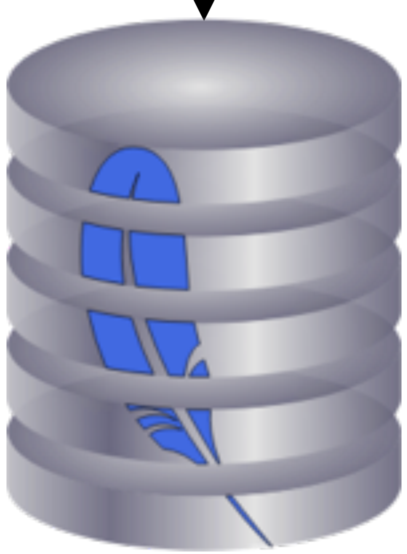

Object-Relational
Mapper




```
pers = Persons.get(10)
name = pers.firstName()
```



Object-Relational Mapper



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```
SELECT first_name
FROM Persons
WHERE id = 10;
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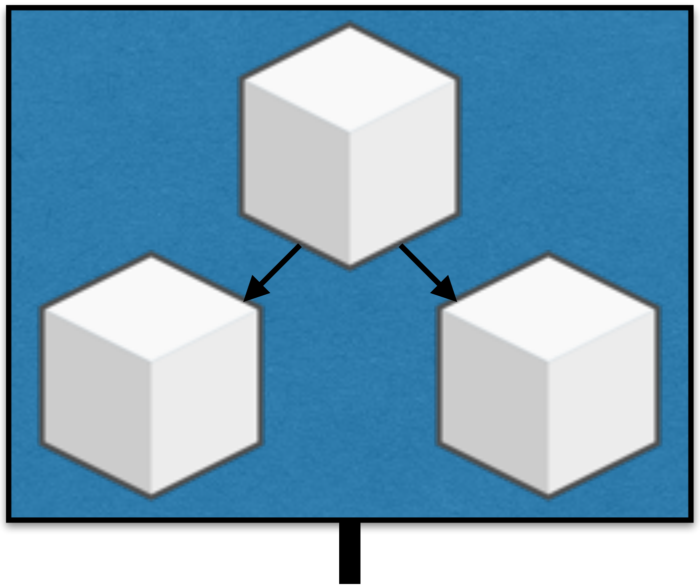
Image courtesy of http://openclipart.org



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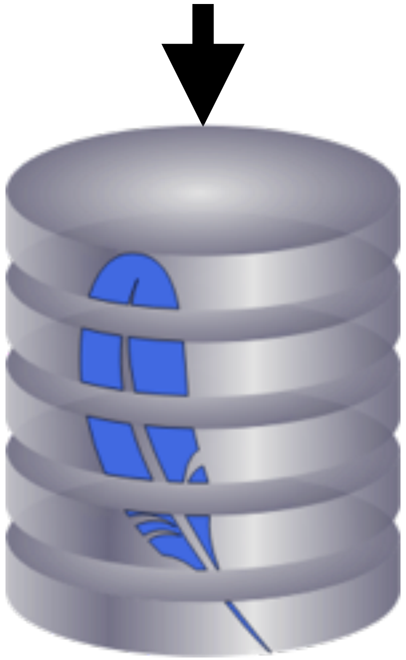

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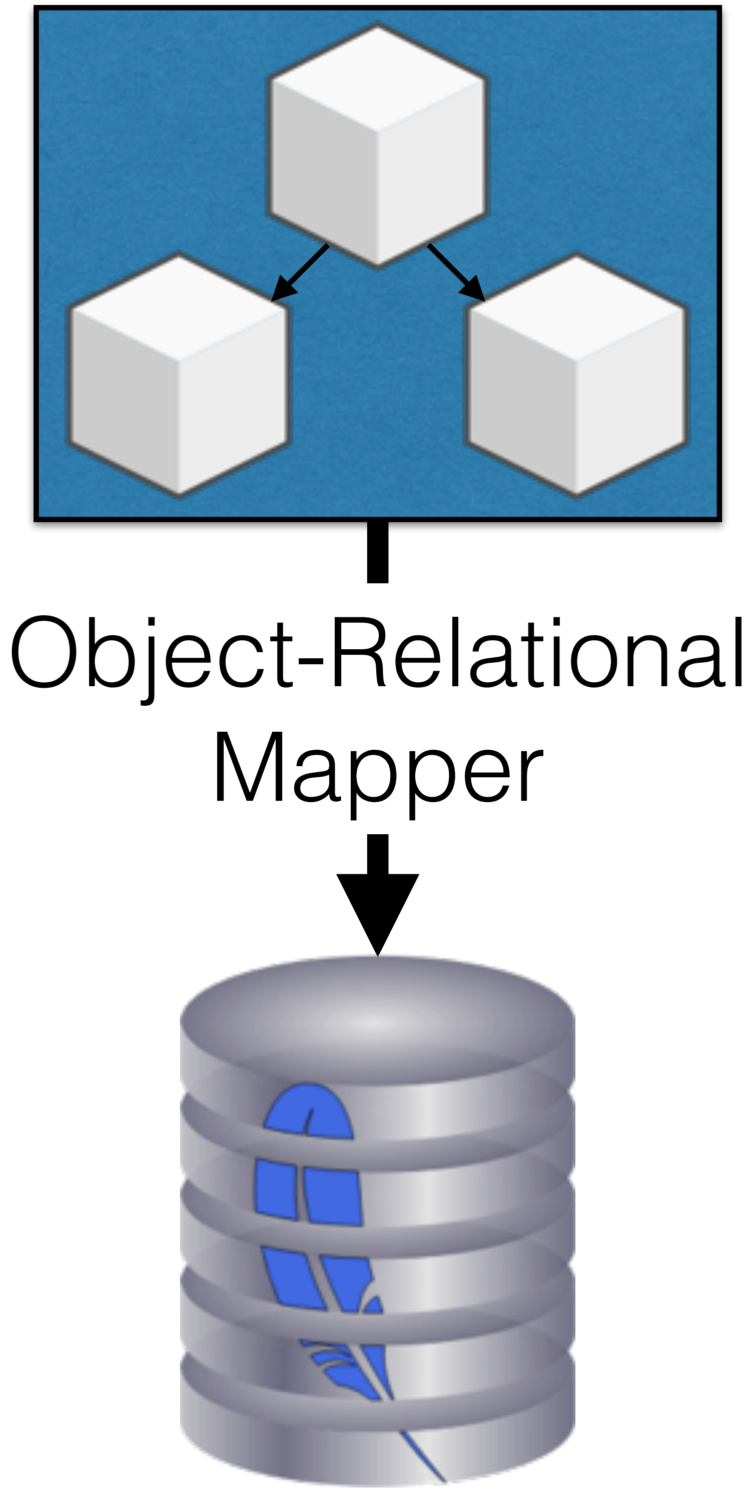
SQL DB used for persisting objects

