Program Analysis

Call Graphs (Part 1)

Prof. Dr. Michael Pradel

Software Lab, University of Stuttgart

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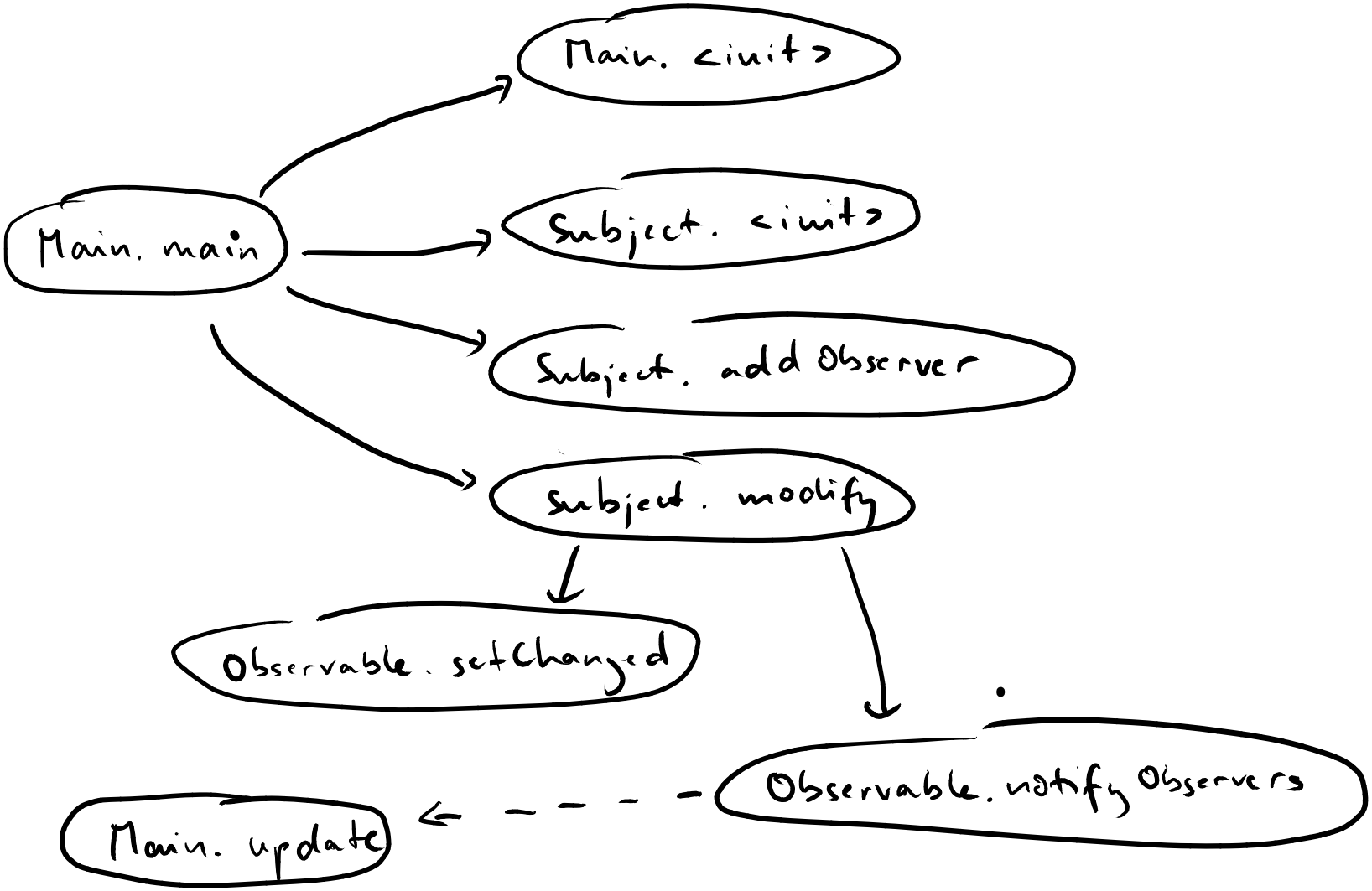
Slides adapted from Eric Bodden

Call Graph Analysis

- **Call graph: Abstraction of all method calls in a program**
  - Nodes: Methods
  - Edges: Calls
  - Flow-insensitive: No execution order
- **Here: Static call graph**
  - Abstract of all calls that may execute

