TUTORIAL

TRACK II

ADVANCED ADA TOPICS

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Tutorial Track II. Advanced Ada Topics

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This document contains prints of viewgraphs presented at the Advanced Ada Topics Tutorial, Track II June 9, 1987. Topics covered were Data Abstraction, Tasking, Strong Typing, and Exceptions.
Ada* Tasking

Abstraction of Process

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Ada Tasking

Overview

Define Ada Tasking

Define Synchronization Mechanism

Examples
• started after elaboration of parent, and before the parent's first statement

• may also be a type and treated as an object
Ada Tasking

Task Definition

• A program unit for concurrent execution

• Never a library unit

• Master is a ...
  Library Package
  Subprogram
  Block Statement
  Other Task
Callee Provides Service

1. Immediate Response

2. Wait for a while

3. Wait forever

Service is Requested with an entry call statement

Service is provided with an accept statement
Ada Tasking

Synchronization Mechanisms

- Global Variables
- Rendezvous

Main Program in a Task

Caller Requests Service

1. Immediate Request
2. Wait for a While
3. Wait Forever
Scenario I
"The Golden Arches"

McD Tasks:
Service Provided: Food
Service Requested: None

Gonzo Tasks:
Service Provided: None
Service Requested: Food
Ada Tasking

- Select statement provides ability to program the different 'request' and 'provide' modes.

- Guards are "if statements" for the providing service.

- Termination is an alternative if a service is no longer needed.
Task McD is
  entry SERVE(TRAY_OF : out FOOD_TYPE);
end McD;

Task GONZO;

Task Body McD is
  NEW_TRAY : FOOD_TYPE;
  function COOK return FOOD_TYPE is
  begin
    loop
      accept SERVE (TRAY_OF : out FOOD_TYPE) do
        TRAY_OF := COOK;
      end;
    end loop;
  end McD;
Task Body GONZO is

MY_TRAY : FOOD_TYPE;

procedure CONSUME (MY_TRAY : in FOOD_TYPE) is ... begin
  loop
    McD.Serve (MY_TRAY);
    CONSUME (MY_TRAY);
  end loop;
end GONZO;
Task Body HoD is
  NEW_TRAY : FOOD_TYPE;

  function COOK return FOOD_TYPE is
    ...
    end COOK;

  begin
    loop
      NEW_TRAY := COOK;
      accept SERVE (TRAY_OF : out FOOD_TYPE) do
        TRAY_OF := NEW_TRAY;
      end SERVE;
    end loop;
    end GONZO;
loop

NEW_TRAY := COOK;
select
    accept SERVE (TRAY_OF : out FOOD_TYPE) do...
        TRAY_OF := NEW_TRAY;
    end SERVE;
else
    null;
end select;

end loop;
loop

  NEW_TRAY := COOK;
  select
    accept SERVE (TRAY_OF : out FOOD_TYPE) do...
      TRAY_OF := NEW_TRAY;
    end SERVE;
  else
    terminate;
  end select;

end loop;
loop

    NEW_TRAY := COOK;
    select
        accept SERVE (TRAY_OF : out FOOD_TYPE) do...
            TRAY_OF := NEW_TRAY;
        end SERVE;
    or
        delay 15 * MINUTES;
    end select;

end loop;
loop

select
  McD.SERVE(MY_ORDER); consume(MY_ORDER);
else
  select
    BK.SERVE(MY_ORDER); consume(MY_ORDER);
  else
    exit;
  end select;
end select;

end loop;
loop
select
  Hcb.SERVE(NY_ORDER); consume (NY_ORDER);
or
delay 16.0 * MINUTES;
select
  BK.SERVE(NY_ORDER); consume (NY_ORDER);
or
  delay 5.0 * MINUTES;
  exit;
end select;
end select;
end select;
end loop;
loop

select
    McD.SERVE (MY_ORDER);
or
    BK.SERVE (MY_ORDER);
end select;

consume;

end loop;
loop

select
   McD.SERVE (NY_ORDER);
or
   BK.SERVE (NY_ORDER);
else
   delay 10 * MINUTES;
   exit;
end select;

consume;

end loop;
Service Requested: Food
Service Provided: Money

GONZO TASK

Service Requested: Money
Service Provided: Food

MCD TASK

"NO FREE LUNCH"

SCENARIO II

AHA TASKING
Task McD is
  entry SERVE ( ORDER : out FOOD_TYPE;
                 COST : in MONEY_TYPE);
end McD;

TASK GONZO;