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pers = Persons.get(10)
org = pers.employer()
name = org.name()
```

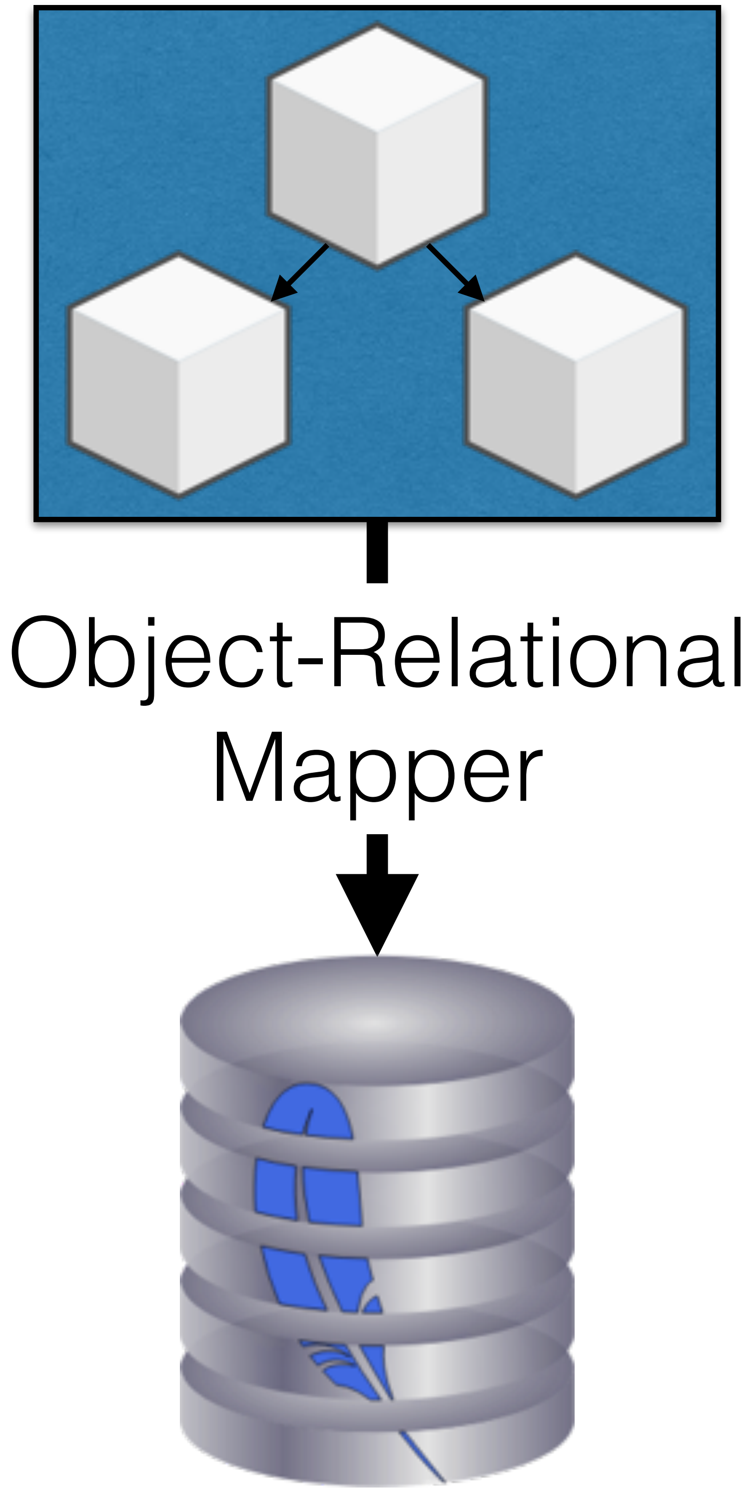


```
pers = Persons.get(10)
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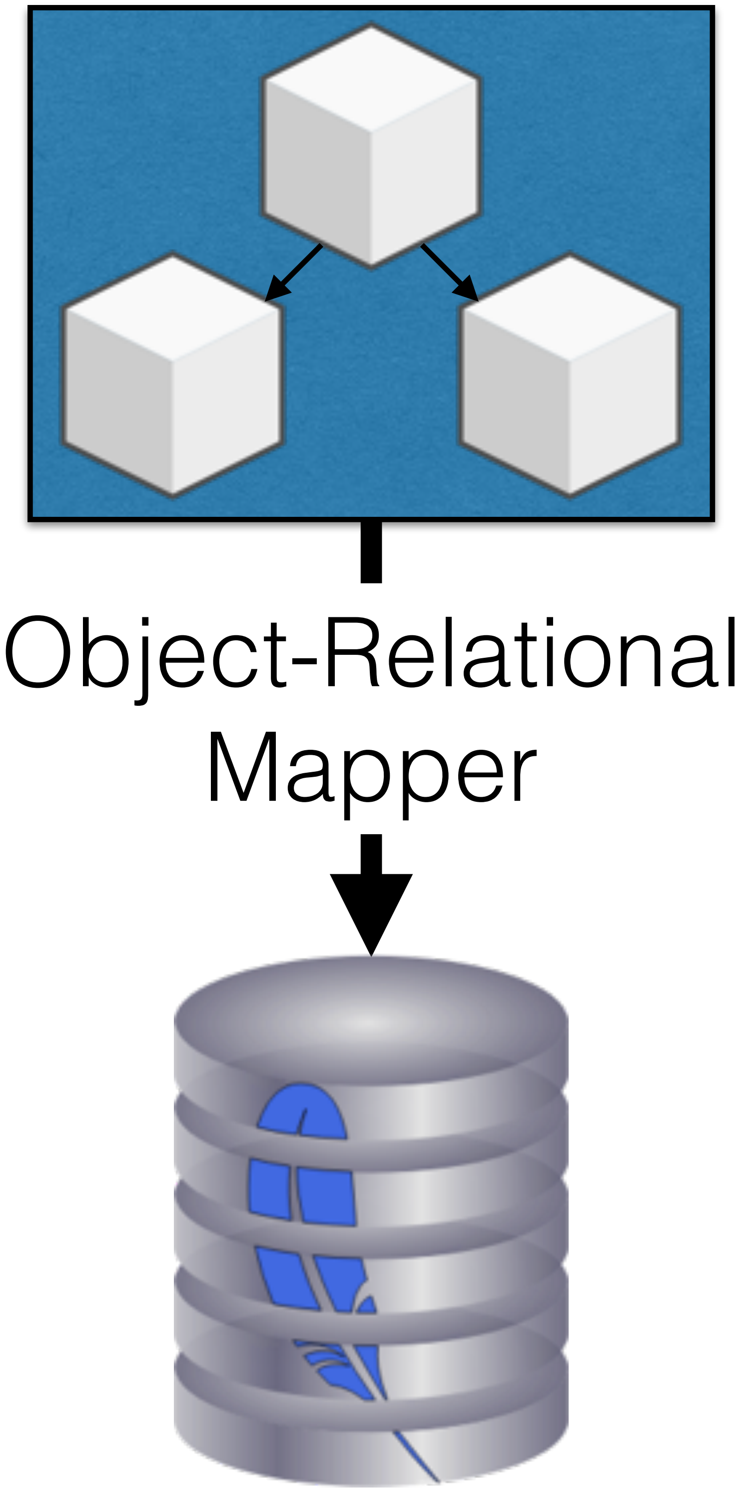
```
SELECT employer_id
FROM Persons
WHERE id = 10;

SELECT name
FROM Organizations
WHERE id = ?;
```

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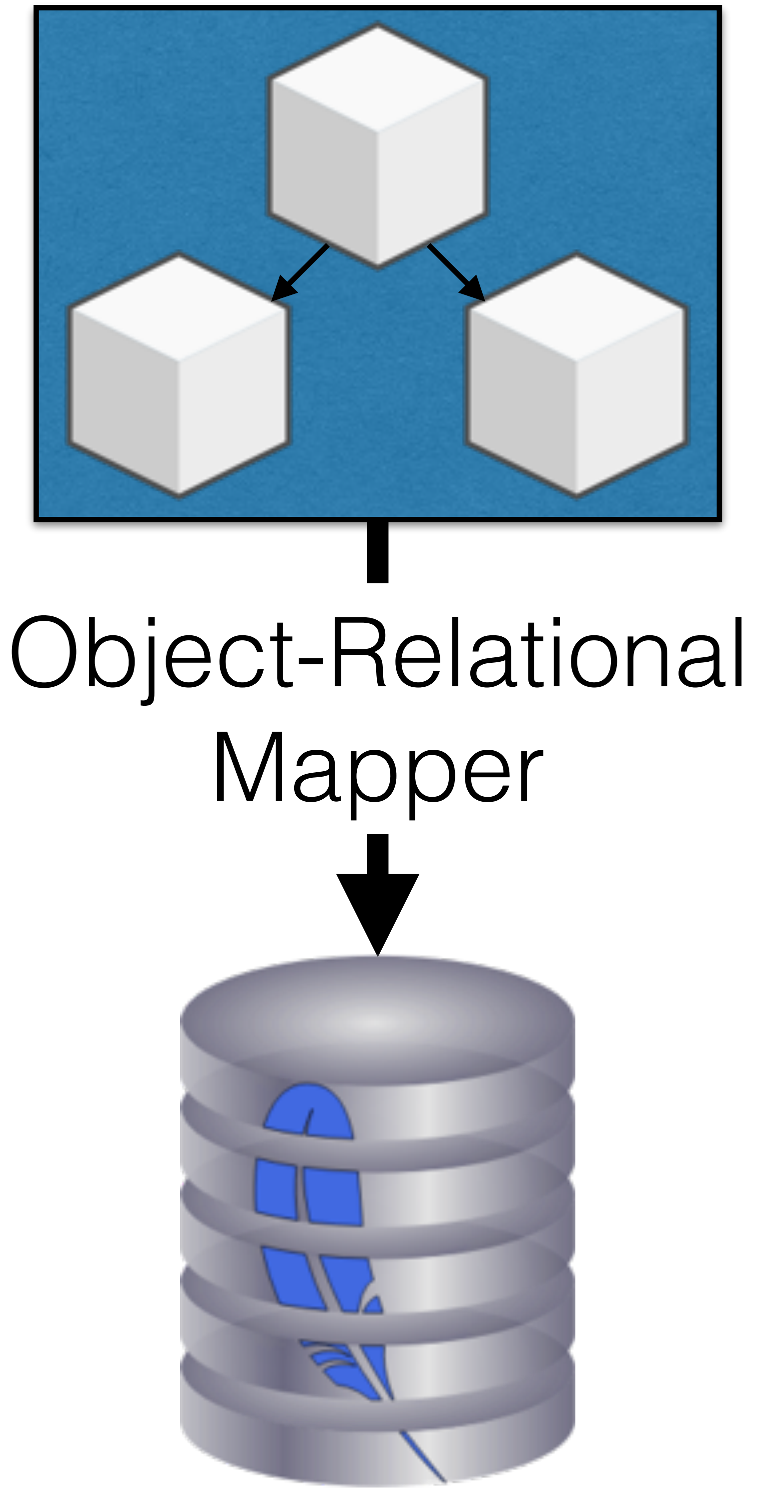
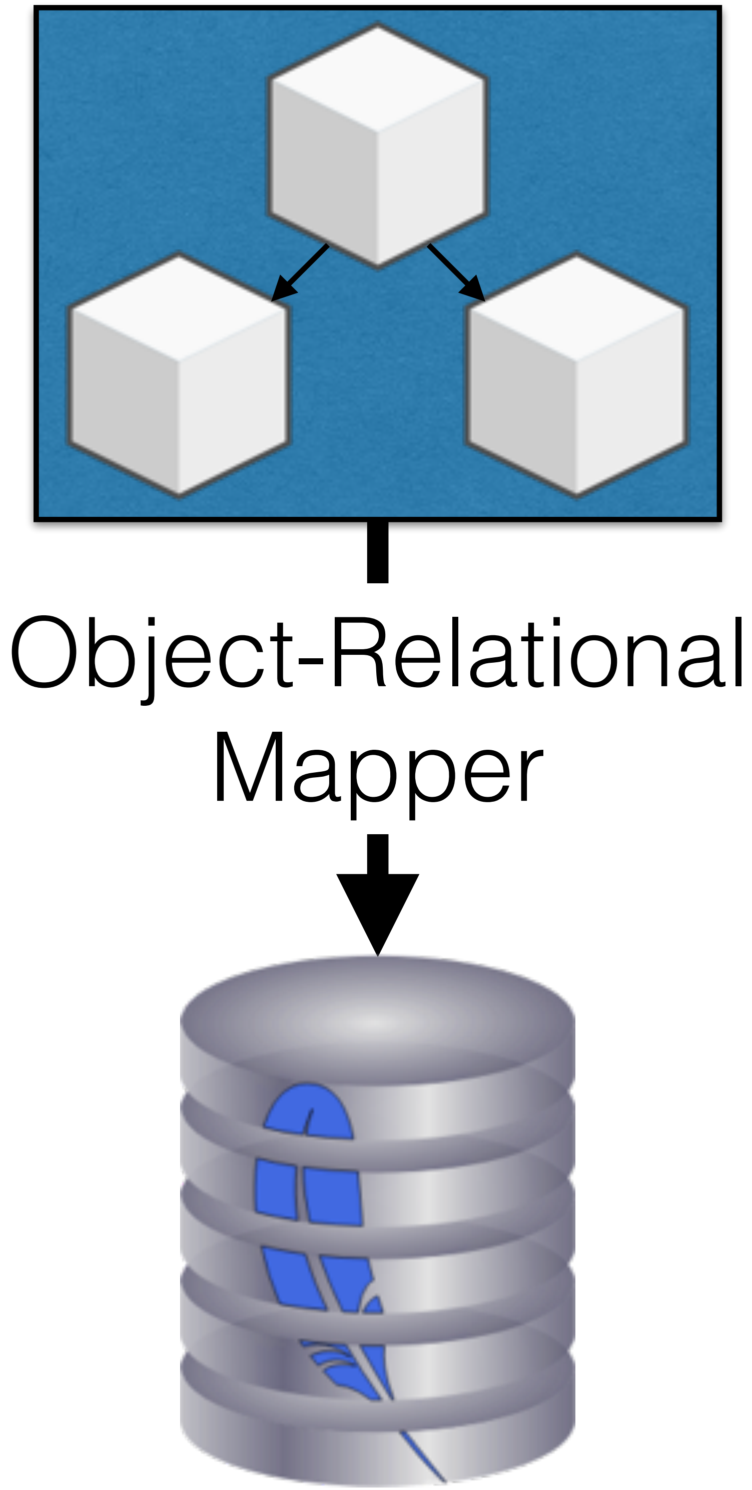
ORMs are not always efficient




```
pers = Persons.get(10)
pers.setSalary(
  pers.salary() * 1.1
)
```