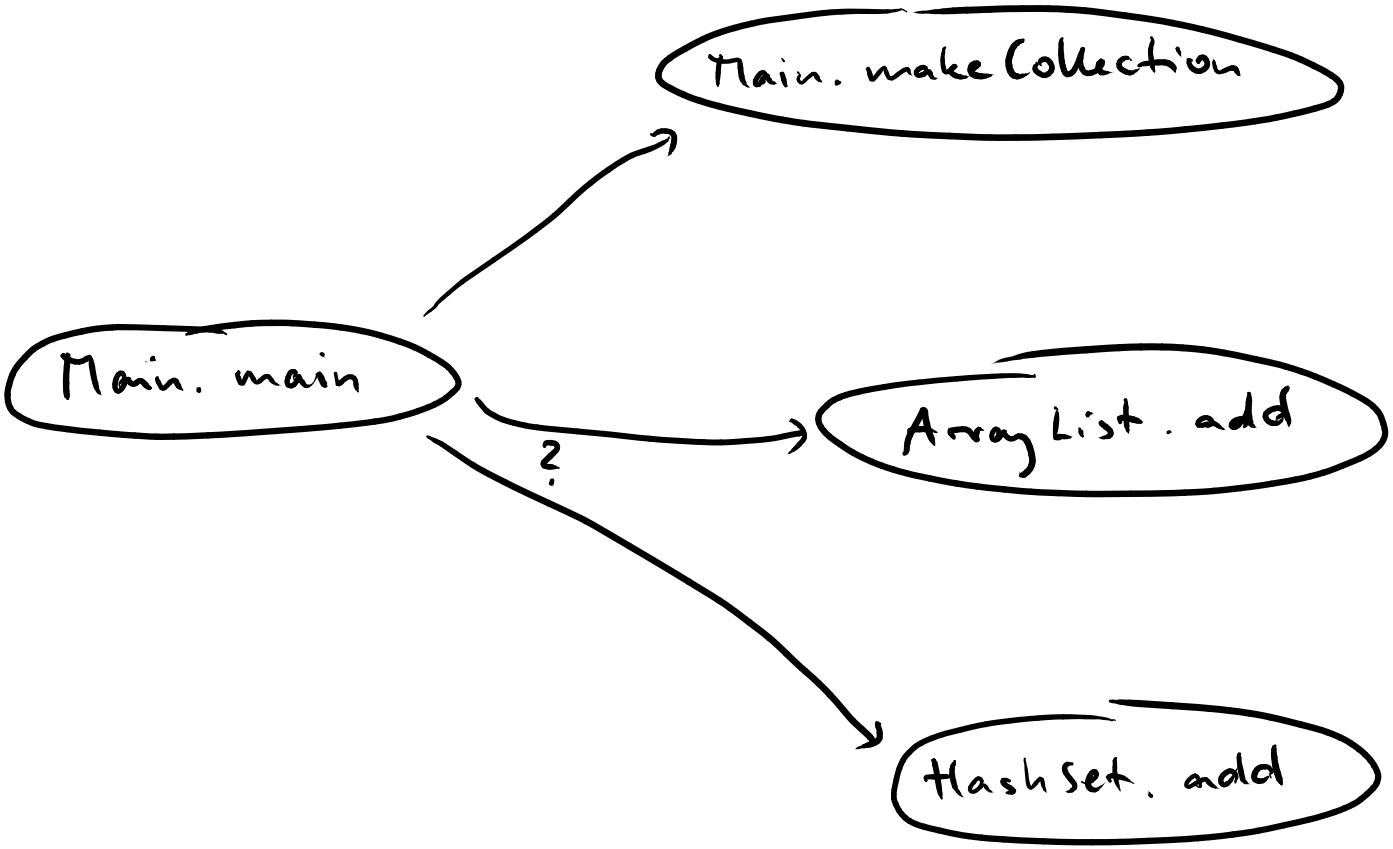
Example

```
public class Main implements Observer {
  public static void main(String[] args) {
    Main m = new Main();
    Subject s = new Subject();
    s.addObserver(m);
    s.modify();
  }

  public void update(Observable o, Object arg) {
    System.out.println(o+" notified me!");
  }

  static class Subject extends Observable
    public void modify() {
      setChanged();
      notifyObservers();
    }
}
```


Main.<init>
Main.main
Subject.<init>
Subject.addObserver
Subject.modify
Observable.setChanged
Observable.notifyObservers
Main.update

