School of Electrical Engineering and Computing

SENG2200/6220 Programming Languages & Paradigms

Topic 7
Parameter-Passing

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Topic 6 Part 1 Overview

In, Out and In-Out Parameters
Pass-by-Value
Pass-by-Result
Pass-by-Value-Result
Pass-by-Reference
Pass-by-Name

In, Out & In-Out Parameters

In
- Caller provides data (input) to the procedure

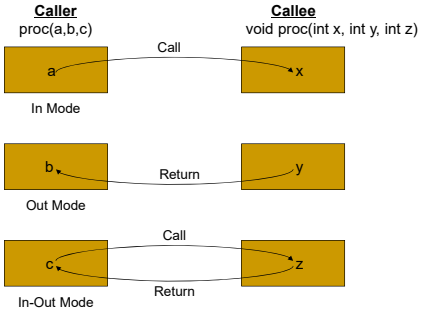
Out
- Procedure provides data (output) back to the caller

In-Out
- Caller provides input to procedure, and
- Procedure provides output back to the caller

Actual Parameter
- Specification in the actual procedure call

Formal Parameter
- Specification within the procedure definition

In, Out & In-Out Parameters



In, Out & In-Out Parameters

Example

C++:
```
void method(int  i, int& j) {
     i = 55; //The caller will not see this new value.
     j = 44; // The caller will see this new value.
}
```

C#:
```
void Method(string in, out int i, out string s1) {
  in = "The caller will not see this new value.";
  i = 44; // the caller will see this new value
  s1 = "The caller will see this new value.";
}
```


Pass-by-Value

The value of the actual parameter is used to initialise the corresponding formal parameter

The formal parameter then acts as a local variable

Usually implemented using copy (esp for primitives)
- Access path (alias) plus write-protection?
  - Write-protection is difficult to ensure
  - C++ with "const" does this

Pros:
- Easy to implement.
- Fast for primitive value.

Cons:
- Inefficient for non-primitive values.
- Additional storage is used.

Alias Write-Protection Example

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```
// Java
class A {
   private int x = 0;
   public void set(int x) {this.x = x;}
}
class ByValue {
   public static void set(final A a) {
      a.set(5);}
   public static void main (String[]
    args) {
      set(new A());
   }
} // write protected??
```

```
// C++
class A {
   int x = 0;
   public:
      void set(int x) {this->x = x;}
};
void set(const A a) { a.set(5);}
   //compile error
int main () {
   A a;
   set(a);
   return 0;
}
```


Pass-by-Result

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No value is transmitted to the procedure – out mode

Corresponding formal parameter must be initialised to a default value within the procedure and then acts as a local variable

Part of the return mechanism is to copy the value of the formal parameter back to the actual parameter

- Actual param needs to be a variable, not an expression

Similar problems with access path implementation to pass-by-value

Actual parameter collision can cause difficulty with the semantics, as the order of copy-back is crucial

- e.g. proc(p1,p1) -> different formals, same actual

What happens if the procedure throws an exception?

Pass-by-Result (cont)

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Example

```
// C# code
static void Method(out int i, out string s1) {
     i = 44;
     s1 = "I've been returned.";
}

static void Main() {
     int value;
     string str1, str2;
     Method(out value, out str1);
     // value is now 44
     // str1 is now "I've been returned."
}
```


Pass-by-Value-Result

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Often referred to as Pass-by-Copy

Calling is by Pass-by-Value

Return is by Pass-by-Result

Similar disadvantages as Pass-by-Value and Pass-by-Result

- Requires multiple storage for parameters
- Requires time for copying values in and out
- Problems associated with copy-out order of parameters

What happens if the procedure throws an exception?

- No result should be returned for the parameter

Pass-by-Reference

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Used as an In-Out mechanism

Access path is established between the actual and formal parameters (usually an address)

The procedure alters the actual parameter at will, via the access path

Efficient in both time and space - no duplicate space required

Disadvantages

- Slower access to formal parameters
- Can create aliases via parameter collisions

If the procedure throws an exception?

- Partial results will be left in the calling environment

Pass-by-Name

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Actual parameter is textually substituted for the corresponding formal parameter

Formal parameter is bound to an access mechanism at the time of the procedure call, but the actual binding to a value or an address is delayed until the formal parameter is actually referenced

Not as odd or way-out as it may seem at first - can be thought of as an extension of the late-binding mechanism used to implement polymorphism being extended into the parameter passing mechanism

Often used at compile time by the macros in assembly language and for the generic parameters for templates in C++, generic subprograms in Ada, etc.

Not used as the basic mechanism by any widely used language

Pass-by-Name (2)

This was used in early versions of Algol, BUT …

An example that showed how *interesting* it is as a general parameter passing mechanism is as follows:

procedure Swap (var int m, var int n) begin …. end;

When this is invoked with the call:

Swap(i, A[i]);

then it is extremely difficult to come up with meaningful semantics for this procedure call using pass-by-name.

Comparison of Mechanisms

	In	Out
Pass-by-Value	Copy	No out
Pass-by-Reference	Not copy, evaluate actual parameter.	Not copy, actual parameter may be modified.
Pass-by-Name	Substitute formal parameter by the text expression of actual parameter. Re-evaluate whenever appears in procedure.	
Pass-by-Result	No input value	Copy
Pass-by-Value-Result	Copy	Copy

Design Considerations

Two main considerations

- Efficiency
- Is one-way or two-way data transfer required?

Need to minimize the access that a procedure has to data outside the procedure itself

Use In-mode params when no data needs to be returned

Use Out-mode params when no data are transferred in

In-Out mode should be used only when data must move in both directions between the caller and the callee

Efficiency considerations drive many languages towards providing an access path coupled with read-only or write-only semantics for the one-way (in or out) transfer

Common Usage

C uses pass-by-value, with pass-by-reference (in out mode) semantics being simulated by using pointer (values) as parameters.

C++ includes a special type of pointer called a reference type which is automatically de-referenced in the called function or method – giving pass-by-reference.

Both C and C++ allow formal (pointer and reference) parameters to be specified as constants (const) which means that they can never be assigned in the procedure.

- This also means that constant objects can be passed in
- Note the differences between const & normal “in-mode” operation (which allows the local copy to change).

Common Usage (2)

All Java parameters are passed by value.

Because objects can only be passed by supplying a reference to that object, object parameters are effectively passed by reference.

The object reference passed in cannot be changed, but the object it refers to can be changed provided a method to do such a change is available.

Scalar (primitive) variables cannot be passed by reference in Java, but if a scalar (attribute) is contained in an object that is passed by reference, then it can be changed.

Distributed Computing

As soon as procedure calls are required to cross a network to be remotely executed on another machine, the whole situation as to what is efficient and what is in-efficient is changed.

Copy-in, copy-out (message passing) becomes a preferred method of communication.

Simulation of explicit pass-by-reference becomes far more costly.