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Generating Assertion Code from OCL:

A Transformational Approach Based on Similarities of Implementation Languages

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Abstract

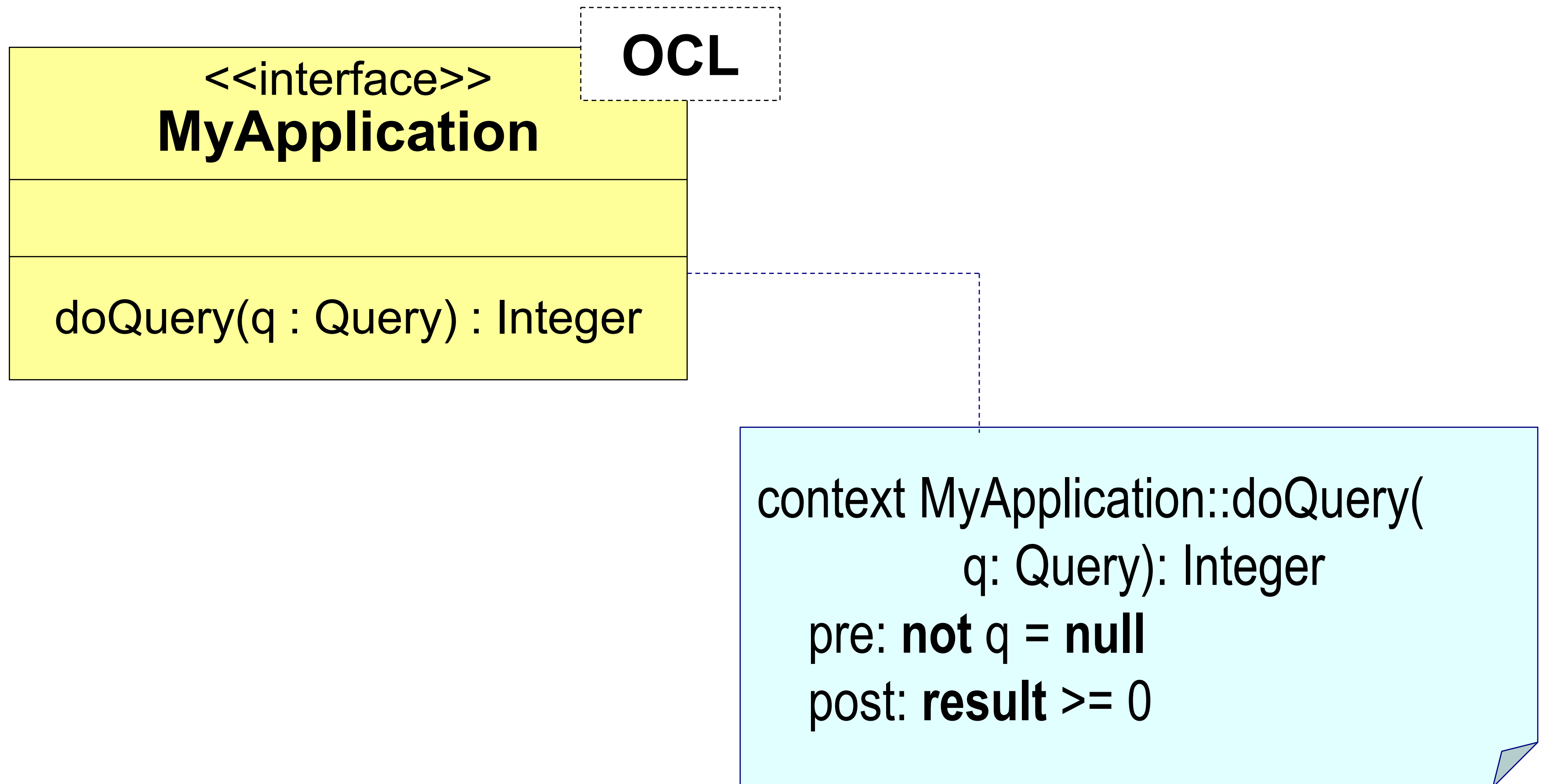
- Generation Assertion Code from OCL
  - **Transformational Approach:** Regarding OCL-to-code as model transformation
  - **Similarities of Implementation Languages:** Constructing a language hierarchy for effective developing of transformation rules
- Results
  - A translation framework has been developed
  - Showed ~50% of effort to construct translation rules saved

Background

- Model-centric approaches are becoming important in academia and industry
- OCL is often the language of choice for stipulating constraints on models
- Successful application depends on mature tool support:
  - Support for multiple programming languages
  - Customizable assertion code/test case generation

