The ObjectStore Database System

Charles Lamb, Gordon Landis, Jack Orenstein, Dan Weinreb
(1991)

Devyani McLaren

(slides adapted from Ricardo Pedrosa, Jian Xu)

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CPSC 504

Who’s gonna take the biggest chunk of the pie?

A **B I G** Company has a need for DBMSs to control the **WIDEST – HUGHEST** amount **EVER** seen of applications. Two options come to the plateau: one group of developers offering the somewhat well known Relational model and another one offering an object oriented approach based on Object Store.

The **B I G** Company decides to hear what’s good and bad of this new approach before deciding in whose hands each one of its applications are going to end.

Motivation

- Impedance mismatch between application code and database code (eg, C++ and SQL)
- ObjectStore provides a uniform programmatic interface to both **persistent** and **transient** data.

Persistent = data stored in a database

Transient = data when running a program

C++

- Object-oriented (OO) programming language
  - Classes w/
    - Abstraction, encapsulation, inheritance, polymorphism
- Pointers
  - Variable the stores the memory address of an object
  - Can ‘directly’ manipulate memory (more low-level than other languages)
  - But! Can lead to a lot of memory mixup and errors because of empty memory that may not be allocated for

Goal: add persistence to C++

- Ease of learning: C++ plus a little extra.
- No translation code: persistent data is treated like transient data.
- Expressive power: general purpose language (as apposed to SQL)

- Reusability: same code can operate on persistent or transient data
- Ease of conversion: data operations are syntactically the same for persistent and transient data.
- Type checking: same static type-checking from C++ works for persistent data.
- Temporal/Spatial locality: take advantage of common access patterns.
- Fine interleaving: low overhead to allow frequent, small database operations
- Performance: do it all with good performance compared to RDBMSs

Application Interface

- Three programming interfaces: libraries for C and C++, and an extended C++ language. We focus on language extension.
- Keyword **persistent**. Used when declaring variables
- A few other keywords (**inverse_member, indexable**) for defining how objects in the DB relate.

```
main()
{
  database *db = database::open("/company/records");

  persistent<db> department* engineering_department;

  transaction::begin();

  employee *emp = new(db) employee("Fred");
  engineering_department->add_employee(emp);
  emp->salary = 1000;

  transaction::commit();
}
```

Collections

- Similar to arrays in PL’s or tables in DBMSs
- Allow performance tuning: developers specify access patterns and an appropriate data structure is chosen
- Elements may be selected from collections with queries

Relationships
(this can be skimmed or skipped as needed)

- Pairs of inverse pointers which are maintained by the system.
- One-to-one, one-to-many, and many-to-many are supported.
- Syntactically, relationships are C++ data members, however, updating causes its inverse to be updated.

Associative Queries

- Selection predicates can be applied to collections.
- Special syntax: `[: predicate :]`
- Eg.

```
employees [: salary >= 10000 :]
```

- Queries may be nested.

Approx Query example

os_Set(employee*)> & overpaid_employees=
all_employees->query(‘employee*’, “ [: salary >=
100,000:]”);

C++

os_Set(employee*)& overpaid_employees =
all_employees [: salary >= 100,000 :];

Extended C++

SELECT * ~~salary~~
FROM all_employees ??
WHERE salary >= 100,000

SQL

Accessing persistent data

- Overhead is a major concern.
- Once objects have been retrieved, subsequent references should be as fast as an ordinary pointer dereference.
- Similar goals as a virtual memory system-- use VM system in OS for solution

