Extracting Queries by Static Analysis of Transparent Persistence

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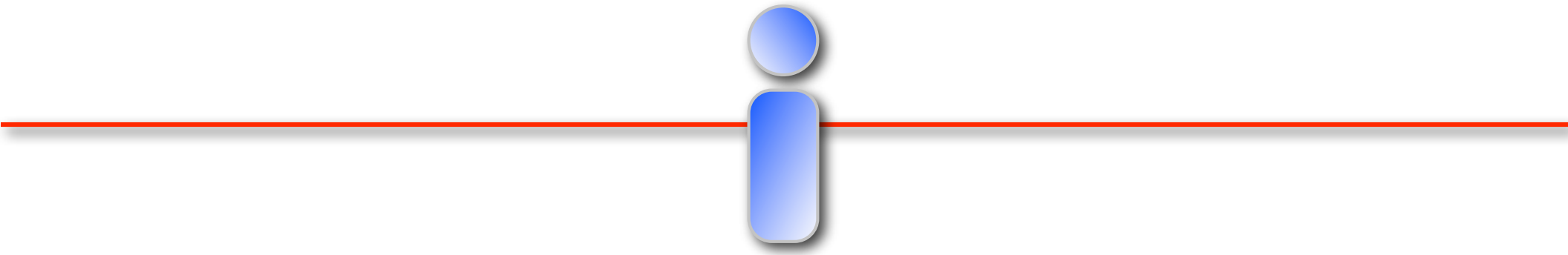
Databases

Programming Languages

Databases



Programming Languages

Databases

Print name and manager's name
of every employee
whose salary > $65,000

Programming Languages

Database APIs (JDBC, etc)

Print name and manager's name
of every employee
whose salary > $65,000

Transparent Persistence

```
String query = "from Employee e
                left join fetch e.manager
                where e.salary > 65000";

List result = session.createQuery(query);
for (Employee e : result.list()) {
    print(e.name + e.manager.name);
}
```

Query string

- Runtime type errors
- Hard to paramaterize
- Programmer burden

Subtle dependency

- Programmer burden

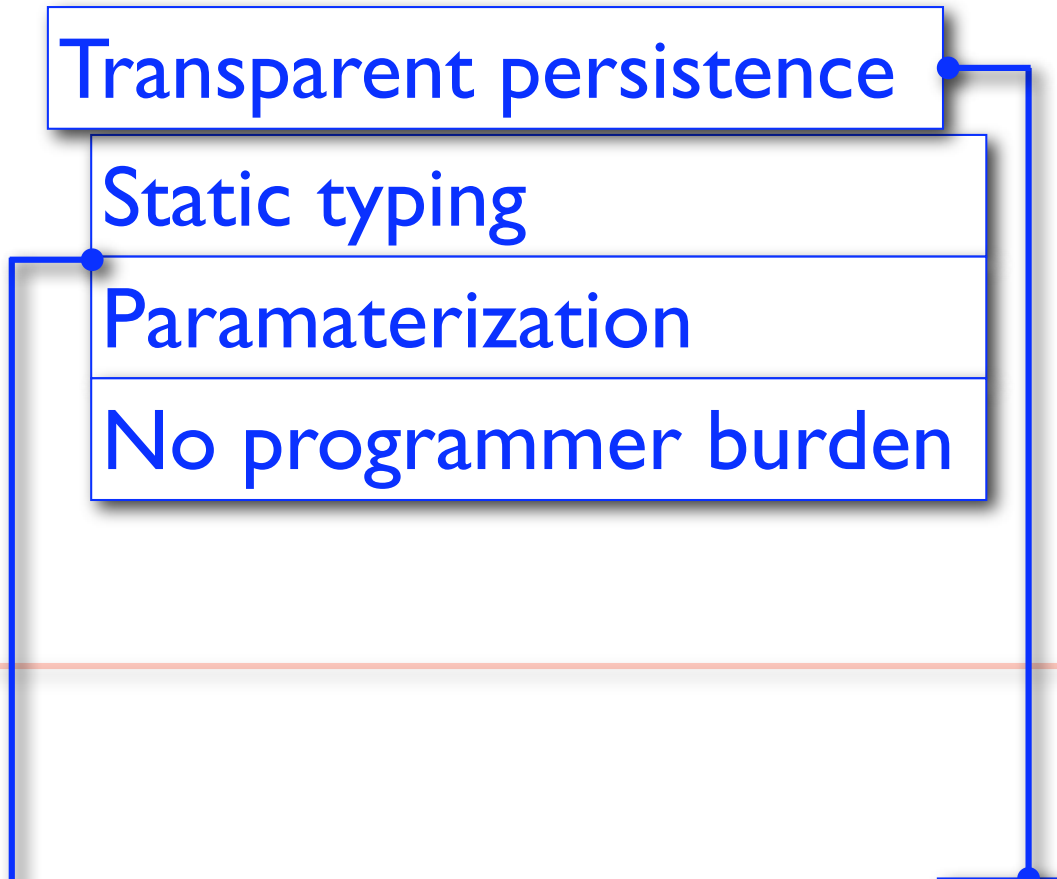
```
String query = "from Employee e
                left join fetch e.manager
                where e.salary > 65000";
List result = session.createQuery(query);
for (Employee e : result.list()) {
    print(e.name + e.manager.name);
}
```

