AutoFetch

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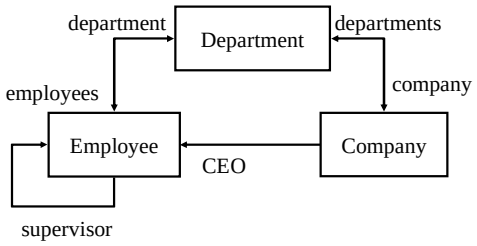
Object Persistence

- Transparent access to persistent objects
  - Load as needed: “Object faulting”
- Examples
  - Object-relational mapping tools
    - EJB, JDO, TopLink, Hibernate, OJB, and many more
  - Object databases
    - Versant, db4o, Gemstone, etc.
  - Orthogonally Persistent Programming Language
    - PJama, OPJ, etc.
- Object faults are expensive
  - connection overhead > query execution

Example Data Model



Queries + Traversal

```
String q = “from Employee e
            where e.overtime > 100”;

for (Employee emp: runQuery(q)) {

  Employee mgr = emp.getSupervisor();

  sendEncouragingEmail(emp.getEmail(),
                       emp.getName(),
                       mgr.getName());
}
```

SLOW! Every manager is faulted separately

Should **prefetch** managers

Manual Prefetch

```
String q = “from Employee e
            left outer join fetch e.supervisor
            where e.overtime > 100”;

for (Employee emp: runQuery(q)) {

  Employee mgr = emp.getSupervisor();

  sendEncouragingEmail(emp.getEmail(),
                       emp.getName(),
                       mgr.getName());
}
```

Subtle dependency..

... must be maintained if code change

AutoFetch Goals

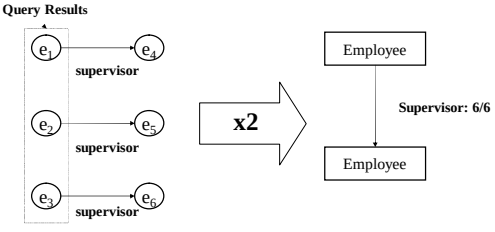
- No programmer provided prefetch hints or directives
  - Programs easier to write
  - Programs more modular
- Performance as good as or better than programmer provided prefetch directives

AutoFetch

- AutoFetch transparently prefetches objects based on program history
- AutoFetch can be broken into 3 aspects:
  - Traversal Profiling
  - Query Classification
  - Traversal Prediction
- Implemented as extension to Hibernate 3.0
  - Object proxies used to monitor association traversals
- Idea not specific to Hibernate or ORDBMS

Traversal profiling

- Each query produces a program traversal.
- Program traversals are aggregated into traversal profiles.



Query Classification

- Identify similar query invocations
  - Traversal Profiles aggregate similar invocations
  - Apply prefetch corresponding to previous traversals
- Use the program state to classify queries
- How about?
  - query string
  - line number where query invoked

1 Query / 2 Traversals

```
for (Employee emp : getGreatEmployees()) {
  Employee manager = emp.getSupervisor();
  manager.setSalary(manager.getSalary() * 2.0);
}
```

```
for (Employee emp : getGreatEmployees()) {
  sendEmail(emp.getEmail(), emp.getName());
}
```

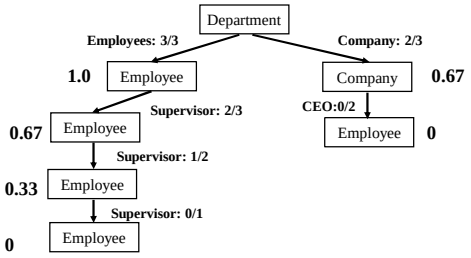
```
List<Employees> getGreatEmployees() {
  String q = "from Employee e
              where e.overtimeHours > 100";
  return (List<Employees>)runQuery(q);
}
```


Classifying by Stack Trace

- Query invocations with same stack trace are classified together
- Benefits of stack trace:
  - easy to compute
  - finite number of stack traces
- Stack trace predicts future control flow

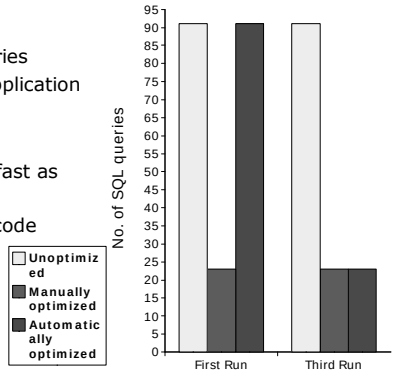
Traversal Prediction

- Query class ⟶ traversal profile
- Add association paths with probability greater than a threshold as prefetch specifications



Torpedo Benchmark

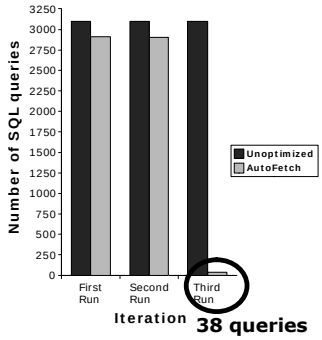
- Measures: number of queries
- Web auction application
- 17 use cases
- AutoFetch is a fast as hand optimized
- …with simpler code



OO7 Benchmark

- Measures: traversals, queries, and updates
- Based on CAD applications
- AutoFetch executes approximately 100 times fewer queries

T1 Traversal



Related Work

- Prefetch for Object Databases
  - Object clustering
  - Object prefetch based on pattern analysis of object requests (Curewitz 93, Knafla 98, Palmer 91)
- **PrefetchGuide** (ORM)
  - Bernstein VLDB 1999, Han Infor. Sciences 2003
  - Optimizes traversals within a single query
  - Looks for recursive or iterative patterns

How is AutoFetch different?

- Disadvantages:
  - Does not optimize initial query executions
    - Use AutoFetch + PrefetchGuide
- Advantages:
  - Best performance:
    - AutoFetch: 1 query
    - PrefetchGuide: at least 2 queries
  - Can prefetch arbitrary object graphs
  - More data for prediction

Future Work

- Improving benchmarks for OPA.
- Using AutoFetch ideas for general prefetch in distributed applications.
- Optimizing other aspects of OPA such as memory management.

Conclusion

- Predicts correct prefetch directives based on past program query executions
- Uses dynamic profiling
- Encourages more modular programs
- General technology for object persistence architectures