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;
}
```

A

B

C

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.

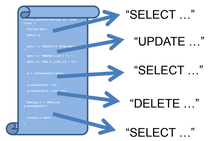
Deep Refactoring extends this analysis to enable common software engineering tasks.

Deep Typechecking

Goal:

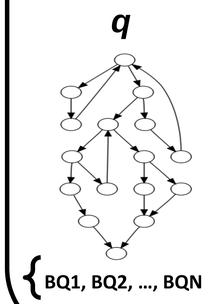
Ensure there are no bugs from DB interaction.

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.

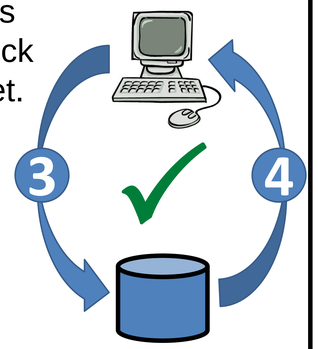
Yields a set of bindings from a parameter to the types of data it has been set to.

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:

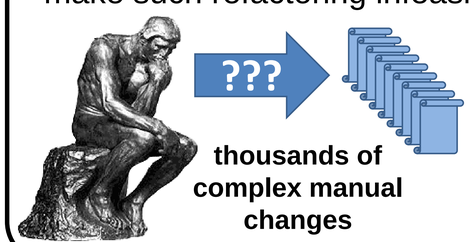
1. Deep Typechecking ensures safety
- No silent failures

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.



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.