

Deep Typechecking and Refactoring

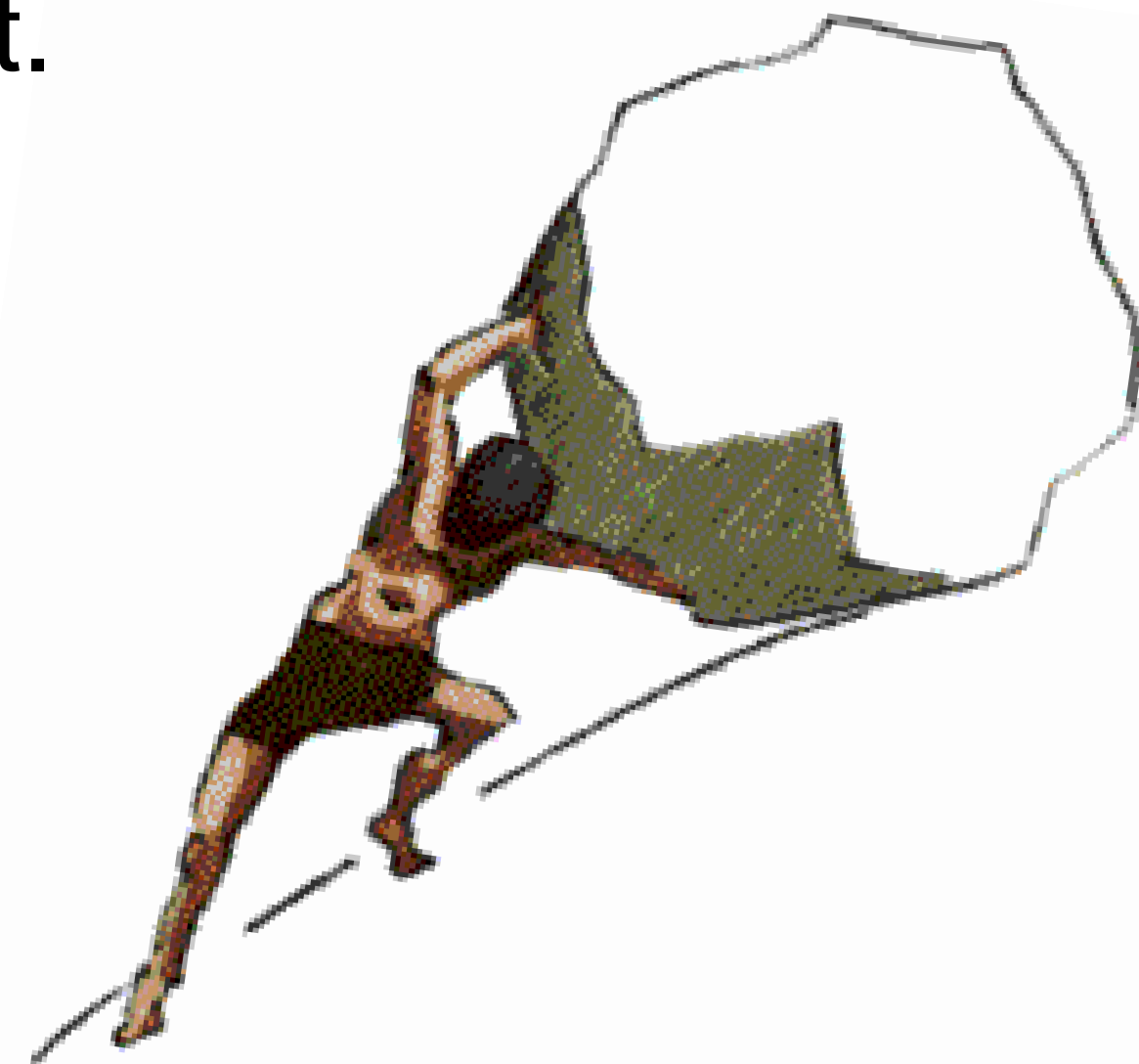
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Communicating with Databases

Database interaction is crucial for many programs, especially web applications. Unfortunately, the Database / Programming Language *Impedance Mismatch* makes this interaction difficult.

A prevalent solution is to embed query strings directly in the application. This approach is *efficient* and *flexible* but **unsafe**.



The Problem :

Database query fragments are scattered throughout the program.

These fragments are **opaque** to the compiler.

