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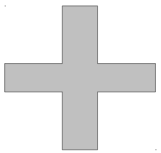

JDT Embraces Java 8

Stephan Herrmann

Committer:
- JDT
- Object Teams

Eclipse Track @ JavaLand 2014, Brühl, Germany

Berlin
Köln

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Schöneck, Vogtland
St. Ingbert, Saarland

THE RETAIL APPLICATION Company

- POS
- Store Integration
- Mobile Devices
- ...

...

Domain Specific Languages

Java (Server & Client)

Hardware Integration

Eclipse Track @ JavaLand 2014, Brühl, Germany

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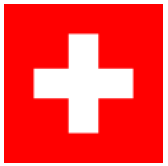
Released March 18th!

- Andy Clement
- Steve Francisco
- Michael Rennie
- Olivier Thomann
- Curtis Windatt

- Walter Harley
- David Williams

- Jesper S. Møller

- Stephan Herrmann



- Dani Megert
- Markus Keller

- Jay Arthanareeswaran
- Anirban Chakarborty
- Manoj Palat
- Shankha Banerjee
- Manju Mathew
- Noopur Gupta
- Deepak Azad
- **Srikanth Sankaran**

http://download.eclipse.org/eclipse/downloads

http://wiki.eclipse.org/JDT/Eclipse_Java_8_Support_For_Kepler

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Eclipse and Java™ 8

- Java 8 features supported:
  - JSR 308 - Type Annotations.
  - JEP 120 - Repeating Annotations.
  - JEP 118 - Method Parameter Reflection.
  - JSR 269 - Pluggable Annotation Processor API
    & javax.lang.model API enhancements for Java 8.
  - JSR 335 – Lambda Expressions
    - Lambda expressions & method/constructor references
    - Support for “code carrying” interface methods
    - Enhanced target typing
      new overload resolution & type inference

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The Engine behind Lambda Expressions

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Prologue: Parser

- Eclipse uses the Jikes Parser Generator
  - requires an LALR(1) grammar
  - generates an automaton
- Java 8 grammar
  - is not LALR(1)
  - rewrite estimated to 10-15 person years
- Rewrite could be avoided
  - a number of advanced tricks
  - unorthodox communication between scanner & parser

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Goal: Brevity

- What we do in Java 7 (instance of an anonymous class):

```
new BinaryOperator<Integer>() {
    @Override
    public Integer apply(Integer i1, Integer i2) {
        return i1+i2;
    }
}
```

- What want in Java 8 (lambda):

```
(i1, i2) -> i1+i2
```

- What can be omitted:
  - the functional interface
  - its generic type arguments
  - the function signature
  - …
- How come this works?

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Goal: Reuse

- Lambdas are typically arguments to generic library functions

```
public static <T, K, U, M extends Map<K, U>>
Collector<T, ?, M> toMap(Function<? super T, ? extends K> keyMapper,
                         Function<? super T, ? extends U> valueMapper,
                         BinaryOperator<U> mergeFunction)
```

- Would you prefer to call:

```
Collectors.<Person,String,Integer,Map<String,Integer>>toMap(..)
```

or:

```
Collectors.toMap(..)
```

?

- Again: omitting “unnecessary” boiler plate
- Similar for instantiation of generic class (Java 7)

```
Collector<String,Integer> coll = new MyCollector<>();
```

- How ***does*** it work?

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Solution: Type Inference

- Present since Java 5 – but completely rewritten
- Let the compiler collect *all available* type information
- Let it deduce the types
  - instantiation of type parameters of
    - generic methods
    - diamond instantiations
    - functional interface
  - lambda parameters
- If inference finds a solution, it is type safe – by definition
- If it doesn't find a solution ... ? ...

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Type Inference Details

- Solving this little example

```
Map<String, Integer> test3(Stream<Person> persons) {
    return persons.collect(Collectors.toMap(
                                p -> p.getLastName(),
                                p -> p.getAge(),
                                (i1, i2) -> i1+i2));
}
```

- Produces these constraints:

