TECHNISCHE UNIVERSITÄT
KAISERSLAUTERN

The Dafny and Boogie Verification Tools

Software-Engineering Seminar, Winter 2017/18

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Content

Motivation

A correct implementation of the recursive insertion sort?

```
1  method insertionSort(a: array<int>, b: int) {
2    if (b = 1) { return; }
3    insertionSort(a, b-1);
4    var j: int := b-1;
5    while j > 0 ∧ (a[j] < a[j-1]) {
6      swap (a, j-1, j);
7      j := j - 1;
8    }
9  }
```

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- Writing correct algorithms = Writing + Verification
- Traditionally shown by proof with pen and paper
- Interactive proof-systems simplified process
- SMT-solvers allow automatic verification

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Desirable features:

- Completeness (*i.e.* find all errors)
- Abstraction (algebraic datatypes, side-effect free methods)
- Unrestricted quantifier support
- Termination metrics
- Verified standard libraries

Developed tools (*e.g.* ESC/Java, Spec#) miss some functionalities.

Dafny

- Imperative, class-based language
- Identically named, automatic verifier
- Uses Boogie as underlying system
- Just-in-time verification by using appropriate tools

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Language features:

- No syntactic sugar (*e.g.* do-while loops)
- Pre- and postconditions, predicates
- Loop invariants, termination metrics
- Ghost variables, functions, assertions
- Integrated datatypes, user defined datatypes, custom classes
- *No* libraries

Boogie

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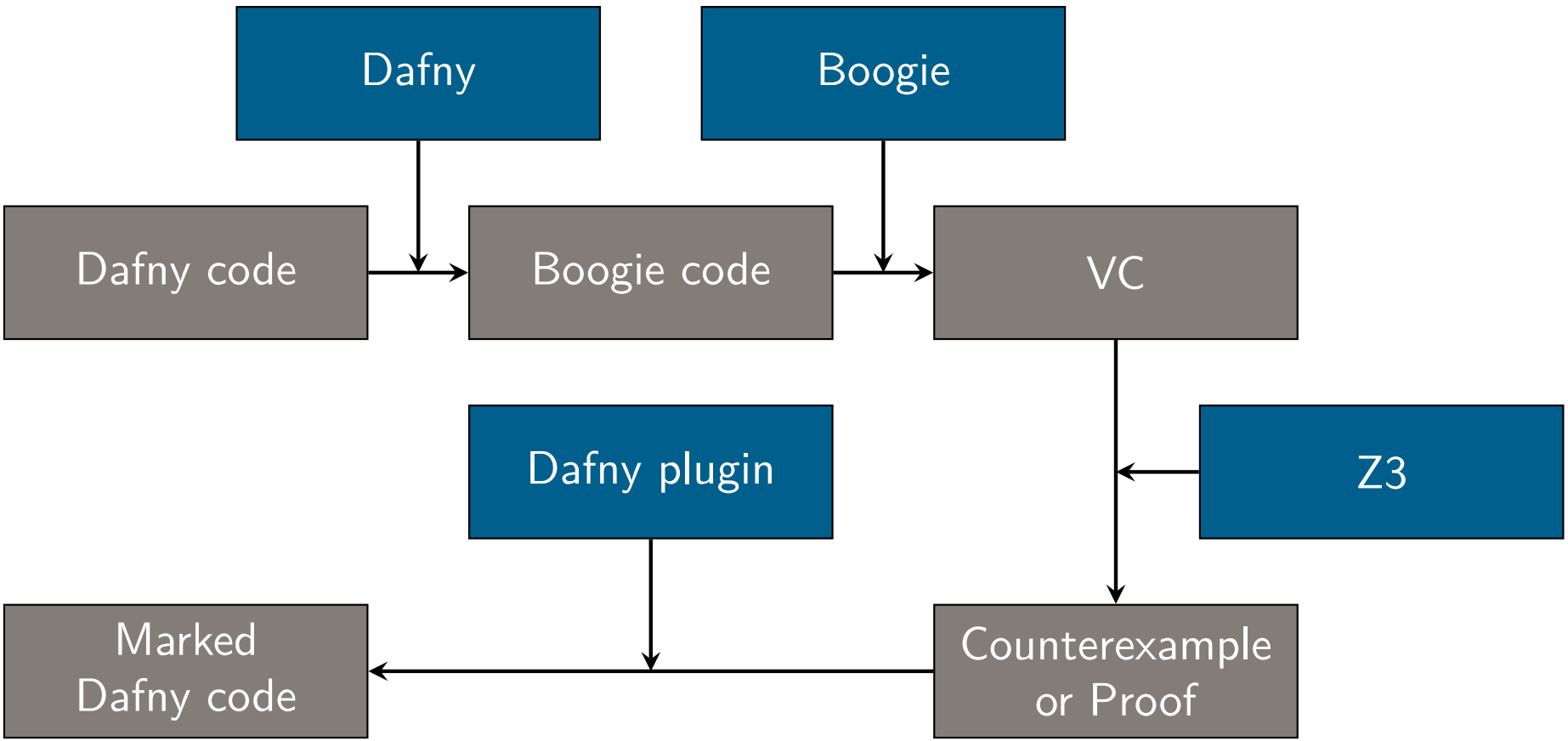
Language features:

- Similar annotations as in Dafny
- Implementations and declarations for methods
- `goto` with labels
- `havoc` commands and `where` clauses
- Explicit Heap
- No call-by-reference parameter passing
- Axioms for language features

Interaction of the Tools



Dafny – Conclusion

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- Design-time-feedback
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The Ugly

- No true invariants for objects
- Boogie knowledge required (*e.g.* error messages, counterexamples)

Back to the Start

A correct implementation of the recursive insertion sort?

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14                   {
15     swap (a, j-1, j);
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```
1  method insertionSort(a: array<int>, b: int)
2   requires a ≠ null
3   requires a.Length ≥ b > 0
4   modifies a
5   ensures sorted(a, 0, b)
6                 {
7    if (b = 1) { return; }
8    insertionSort(a, b-1);
9    var j: int := b-1;
10   while j > 0 ∧ (a[j] < a[j-1])
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8    insertionSort(a, b-1);
9    var j: int := b-1;
10   while j > 0 ∧ (a[j] < a[j-1])
11    invariant b ≥ j ≥ 0
12    invariant sorted(a, 0, j) ∧ sorted(a, j, b)
13    invariant ∀ k,l • 0 ≤ k < j ∧ j < l < b ⟹ a[k] ≤ a[l]
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2   requires a ≠ null
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5   ensures sorted(a, 0, b)
6   decreases b {
7    if (b = 1) { return; }
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References

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Getting started with dafny: A guide.
https://rise4fun.com/Dafny/tutorial/Guide.
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