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SELECT salary
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UPDATE Persons
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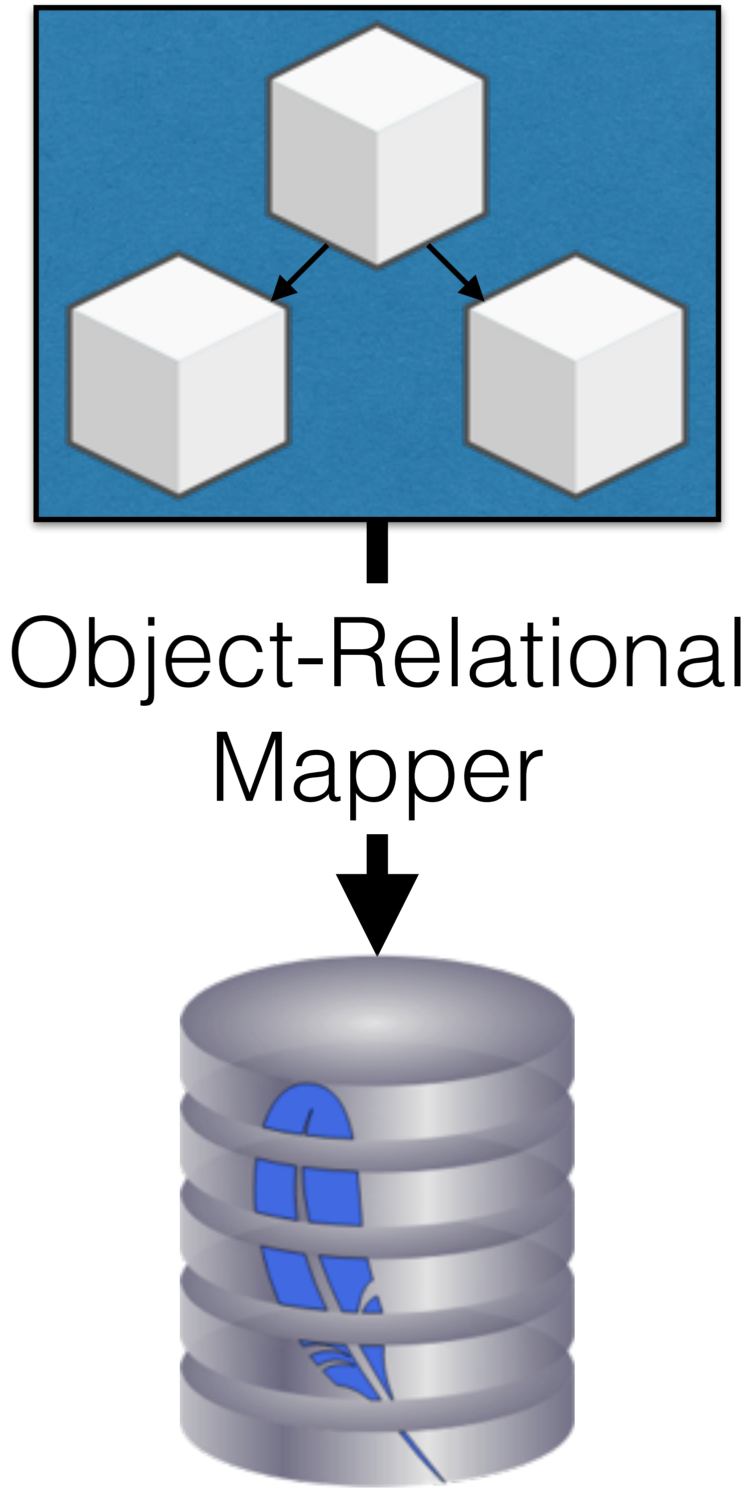
Image courtesy of http://openclipart.org

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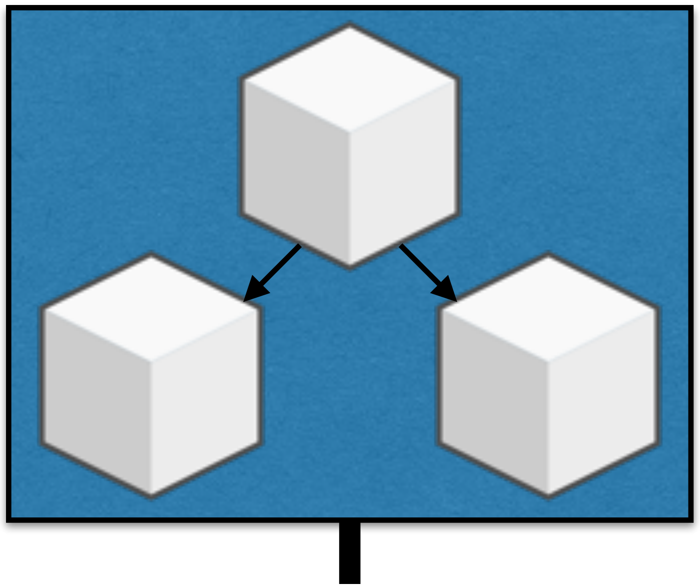
We saw NO update value computations in SQL



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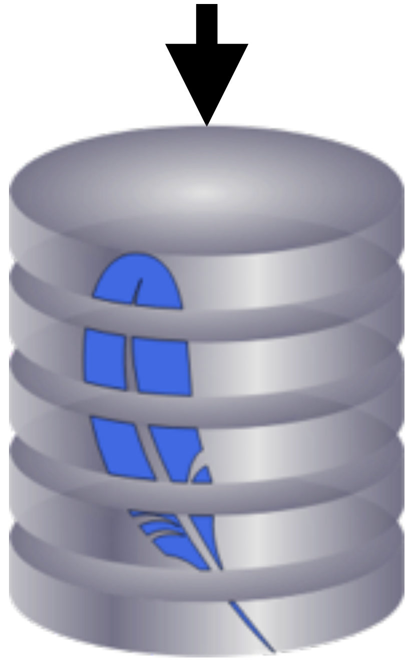

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INSERT OR REPLACE INTO
 Persons(id, salary)
VALUES (?, 10);
```

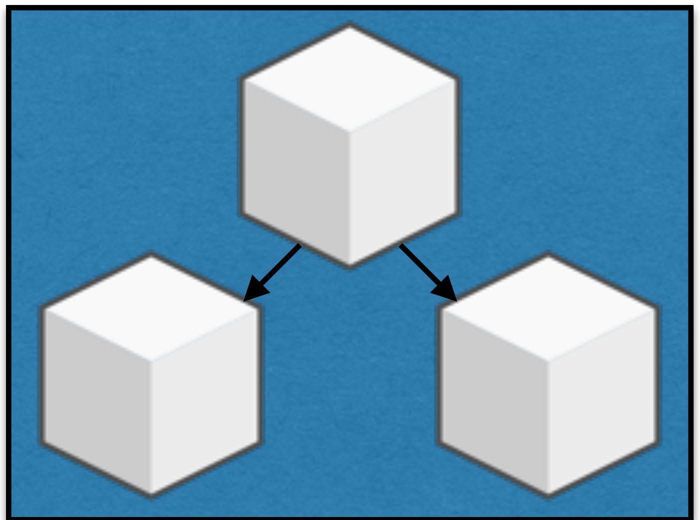