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- Solving th

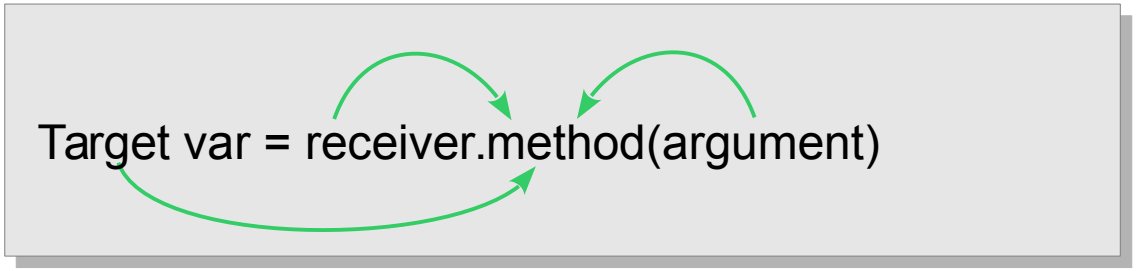
```
Map<Strin
    retur


}
```

- Produces

```
TypeBound  K#3 :> java.lang.String
Dependency K#3 = K#3
TypeBound  K#3 = java.lang.String
TypeBound  K#3 <: java.lang.Object
Dependency R#0 = java.util.Map<K#3,U#4>
Dependency R#0 = java.util.Map<java.lang.String,U#4>
Dependency R#0 = java.util.Map<K#3,java.lang.Integer>
TypeBound  R#0 = java.util.Map<java.lang.String,java.lang.Integer>
TypeBound  R#0 <: java.util.Map<java.lang.String,java.lang.Integer>
TypeBound  R#0 <: java.lang.Object
TypeBound  T#2 :> Person
Dependency T#2 = T#2
TypeBound  T#2 = Person
TypeBound  T#2 <: java.lang.Object
Dependency Map<K#3,U#4>#6 = java.util.Map<K#3,U#4>
Dependency Map<K#3,U#4>#6 = java.util.Map<java.lang.String,U#4>
Dependency Map<K#3,U#4>#6 = java.util.Map<K#3,java.lang.Integer>
TypeBound  Map<K#3,U#4>#6 = java.util.Map<java.lang.String,java.lang.Integer>
Dependency Map<K#3,U#4>#6 = R#0
TypeBound  Map<K#3,U#4>#6 <: java.lang.Object
TypeBound  Map<K#3,U#4>#6 <: java.util.Map<java.lang.String,java.lang.Integer>
TypeBound  A#1 = java.lang.Object
TypeBound  A#1 <: java.lang.Object
TypeBound  U#4 :> java.lang.Integer
TypeBound  U#4 = java.lang.Integer
Dependency U#4 = U#4
TypeBound  U#4 <: java.lang.Object
TypeBound  ?#5 = java.lang.Object
Dependency ?#5 = A#1
TypeBound  ?#5 <: java.lang.Object
```

Type Inference Details

- Information flows:
  - Used for inference:
    - receiver type
    - argument types
    - target type



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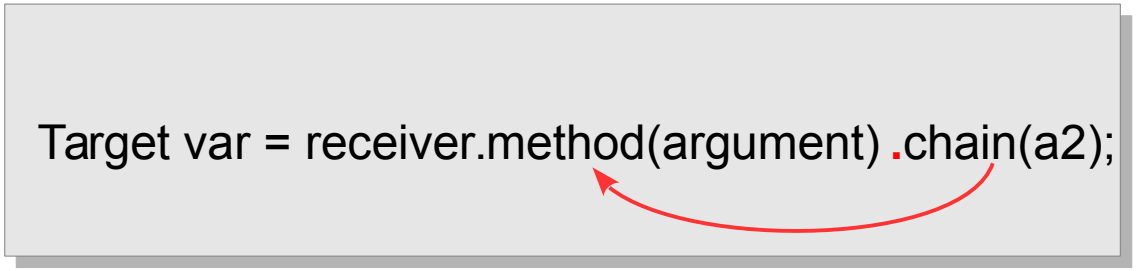
Type Inference Details

- Information flows:
  - Used for inference:
    - receiver type
    - argument types
    - target type
  - Never
    - what's right of the next dot



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Type Inference Details

- Information flows:
  - Used for inference:
    - receiver type
    - argument types
    - target type
  - Never
    - what's right of the next dot
  - Nested inference
    - expressions nested as call arguments
    - combine inner and outer to one inference

```
Map<String, Integer> test3(Stream<Person> ps) {
    return ps
        .collect(
            Collectors.toMap(
               p -> p.getLastName(),
               p -> p.getAge(),
               (i1, i2) -> i1+i2));
}
```

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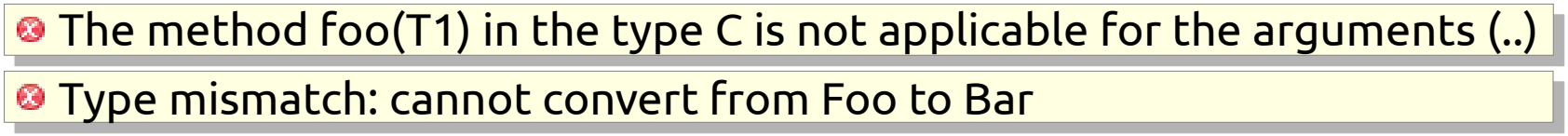
If it fails … ?