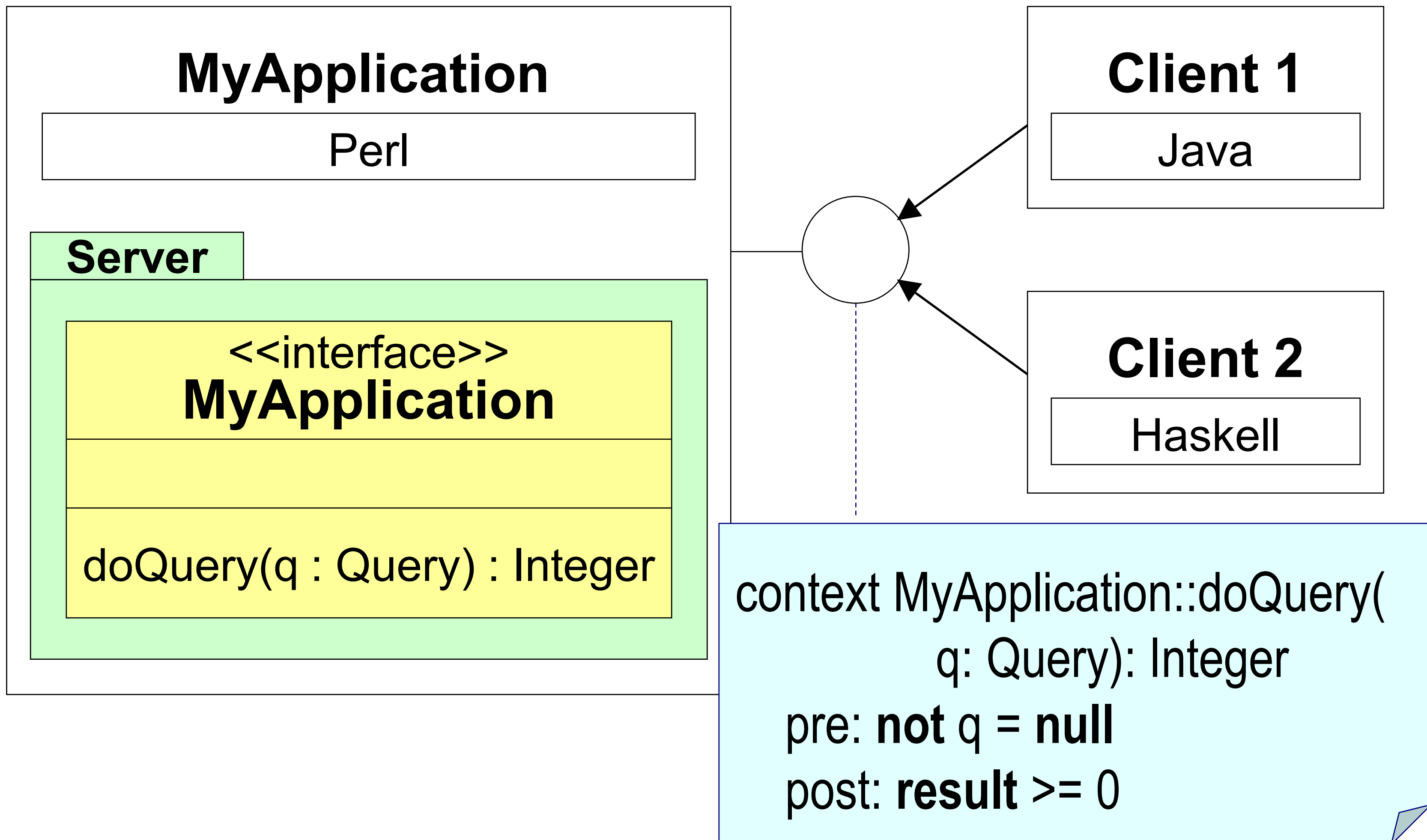
Motivating Example

- Application design: UML with OCL

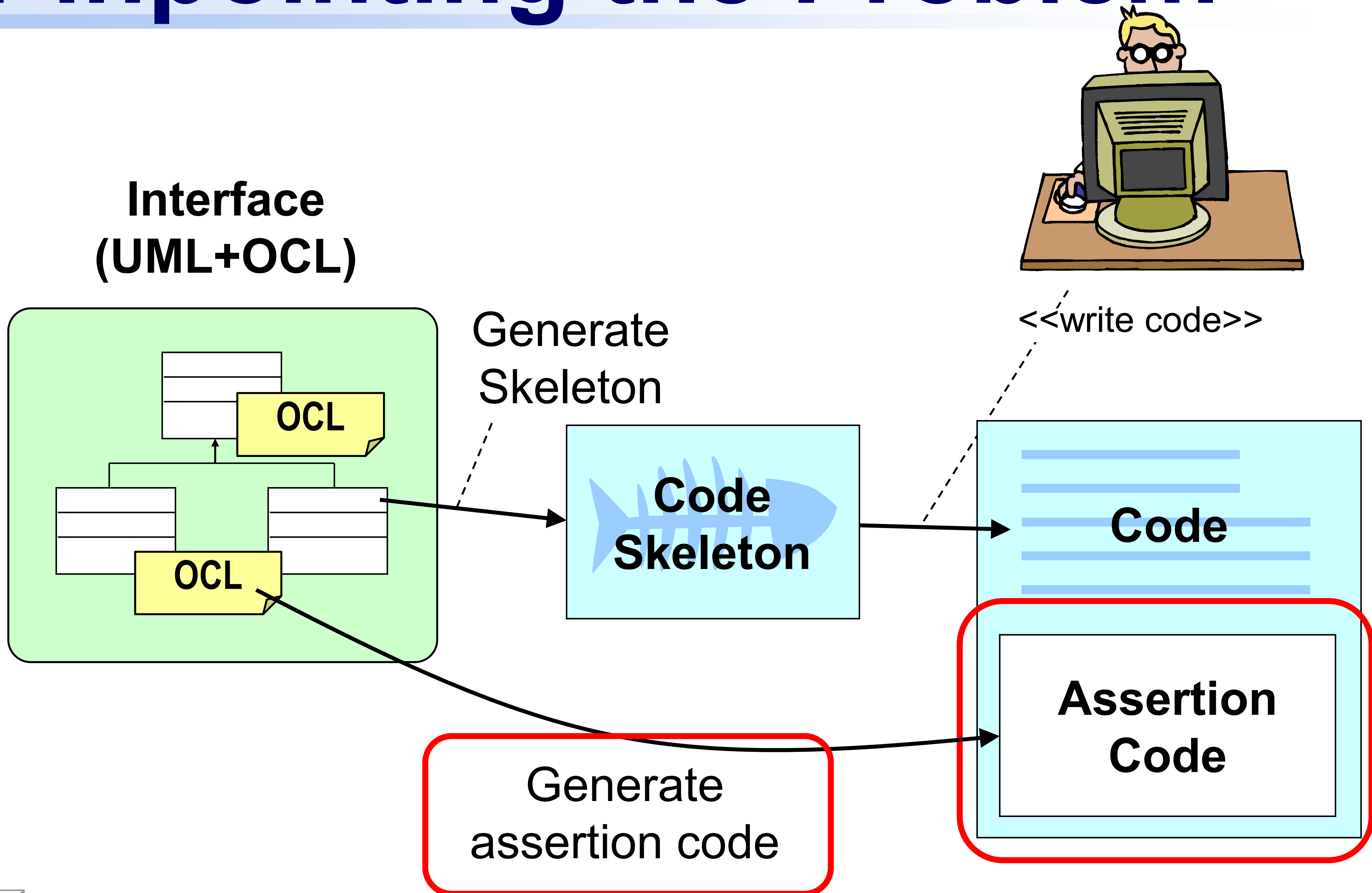


Motivating Example

- A need to check OCL for multiple languages



Pinpointing the Problem



Problems

- Troublesome to make individual OCL translators
  - Many languages exist
    - Most of existing tools are tailor-made for a specific language
  - Creating a translator requires efforts
    - Specifying OCL translation rules for each individual OCL concept, operator, etc.