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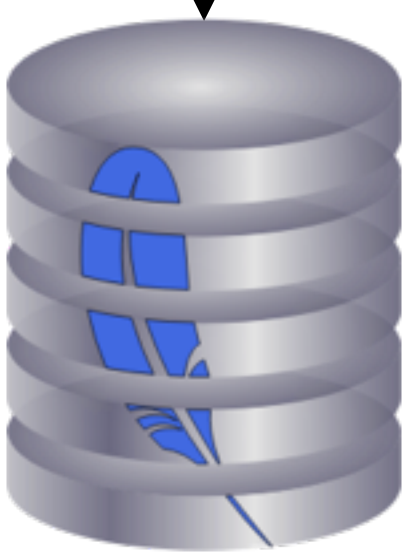

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Insert or Replace used very frequently

- SELECT Complexity
- ORM Effects

Function Usage

- Read/Write Ratios
- Query Periodicity

Aggregates

Function	Call Sites
GROUP_CONCAT	583,474
SUM	321,387
MAX	314,970
COUNT	173,031
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AVG	15

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Aggregates most common function type

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Concatenate all strings in a column: Non-algebraic

Other Functions

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- Some Android-Specific (`phone_numbers_equal`)

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- Mostly string manipulation (`length, substr`)
- Some Android-Specific (`phone_numbers_equal`)
- **NO** UDFs at all

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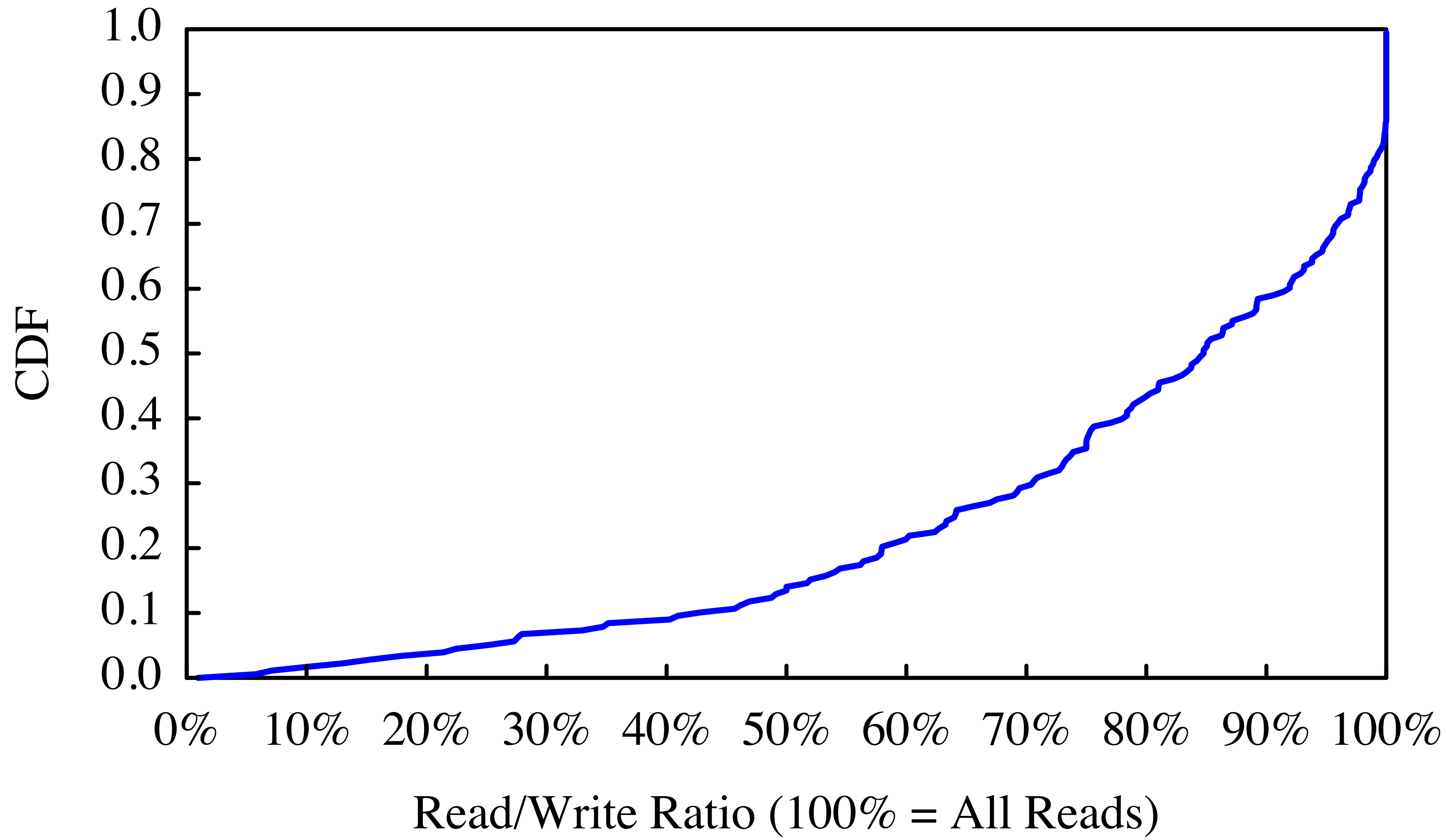
Reads vs Writes



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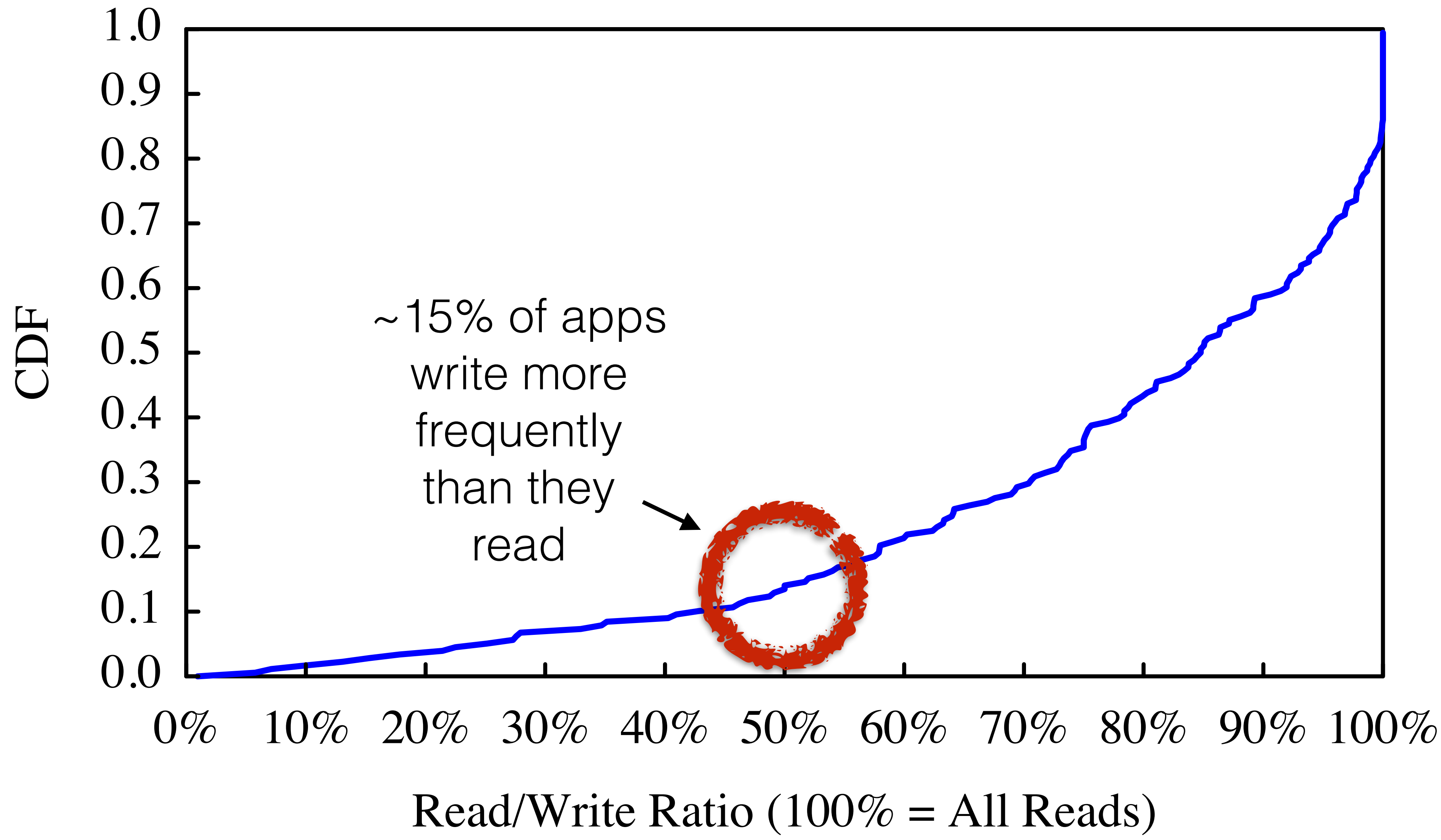

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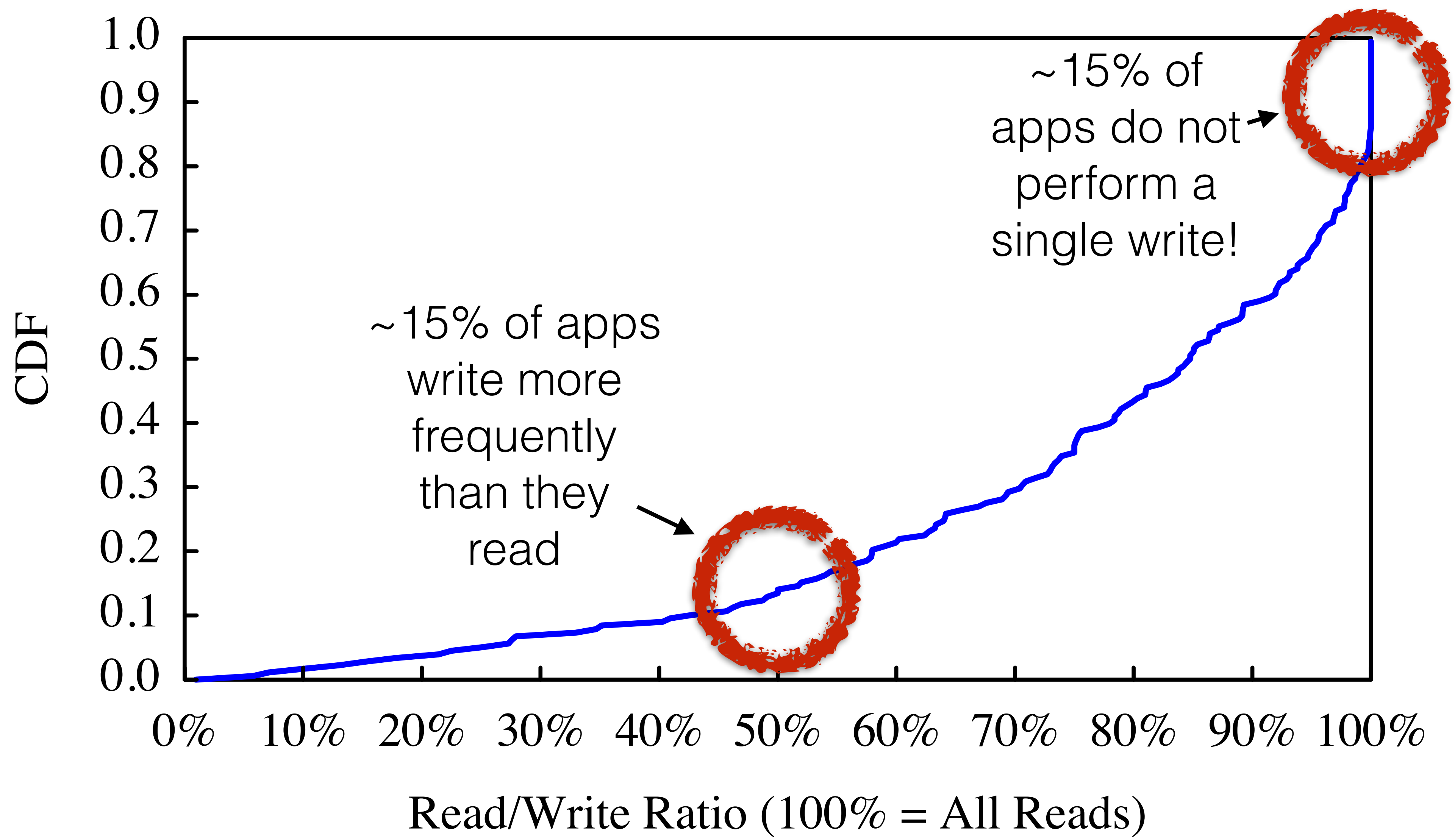

Read-Only Workloads