- To make sure you know what you're doing:
  - insert explicit types
- There's no guarantee that inference finds every solution
  - *“reduction is not completeness-preserving” (JLS 18.2.)*
- Inference is constraint solving
  - unlike common sense reasoning
  - if it fails, it's **hard** to say, why



    - Better error reporting: future work
- Simplification for users
  - bought by tremendous complexity in the compiler

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The Process behind a new Java Feature

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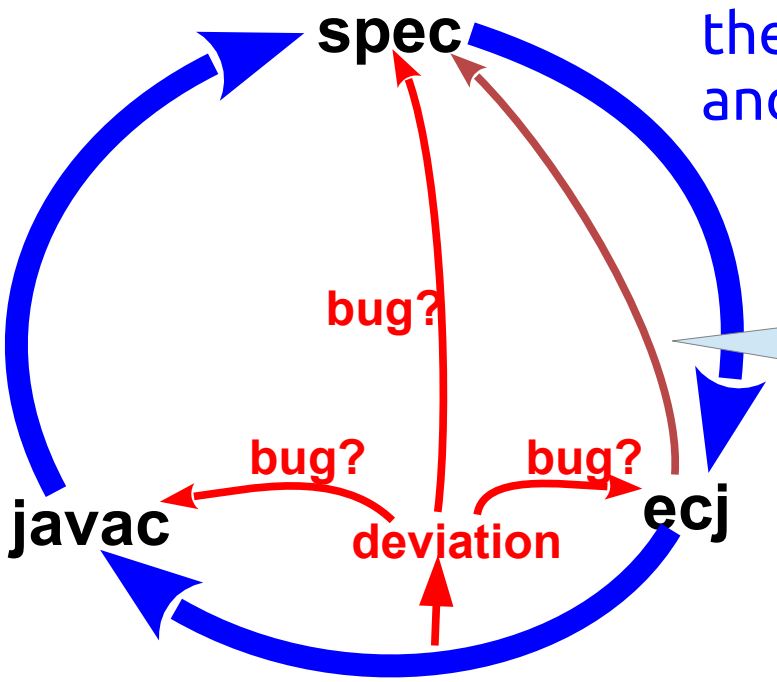
Java Quality Assurance

abstractly capture
the concepts



implement the spec,
the full spec,
and nothing but the spec

spec is not implementable
(incomplete)
(Apr – Sep 2013)

compare behavior

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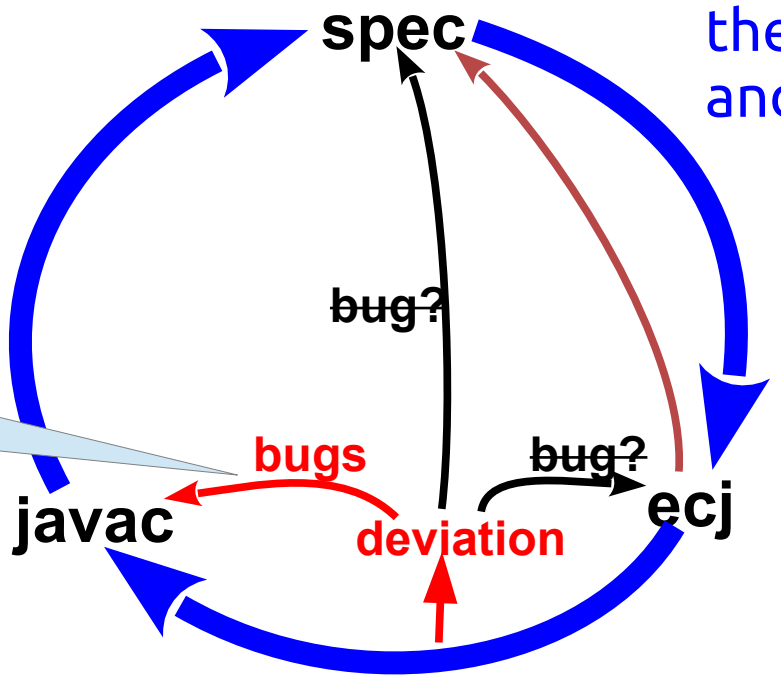
Java Quality Assurance

implement the spec,
the full spec,
and nothing but the spec

abstractly capture
the concepts

far too risky
to cram late into 8
(Nov 2013)



compare behavior

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Raw Types in Type Inference

- Where are unchecked conversions allowed?
  - List <: List<String> ?
    - spec: NO
    - javac: maybe, sometimes
    - ecj ?
  - raw types
    - supported in Java 5 to allow migration
    - some programs using raw types will eventually be rejected
- Serving two masters – JLS & javac?
  - should we exactly copy javac behavior?
  - is precisely implementing the spec better?
  - competition helps improve quality

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Status Reached

- JLS 8 is more precise than previous versions
  - will be a good judge in case of doubt
- Ecj implementation is very close to the spec
  - bugs can be easily identified and fixed
  - 1 unimplemented branch, if you see:

    Problem detected during type inference: ...

    you win! :)

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- DEMO JDT Support for Lambda
  - Quick assist
    - to / from lambda
    - expression ↔ block
  - Search / Type hierarchy / Refactoring
    - are lambda aware
  - Hover
    - to see the functional type

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Breathing Life into Types

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Annotations in more Places

- Java 5: annotate declarations
  - ElementType: packages, classes, fields, methods, locals …
- Java 8: annotate types
  - ElementType.TYPE_USE
  - ElementType.TYPE_PARAMETER

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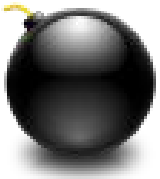
Why Care About Types?