Send to database

1 communication

Optimized search

Good performance




```
for (Employee e : root.employees) {
    if (e.salary > 65000) {
        print (e.name + e.manager.name);
}}
```

Linear search

- "Record-at-a-time"
- No DB optimzation
- Poor performance

```
for (Employee e : root.employees) {
    if (e.salary > 65000) {
        print (e.name + e.manager.name);
}}
```

Database APIs

Transparent Persistence

- Not true integration
- Not type-safe
- Burdens programmer
- Good performance

- Better integration
- Type safe
- Relieves programmer burden
- Poor performance

Query Extraction

- Good performance

&

- Better integration
- Type safe
- Relieves programmer burden

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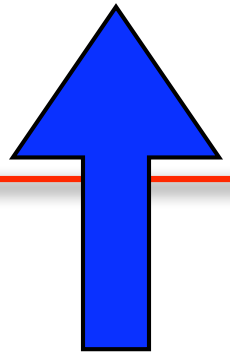
Query Extraction



```
for (Employee e : root.employees) {
    if (e.salary > 65000) {
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}}
```
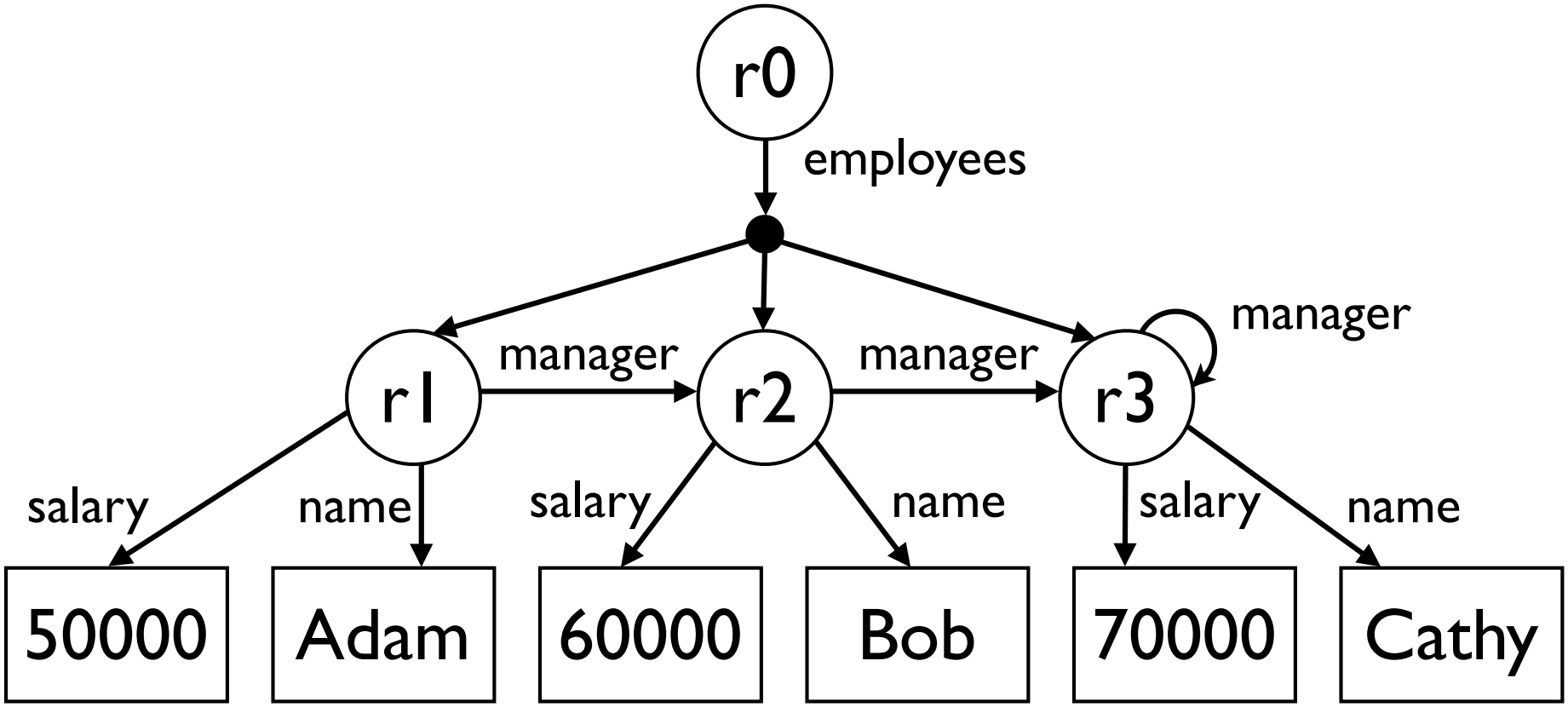
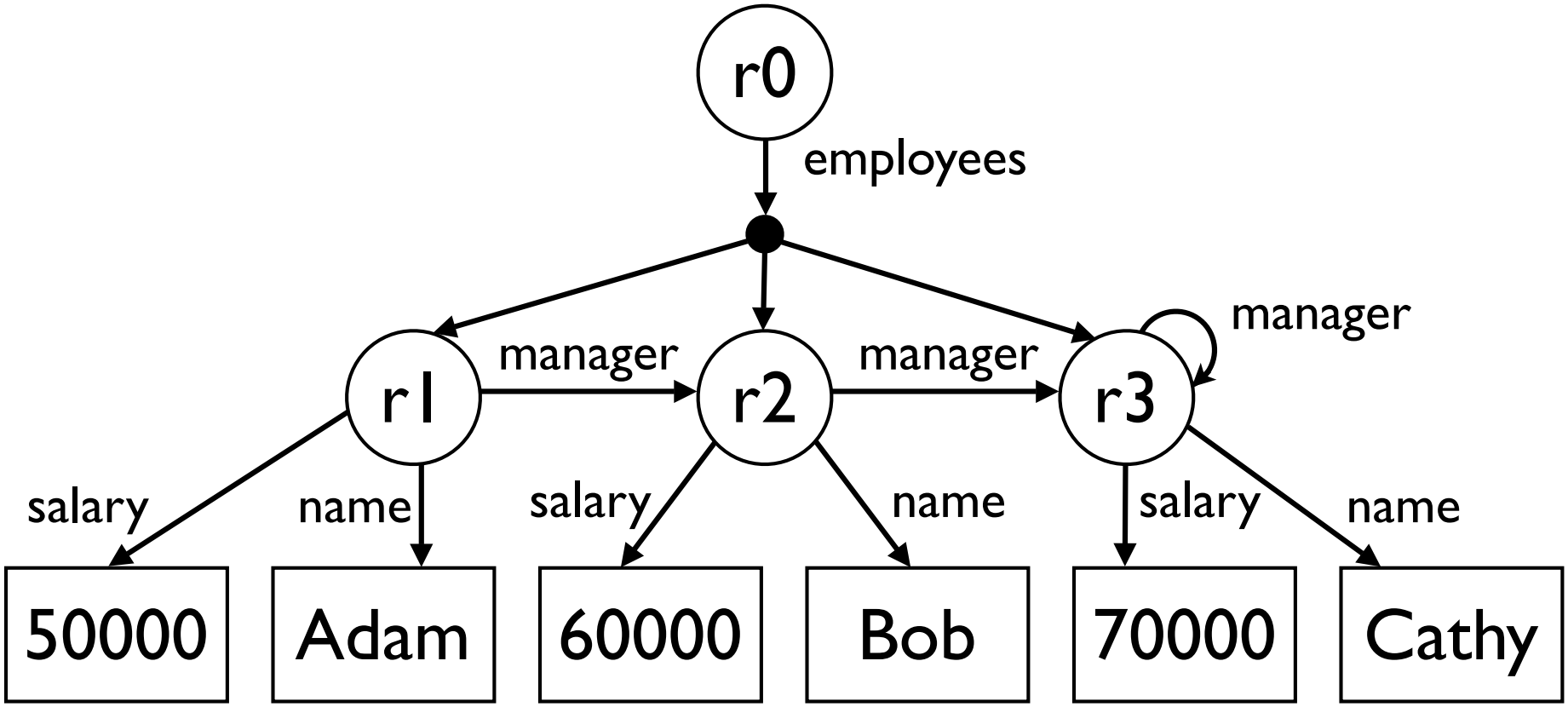

