CPCS 504 – Data Management

The **ObjectStore** Database System

Charles Lamb
Gordon Landis
Jack Orenstein
Dan Weinreb

Presented by: Nguyet Minh Nguyen
Discussion by: Immad Naseer

Outline

- Introduction (ObjectStore, Motivation, Goals)
- Application interface (Collection facility, Relationship facility, Accessing persistent data, Query facility)
- Memory-mapped architecture
- Distributed data access
- Query optimization
- Conclusions

ObjectStore

- Object-oriented DBMS
- Some different packages (C++, Java)
- C++ package
  - Closely integrated with the C++ language
  - Persistent storage capabilities for C++ objects
  - Associative queries
  - Transaction management
  - Distributed data access

Motivation

- Target applications (CAD, CAE, GIS…)
  - Complex manipulations
  - Large databases of objects with intricate structure
- Impedance mismatch between application code and database code
- a *uniform programmatic interface* to both *persistent* and *transient* data.

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 opposed 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.

Goal: add persistence to C++

- Type checking:
  - The 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

Discussion #1

- What are the *pros* and *cons* of merging programming languages & databases ? For example:
  - “*Expressive power*”: You can express more queries using a programming language as compared to, say, SQL. What are the pros and cons? Are there alternate solutions?
  - *“Reusability”:* Does the data model become more or less reusable across applications?
  - *“Using the data”*: Does manipulating the data in the application become easier or difficult?
  - Other?

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Application Interface

- Three programming interfaces
  - C library interface
  - C++ library interface
  - **Extended C++ language**
    - Collection facility
    - Relationship facility
    - Accessing persistent data
    - Query facility

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Collection facility

- Object class library
  - Ordered collections (os_list)
  - Collections with or without duplicates (os_bag or os_set)
- Behaviors
  - insert(e), remove(e), create(e),…
- Looping construct (Cursor interator)

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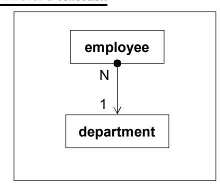
Collection facility (cont.)

```
/* file records.H */

class employee
{
public:
  char* name;
  int salary;
};
class department
{
public:
  os_Set⟨employee*⟩ employees;

  void add_employee (employee *e)
    { employees—>insert (e); }

  int works_here (employee *e)
    { return employees—>contains (e); }
};
```

FIGURE 2.
Using collections

```
department* d;
 . . .
foreach (employee* e, d—>employees)
  e—>salary *= 1.1;
```

FIGURE 3.
Iteration over a collection



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Relationship facility

- Modeling complex objects
- A pair of inverse pointers
- Maintaining the integrity of the pointers
- Relationships
  - One-to-one
  - One-to-many
  - Many-to-many

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Relationship facility (cont.)

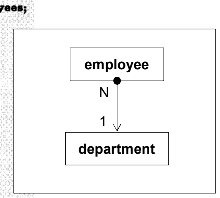
```
/* file records.H */

class employee
{
public:
  string name;
  int salary;
  department* dept
      inverse_member department::employees;
};

class department
{
public:
  os_Set⟨employee*⟩ employees
      inverse_member employee::dept;

  void add_employee (employee *e)
    { employees—>insert (e); }

  void works_here (employee *e)
    { employees—>contains (e) ; }
};
```



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Accessing Persistent Data

```
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();
}
```

Accessing Persistent Data (cont.)

- Manipulation of persistent data like an ordinary C++ program
- Protecting the integrity of database
  - Automatically set read and write locks
  - Keep track of what has been modified
  - Access to persistent data guaranteed to be transaction-consistent, and recoverable

Discussion #2

- ObjectStore employs page level locking as the only mode of locking
  - What implications does it have for transactions and concurrency?
  - Should other granularities of locking be provided as well? If yes, which ones?

Query Facility

- Closely integrated with the host language
  - Expressions operating on collections
  - Producing a collection or a reference to an object
- Selection predicates can be applied to collections.
  - Special syntax: `[: predicate :]`
  - Eg.

    `employees [: salary >= 10000 :]`

Query Facility (cont.)

- Queries may be nested to form more complex queries

```
os_Set<employee*> &work_with_fred =
  all_employees → query ('employee*',
  "dept → employees [: name == \'Fred'\ :]");
```

Memory-mapped Architecture

- **Goal**: object-access speed for persistent data equal to that of an in-memory dereference of a pointer to transient data
- 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:
  - Set flags so that accessing a non-fetched persistent object causes page fault
  - Upon fault, retrieve object
  - Subsequent access is a normal pointer dereference

Distributed Data Access

- Client/Server communication method
  - Local area network
  - Shared memory, local sockets
- During transaction
  - Whole pages of data brought from server to client
  - Placed in the client's cache
  - Mapped into virtual memory
  - Objects stored on the server in the same format
- Transaction finish
  - All the pages removed from the address space
  - Modified pages written back to server

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Distributed Data Access (cont.)

- Applications control the placement of objects within databases
  - Cluster objects that are frequently referenced together
- Objects can cross page boundaries
  - Ex. Image data
  - Page-granularity transfer
- Many small objects can reside on a single page
  - Locking granularity on a per-page basic
  - Clustering → decreasing locking overhead

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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
  - Data members (**indexable**)→ potential index keys

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Conclusions

- ObjectStore provides the applications
  - High productivity
  - High performance
- Achieved by a virtual memory-mapping architecture
- Support for conceptual modeling constructs by collection, relationship, and query facilities

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