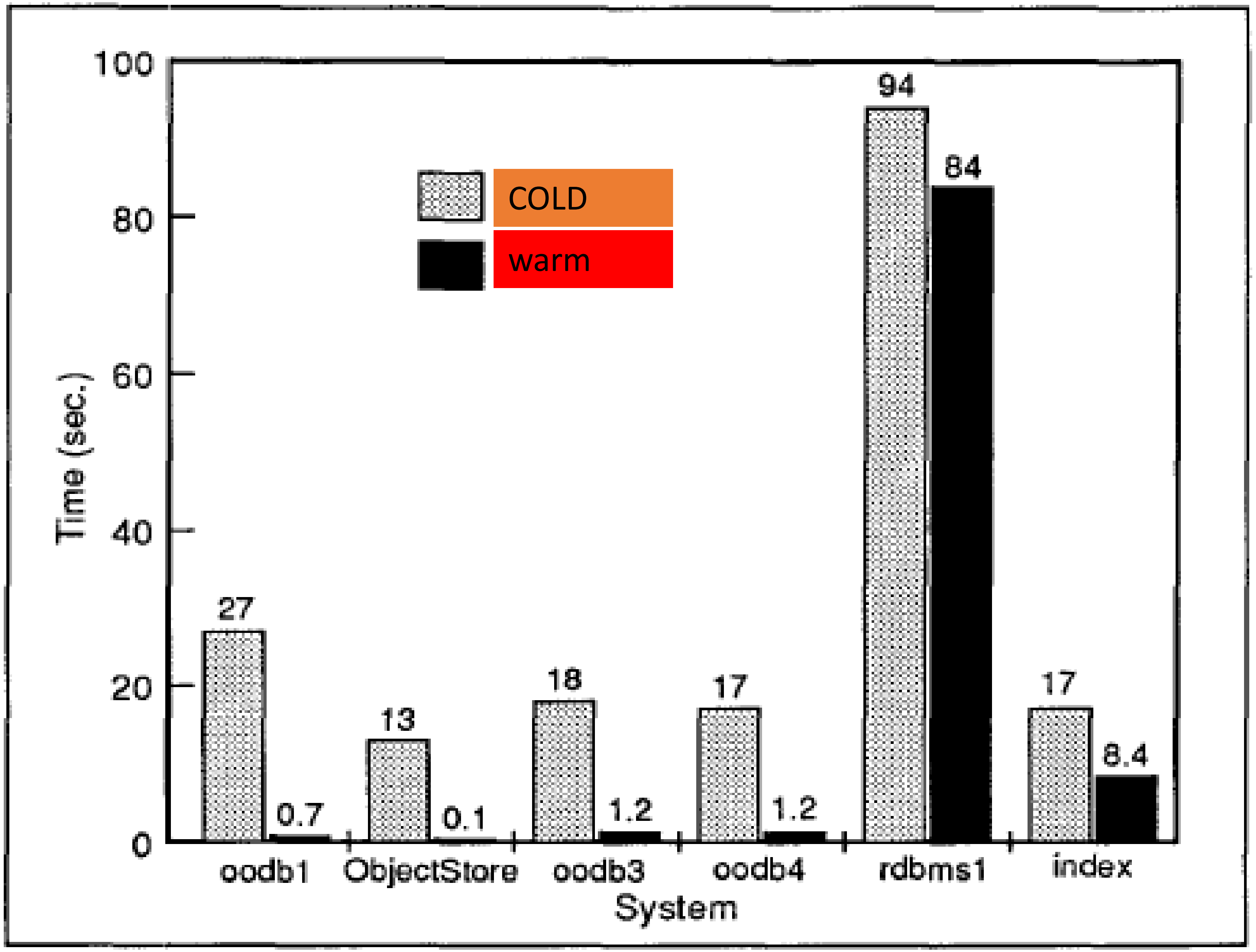
Query optimizations

Some RDBMS query optimization techniques don’t work or make sense

- Collections are not known by name
- Join optimization is less of a problem
  - paths can be viewed as precomputed joins
  - optimization is index selection
  - “true joins” are rare
- Index maintenance is more of a problem

Discussion (from Matt)

Learning from the history of “excellent” ideas that didn't make it - should we be cautious about deployment right away? How can we tell when the winds favor us? Is it luck, or is there something we can research/plan for?



100
80
60
40
20
0
Time (sec.)
COLD
warm
27
0.7
13
0.1
18
1.2
17
1.2
94
84
17
8.4
oodb1
ObjectStore
oodb3
oodb4
rdbms1
index
System

Conclusion

- Performance experiments show caching and virtual memory-mapping architecture work.
- Small case study shows productivity benefits
- ObjectStore provides
  - Ease of use
  - Persistent C++
  - Expressive power
  - High performance due to VM mapping architecture

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Of Objects and Databases: A decade of Turmoil

Michael J. Carey, David J. DeWitt
(1996)

Devyani McLaren

(slides adapted from Ricardo Pedrosa, Jian Xu)

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Objects and Databases. Areas of research

- Extended relational database systems.
- Persistent programming languages.
- Object-oriented database systems.
- Database system toolkits/components.