Approach

- Identify subset of the database used by program
  - Traversals from root define shape of query
  - Identify conditions under which data is used
- Current Assumptions
  - 1 transaction per program
  - Query result has same structure as database

Object View of Database



Object View of Database



Retrieve subgraph program requires

Simple Study Language

- Transparent persistence
  - Access through variable `root`
- Imperative
  - `x := y + z;`
  - No database updates
- Iteration over persistent collections
  - `for e in root.employees {...}`
- No procedures

Extracting Traversal Paths

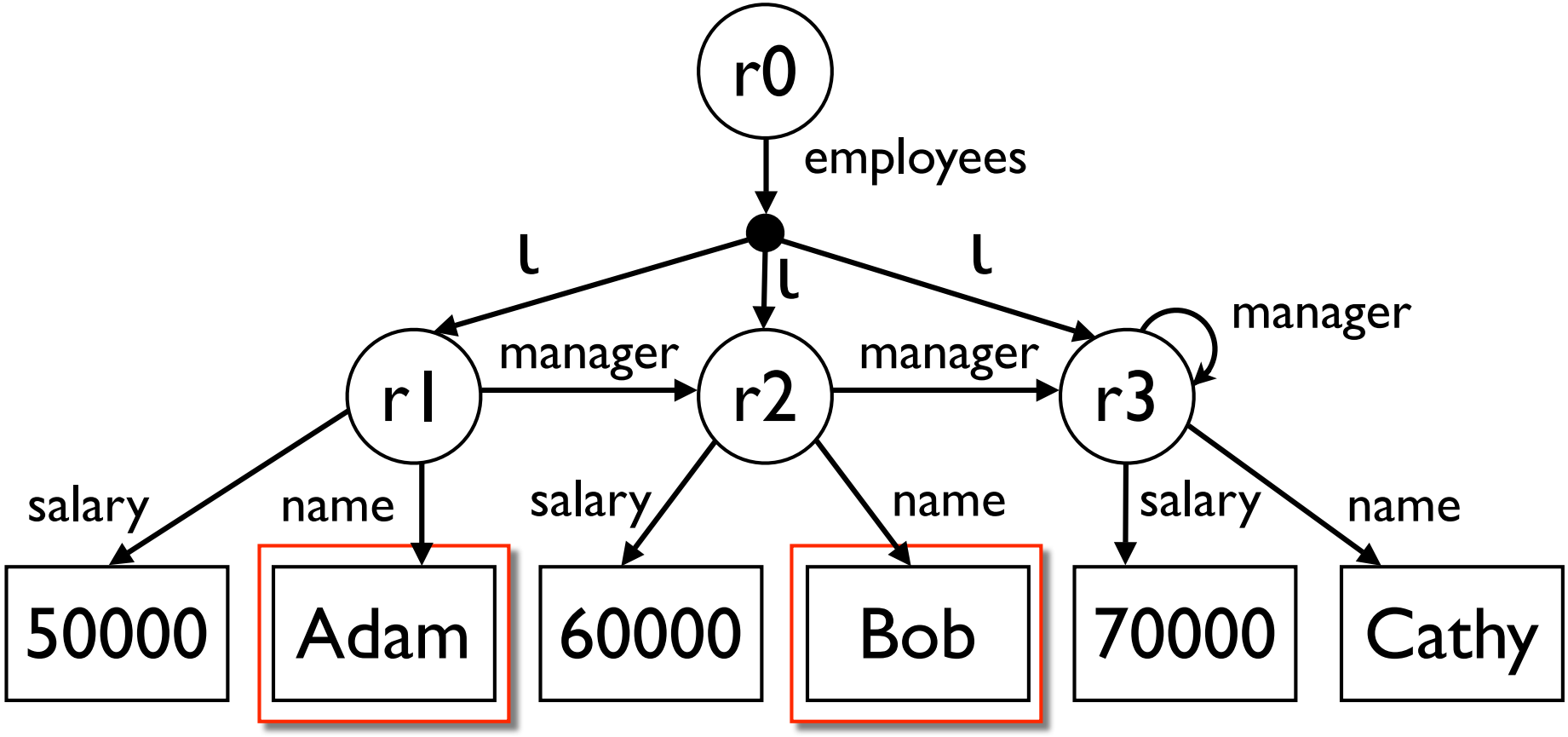
```
for (Employee e : root.employees) {
    if (e.salary > 65000) {
        print (e.name + e.manager.name);
}}
```

```
employees
employees.ι
employees.ι.salary
employees.ι.name
employees.ι.manager
employees.ι.manager.name
```