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- *JuiceSSH, Key Chain*
  - Credential store, infrequent writes

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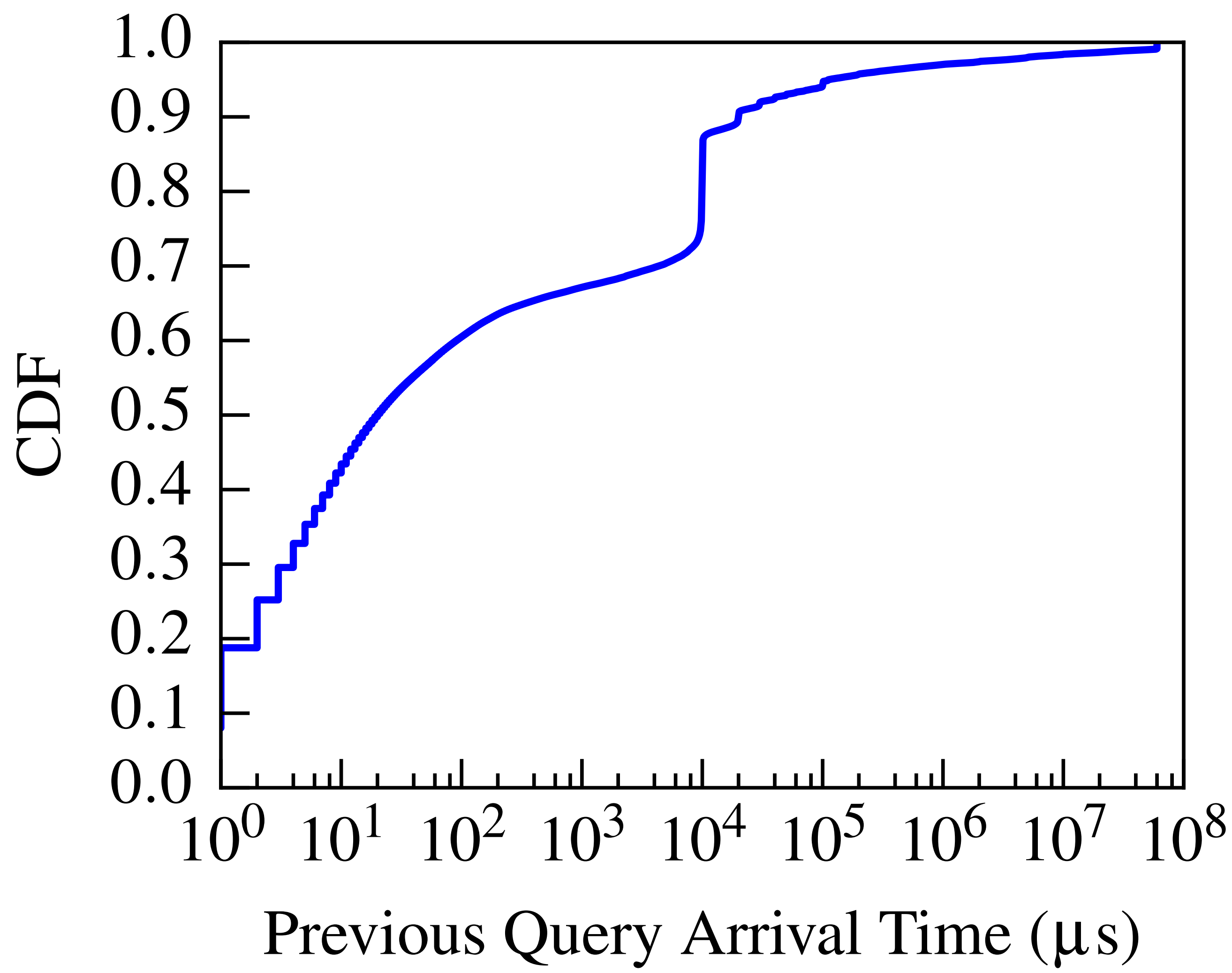
- *JuiceSSH, Key Chain*
  - Credential store, infrequent writes
- *Google Play Newsstand, Eventbrite, …*
  - Frequent queries over changing data
  - Data bulk updated by **copying entire SQLite DB**

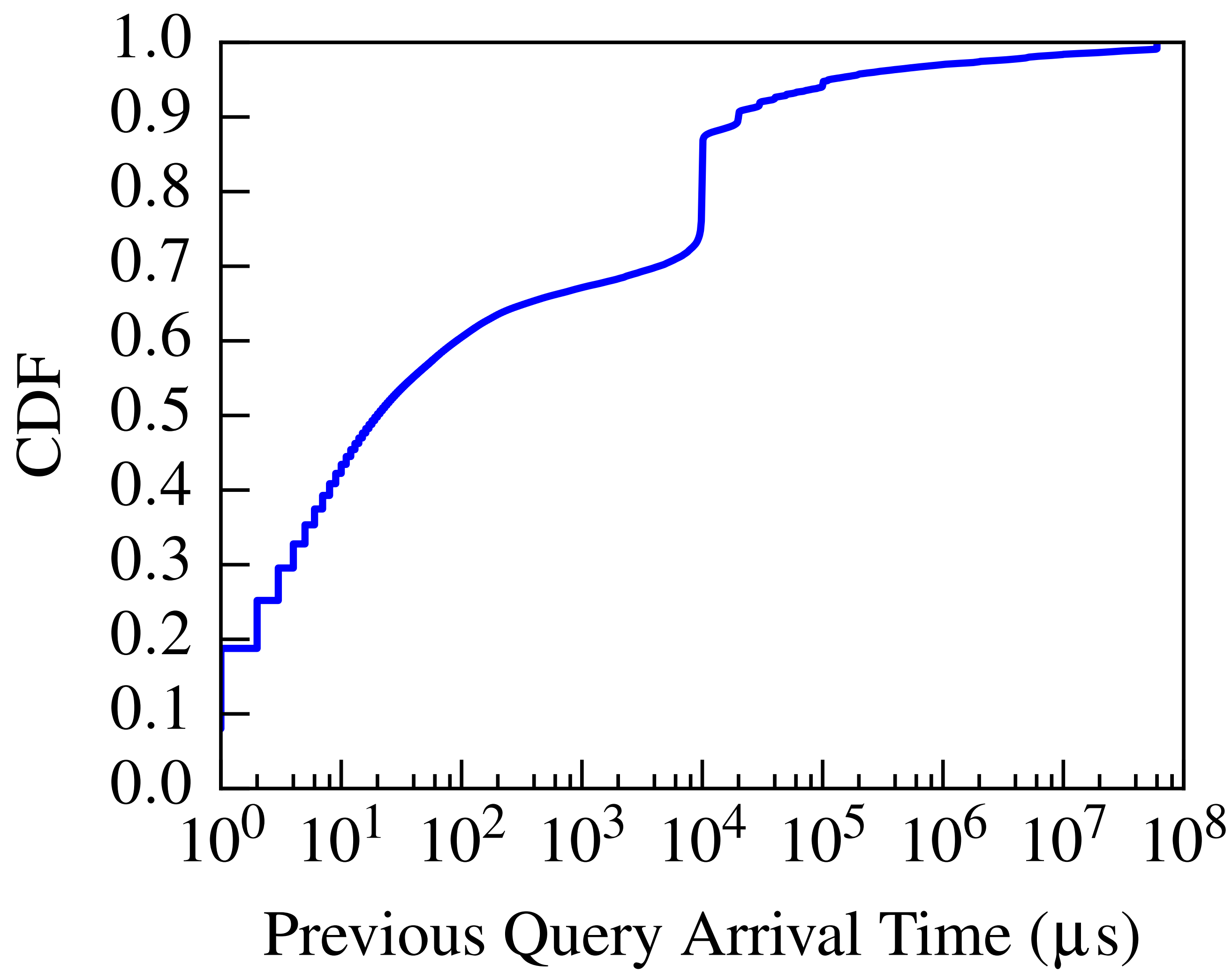
- SELECT Complexity
- ORM Effects
- Function Usage
- Read/Write Ratios

Query Periodicity

Query Arrival Frequency

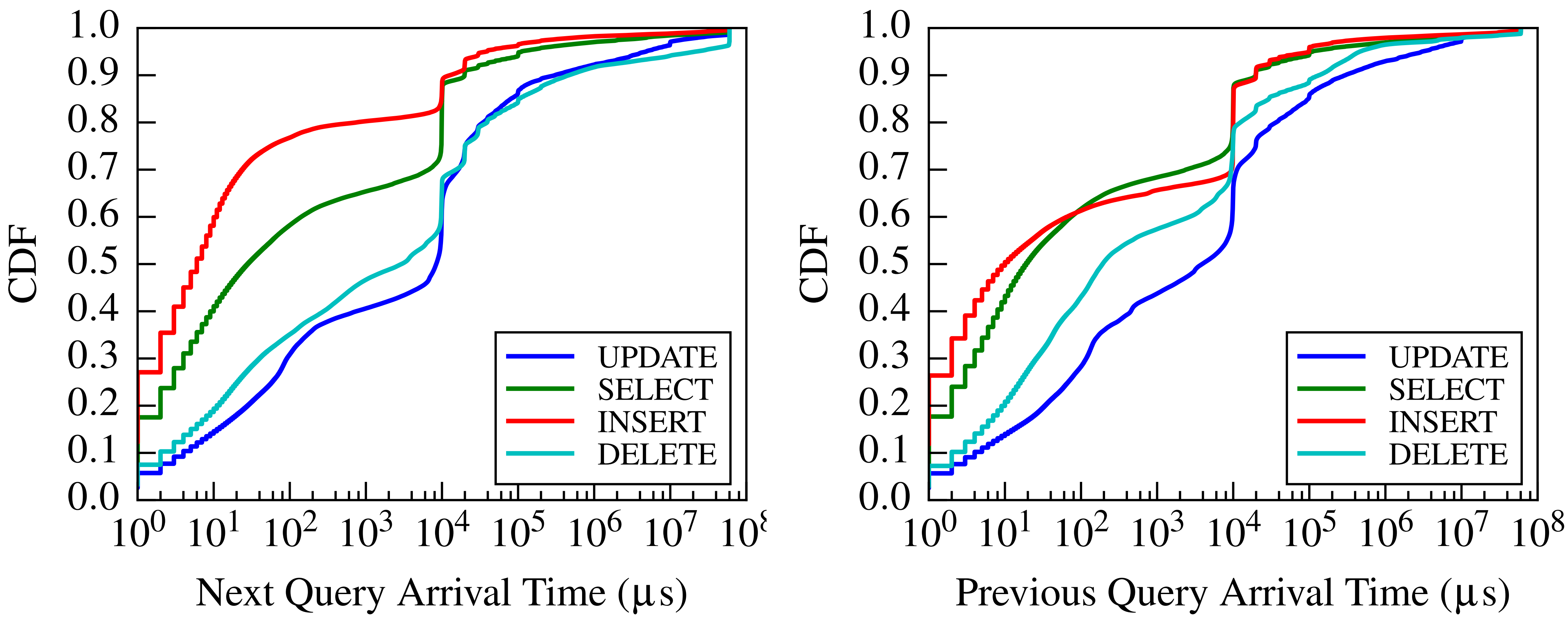


Query Arrival Frequency



