Transformations you can trust -- Towards high-confidence program transformations

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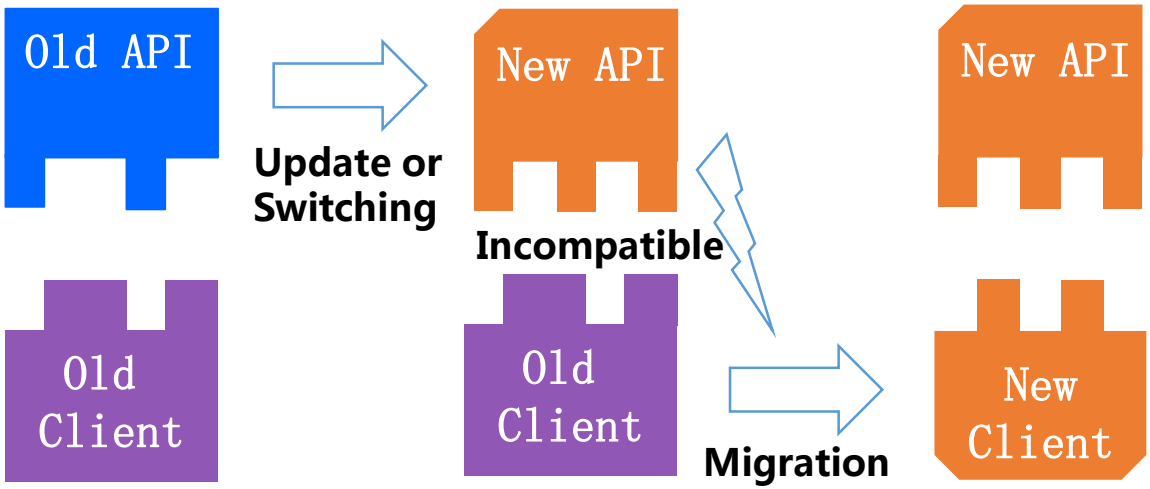
About the Speaker

- Yingfei Xiong
- 2012~Now, Assistant Professor @ Peking University
- 2009~2011, University of Waterloo, Postdoc
  - Advisor: Krzysztof Czarnecki
- 2006~2009, The University of Tokyo, Ph.D.
  - Advisor: Zhenjing Hu, Masato Takeichi
- 2004~2006, Peking University, Pre Ph.D. courses
  - Advisor: Hong Mei, Fuqing Yang
- 2000~2004, University of Electronic Science and Technology of China, B. Eng.