- **Our solution:**
  Usage of language similarities

Language Similarities

- E.g., for-loop iterating over a collection

```
For Each apple In apples Do:
    If apple.color == "red" Then
        ...
Next
```

Imperative Pseudo-language

```
for (Iterator it = apples.iterator(); it.hasNext(); ) {
    Apple apple = (Apple) it.next();
    if (apple.color == "red") {
        ...
```

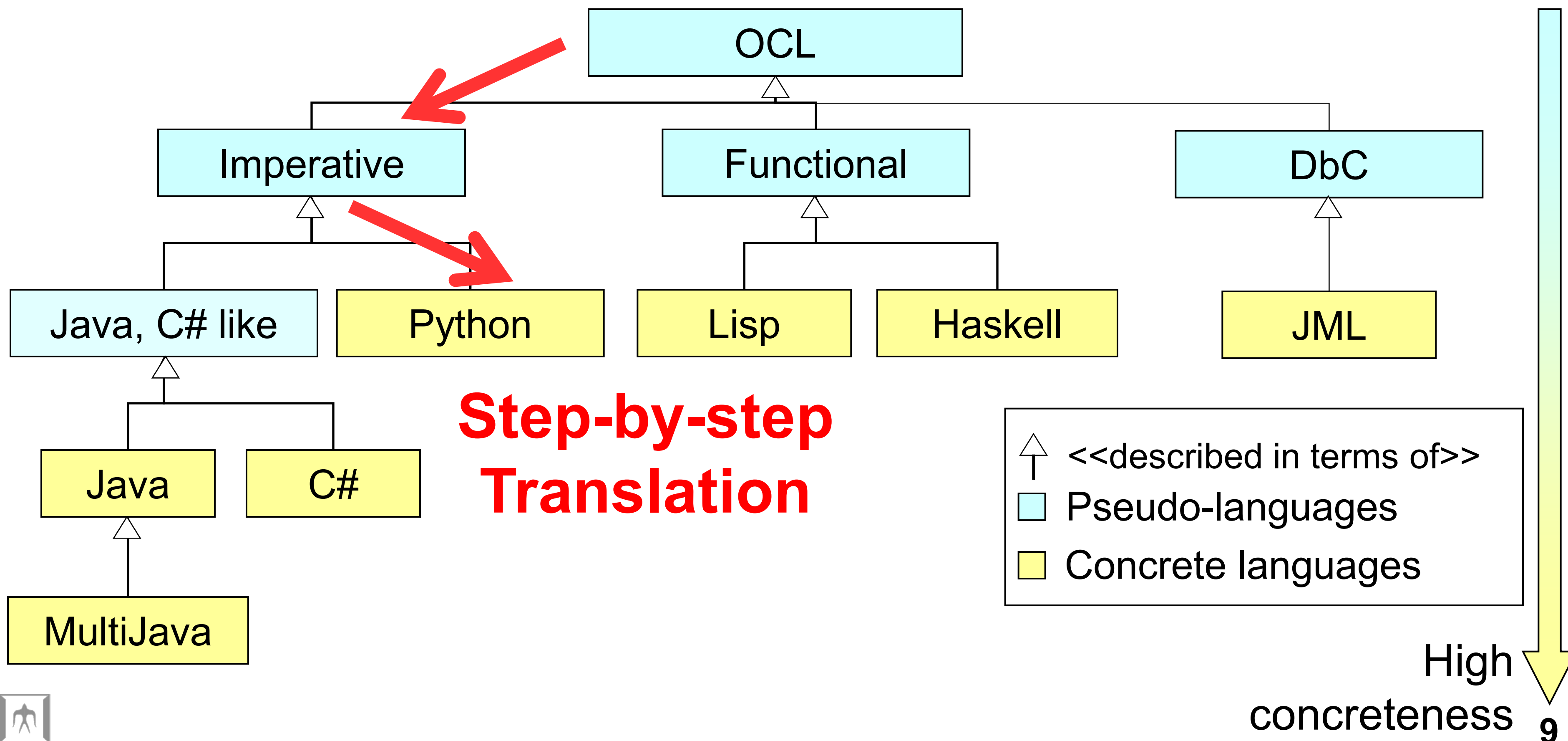
Java

```
for apple in apples:
    if apple.color == "red":
        ...
```