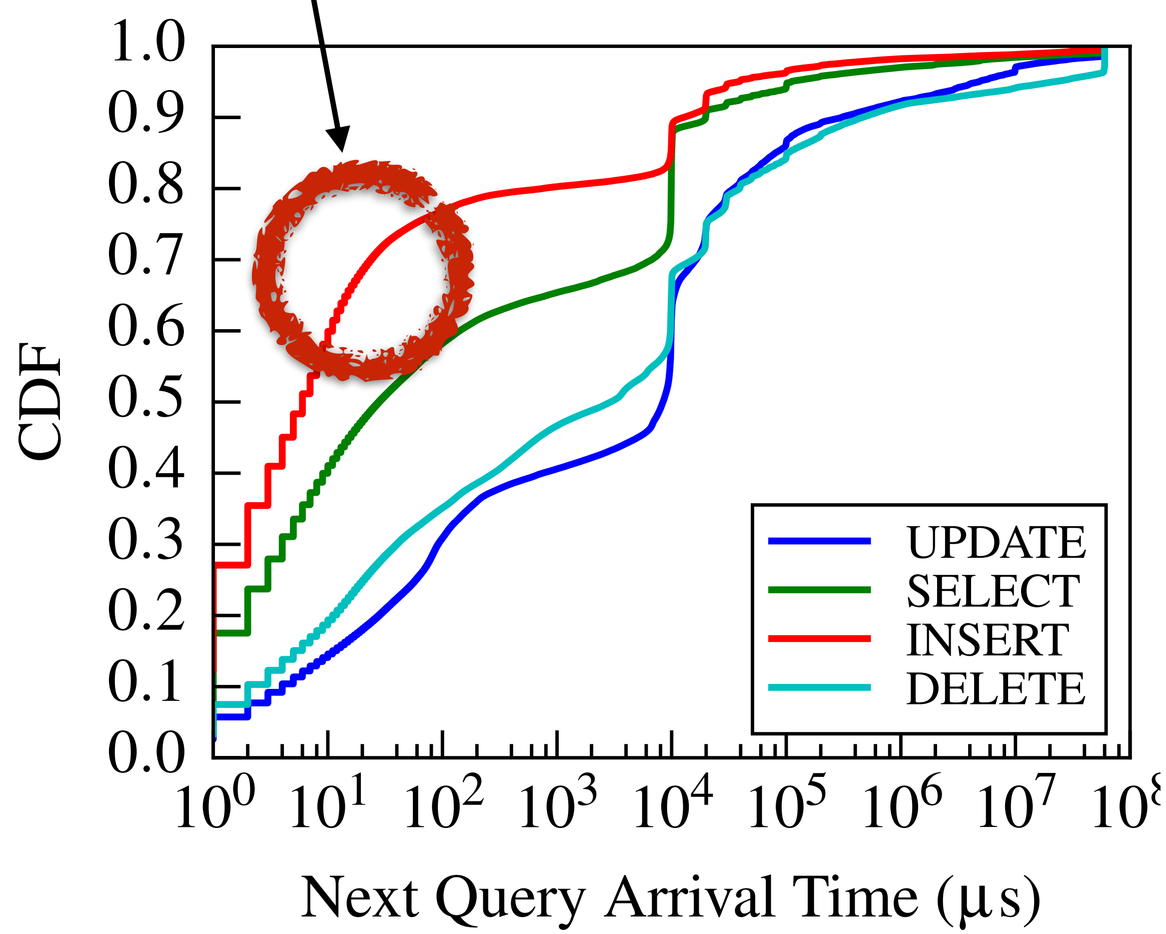
15-20% of queries arrive ~10ms after last query

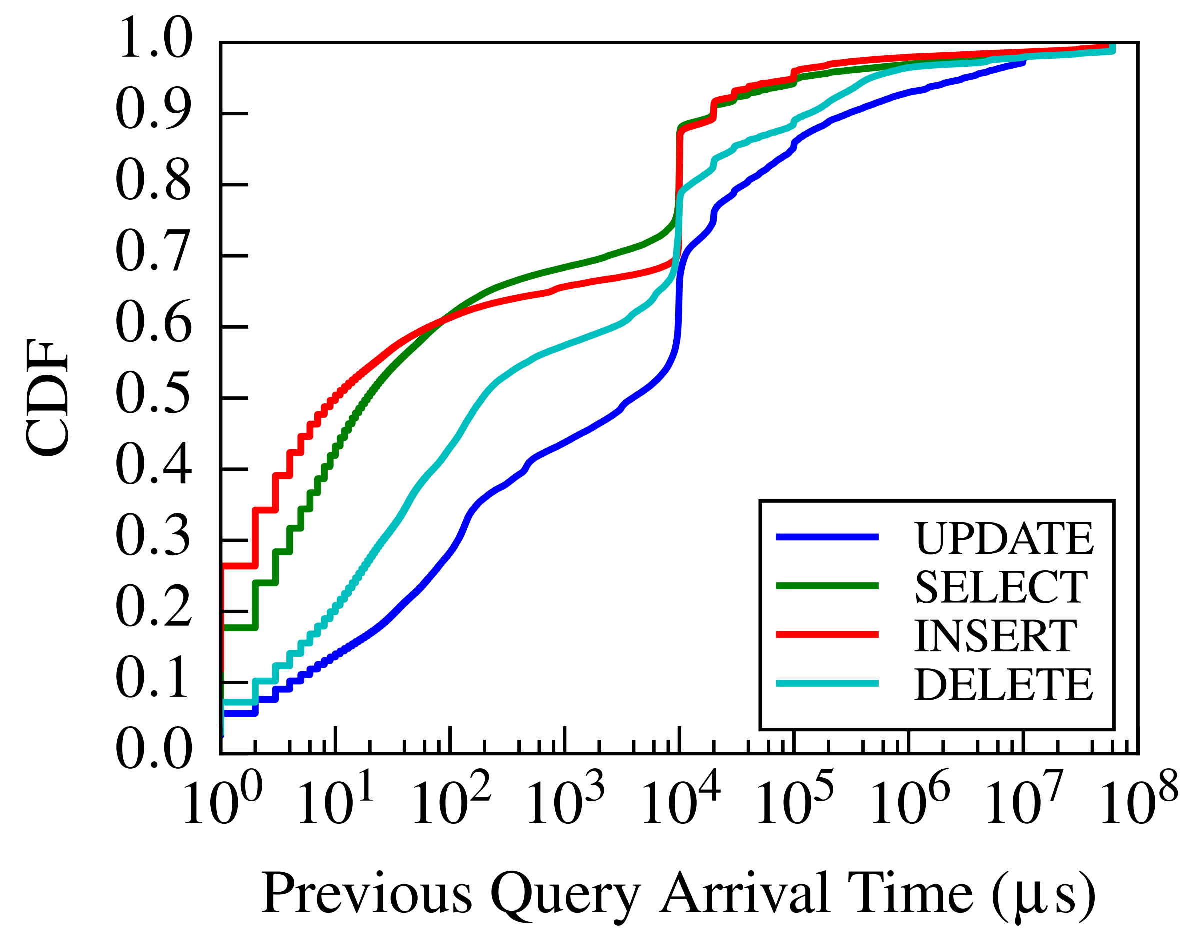
By Query Type



By Query Type

70% of inserts come less than
0.1 ms before another query





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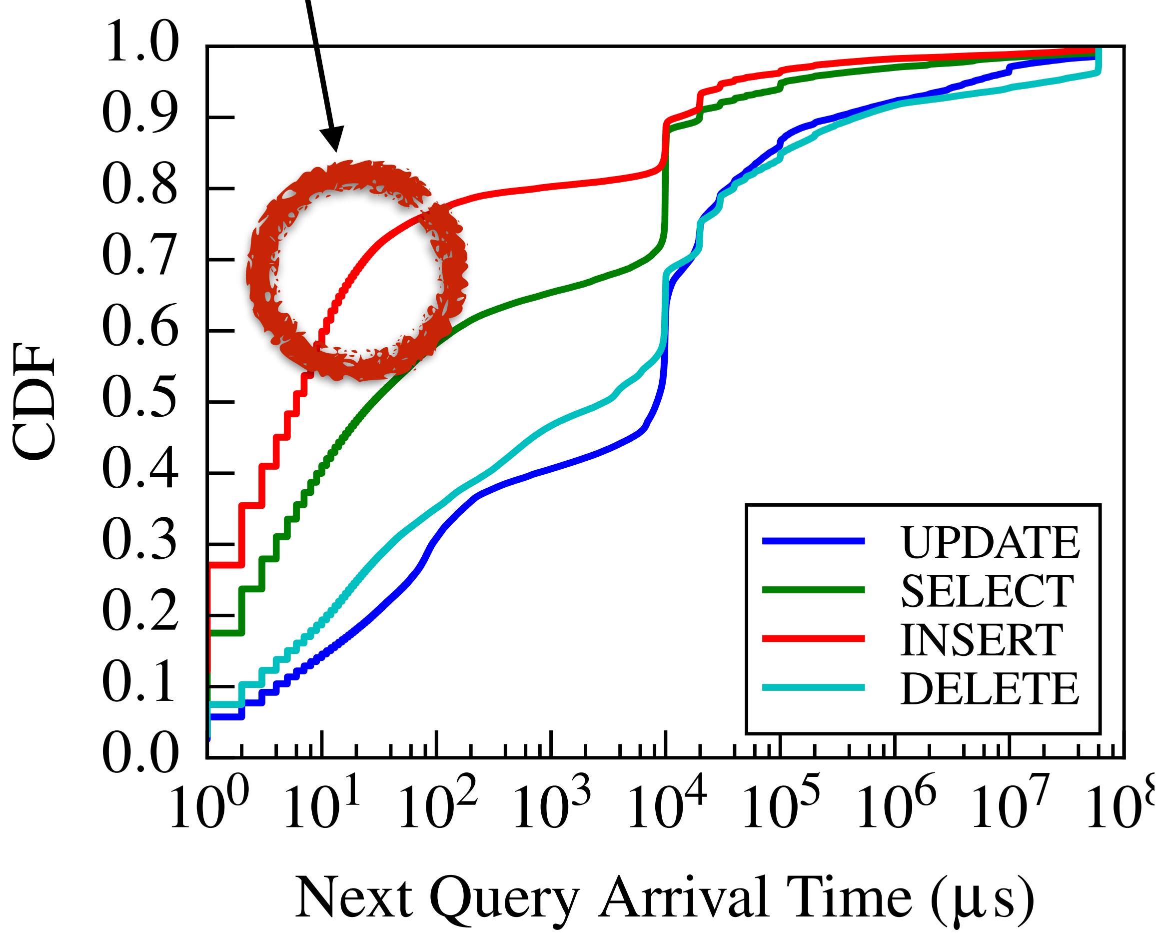
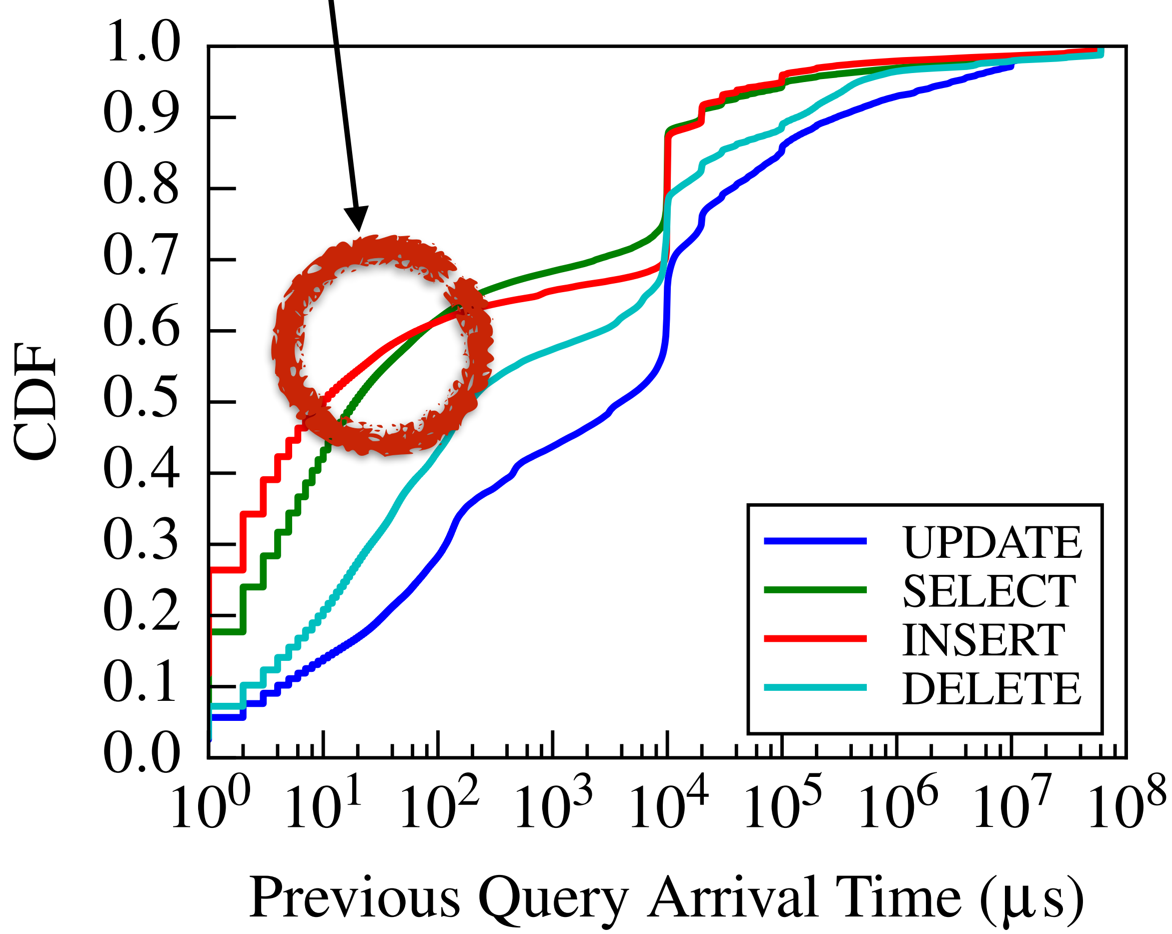
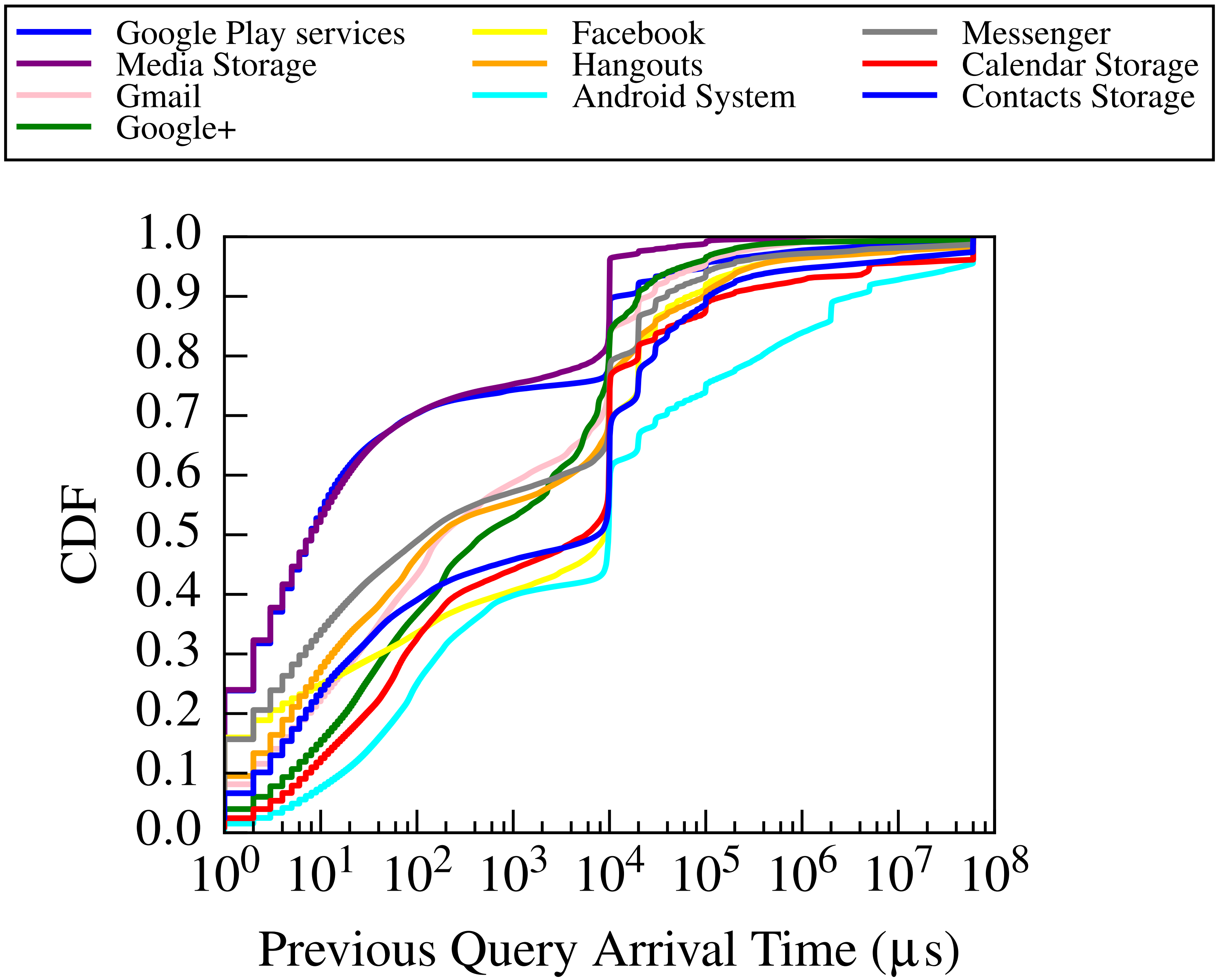


Most sequences consist of INSERTs and SELECTs



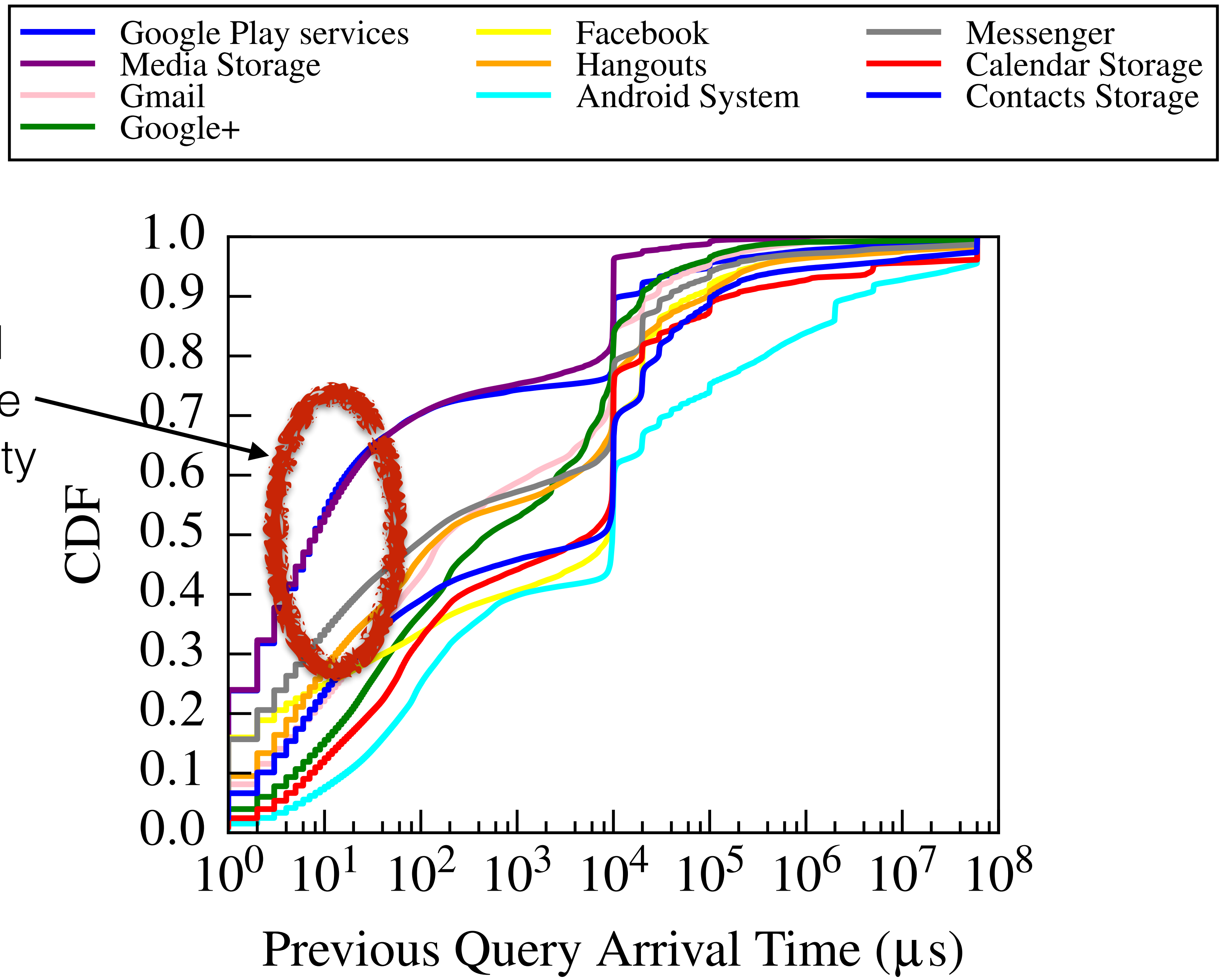
By App



Google Play services
Media Storage
Gmail
Google+
Facebook
Hangouts
Android System
Messenger
Calendar Storage
Contacts Storage