- Dynamically typed languages
  - anything goes
  - but may fail at runtime
  - e.g.: “method not understood”



```
dog1 = new Dog();
dog1.bark();

dog2 = new Object();
dog2.bark();
```

- Type = Constraints on values

  To *statically* detect anomalies
  - missing capability
  - incompatible assignment
  - undeclared capability

```
Dog dog1 = new Dog();
dog1.bark();

Object dog2 = new Object();
dog2.bark();

Dog dog3 = new Object();
dog3.bark();

Object dog4 = new Dog();
dog4.bark();
```

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Why Care About Types?

- Dynami
  - anyth
  - but m
  - e.g.: "

Annotate source code:
- make assumptions explicit
- convince the compiler that code is safe

```
);

ct();
```

- Type = Constraints on values

  To *statically* detect anomalies
  - missing capability
  - incompatible assignment
  - undeclared capability

```
Dog dog1 = new Dog();
dog1.bark();

Object dog2 = new Object();
dog2.bark();

Dog dog3 = new Object();
dog3.bark();

Object dog4 = new Dog();
dog4.bark();
```

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Why Care About Types?

- Constraint checking avoids errors
  - No Such Method / Field
    - Basic statically typed OO
  - ClassCastException
    - Generics
  - ??Exception
    - SWTException("Invalid thread access")
    - …
    - **NullPointerException**

```
void letemBark(Vector dogs) {
    Dog aDog = (Dog) dogs.get(0);
    aDog.bark();
}
```

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Pluggable Type System

- Make it easier to add new constraints
  - Only one new syntax for all kinds of constraints
- Make it easier to add new type checkers
  - Checker Framework (Michael Ernst – U of Washington)
- Examples
  - @NonNull
  - @Interned equals(== , equals)
  - @Immutable value cannot change (Java 5 ?)
  - @ReadOnly value cannot change *via this reference*
  - @UI code requires to run on the UI thread

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Can't Java 5 Do All This?

```
@Target(ElementType.PARAMETER)
@interface NonNull5 {}

void java5(@NonNull5 String arg);
```

arg is qualified to be non-null

```
@Target(ElementType.METHOD)
@interface NonNull5 {}

@NonNull5 String java5();
```

java5 is qualified to be non-null

```
@Target(ElementType.TYPE_USE)
@interface NonNull8 {}

void java8(@NonNull8 String arg);
```

String is qualified to be non-null

```
@Target(ElementType.TYPE_USE)
@interface NonNull8 {}

@NonNull8 String java8();
```

String is qualified to be non-null

- We've been lying about the method result
  - but we can't lie about everything, e.g.:

```
void printFirstDog(@NonNull List<Dog> dogs) {
    dogs.get(0).bark();
}
```

NPE?

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Annotated Generics

```
void good() {
   @NonNull List<@NonNull String> l1 = new ArrayList<>();
   l1.add("Hello");
   for (String elem : l1)
      System.out.println(elem.toUpperCase());

   @NonNull List<@Nullable String> l2 = new ArrayList<>();
   l2.add(null);
   for (String unknown : l2)
      if (unknown != null)
         System.out.println(unknown.toUpperCase());
}
```

l1 cannot contain **null** elements

l2 can contain **null** elements

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Annotated Generics

```
void bad(List<String> unknown, List<@Nullable String> withNulls) {
   @NonNull List<@NonNull String> l1 = new ArrayList<>();
   l1.add(null);
   String
   if (fir
   l1 = unknown;
   l1 = withNulls;

   String canNull = withNulls.get(0);
   System.out.println(canNull.toUpperCase());
}
```

Null type mismatch: required '@NonNull String' but the provided value is null

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Annotated Generics

```
void bad(List<String> unknown, List<@Nullable String> withNulls) {
   @NonNull List<@NonNull String> l1 = new ArrayList<>();
   l1.add(null);
   String first = l1.get(0);
   if (first == null) return;

   l1 =
   l1 =

   String canNull = withNulls.get(0);
   System.out.println(canNull.toUpperCase());
}
```

Null comparison always yields false:
The variable first cannot be null at this location

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Annotated Generics

```
void bad(List<String> unknown, List<@Nullable String> withNulls) {
   @NonNull List<@NonNull String> l1 = new ArrayList<>();
   l1.add(null);
   String first = l1.get(0);
   if (first == null) return;

   l1 = unknown;
   l1 = 

   Strin
   System.out.println(canNull.toUpperCase());
}
```

Null type safety (type annotations): The expression of type 'List<String>' needs unchecked conversion to conform to '@NonNull List<@NonNull String>'

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Annotated Generics

```
void bad(List<String> unknown, List<@Nullable String> withNulls) {
   @NonNull List<@NonNull String> l1 = new ArrayList<>();
   l1.add(null);
   String first = l1.get(0);
   if (first == null) return;

   l1 = unknown;
   l1 = withNulls;

   Strin
   Syste
}
```