Python

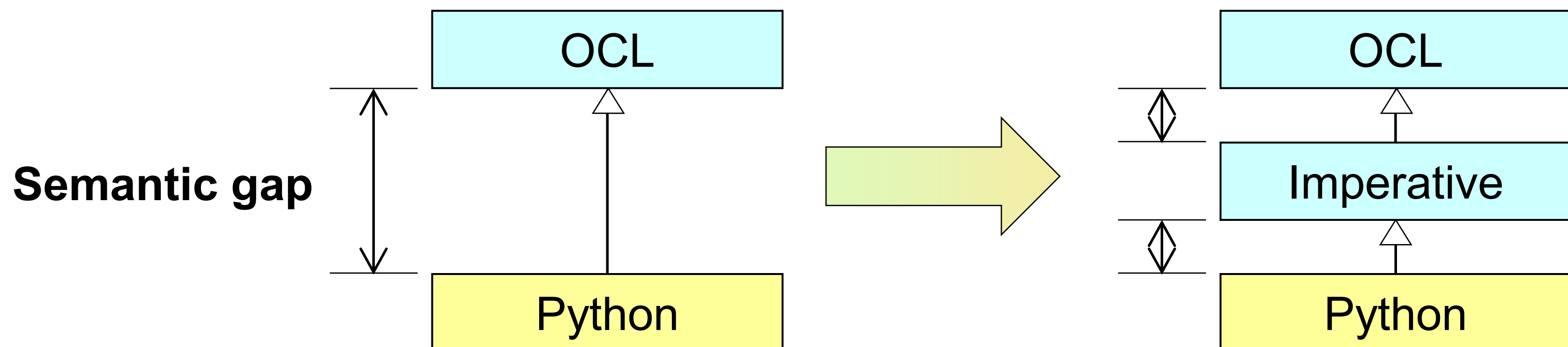
The Approach

- Hierarchy of programming languages based on their structural similarities



Advantages

- Provide a single framework for creating OCL translators for any language
  - Reuse translator implementations
- Bridges semantic gap
  - Effort of understanding OCL is alleviated
  - Manual effort of creating OCL translators is reduced