Extended Relational Database Systems

Areas of Research 1

- Allow the additional of new, user-defined abstract data types (ADTs).
  - ADTs are implemented in an external language
  - After being registered with the database, ADT’s functions can be used in queries

- Projects
  - Ingres
  - Postgres
    - Query optimizers with ADT’s properties and functions awareness
    - Support for storing and querying complex data types

Persistent Programming Languages

Areas of Research 2

- Add data persistency and atomic program execution to traditional object-oriented programming languages

- Problems addressed:
  - Impedance mismatch

Object-Oriented Database Systems

Areas of Research 3

- Combine all of the features of a modern database system with those of an object-oriented programming language, yielding an objected-oriented database (OODB) system.

- Focused on:
  - Support for querying, indexing and navigation
  - Addressing version management needs of engineering apps

Database system toolkits/components

Areas of Research 4

- Provide a DBMS that can be extended at almost any level and have additional tools that help building domain-appropriate DBMS

- Projects:
  - Exodus
    - Storage manager for objects
    - E: a persistent programming language
    - Query optimizer generator
  - Starburst
    - Clean architectural model that facilitates storage and indexing extensions
    - Rule-based extensible query subsystem

What happened?

Objects & Databases in 1996

- **System toolkits & persistent programming languages:**
  - Despite some interesting results these were a failure from a commercial POV
- **OO Database systems:**
  - Many results from the academic POV. Not expanded commercially as expected by its developers
- **Language-specific object wrappers for relational databases:**
  - New approach that appears to be important for building OO, client-side apps
- **Extended relational DBS**
  - Renamed as Object-Relational DBMS. Appears to be a settling in terms of providing objects for enterprise DB apps

The database toolkit approach problem

Causalities 💔

- Require a lot of expertise
- End up in being inflexible awkward of incomplete
- As OO and O-Relational database systems provide enough extensibility, it's not worthy to start from scratch even given a toolkit to help in the process

Why Exodus failed?

Causalities 💔

- The client/server architecture introduced an unwanted level of indirection when users tried to use EXODUS to implement their own object servers
- E programming language: Too general for skilled database implementors and too low-level for application-oriented programmers
- The query optimizer was inefficient and hard to use

Persistent Programming Languages

Causalities 💔

- No commercial implementation of such a language
- Still active as a research area in academia
- Work on this area has had a significant impact and has been transferred to OODBMS
  - Navigational programming interfaces
  - Persistent models
  - Garbage collection schemes for persistent data

What OODBM's must support

Object-Oriented Database Systems (OODBMS)

- Complex objects
- Object identity
- Encapsulation
- Inheritance & substitutability
- Late binding
- Computationally complete methods
- Extensible type system
- Persistence
- Secondary storage management
- Concurrency control
- Recovery
- Ad hoc queries