- Research Interests:
  - Software Engineering and Programming Languages

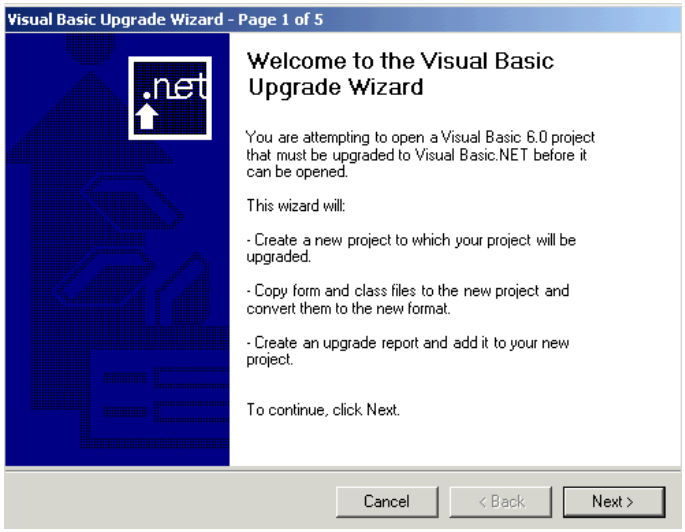
Motivation



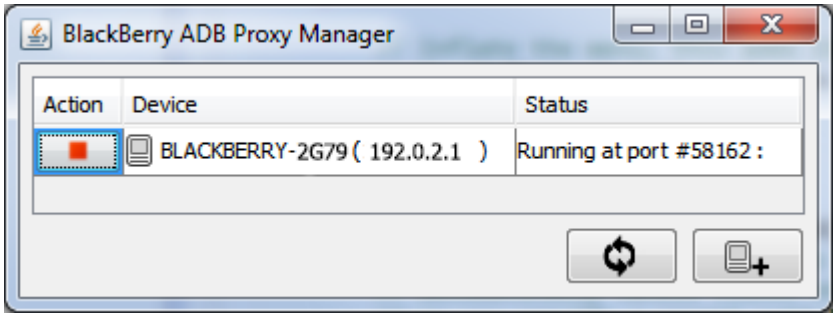
API Migration

- API update and API switching may introduce incompatibilities in the client code

Automatic Transformation Tool is Essential



Visual Basic Upgrade Wizard



Android to Blackberry Conversion Tool

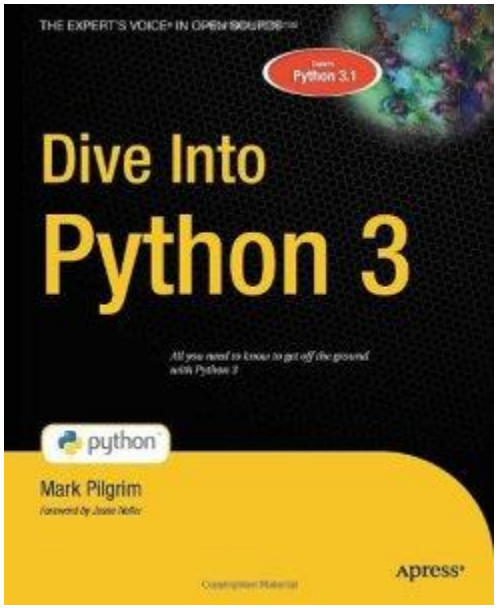
Static vs Dynamic Program Adaptation

- Static Program Transformation
  - Change client code directly
  - Usually more difficult to implement
  - Incurs no runtime overhead
- Dynamic Program Adaptation
  - Create a proxy from the old API to the new API
  - Usually easier to implement
  - Incurs runtime overhead

- Our target: static program transformation

Automatic Transformation Tool is not Easy

- Python has an upgrade tool from Python 2.x to Python 3.x
- “Dive into Python 3” use a whole chapter to discuss how to deal with the bugs in the transformation tool.
- Syntax errors, typing errors, runtime errors, silent misbehavior



Our goal: high-confidence (=safety) program transformation language

- A language for program transformation between different APIs
- The programmers describe the mappings between APIs in a declarative way
- The programs using the source API are automatically transformed to programs using the target API
  - No compilation error -- safety in statics
  - No runtime misbehavior -- safety in dynamics

Roadmap

Safety in statics for Java

- Type-safe program transformation

Safety in dynamics for Java

- Behavior-preserving program transformation

Generality

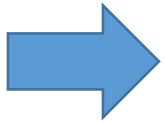
- Transformations beyond a single language

Transformation Language

- Changes from JDK 1.0 to 2.0

```
void f(Hashtable t) {
  Enumeration e = t.elements():
  while (Object o = e.next()){
    ...
  }
}
```

Old client code



```
void f(HashMap t) {
  Iterator e = t.values().iterator():
  while (Object o = e.next()){
    ...
  }
}
```

New client code

```
(t: Hashtable  ->> HashMap)
{
  - t.elements();
  + t.values().iterator();
}
```

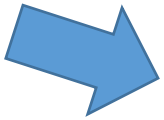
Transformation Code

Transformation Language

- Changes in Jboss from 3.2.5 to 3.2.6

```
SnmpPeer peer = new SnmpPeer(this.address);
peer.setPort(this.port);
peer.setServerPort(this.localPort);
```

Old client code



New client code

```
SnmpPeer peer = new SnmpPeer(this.address, this.port, this.localPort);
```

```
(x: String ->> String, y: String ->> String, z: String ->> String)
{
  - SnmpPeer p = new SnmpPeer(x);
  - p.setPort(y);
  - p.setServerPort(z);
  + SnmpPeer p = new SnmpPeer(x, y, z);
}
```

Transformation Code

Problems in statics

- Are the following transformations safe?