Null type mismatch (type annotations):
required '@NonNull List<@NonNull String>'
but this expression has type 'List<@Nullable String>'

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Annotated Generics

```
void bad(List<String> unknown, List<@Nullable String> withNulls) {
   @NonNull List<@NonNull String> l1 = new ArrayList<>();
   l1.add(null);
   String first = l1.get(0);
   if (first == null) return;

   l1 = unknown;
   l1 = withNulls;

   String canNull = withNulls.get(0);
   System.out.println(canNull.toUpperCase());
}
```

Potential null pointer access:
The variable canNull may be null at this location

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Status

- Null Annotations
  - org.eclipse.jdt.annotation_2.0.0
    - @NonNull, @Nullable specify Target(TYPE_USE)
    - @NonNullByDefault: more fine tuning
- Null Analysis (per compiler option)
  - Nullness is an integral part of the type system
  - Fine tuned defaults only in Luna
  - TODO: Strict checking against type variables

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Status

- Null Annotations
- Null Analysis (per compiler option)
- Planned: @Uninterned
  - Detect accidental comparison using == or !=
- Proposed: @UiEffect, @Ui …
  - by [Colin S. Gordon, Werner Dietl, Michael D. Ernst, and Dan Grossman]
  - SWT: bye, bye, "Invalid thread access"

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Status

- Null Annotations
- Null Analysis (per compiler option)
- Planned: @Uninterned
- Proposed: @UiEffect, @Ui …
- JDT/UI
  - OK: completion, refactoring, etc.
  - TODO: show in hover
  - TODO: update / add more quickfixes

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Status

- Null Annotations
- Null Analysis (per compiler option)
- Planned: @Uninterned
- Proposed: @UiEffect, @Ui …
- JDT/UI

Do You care about Types?

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Breathing Life into Objects (beyond Java)

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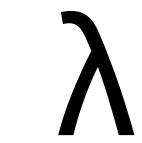
Areas Covered

- Algorithms
  - lambda expressions
  - library updates for lambdas
- Types
  - type annotations
- Objects? – Connecting objects to a module / a system?
  - references
    - bad for analyzeability / modularity
  - inheritance
    - doesn't scale
    - rigid



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Introducing Object Teams

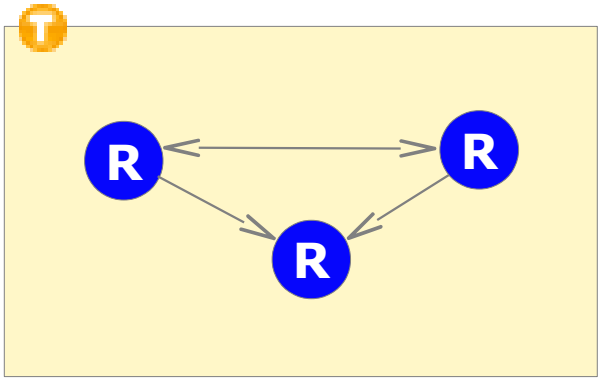
- 2002: Research on Language Design beyond standard OO
  - Object Teams – programming with roles and teams
  - OT/J – extends Java

- 2010: Eclipse Object Teams Project established
  - Outgrown the research niche
  - Mature language (OT/J) & IDE (OTDT)
  - Object Teams Development Tooling written in OT/J

Object Containment

eclipse.org/objectteams

- OO: Message passing among objects



- Team: A group of interacting Roles
  - A team instance **owns** its role instances
  - Team provides a boundary for **isolation**

```
team class Company {

    class Employee {

    }

}
```

