

Parameter Passing Styles

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Objectives

You should be able to ...

The function call is one of the most fundamental elements of programming. The meaning of a function call is greatly affected by the choice of parameter passing style.

► Explain five kinds of parameter passing:

1. Call by value
2. Call by reference
3. Call by name
4. Call by need
5. Call by value-Result

Running Example

We will use the following code to illustrate the concepts:

```
let foo x y z =  
  x := z * z * y;  (* let's pretend that this *)  
  y := 5;          (* is legal *)  
  x + y
```

```
let main () =  
  let a = 10 in  
  let b = 20 in  
    foo a b (a+b)
```

Call By Value

- ▶ Parameters are evaluated before the function call takes place.
- ▶ The function receives a copy of the parameters.
 - ▶ Changes made to variables in the function are not visible outside.
- ▶ Advantage: speed
- ▶ Disadvantage: instability

```
Main> let pi1 a b = a
```

```
pi1 : a -> b -> a
```

```
Main> let foo () = pi1 5 (foo ())
```

```
foo : () -> Int
```

```
Main> foo ()
```

```
Stack overflow during evaluation (looping recursion?).
```

Result of CBV

```
let foo x y z =  
  x := z * z * y;  
  y := 5;  
  x + y
```

```
let main () =  
  let a = 10 in  
  let b = 20 in  
    foo a b (a+b)
```

- ▶ a is copied into x.
- ▶ b is copied into y.
- ▶ a+b is evaluated to 30, the 30 is copied into z.
- ▶ x is assigned $30 * 30 * 20$.
- ▶ y is assigned 5.
- ▶ Upon return, a and b have their original values.
- ▶ This is used by C, C++, OCaml, ... "most languages."

Call By Reference

- ▶ Parameters are evaluated before the function call takes place.
- ▶ The function receives a copy of the parameters.
- ▶ Variables are passed as pointers.
 - ▶ Changes made to variables in the function are visible outside.
- ▶ Advantages: speed, saves some memory, side effects are possible when you want them.
- ▶ Disadvantage: side effects are possible when you don't want them.

Result of Call By Reference

```
let foo x y z =  
  x := z * z * y;  
  y := 5;  
  x + y
```

```
let main () =  
  let a = 10 in  
  let b = 20 in  
    foo a b (a+b)
```

- ▶ a and x share the same memory.
- ▶ b and y share the same memory.
- ▶ a+b is evaluated to 30, the 30 is copied into z.
- ▶ x and a are assigned $30 * 30 * 20$.
- ▶ y and b are assigned 5.
- ▶ Upon return, a and b have new values.
- ▶ Used by C, C++, OCAML optionally; JAVA by default.

Example

```
int inc(int i) {  
    return ++i;  
}
```

```
int main() {  
    int i = 10;  
    cout << inc(i) << " " << i << endl;  
}
```

What will be the output of this code?

Example

```
int inc(int &i) {  
    return ++i;  
}
```

```
int main() {  
    int i = 10;  
    cout << inc(i) << " " << i << endl;  
}
```

What will be the output of this code?

Call By Result

- ▶ Parameters are updated before the function call *returns*.
- ▶ Often combined with call by value. Call by result, call by value, and call by value-result are “subclasses” of call by copy. What changes is when the copy occurs.
 - ▶ Changes made to variables in the function are visible outside – in fact, that’s the whole point.
- ▶ Advantage: you can return multiple values from a single function.
- ▶ Disadvantage: variables can be clobbered inadvertently.

Result of Call By Result

```
let a = 10
```

```
let b = 20
```

```
let foo x y z =  
  x := z * z * y;  
  y := 5;  
  a + b
```

- ▶ a is copied into x.
- ▶ b is copied into y.
- ▶ a+b is evaluated to 30, the 30 is copied into z.
- ▶ x is assigned $30 * 30 * 20$.

```
let main () =  
  foo a b (a+b)
```

- ▶ y is assigned 5.
- ▶ a + b will evaluate to 30
- ▶ Upon return, x is copied into a, and y is copied into b.
- ▶ This is used by C# via "out" parameters.

Call By Name

- ▶ Parameters are evaluated after the function call is made.
- ▶ The parameters are substituted into the function body.
- ▶ Advantage: stability
- ▶ Disadvantage: inefficiency – computations can be duplicated.

```
Main> let pi1 a b = a
pi1 : a -> b -> a
Main> let foo () = pi1 5 (foo ())
foo : () -> Int
Main> foo ()
5
```

Result of Call By Name

```
let foo x y z =  
  x * x + y * y
```

```
let main () =  
  foo (10+10) (20+20)  
  (main ())
```

- ▶ x is replaced by (10+10).
- ▶ y is replaced by (20+20).
- ▶ z is replaced by (main ()).
- ▶ The call to `main` via `z` never happens.
- ▶ The `+` operation happens five times.
- ▶ This was used by ALGOL. Also used by some “term rewriting” systems.

Call By Need

- ▶ Parameters are encapsulated into a *thunk*.
- ▶ The thunks are passed into the function.
- ▶ The first time a thunk is executed, the value is cached.
- ▶ Remaining executions use the cached value.
- ▶ Advantage: stability
- ▶ Disadvantage: efficient, but sensitive to order

```
Main> let pi1 a b = a
pi1 : a -> b -> a
Main> let foo () = pi1 5 (foo ())
foo : () -> Int
Main> foo ()
5
```

Result of Call By Need

```
let foo x y z =  
  x * x + y * y
```

► x is replaced by a pointer to (10+10).

```
let main () =  
  foo (10+10) (20+20)  
  (main ())
```

► y is replaced by a pointer to (20+20).

► z is replaced by a pointer to (main ()).

- The call to `main` via `z` never happens.
- The `+` operation happens only once for each variable.
- This is used by HASKELL. Also known as *lazy evaluation*.
- Not compatible with assignment.