Java Class Hierarchies with Maximal Sharing

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Context

- Goal:

  Automatic implementation of tree-like data-structures

  Compilers, Transformers, Analyzers, XML Processors

  Memory Efficiency seems to be a problem

- Maximal Sharing

  Works well in functional programming, rewriting

  (Where all *data representation* is automatic)

  So let’s carry this over to Java data-structures

- For our purposes:

  Meta-Environment tools in Java (AsFix, ATerms)

  DocGen-like tools

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Requirements

- Fast access time, and
- Memory efficient
- Data-hiding:

  Documentation

  Use of types prevents programming errors

  Profiling

  Consistency checks

- Extensibility
- Linearization {Debugging, Communication}

The Java ATerm library

- Redundancy + Maximal Sharing $\equiv$ Memory Efficiency
- Types of redundancy

  Natural (e.g. layout nodes in a parse tree)

  Artificial: use redundancy to store data close to use sites
- Annotations $\equiv$ Extensibility
- Textual (Shared) representation
- Data-hiding? Not quite enough.

  Lessons learned in the GLT project $\rightarrow$ ApiGen

Algebraic data-types

- Syntax definitions, Tree Grammars, Signatures, ...
- *Generate* implementations of tree-like data-structures
- Many types $\equiv$ compile-time feedback $\equiv$ safe code
- Refactoring the representation itself becomes feasible
- Extra (hard,boring,expensive) features for free:

  Linearization

  Traversal

  Profiling

  Consistency checks

  And why not... *Maximal Sharing*??

Generate classes based on the ATerm library

- Just like ApiGen for C...
- Type-system of Java prevents simple aliasing like in C
- Composition → we loose maximal sharing
- Inheritance

  Not possible for trivial reasons

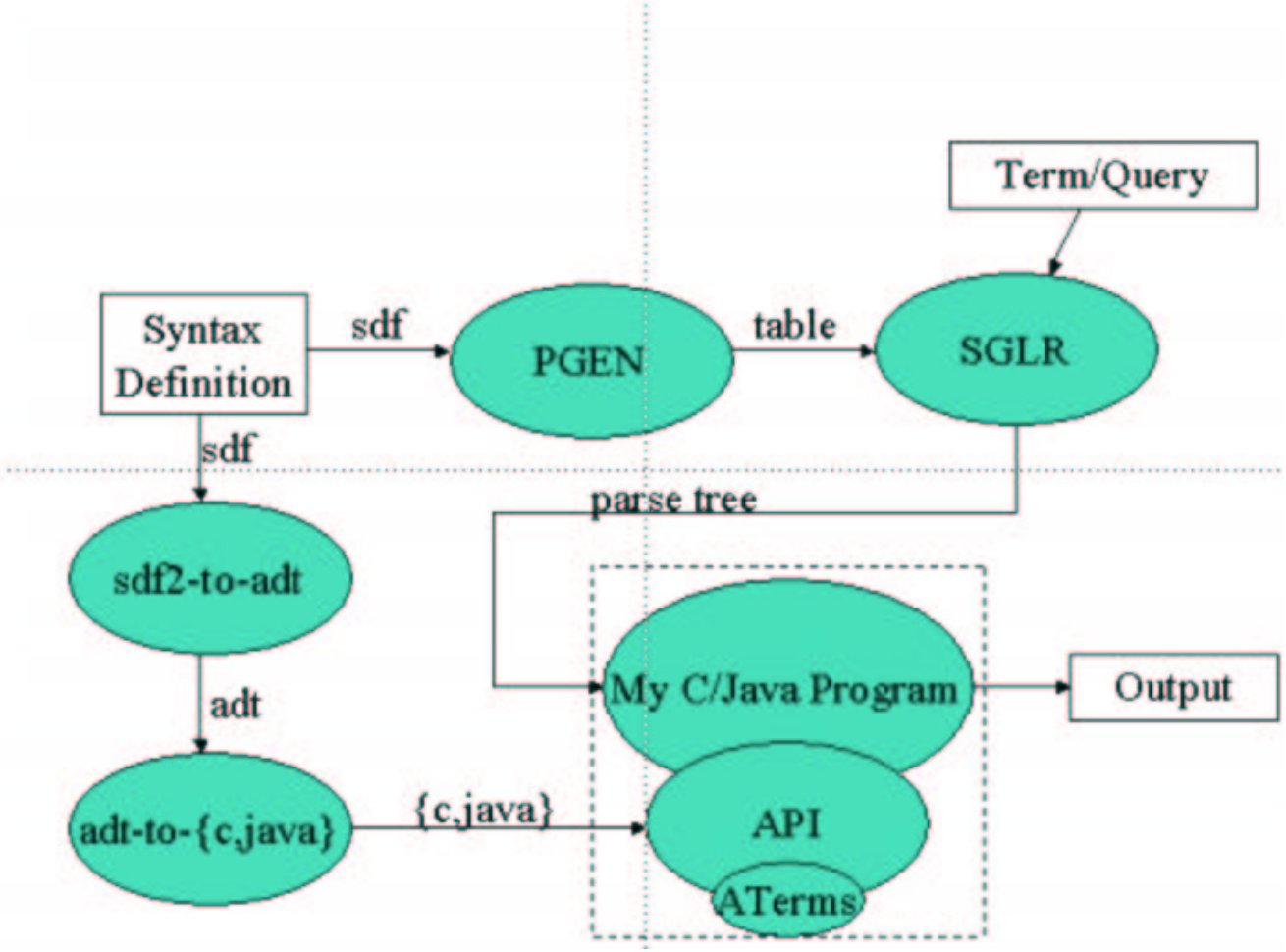
  Not practical due to code duplication
- Recipe:

  Refactoring the ATerm library for extensiblity

  Try to keep the efficiency

  Generate extensions of PureFactory and ATermAppl

ApiGen organization



Shared Object Factory

- Maximal Sharing is implemented using hash-consing
- The SOF implements only hash-consing, nothing more
- Design Patterns:

  Factory - a class that builds objects from other objects

  Prototype - minimize allocations

- HashFunctions - a practical collection of hash functions

The Shared Object Factory

```
public class SharedObjectFactory {
   public SharedObject build(SharedObject prototype);
   public String toString(); // profile report
}

public interface SharedObject {
  SharedObject duplicate(); // clone
   boolean equivalent(SharedObject o);
   int hashCode();
}

public class HashFunctions {
   static int simple(Object[] o);
   ...
}
```

Inheriting from SharedObjectFactory

```
public class PureFactory
extends SharedObjectFactory implements ATermFactory {
  static ATermApplImpl protoAppl;
  ...

  public PureFactory() {
    protoAppl = new ATermApplImpl();
    ...
  }

  public ATermAppl makeAppl(AFun fun, ATermList args) {
    protoAppl.init(fun, args);
    return build(protoAppl);
  }
}
```

Composite SubClasses of ATermAppl

- `Factory` - subclass PureFactory (prototypes and make methods)
- `Constructor` - subclass ATermAppl to deal with patterns

  implements `toTerm()` and `toString()`

  adds a field: **static private** `ATerm pattern;`
- `Types` - Abstract subclasses of `Constructor`