Generation Process

Environment containing type information

Parser + type checker

OCL AST

ENV

AST→Imperative DL | AST | ENV

Imperative DL

Imper. DL→Python DL | Imper. DL | ENV

rewriting rules

Python DL

Python Code

Python DL→Python Code | Python DL | ENV

printing rules

OCL

OCL

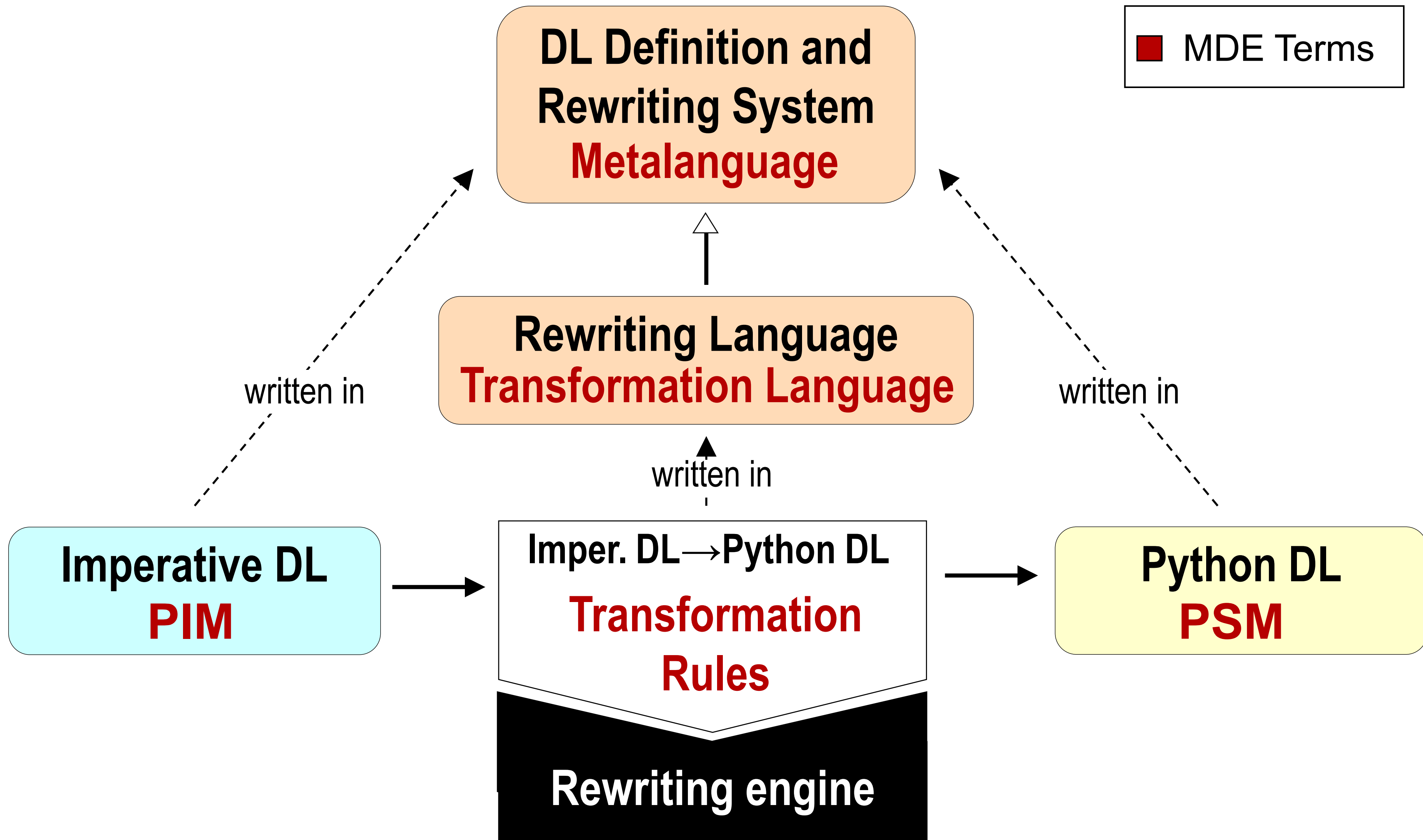
Input

UML + OCL

DL = Definition Language

(Structural representation of pseudo/implementation languages)

Comparison with MDE



Transformation Example

All employees in the company earn more than 10,000

employees->forAll(e : Employee | e.salary > 10000)

OCL AST:

iteratorExp

(assocEndCallExp simpleName("self") . simpleName(**"employees"**))

-> simpleName(**"forAll"**) (varDecl(simpleName("e"), pathName("Employee")) **|**

operCallExp(

attrCallExp simpleName("e") . simpleName(**"salary"**),

simpleName(**">"**),

intLitExp(**"10000"**)

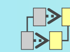
)

)

Rewriting Rules

iteratorExp OE -> simpleName**("forAll")** `( varDecl(SN, TYPE) | OE" `)

```
impMethodExtract(
{
    impForLoop( OE, impVarDecl(TYPE, SN),
    {
        impIf( impNot(OE"),
        {
            impReturn( boolLitFalse )
        })
    })
    ; impReturn( boolLitTrue )
}, pathName("Boolean")) .
```



OCL AST→Imperative DL

Imperative DL

```
impMethodExtract(
   {emptyCtx |
      impForLoop(
         assocEndCallExp simpleName("self"). simpleName("employees"),
          impVarDecl(pathName("Employee"),simpleName("e")),
       { "ctx:iter" = simpleName("it_e") |
            impIf( impNot(operCallExp(
               attrCallExp simpleName("e"). simpleName("salary"),
               simpleName(">"),
               intLitExp("10000"))),
            {emptyCtx |
               impReturn(boolLitFalse)
            })
        })
     };
     {emptyCtx |
        impReturn(boolLitTrue)
     },pathName("Boolean"))
```