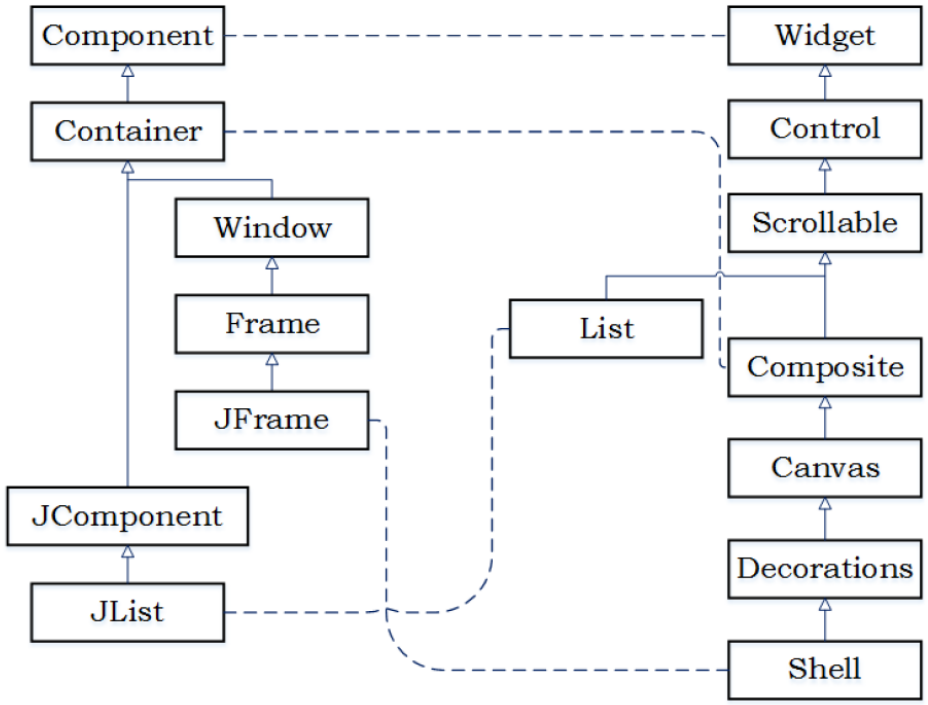
```
(t: Hashtable  ->> HashMap)
{
  - t.elements();
  + t.yingfei_xiong();
}
```

```
(t: Hashtable  ->> HashMap)
{
  - t.elements();
  + t.iterator();
}
(t: Hashtable t ->> HashMap)
{
  - t.elements();
  + t.iterator().elements();
}
```

Problems in Statics

- Is the following transformation from Swing to SWT safe?

```
(t: Container ->> Compsite)
{
  - new Container();
  + new Composite(new Shell() 0);
}
(t: ->> HashMap)
{
  - t.elements();
  + t.iterator().elements();
}
```