Errors from DB interaction aren't caught until runtime!

```
String getText(String id, Link link) {
    String qStr;
    Query q;

    qStr = "SELECT w FROM Weblog w ";
    qStr += "WHERE w.id = ?1 ";
    qStr += "AND w.link.id = ?2";

    q = createQuery(qStr);
    q.setParam(1, id);
    q.setParam(2, link.id);

    Weblog w = (Weblog) q.execQuery();
    return w.text;
}
```

To ensure **safety**, we must guarantee:

- A. All query parameters are set
- B. All parameters are set to the correct type
- C. Query results are safely used (correctly downcast)

Deep Typechecking ensures that these properties hold.

Deep Refactoring extends this analysis to enable common software engineering tasks.

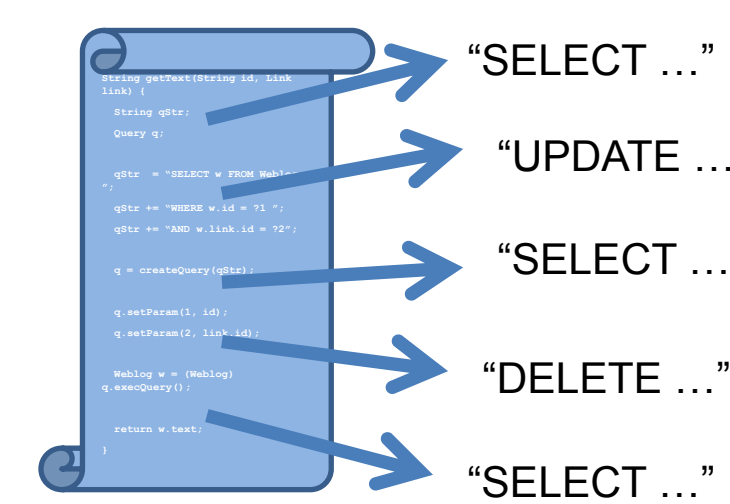
Deep Typechecking

Goal:



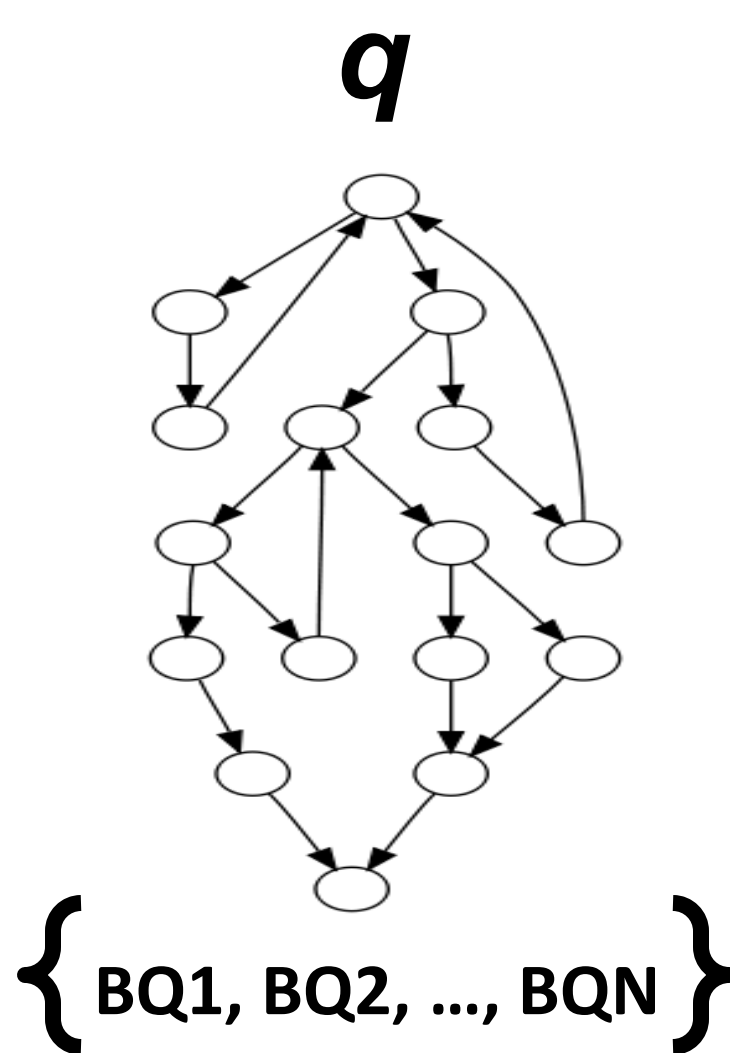
Ensure there are no bugs from DB interaction.

Step 1: String Analysis



For each query object **q**, compute the query strings **q** may represent.