Generation Result

From UML

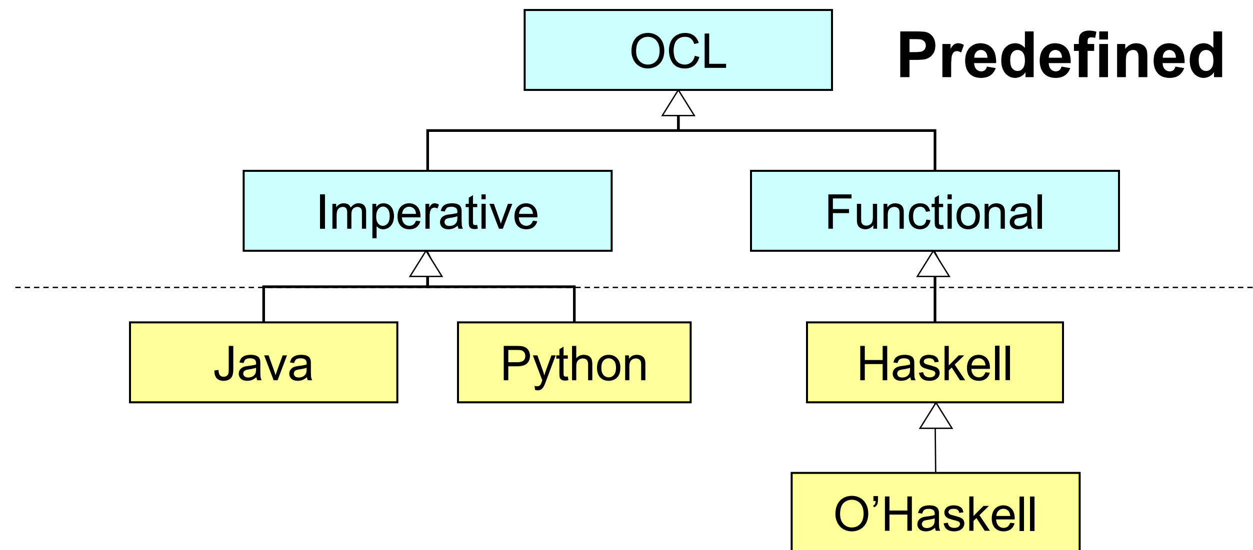
```
class Employee:
    def __init__(self, name, salary):
        self.name = name
        self.salary = salary

class Company:
    def __init__(self, employees):
        self.employees = employees
```

From OCL

```
def callExtMethod_A(self):
    for e in self.employees:
        if (not (e.salary > 10000)):
            return False
        return True
def inv(self):
    return self.callExtMethod_A()
```

Approach Evaluation

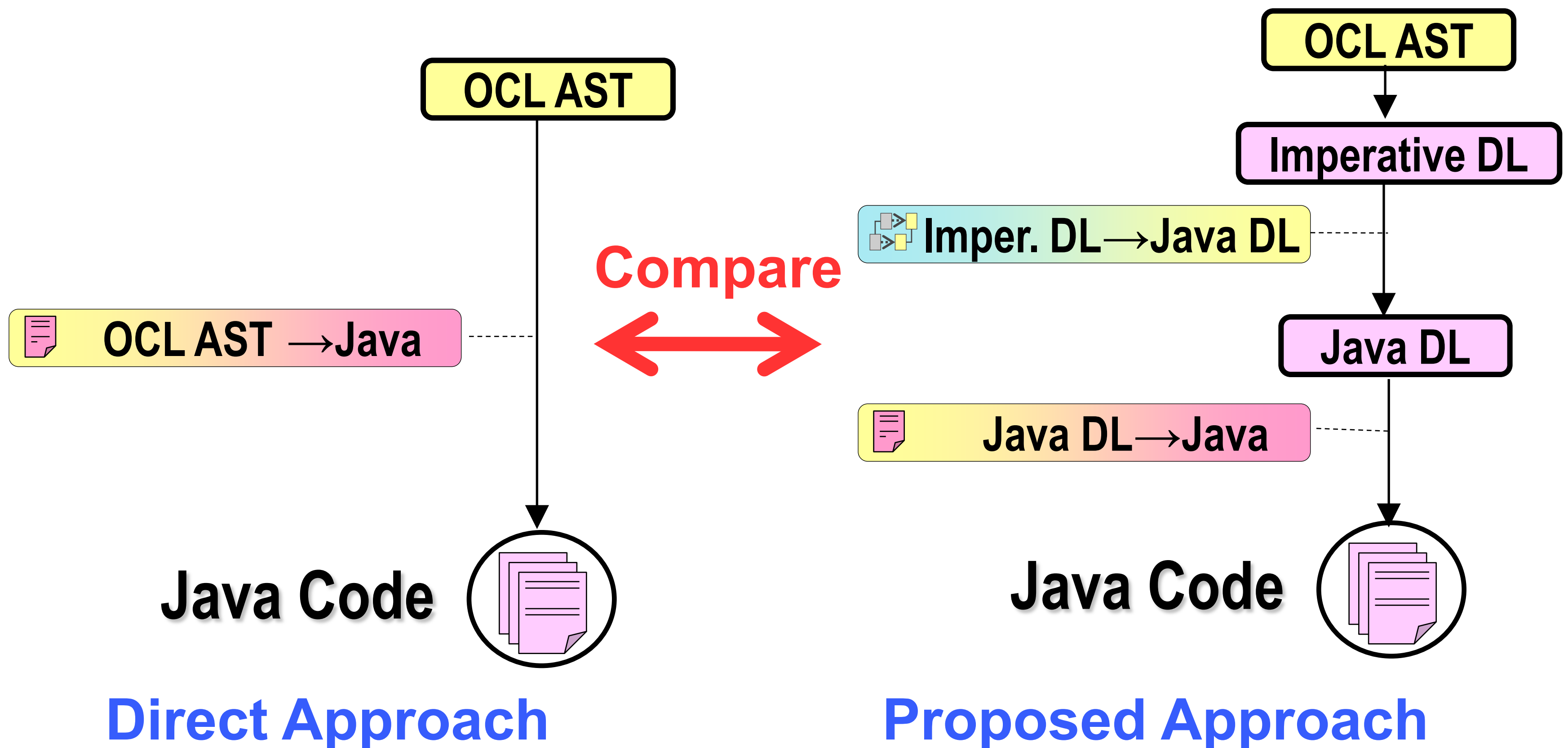
- Implemented a tool in the Maude System (*)
- To show the ability to implement several OCL translators with significant effort savings
- Target languages
  - Imperative
    - Java
    - Python
  - Functional
    - Haskell
    - O'Haskell



