Announcements

- Midterms returned today in recitation
- HW8 due Thu at 11:55pm
- PROJ1 and HW6 grades posted
  - PROJ1 redo: interview before the last class (12/10)

One-Slide Summary

- Procedures/functions/subprograms allow code to be reused.
- On a call, formal parameters used by the callee are bound to actual parameters (or arguments) provided by the caller.
- In eager evaluation, actuals are evaluated before a call. In lazy evaluation, they are evaluated only when used.
- Pass-by-value, pass-by-reference, pass-by-value-result are parameter passing modes in an eager setting. Pass-by-name gives rise to lazy evaluation.

Review Parameter Passing

Pass-by-value

\[
\text{fun add } (x, y) = x + y \\
\text{add (3-4, 5) → } \\
\text{add (-1, 5) → } \\
\text{[x↦-1, y↦5] x↦y}
\]

\[
\text{val a = 24} \\
\text{add (a + 2, 1) → add (26, 1)}
\]

Pass-by-value-result

\[
\text{pass in a value on call} \\
\text{and pass out value on return}
\]

\[
\text{and } f(\text{out } x+1) \{
\text{x = x + 1} \\
\text{z := y} \\
\text{int y := 0} \\
\text{f(x)} \\
\text{print y}
\}
\]
Pass-by-reference

```plaintext
void f(int x) {
    int a = x;
    f(&a) // 2
    a = 2; // 3
    x = 1; // 4
    5
}
```

Exercises

• Write a MYSTERY program to distinguish between call-by-value and call-by-reference

```plaintext
VAR a : INTEGER;
PROCEDURE f(                           )   =
    BEGIN
    END;
    BEGIN
    PRINT a;
    END
```

Lazy evaluation: Pass-by-name

```
I'm: "don't evaluate argument (a value)
    pass the code to caller"!
    won't evaluate if argument not used
fun f x = 1 fun lazyEval () = lazyEval
f ( lazyEval () ) // 1 ( lazy eval )
f ( lazyEval () ) // 2 ( eager eval )
```

Pass-by-reference

```plaintext
void f(int &x, int &y)
    x = x+1;
    y = 2;
```

Exercises

• Write a MYSTERY program to distinguish between call-by-reference and call-by-value-result

```plaintext
VAR a : INTEGER;
PROCEDURE f(                           )   =
    BEGIN
    END;
    BEGIN
    PRINT a;
    END
```

Lazy evaluation: Pass-by-name
Exercise

- Write a MYSTERY program to distinguish between call-by-name and call-by-value

For Next Time

- Reading
- Forum comment
- HW8