  delegates `fromTerm(ATerm trm)` to subclasses

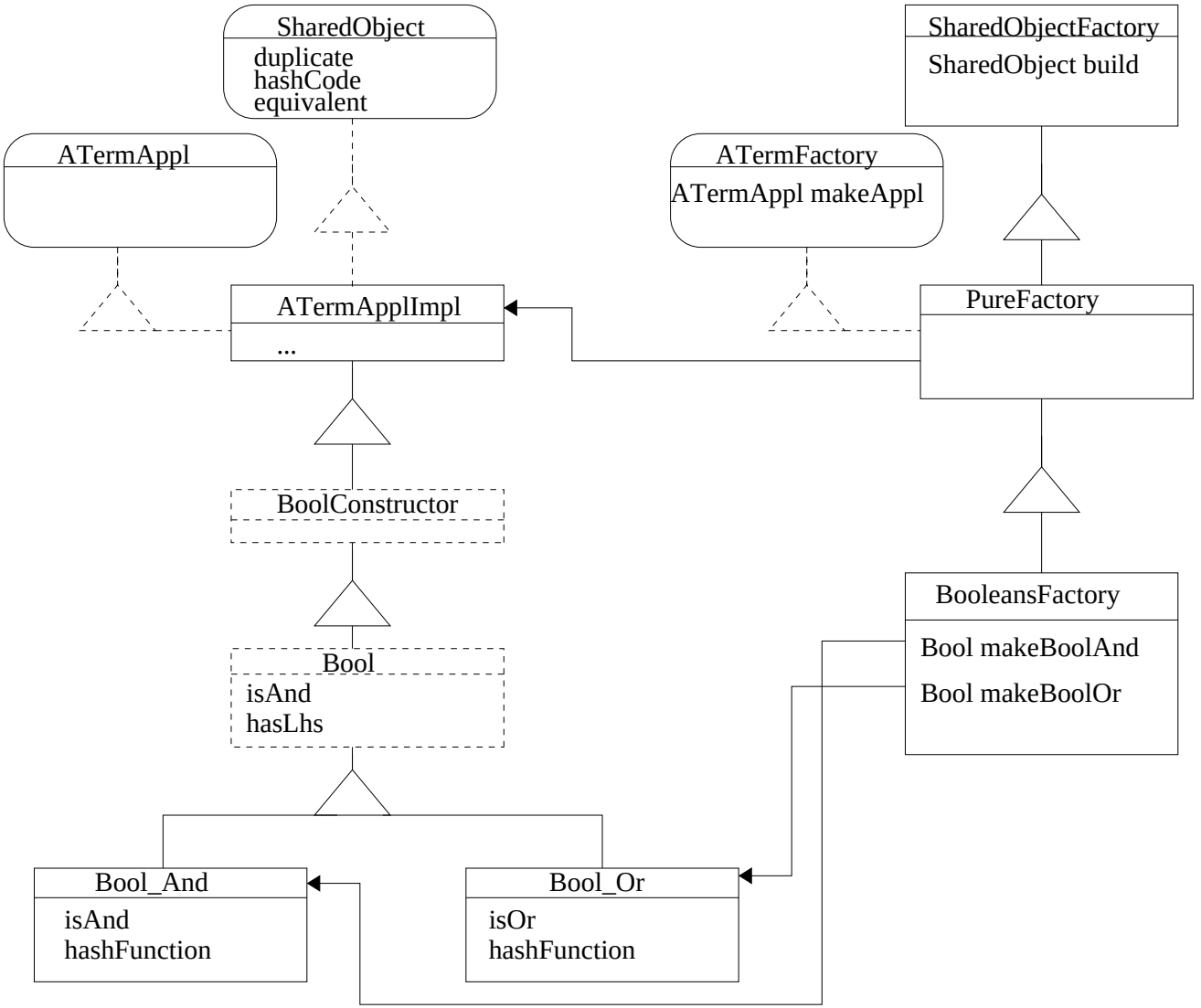
  provides default `false` value for all kinds of static properties
- `Operators` - subclasses of abstract types

  implements `fromTerm(ATerm trm)` using the pattern

  overrides values for static properties

  specializes `hashFunction()` as an optimization

The Big Picture



Example

```
{
   BooleansFactory f = new BooleansFactory();
   Bool b = f.makeBoolAnd(f.makeBoolTrue(),
                          f.makeBoolFalse());

   if (b.hasLeftHandSide()) {
     Bool l = b.getLeftHandSide();
     System.out.println("This is the lhs:" + l);
   }

   Bool c = Bool.fromTerm(f.readFromFile("input.trm"));
   if (c.isAnd()) {
     System.out.println("It's a conjunction");
   }
}
```

Experience

- Benchmarks: EvalTree, EvalExp, Fibonacci, etc...
  - Compared to (new) ATerm code: slightly faster
  - Compared to (old) ATerm code: 10-20% slower
  - Compared to non-shared API: much faster and smaller
  - Significant reduction in LOC (sometimes 50%)
- Refactoring the Tom compiler
  - Incremental reverse engineering of TomFix
  - Detected bugs and design flaws
  - Reduction in LOC
  - Bootstrapped (but without support for list matching)
  - Compared to ATerm code: much faster

Sales Department

- Only dependencies: shared-objects and aterm-java
- Coupled with SDF2 via ADT files

  Hierarchy provides abstract view,

  but linearized representation can be anything (AsFix!)
- Coupled with Tom via generated signature definition

  Simple pattern matching for free
- Coupled with JJTraveler (W.I.P.)

  Safe Traversal for free
- Generates empty class files

  Implementation is hidden in separate package

  Empty classes can be filled with user-code

Discussion

- Conclusion

  Class Hierarchies with Maximal Sharing

- Future work

  Specialized support for list types

  Applications:

    Meta-Environment, Analysis, Reengineering

- Questions?