* *http://maude.cs.uiuc.edu/*

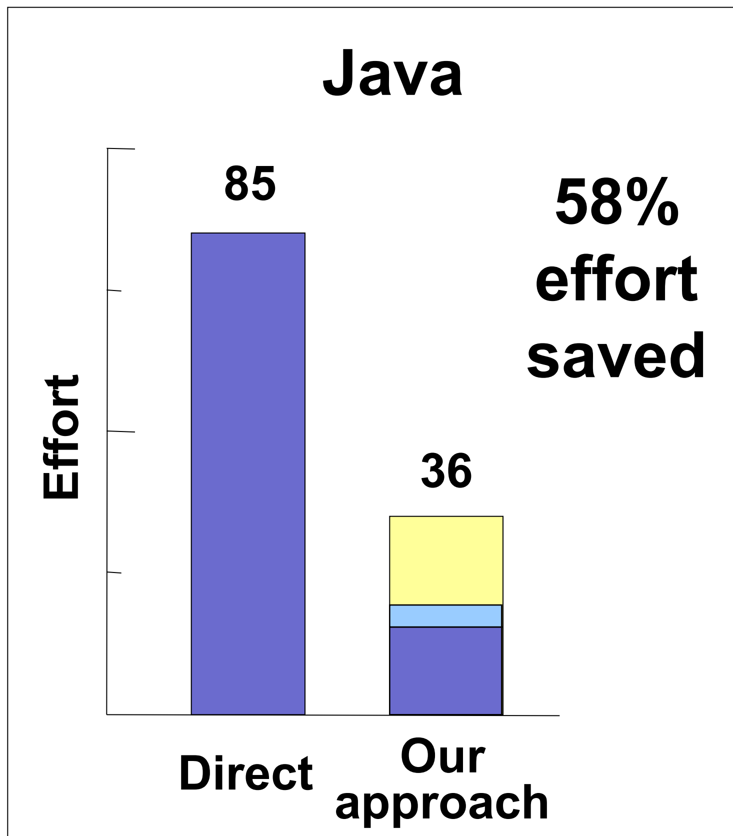
Approach Evaluation

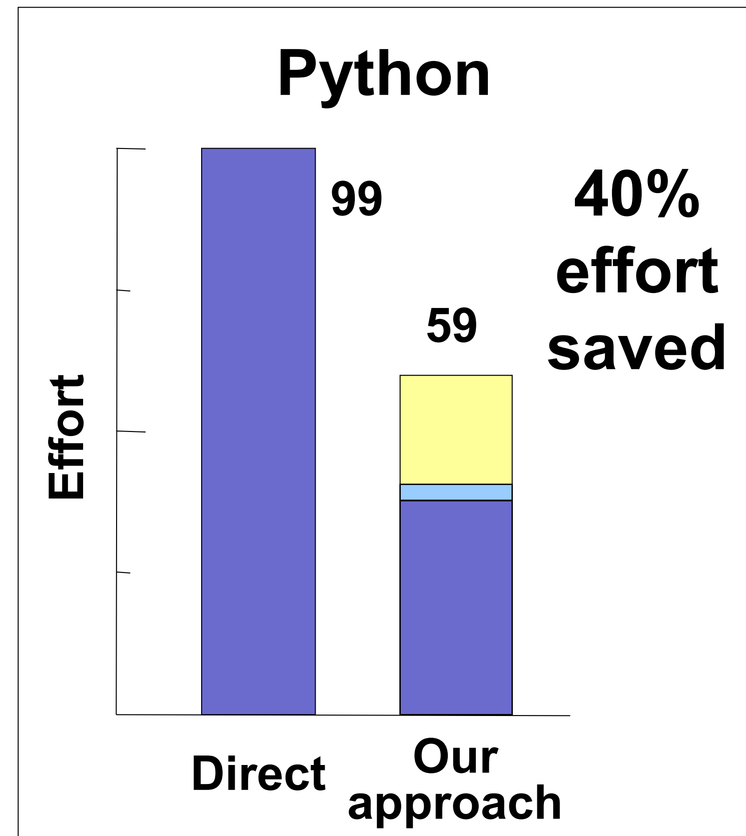
- Compare effort in our approach vs. direct approach:
  - # rewriting rules + # structures + # printing rules