Abstract Interpretation

- **Paths** describe **data**
  - Concretization = query execution
  - Computes **sound** over-approximation
- Field traversal generates new path(s)
- Merge conditional branches
- Merge assignments

How Precise Are Paths?



Need more precise approximation

Include Conditions

```
for (Employee e : root.employees) {
C=  if (e.salary > 65000) {
        print (e.name + e.manager.name);
}}
```

Query Condition Restrictions

- Executable by database
- Independent of collection order
- Require no sub-select queries
- Query results reflect database structure

Order Independence

for I_l in p
  x := E[I_l] + x;
  if C[I_l,x] then S;

No Sub-select Queries

```
for l1 in p
   if C1[l1] then
      x := E[l1];
for l2 in p
   if C2[l2,x] then S;
```

Query Results Reflect Structure

for l_1 in p_1
  for l_2 in p_2
    if C[l_1, l_2] then S;

Abstract Interpretation

- Domain: Path x Condition
- Field traversal generates new path(s)
- Merge conditional branches
- Merge assignments
- Attach query conditions to paths

Example

```
for (Employee e : root.employees) {
    if (e.salary > 65000) {
        print (e.name + e.manager.name);
}}
```

```
employees                    employees.ι.name [C]
employees.ι                  employees.ι.manager [C]
employees.ι.salary           employees.ι.manager.name [C]
```

C = employees.ι.salary > 65000

Query Creation

```
struct (employees = (
        select struct (salary = e.salary,
                       name = e.name,
                       manager = struct(name =
                          e.manager.name))
        from employees as e
        where e.salary > 65000)
```

employees	employees.ι.name [C]
employees.ι	employees.ι.manager [C]
employees.ι.salary	employees.ι.manager.name [C]

C = employees.ι.salary > 65000

Program Creation

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result  = session.executeQuery(qs);

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Condition Removal

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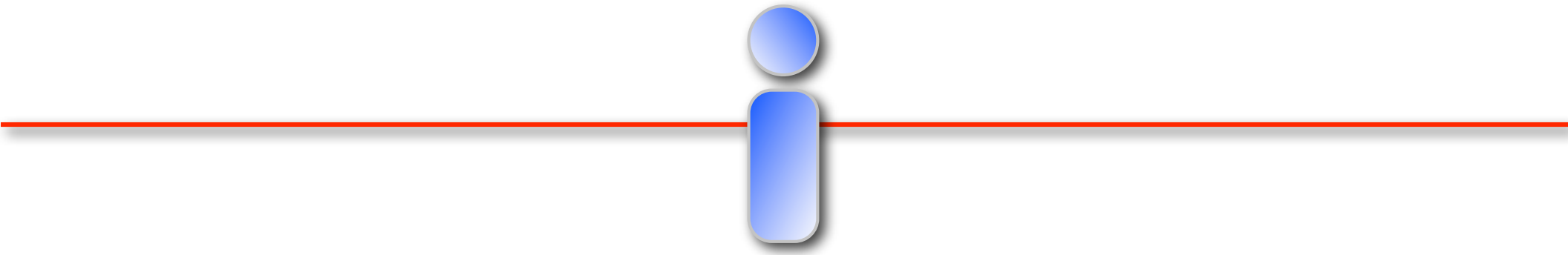
Related Work