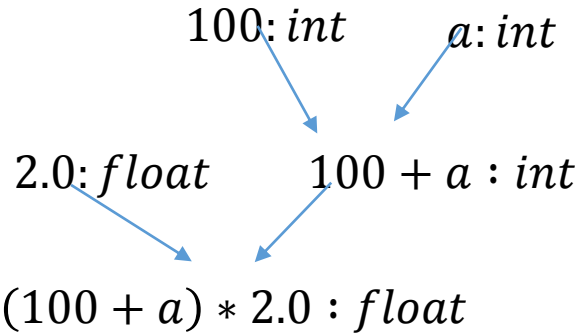
Safety in statics: definition

$$H \vdash p : t \Longrightarrow H \vdash T(p) : T(t)$$

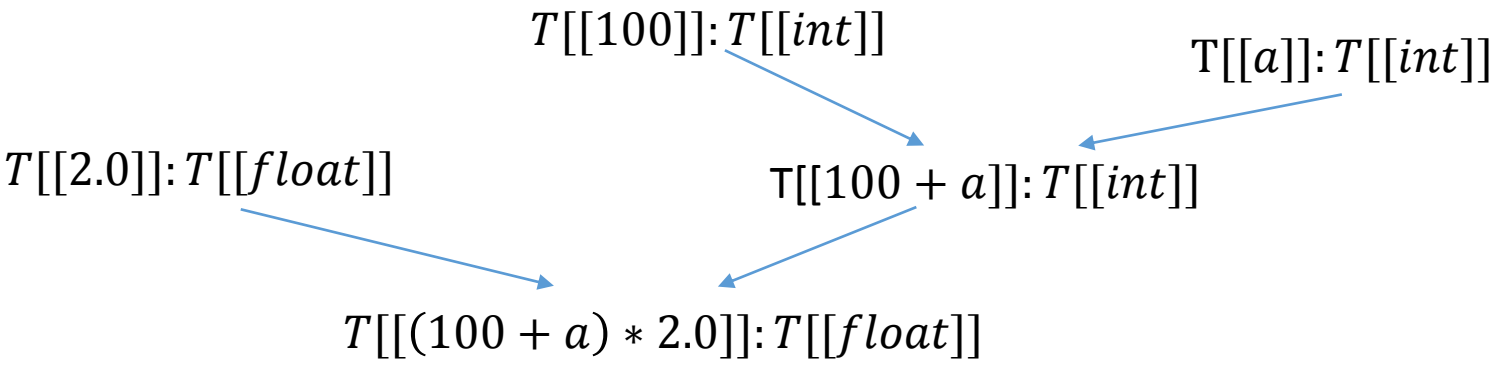
- T: a transformation written in our language
- $\vdash$: type derivation using Java typing rules
- H: hypothesis
- p: a Java program
- t: a Java type

Safety in statics: basic idea

- Type derivation tree



- Transformation should not break the structure of derivation tree



Initial result with single method replacement

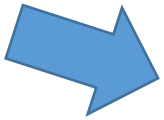
- For each code snippet introduced by a transformation rule, the code snippet itself must be well-typed
- The type mapping must form a function
- The type mapping must preserve the subtyping relation
- The transformation rules must cover all type changes between the source API and target API

Problem in dynamics

- Changes in Jboss from 3.2.5 to 3.2.6

```
SnmpPeer peer = new SnmpPeer(this.address);
peer.setPort(this.port);
peer.setServerPort(this.localPort);
```

Old client code



New client code

```
SnmpPeer peer = new SnmpPeer(this.address, this.port, this.localPort);
```

```
(x: String ->> String, y: String ->> String, z: String ->> String)
{
  - SnmpPeer p = new SnmpPeer(x);
  - p.setPort(y);
  - p.setServerPort(z);
  + SnmpPeer p = new SnmpPeer(x, y, z);
}
```

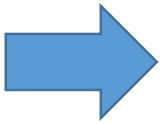
Transformation Code

Problem in dynamics

- Changes in Jboss from 3.2.5 to 3.2.6

```
SnmpPeer peer = new SnmpPeer(this.address);
If (someCondition) {
  peer.setPort(this.port);
  peer.setServerPort(this.localPort);
}
```

Old client code



```
(x: String ->> String, y: String ->> String, z: String ->> String)
{
  - SnmpPeer p = new SnmpPeer(x);
  - p.setPort(y);
  - p.setServerPort(z);
  + SnmpPeer p = new SnmpPeer(x, y, z);
}
```