Evaluation Results

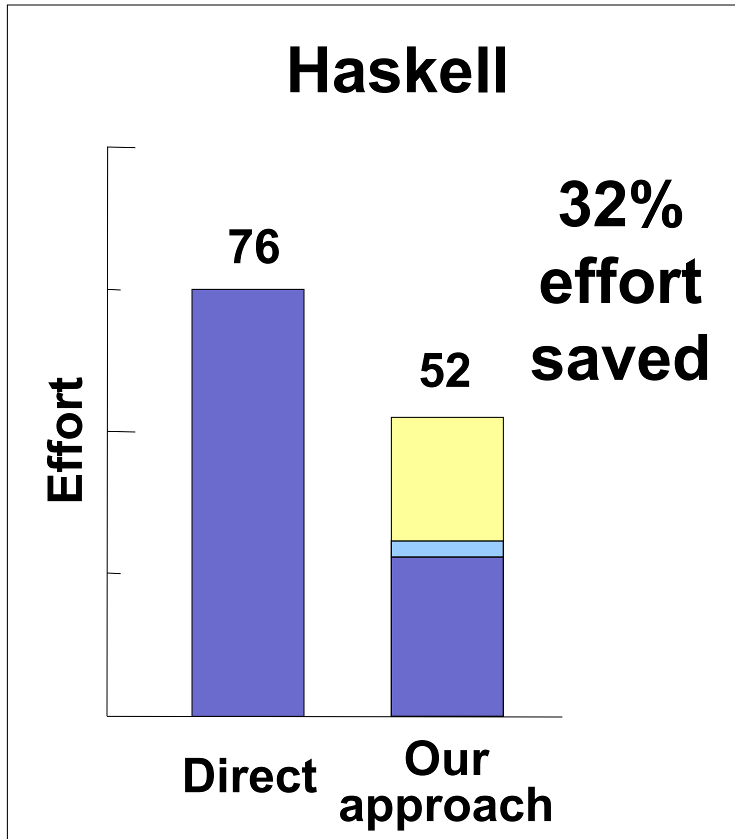
- Imperative languages

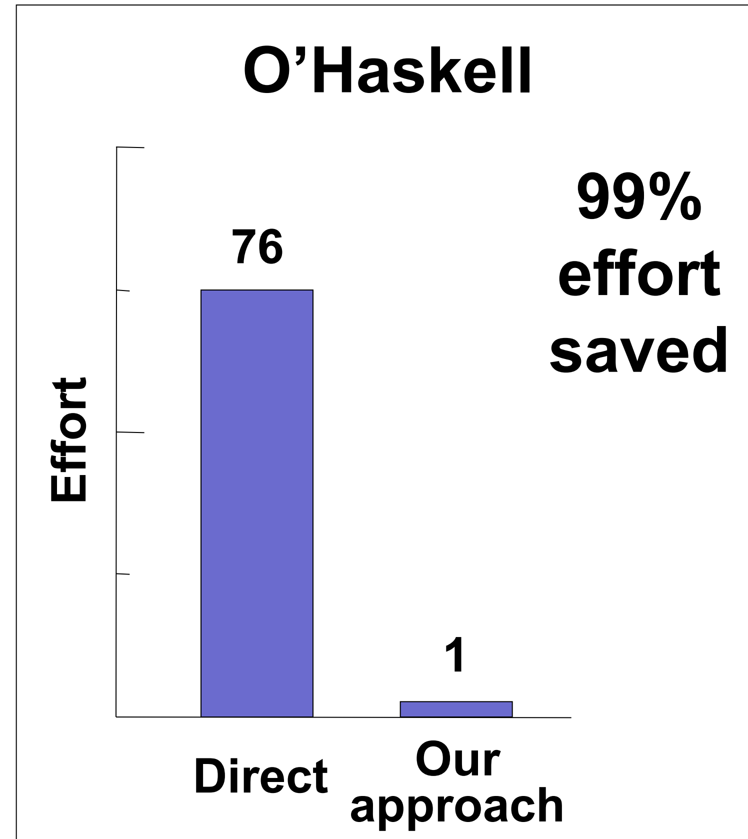




Evaluation Results

- Functional languages





Evaluation Results

	Direct Approach	Proposed Approach
Java	85	36
Python	99	59
Haskell	76	52
O'Haskell	76	1
Total	316	148

~50% effort could be saved on average

Conclusion

- Proposed a novel technique to generate assertion code from OCL constraints
- Used structural similarities of programming languages to enable reusing in OCL translators for multiple languages
  - Saving manual effort
- Run an experiment to show the claimed effort savings by using our approach

Future Work

- Uncovered functionalities of OCL
  - History expressions (`@pre`)
  - OCL messages
  - `allInstances`, etc.
- Hierarchy Limitations
  - Difficult to extend hierarchy from the middle
  - Does not allow multiple parent nodes (e.g. useful for implementing an imperative/functional hybrid)
- Real case study