Energy Reduction via Genetic Improvement

A SBSE technique for a new era in Software Development

Bobby R. Bruce

Small, low energy use

Large, high energy use

Bobby R. Bruce
Energy Reduction via Genetic Improvement

Software dictates energy consumption
(and in ways that are hard to predict)

```
1   public Object[] nonAggregatedComm()
2   {
3     Object[] objectArray =
4                       new Object[10];
5     for(int i=0; i<10; i++){
6       Object temp = downloadObject(i);
7       objectArray[i] =
8           processObject(temp);
9     }
10    return objectArray;
11  }
12
13
```

```
public Object[] aggregatedComm()
{
  Object[] tempArray = new Object[10];
  for(int i=0; i<10; i++){
    tempArray[i] = downloadObject(i);
  }
  Object[] objectArray = new Object[10];
  for(int i=0; i<10; i++){
    objectArray[i] =
        processObject(tempArray[i]);
  }
  return objectArray;
}
```

Banerjee et al. "Detecting Energy Bugs and Hotspots in Mobile Apps" (2014).

A small list of changes known to influence energy consumption….

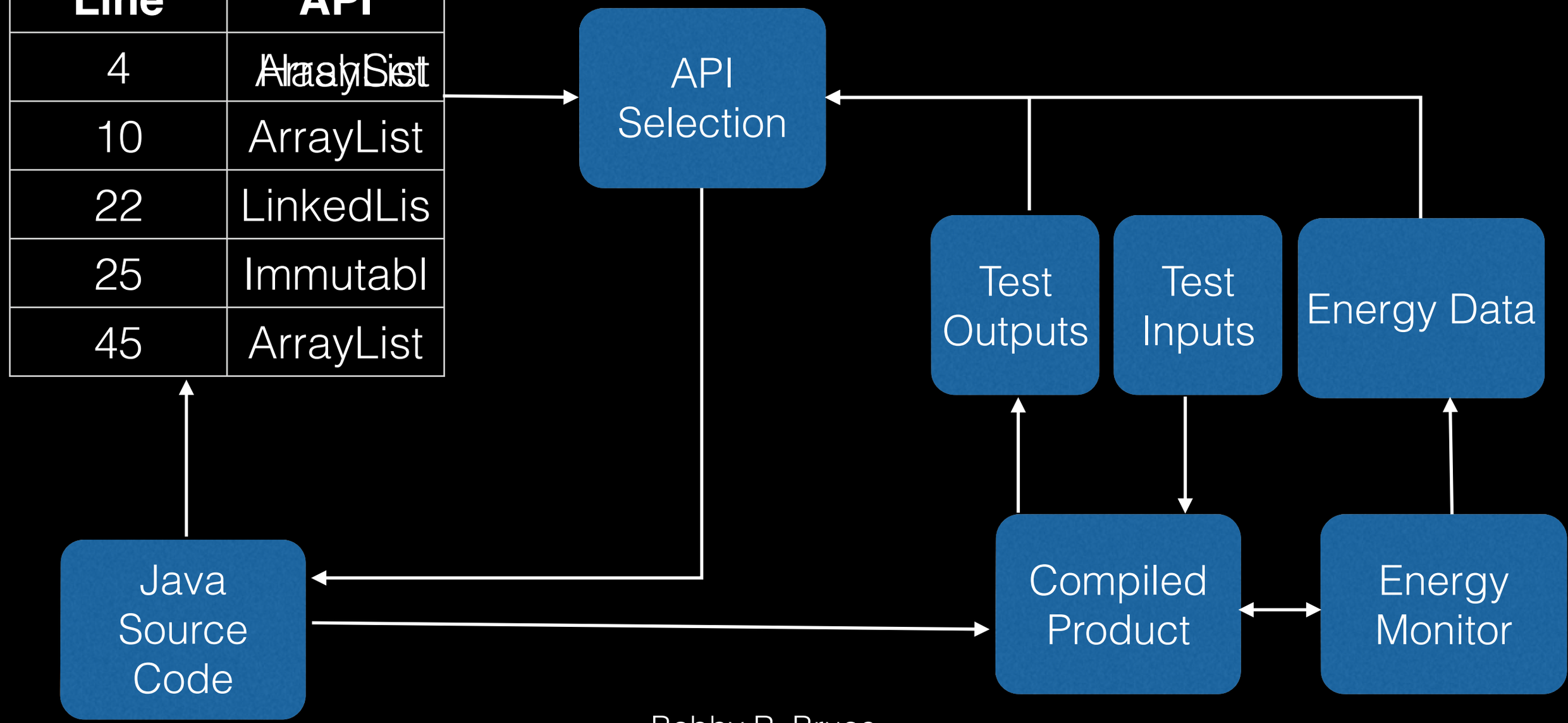
- Collection API Implementations
- Inline Methods
- Code Obfuscation
- Different Design Patterns
- Parameter Objects
- Local variables to and from Field Variables

