

Functional Programming in Typed Racket

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- ▶ If you do not understand what I say or if I speak too fast, **please tell me right away!**

All slides and course materials are available on:

<https://github.com/fbie/parallel-functional-lectures>

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- ▶ Used in financial industry, modern compilers and more.
- ▶ Jobs in functional programming pay better!



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- ▶ Functional language, no side-effects (mostly).
- ▶ Good for meta-programming (we won't look at that).

Hello World in Typed Racket

```
;; Tell run-time which language to use.  
#lang typed/racket  
  
;; Now print something.  
(print "Nihao!")
```

A More Interesting Program

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;; Define x as the result of the computation.  
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We can check its value in the interactive mode:

```
> x  
59
```

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Some functions are *variadic*:

(+ x y z)	\Rightarrow	$x + y + z$
-----------	---------------	-------------

Local Bindings

Just like local variables in Java, but you can never change them!

```
#lang typed/racket
```

```
(let ([x (* 2 16)]  
      [y (* 3 17)])  
  (+ x y))
```

What does this program do?

Note: You cannot reference `x` and `y` after the last closing parenthesis of the `let` expression!

The Same Program in Java

```
int x = 2 * 16;  
int y = 3 * 17;  
x + y;
```


A First Function

```
#lang typed/racket

(: times-two (-> Number Number))
(define (times-two x)
  (* 2 x))
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Several new things on this slide:

- ▶ Functions need no return statement. Their return value is the last executed statement!
- ▶ Type annotations start with `:` and describe the type of a symbol.
- ▶ The type of `times-two` is *Number* \rightarrow *Number*.

Types in Typed Racket

We write the function type $A \rightarrow B$ as:

`(-> A B)`

where `A` is the parameter type and `B` is the return type.

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`(\rightarrow A B C)`

Which types are parameter types, which ones are return types?

Polymorphic Types

Polymorphic types in Typed Racket are very explicit:

```
(: twice (All (A) (-> A (Pairof A A))))  
(define (twice a)  
  (pair a a))
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“For all types *A*, the type of *twice* is such that iff you pass it a value of some type *A* it will return a pair of values of type *A*.”

It's just like generic types in Java!

The Same Program in Java

```
public static Pairof<A, A> twice(A a) {  
    return new Pairof<A, A>(a);  
}
```

Note: There is no build-in pair type in Java :(

Local Bindings, Revisited

Let's turn our local binding example into a function!

```
(: two-three-sum (-> Number Number Number))  
(define (two-three-sum a b)  
  (let ([x (* 2 a)]  
        [y (* 3 b)]])  
    (+ x y)))
```

Local Bindings, Revisited

Let's turn our local binding example into a function!

```
(: two-three-sum (-> Number Number Number))  
(define (two-three-sum a b)  
  (let ([x (* 2 a)]  
        [y (* 3 b)]])  
    (+ x y)))
```

Now, we can call it like any other function:

```
> (two-three-sum 1 1)  
5  
> (two-three-sum 20 20)  
100
```

Anonymous Functions

You can define functions without giving them a name. Such functions are called *lambda expressions*:

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> ((lambda (x) x) 2)  
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Here, we have defined a lambda expression and applied it to the value 2. We call this function the *identity function*.

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```

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We will often come across lambda expressions in functional programming!

Structs in Typed Racket

Structs are containers for values.

```
(struct (myNumberBox  
        [v : Number]))
```

```
(struct (myNumberStringBox  
        ([n : Number] [s : String])))
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(struct (myNumberBox  
        [v : Number]))
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```
(struct (myNumberStringBox  
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```

We can also use type polymorphism here:

```
(struct (A) (myPolyBox [value : A]))
```

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 - ▶ github.com/fbie/parallel-functional-programming
- ▶ You can download Racket from
 - ▶ racket-lang.org

Java Equivalent to Maybe

```
public abstract class Maybe<A> {}

public class None<A> extends Maybe<A> {
    public None() {}
}

public class Some<A> extends Maybe<A> {
    public final A a;
    public Some(A a) {
        this.a = a;
    }
}
```


Java Equivalent to Cons List

```
public abstract class LinkedList<A> {}

public class Nil<A> extends LinkedList<A> {
    public Nil() {}
}

public class Cons<A> extends LinkedList<A> {
    public final A a;
    public final LinkedList<A> tail;

    public Cons(A a, LinkedList<A> tail) {
        this.a = a;
        this.tail = tail;
    }
}
```

Java Equivalent to Binary Tree

```
public abstract class BinaryTree<A> {}

public class Leaf<A> extends BinaryTree<A> {
    public final A a;
    public Leaf(A a) {
        this.a = a;
    }
}

public class Node<A> extends BinaryTree<A> {
    public final BinaryTree<A> left, right;
    public Node(BinaryTree<A> left,
                BinaryTree<A> right) {
        this.left = left; this.right = right;
    }
}
```