Transformation Code

Problem in dynamics

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```
SnmpPeer peer = new SnmpPeer(this.address);
If (someCondition) {
  peer.setPort(this.port);
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}
```
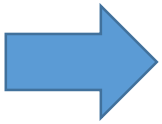

Old client code



```
(x: String ->> String, y: String ->> String, z: String ->> String)
{
  - SnmpPeer p = new SnmpPeer(x);
  - p.setPort(y);
  - p.setServerPort(z);
  + SnmpPeer p = new SnmpPeer(x, y, z);
}
```

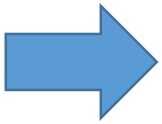
Transformation Code

Problem in dynamics

- Changes in Jboss from 3.2.5 to 3.2.6

```
SnmpPeer peer = new SnmpPeer(this.address);
Port p = peer.getPort();
If (someCondition) {
  peer.setPort(this.port);
  peer.setServerPort(this.localPort);
}
System.out.print(p);
```

Old client code



```
(x: String ->> String, y: String ->> String, z: String ->> String)
{
  - SnmpPeer p = new SnmpPeer(x);
  - p.setPort(y);
  - p.setServerPort(z);
  + SnmpPeer p = new SnmpPeer(x, y, z);
}
```

Transformation Code

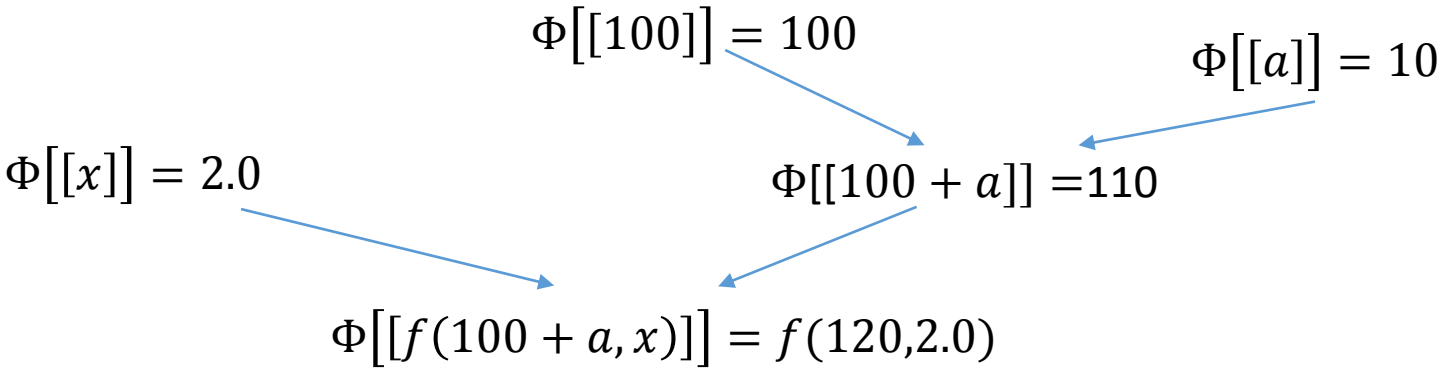
Safety in dynamics: definition

$$\forall i: \Phi\big(T(p), T(i)\big) = T(\Phi(p, i))$$

- i: an input to the program
- Φ: interpretation function, generating a trace of API invocations from a program and an input
- T: a transformation written in our language
- p: a Java program

Safety in dynamics: ideas

- Work in progress
- Φ can also be defined by logic rules



- Transformation should preserve the derivation

Generality

$$H \vdash p : t \Longrightarrow H \vdash T(p) : T(t)$$
$$\forall i : \Phi\big(T(p), T(i)\big) = T(\Phi(p, i))$$

- $\vdash$ and Φ are given by logic rules
- Find parametric safe conditions working for a class of logic rules

Roadmap again

Safety in statics for Java

- Type-safe program transformation

Safety in dynamics for Java

- Behavior-preserving program transformation

Generality

- Transformations beyond a single language