…but only sometimes

A previous attempt at automation…

Manotas et al. "SEEDS: a Software Engineer's Energy-optimisation Decision Support framework" (2014)

Line	API
4	ArrayList
10	ArrayList
22	LinkedLis
25	Immutabl
45	ArrayList



The Results

Table 3: **SEEDS$_{\text{api}}$ effectiveness in improving energy usage.**

Application	% Improvement	
	JCF Only	ALL
Barbecue	17*	17*
Jdepend	3*	6*
Apache-xml-security	5†	5†
Joda-Time	8*	9†
Commons Lang	10†	13†
Commons Beanutils	—	—
Commons CLI	2*	2*

* indicates situations where a single concrete change was most effective.
† indicates situations where a concrete change at more than one location was most effective.

GI to the Rescue?

- Encouraging results for reducing execution time, why not energy consumption?
- Capable of finding changes difficult for humans to find
- Can be used to specialise software to particular hardware configurations
- Changes to the software are human-readable

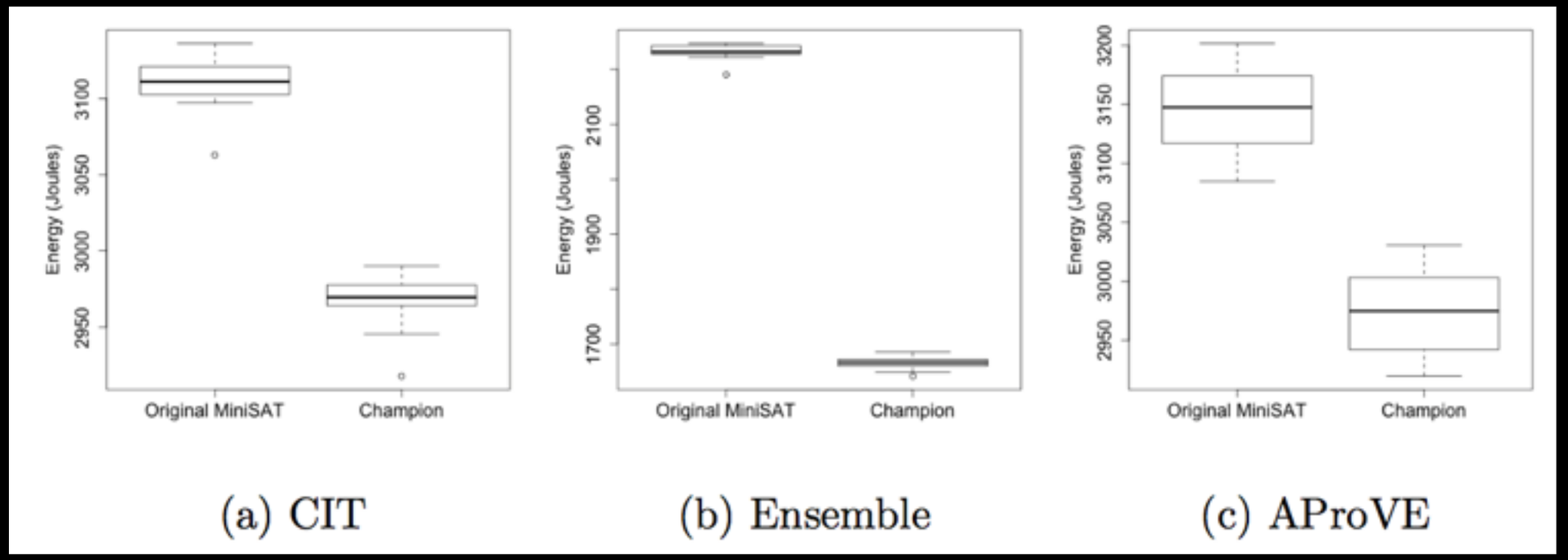
An initial investigation

- Attempted to optimise MiniSAT on a MacBook Pro

- Specialised MiniSAT for specific downstream applications

- Was able to reduce energy consumption by as much as 25%

"Reducing Energy Consumption Using Genetic Improvement" Bruce et al. (2015)



Bobby R. Bruce
Energy Reduction via Genetic Improvement

Current Hurdles

- Methods of profiling software's energy consumption is poor. New methods are required
- Proof of concept on smartphones/servers/ embedded systems has yet to be attempted
- Genetic Improvement is a relatively new area; further research is still required.