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CDF
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8
Previous Query Arrival Time (µs)

By App

Google Play Services and Media Storage are VERY bursty



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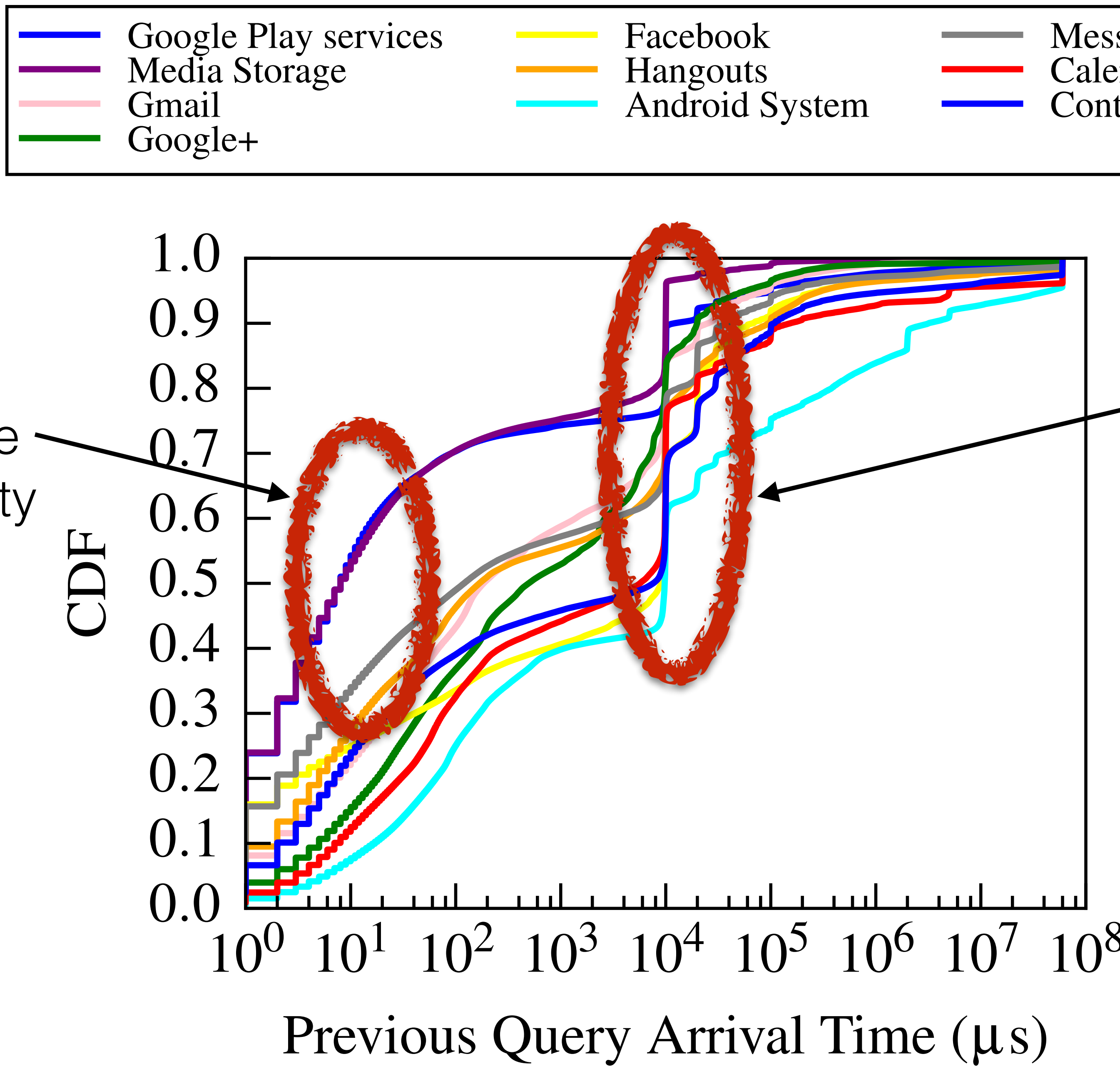

Same 10 ms periodicity evident across all apps

A Call to Action!

- Mobile phones process ~2 queries/second
  - DB performance important for power, latency, …
- Embedded DBs used differently than Server DBs.
  - We need to understand these access patterns before we can optimize for them.

We need a TPC-MOBILE for pocket-scale data!