What OODBM's might support

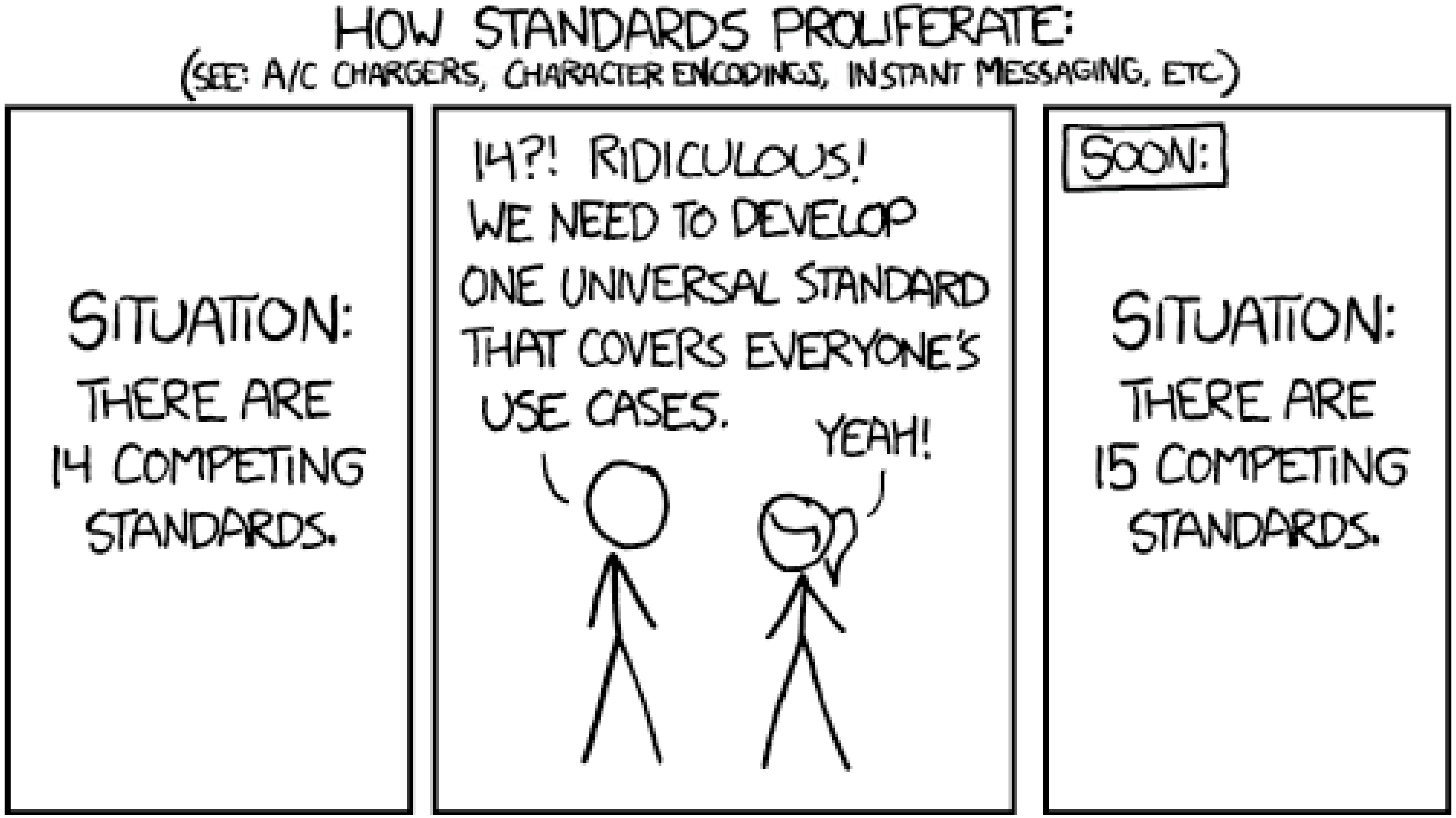
- Multiple (vs. single) inheritance
- Static (vs. dynamic) type checking)
- Distribution
- Long transactions
- Version management

What went wrong with OODMS?

Object-Oriented Database Systems (OODBMS)

- Lack of standards
- OODBMS products are behind RDMS in some terms (e.g. no views)
- Painful schema evolution
- Low availability of application development tools

Standards



https://xkcd.com/927/

Standards (from Jeffrey and Carol)

- What situations/environments lend themselves well to standardization efforts? Which ones devolve into conflict and disagreement?

Main tenets for ORDBMS (aka extended DBMS)

Object-Relational Database Systems (ORDBMS)

- Provide support for richer object structures
- Subsume RDBMS
- Be open to other subsystems (tools and multi-database middleware products)

What ORDBMS should provide?

- A rich type system, inheritance, functions, and encapsulation, optional unique ids and rules/triggers
- A high-level query-based interface, stored and virtual collections, updatable views and separation of data model and performance features

Fully integrated solution

A vision from 1996 -> 2006

- Object relational servers will provide:
  - Support OO ADTs
    - Inheritance among ADTs
    - ADT Implementation in various programming languages
  - Full OO support for row types
  - Support for middle-tier and desktop applications
  - Methods and queries will be run on cached data on servers or clients depending on where's faster

Research Challenges

A vision from 1996 -> 2006

- Server functionality and performance
- Client integration
- Parallelization
- Legacy data sources
- Standards

Many of you, but explicitly Michael

- What determines which solution “wins” out in the end, if any?

Bonus discussion (Yingfeng)

What happens to an area if it lacks commercial value but still has academic/engineering value？