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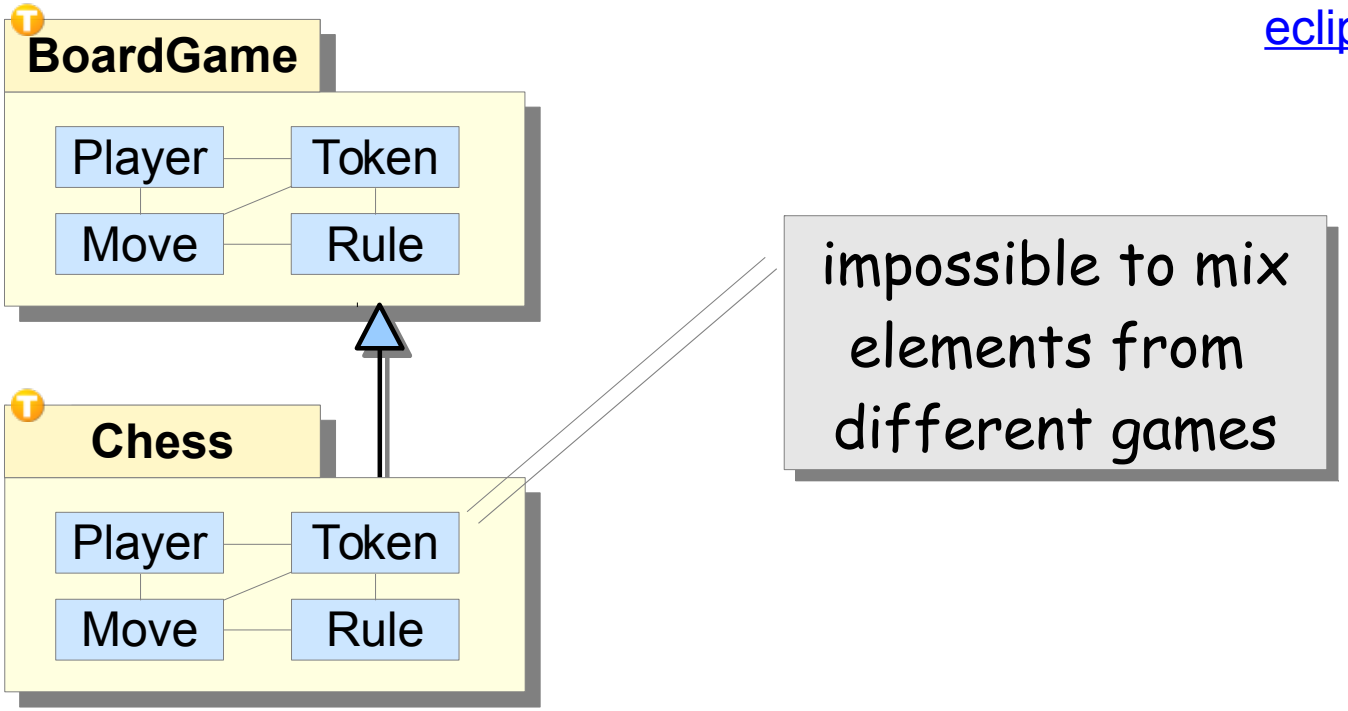
Team Inheritance

eclipse.org/objectteams



- Members of a team are virtual classes
  - consistent refinement of all members

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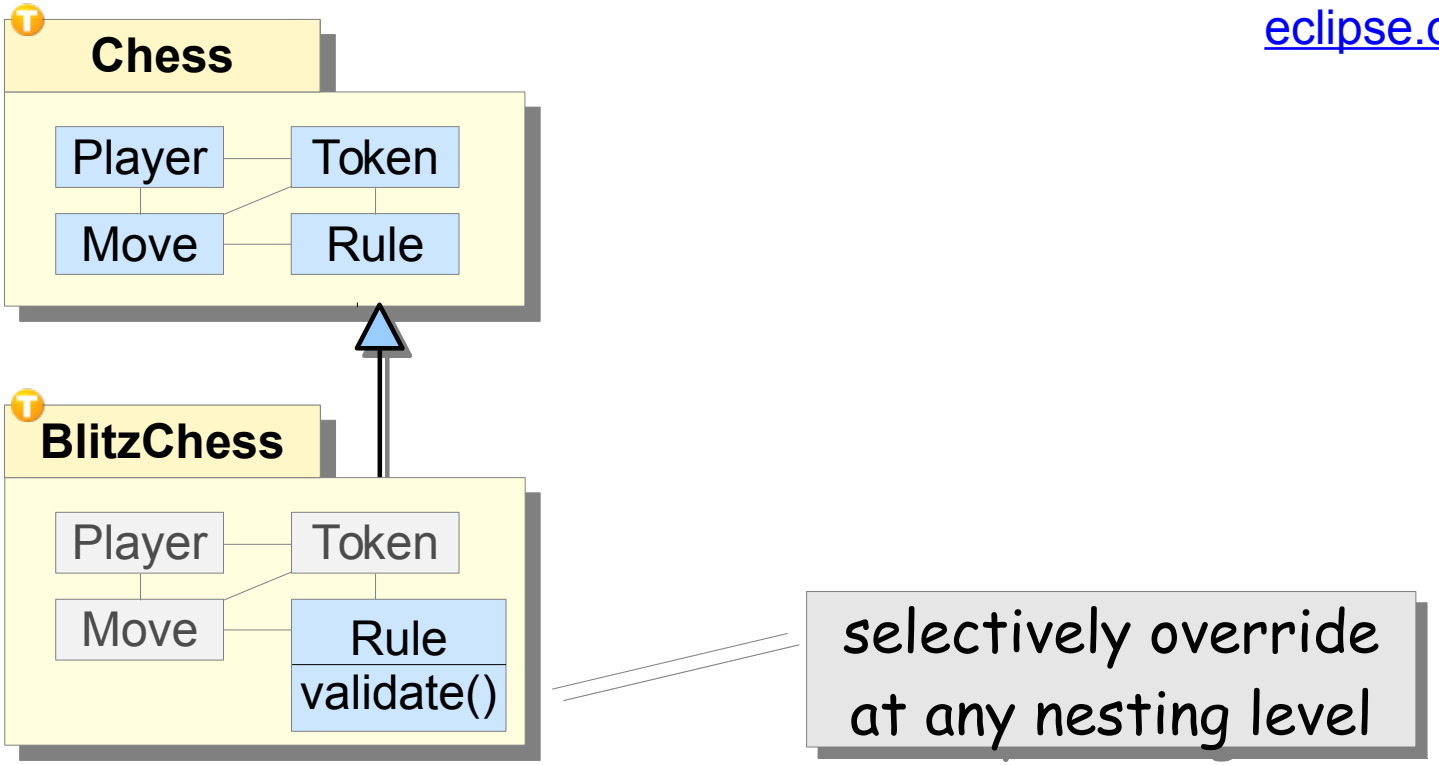
Team Inheritance

