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- Shallow binding?
- Deep binding?
- Ad hoc binding?

Referencing Environment for Subroutine Parameters

- Deep binding and ad hoc binding can be the same when a subroutine is declared and passed by the same subroutine
- In reality, ad hoc binding has never been used
- Static-scoped languages usually use deep binding

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 Dynamic-scoped languages usually use shallow binding

function Sent() { print(x); function Receiver(func) { var x; x = 2; function Sender() {

var x; x = 1: Receiver(Sent)

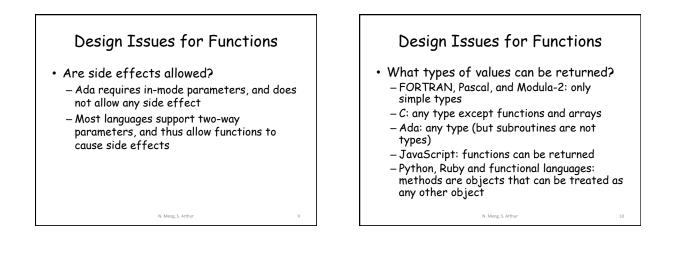
};

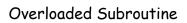
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An Example

 In static-scoped languages, Receiver is not always visible to Sent, so deep binding is natural

 In dynamic-scoped languages, it is natural for Sent to have access to variables in Receiver, so shallow binding is appropriate





• A subroutine that has the same name as another subroutine in the same referencing environment, but its number, order, or types of parameters must be different

– E.g., void fun(float); void fun():

 C++ and Ada have overloaded subroutines built-in, and users can write their own overloaded subroutines

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- A generic or polymorphic subroutine takes parameters of different types on different activations
- An example in C++ template<class Type> Type max(Type first, Type second) {
 return first > second ? first: second; int a, b, c; char d, e, f; c = max(a, b);N. Meng, S. Arthu f = max(d, e);

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Generic Subroutine

- Overloaded subroutines provide a particular kind of polymorphism called ad hoc polymorphism
 - Overloaded subroutines need not behave similarly
- **Parametric polymorphism** is provided by a subroutine that takes generic parameters to describe the types of parameters

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• Parametric polymorphic subroutines are often called generic subroutines

Coroutine

- A special kind of subroutine. Rather than the master-slave relationship, the caller and callee coroutines are on a more equal basis
- A coroutine is a subroutine that has multiple entry points, which are controlled by coroutines themselves

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Coroutine

- The first execution of a coroutine begins at its beginning, but all subsequent executions often begin at points other than the beginning
- Therefore, the invocation of a coroutine is named a **resume**
- Typically, coroutines repeatedly resume each other, possibly forever
- Their executions interleave, but do not overlap

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	sub co1() {
An Example	 resume(co2);
The first time co1 is resumed, its execution begins at the first	 resume(co3); }
statement, and executes down to resume(co2) (with the statement included)	L
 The next time co1 is resumed, its execution begins at the first statement after resume(co2) 	
 The third time co1 is resumed, its execution begins at the first statement after resume(co3) 	
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Coroutine

- The interleaved execution sequence is related to the way multiprogramming operating systems work
 - Although there may be one processor, all of the executing programs in such a system appear to run concurrently while sharing the processor
 - This is called quasi-concurrency
- Coroutines provide quasi-concurrent execution of program units

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