Step 2: Bound Query Analysis ★

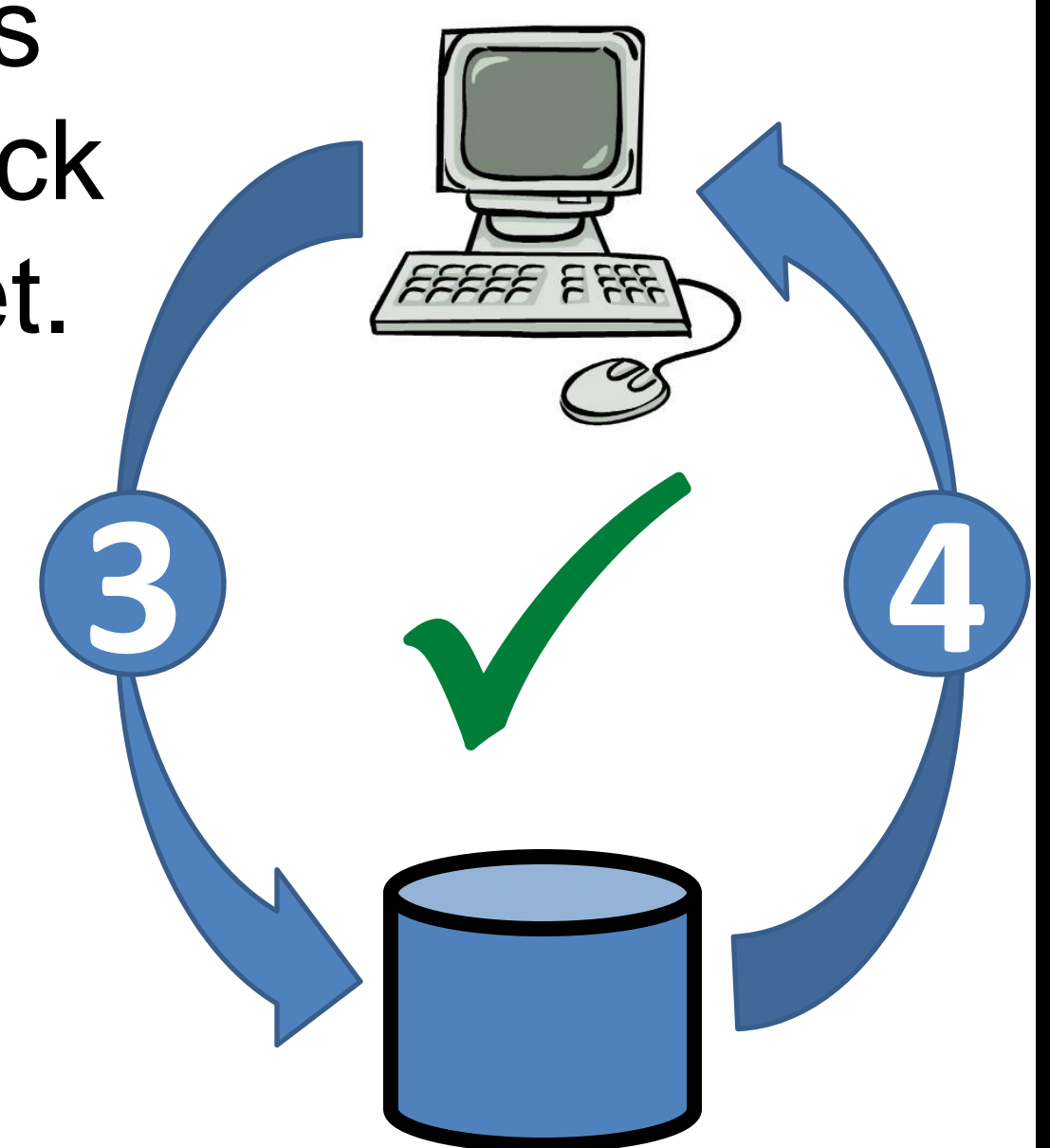


Track how each query object is modified, right up to the point it is executed.

Yields a set of bindings from a parameter to the types of data it has been set to.

Step 3: Check Parameters

Use the set of bound queries and the query strings to check that all params are safely set.