eclipse.org/objectteams



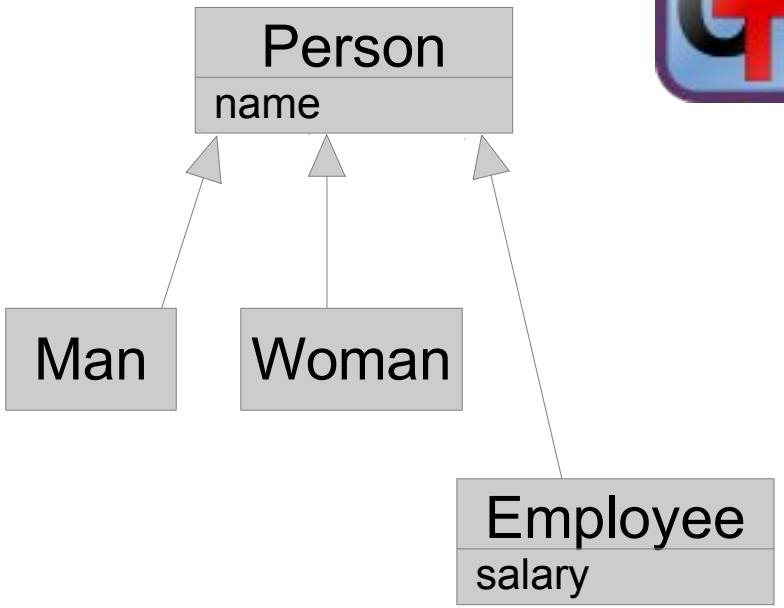
- consistent refinement of all members
- deep overriding
- flexible & modular

Limitations of Inheritance

- **Inheritance** is great, but ...

  A text book example:

  - A man/woman **is a** person, OK
  - An employee **is a** person, OK?
    - Male/female Employees?
    - Born as an employee?
    - Dying when loosing the job?
    - Several jobs, yet only one salary?



Role playing

eclipse.org/objectteams

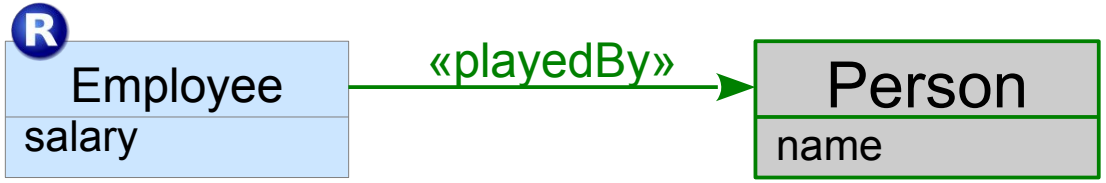
- `playedBy` relationship

joe: Man
name=”joe”

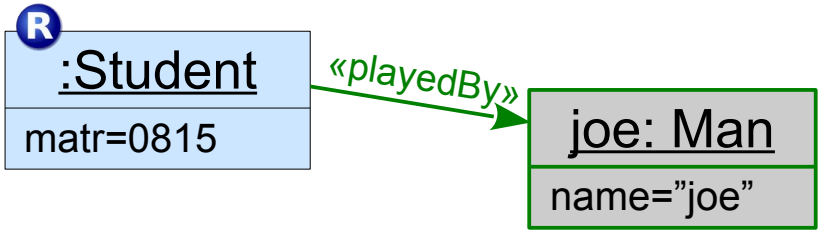
Role playing

eclipse.org/objectteams

- `playedBy` relationship



- Advantages:
  - **Dynamism**:
    roles can come and go
    (same base object)

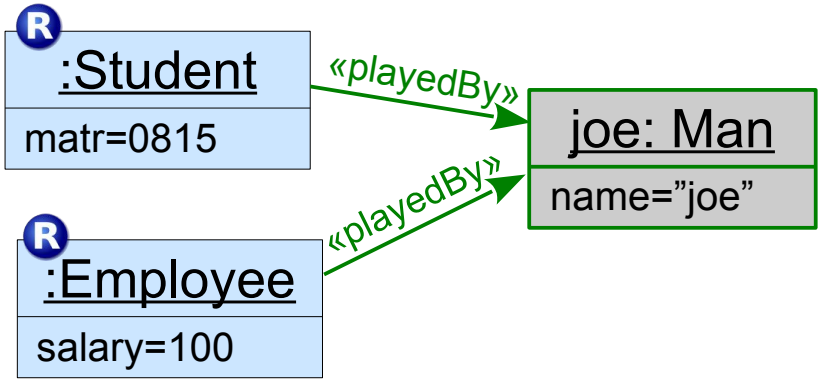


Role playing

eclipse.org/objectteams

- `playedBy` relationship

- Advantages:
  - **Dynamism**:
    roles can come and go
    (same base object)
  - **Multiplicities:**
    one base can play several roles
    (different/same role types)