- Shape Analysis for Data Access
  - Vitenberg, Kvilekval, and Singh [ECOOP04]
  - Kvilekval and Singh [DOA04]
- Queries as First-Class Program Values
  - Bierman, Meijer, and Schulte [ECOOP05]
  - Cooper, Lindley, Wadler, and Yallop (Links)
  - Cook and Rai [ICSE05]
  - Willis, Pearce, and Noble [ECOOP06]

Future Work

- Inter-procedural analysis
- Multiple queries
- Implementation / evaluation
- Persistent update
- More expressive queries

Databases



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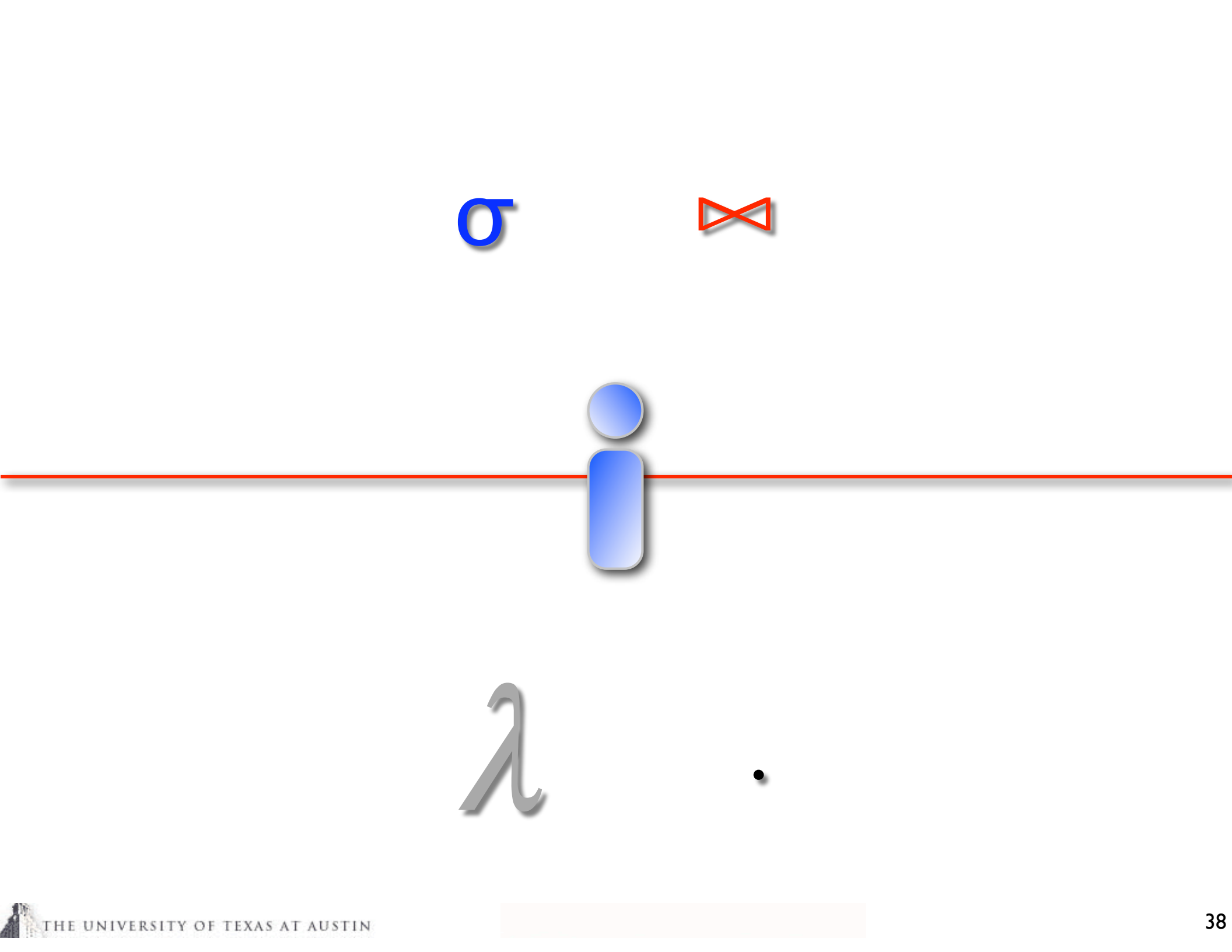
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Query Extraction