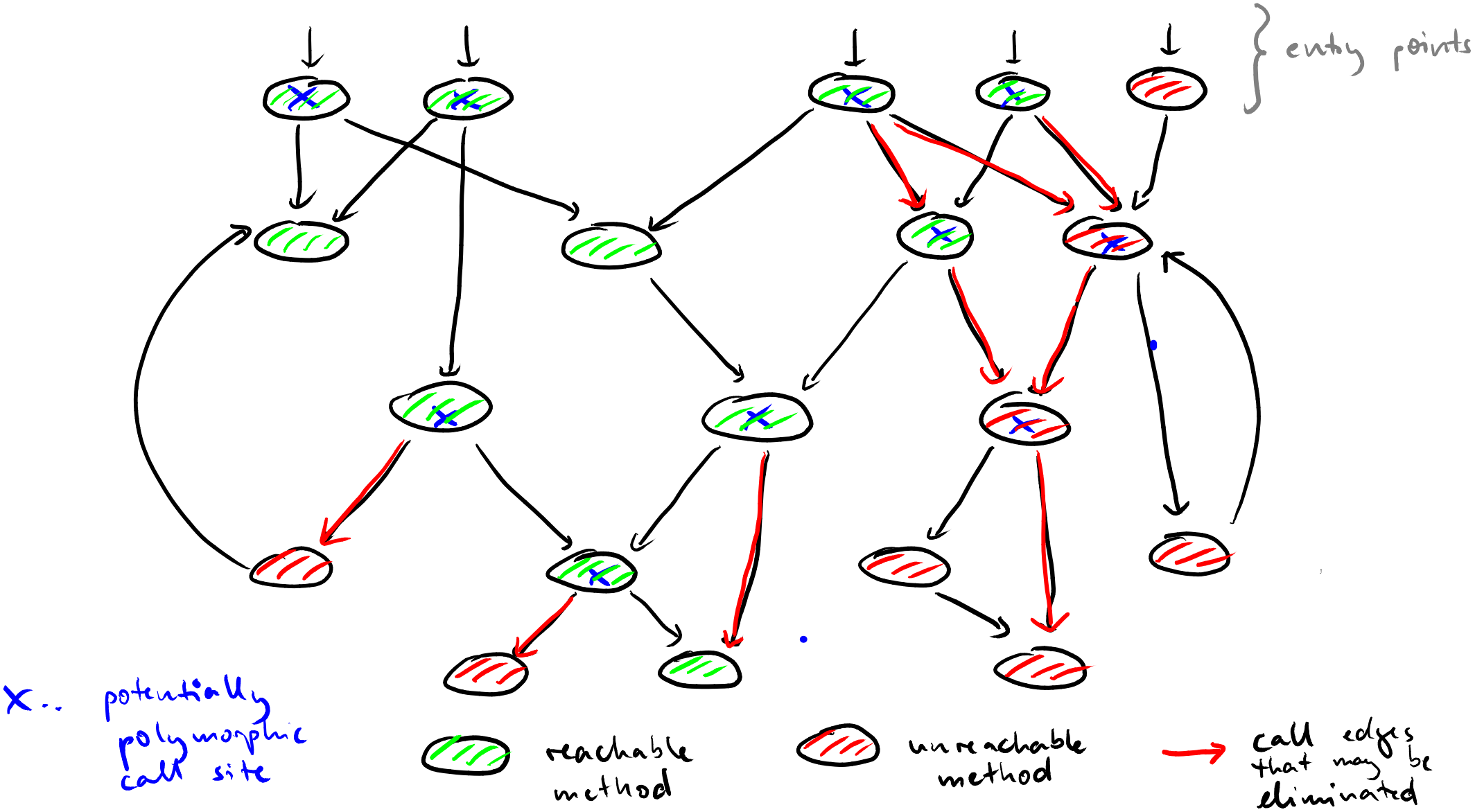
Problem: Polymorphic Calls

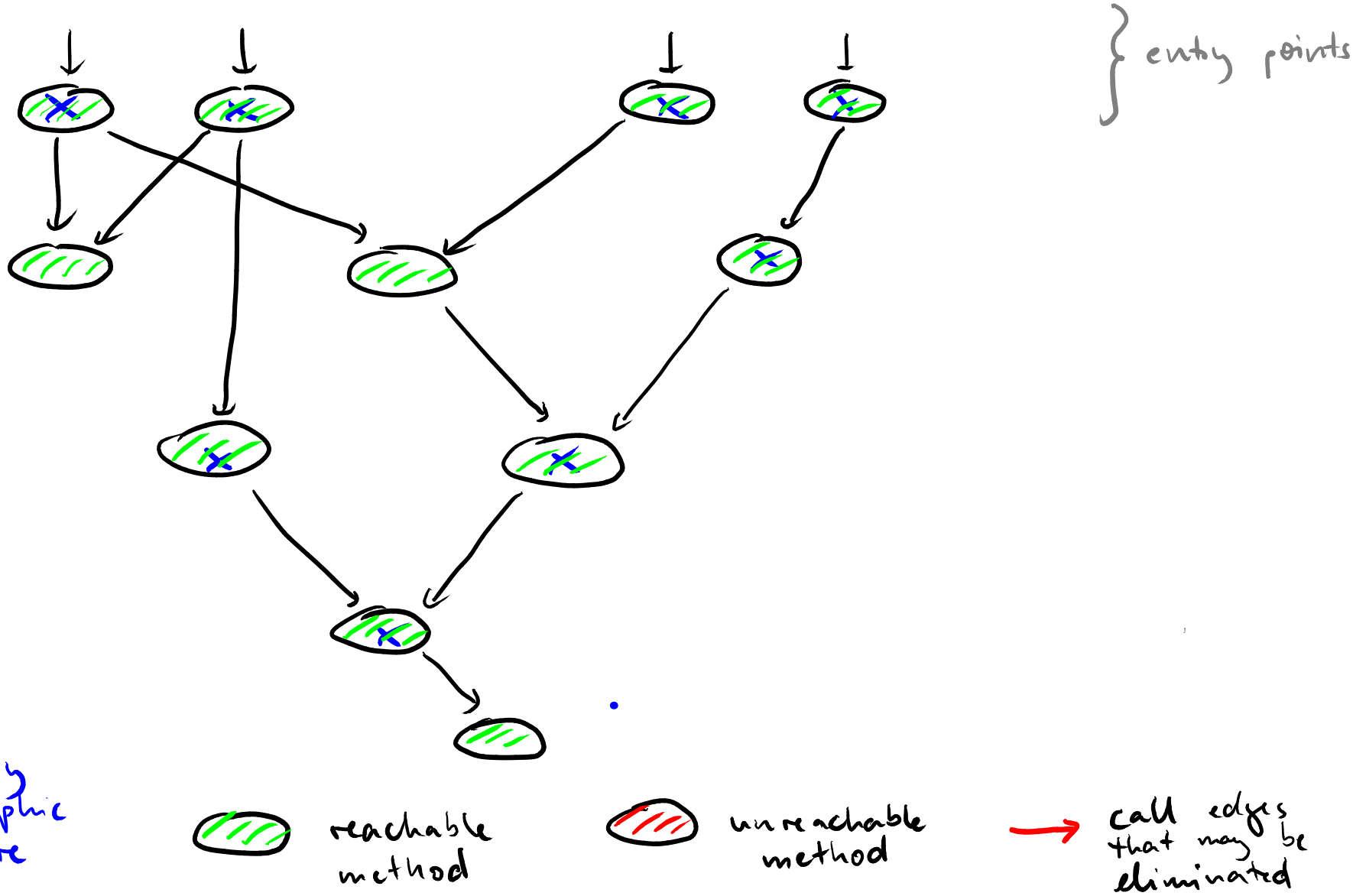
```
import java.util.*;

public class Main {
  public static void main(String[] args) {
    Collection c = makeCollection(args[0]);
    c.add("hello");
  }

  static Collection makeCollection(String s) {
    if(s.equals("list")) {
      return new ArrayList();
    } else {
      return new HashSet();
    }
  }
}
```


Main.makeCollection
Main.main
?
ArrayList.add
HashSet.add

Improving the Call Graph

- **Prune graph:**
  Focus on feasible behavior
- **Want to minimize**
  - Reachable methods
  - Call edges
  - Potentially polymorphic call sites


entry points
X.. potentially polymorphic call site
reachable method
unreachable method
call edges that may be eliminated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Overview

- Introduction ✔
- Single & efficient: CHA, RTA
- Analyzing assignments: VTA, DTA
- Call graphs and points-to analysis: Spark