Role playing

eclipse.org/objectteams

- `playedBy` relationship

- Advantages:
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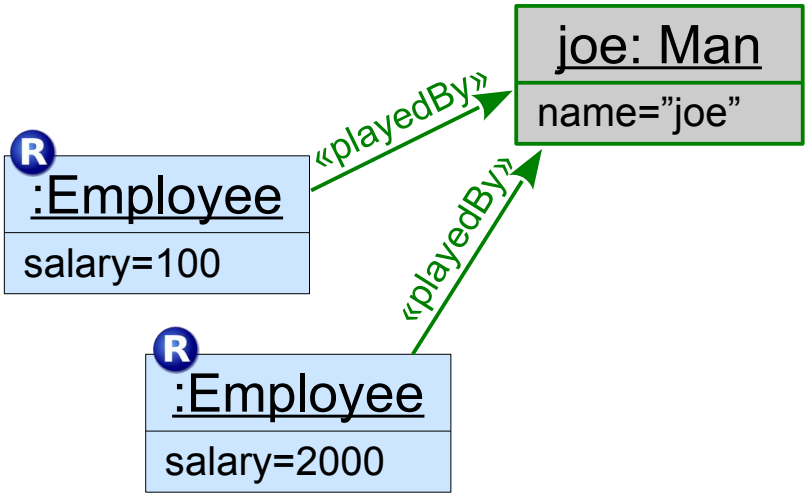
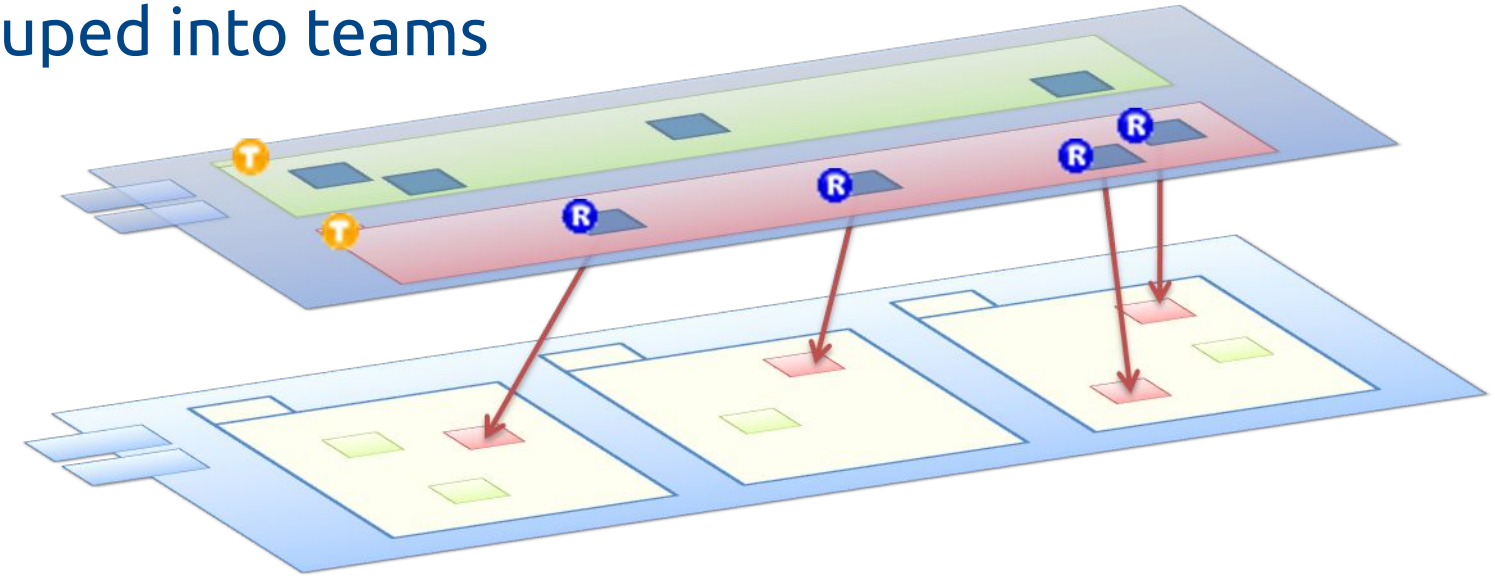


Role playing

eclipse.org/objectteams

- Use role playing for
  - dynamic specialization
  - modes / behavior that should be turn on/off at runtime
  - unanticipated adaptation
- Roles are grouped into teams



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Areas Covered

- Methods & algorithms
  - lambda expressions
  - library updates for lambdas
- Types
  - type annotations
- Connecting objects to a module / a system
  - role containment
  - team inheritance
  - role playing