Step 4: Check Results

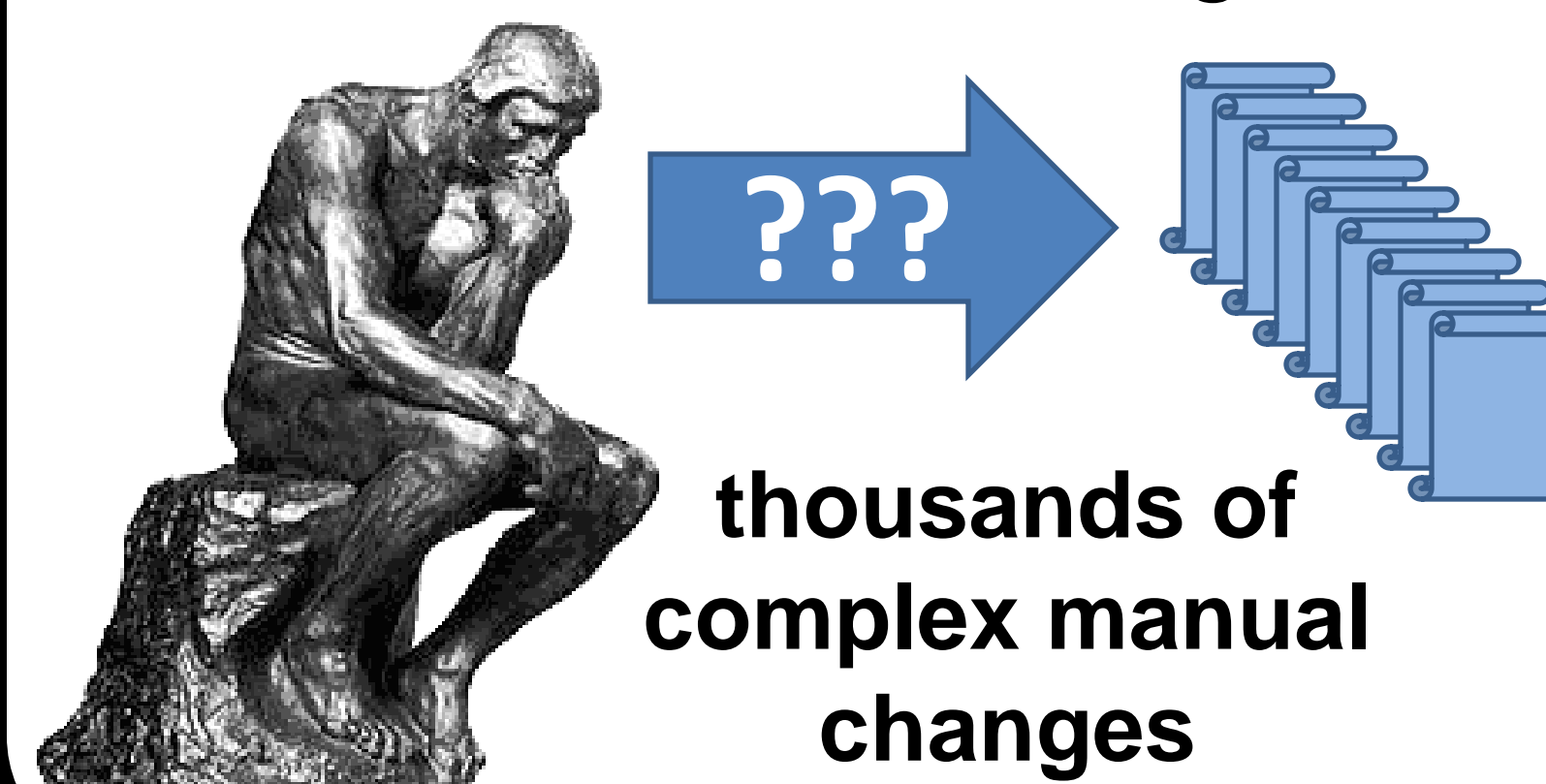
Track query result to each use and ensure safe downcast.

Conclusions:

1. Deep Typechecking ensures safety
 - No silent failures
2. Robust in the face of imprecision
 - Param and result checks independent
3. Effective in practice
 - Analyze 100K lines of industrial code in 40s
 - Able to prove 85% of exec sites safe

Deep Refactoring

Renaming classes and fields is a basic and frequent software engineering task. Unfortunately, string based queries can make such refactoring infeasible.



thousands of complex manual changes

Example: Weblog.id → Weblog.name

```
qStr = "SELECT w FROM Weblog w ";
...
qStr += "WHERE w.id = ?1 ";
...
qStr += "AND w.link.id = ?2";
```

Bound Query Analysis

```
qStr = "SELECT w FROM Weblog w ";
...
qStr += "WHERE w.name = ?1 ";
...
qStr += "AND w.link.id = ?2";
```

Bound Query Analysis is extended to refactor full query strings. Changes are propagated back to the source.