Exception Handling

- **Exception handling is a language feature that allows the programmer to handle runtime "exceptional conditions."**

- **What is an "exceptional condition"?**
  - **hardware error**
  - **failure in underlying software**
  - **any anomalous event**

- **It need not be erroneous -- just something that requires special handling.**

Terminology

- **An exception is *raised*, or *signalled*, when its associated condition occurs.**

- **The code that is executed after an exception is raised is called the *exception handler*. This code processes the exception.**

Issues

- **Form of handler.**
  - **Complete program unit, or code segment?**
- **Location of handler.**
  - **Are exceptions handled in unit where raised, in calling unit, or elsewhere?**
- **Binding of handlers to exceptions.**
  - **Static or dynamic?**
- **Transfer of control after exception is handled.**
  - **Allow unit that raised exception to continue executing?**

Issues (continued)

- **Default exception handlers.**
  - **Should they be provided?**
- **Specification of user-defined exceptions.**
  - **Form, location, scope.**
- **Built-in exceptions.**
  - **Can the user raise them explicitly?**
- **Disabling of exceptions.**
  - **Should it be allowed?**

Exceptions in PL/I

- **Conditions = exceptions**
- **Built-in and user-defined**
- **Default handlers for built-in conditions, but can be overridden.**
- **Dynamic binding of handlers to exceptions**
- **Handlers are code segments, no parameters**
- **After handling exception, can send control anywhere. Default handlers go to *raise* of or cause.**

PL/I Example

```
declare condition bad_input;
. . .
on condition bad_input
    begin;
    . . .
    end;
. . .

read(x);
if (x < 0) or (x > 10) then
    signal condition bad_input;
```

Exceptions in CLU

- **More restricted than PL/I**
- **Static binding of handlers to exceptions**
- **Handlers are attached to statements**
- **Exceptions must be handled by calling routine**
- **Unit raising exception is terminated; control transfers to statement following that with handler**
- **No disabling of exceptions**
- **Handlers can have parameters**
- **Exception failure raised if an exception has no handler**

CLU Example

```
begin
    x := f(y);
    z := g(h);
end
    except when bad_input(c):
    . . .
    end
```

```
f = proc (<formals>)
    signals(bad_input(char))
begin
    . . .
    signal(bad_input(. . .))
    . . .
```

Exceptions in Ada

- **Less restrictive than CLU, more controlled than PL/I**
- **Static binding of handlers to exceptions, but if no local handler, exception is propagated back call chain**
- **Handlers have no parameters**
- **Block that raises exception terminates, but enclosing block may continue execution.**
- **Disabling of exceptions possible**

Ada — Error Recovery

```
procedure Sort (X: in out ELEM_ARRAY ) is
            Copy: ELEM_ARRAY ;
begin
            -- Take a copy of the array to be sorted.
             for i in ELEM_ARRAY'RANGE loop
            Copy (i) := X (i) ;
            end loop ;
             -- Code here to sort the array X in ascending order
            -- Now  test that the array is actually sorted
            for i in ELEM_ARRAY'FIRST..ELEM_ARRAY'LAST-1 loop
            if X (i) > X (i + 1) then
                                        -- a problem has been detected - raise exception
                        raise  Sort_error ;
            end if ;
            end loop ;
exception
            -- restore state and indicate to calling procedure
            -- that a problem has arisen
              when Sort_error =>
                        for i in ELEM_ARRAY'RANGE loop
                        X (i) := Copy (i) ;
                        end loop ;
            raise ;
            -- unexpected exception. Restore state and indicate
            -- that the sort has failed
            when Others =>
                        for i in ELEM_ARRAY'RANGE loop
                       X (i) := Copy (i) ;
            end loop ;
            raise Sort_error;
end Sort ;
```

Summary

- **Trade-offs between power, flexibility (PL/I) and safety (CLU).**
  - ➙ **Ada provides a compromise.**
- **But is exception handling really necessary?**
  - ➙ **Arguments both ways (Black, "Exception Handling: The Case Against")**

Handling Exceptions without Exception Handling

- **Two approaches:**
  - **Pass a "status variable."**
  - **Pass a subroutine to be called under certain conditions.**
- **In both cases, the exception handling is provided by the caller.**
- **To handle an exception locally, simply insert appropriate code.**