-- OR

Task McD is
  entry SERVE ( ORDER : out FOOD_TYPE);
end McD;

Task GONZO is
  entry PAY ( COST : in MONEY_TYPE;
              PAYMENT : out MONEY_TYPE);
end GONZO;
Task Body McD is
  CASH_DRAWER : MONEY_TYPE;
  NEW_ORDER   : FOOD_TYPE;
  function COOK  ................
  function CALC_COST (ORDER : in FOOD_TYPE )
    return MONEY_TYPE is ...........

begin
  loop
    NEW_ORDER := COOK;
    select
      accept SERVE(ORDER : out FOOD_TYPE) do
        ORDER := NEW_ORDER;
        COST := CALC_COST (NEW_ORDER);
        GONZO_PAY (COST, AMOUNT_PAID);
        CASH_DRAWER := CASH_DRAWER + AMOUNT_PAID;
      end SERVE;
      or
        delay 15.0 * MINUTES;
    end select;
  end loop;
end McD;
Task Body GONZO is

ACCOUNT_BALANCE : MONEY_TYPE;
MY_ORDER : FOOD_TYPE;

function GO_TO_WORK return MONEY_TYPE is...
begin
ACCOUNT_BALANCE := GO_TO_WORK * ACCOUNT_BALANCE;
loop
Mcd.SERVE (MY_ORDER);
accept PAY (COST : in MONEY_TYPE;
PAYMENT : out MONEY_TYPE) do
ACCOUNT_BALANCE := ACCOUNT_BALANCE -
PAYMENT := COST;
end PAY;
end loop;
end loop;
end GONZO;
Service Requested: None
Service Provided: Make new water
Manager Task

Service Requested: Food
Service Provided: Money
 Gonzalo Task

Service Requested: Money
Service Provided: Food
MC2 Task

„No wait for the waiters“

Scenario II A

Ada Tasking
Task type McD is
  entry SERVE....
end McD;

Task GONZO is
  entry PAY....
end GONZO;

Task MANAGER;

Type CASHIER POINTER is access McD;

Type REGISTER_TYPE is array (1..NO_REGISTERS)
  of CASHIER_POINTER;

THE_REGISTERS : REGISTER_TYPE := (others => new McD);
Task Body McD is

... 
...
...
begin
loop
  NEW_ORDER := COOK;
  select
    accept SERVE.....
    ...
    end SERVE;
  or
    delay 2.0 * MINUTES;
    exit;
    end select;
  end loop;
Task Body GONZO is

...  
...
begin
...
...
---Now, GONZO has to search for the open
-- registers, and select the one with
-- the shortest line
...
...
THE_REGISTERS(MY_REGISTER).SERVE;
...

dend GONZO;
Task Body MANAGER is
  ...
  ...
  begin
    loop
      -- The MANAGER will look at the queue lengths of
      -- the open registers, and, when necessary
      -- will open registers that are currently
      -- closed
      ...
      if ............ then
        THE_REGISTERS(CLOSED_REGISTER) := new McD;
        end if;
      end loop;
    end MANAGER;
Ada Tasking

Scenario III

"A Sugar Cone, Please:

BR Task
Service Provided: Ice Cream
Service Requested: An Order

Servomatic Task
Service Provided: A Number

Customers Task
Service Provided: An Order
Service Requested: Ice Cream
task BR is
  entry SERVE (ICE_CREAM : out DESSERT_TYPE);
end BR;

task SERVOMATIC is
  entry TAKE (A_NUMBER : out SERVOMATIC_NUMBERS);
end SERVOMATIC;

task type CUSTOMER_TASK is
  entry REQUEST (ORDER : out ORDER_TYPE);
end CUSTOMER_TASK;

type CUSTOMER is access CUSTOMER_TASK;
CUSTOMERS : array (SERVOMATIC_NUMBERS) of CUSTOMER;
task body BR

NEXT_CUSTOMER: SERVOMATIC_NUMBERS := SERVOMATIC_NUMBERS'last;
CURRENT_ORDER: ORDER_TYPE;
ICE_CREAM: DESSERT_TYPE;

function MAKE (ORDER: in ORDER_TYPE) return DESSERT_TYPE is
begin
loop
begin
    NEXT_CUSTOMER := (NEXT_CUSTOMER + 1) mod SERVOMATIC_NUMBERS'last;
    CUSTOMERS(NEXT_CUSTOMER).REQUEST (CURRENT_ORDER);
    ICE_CREAM := MAKE(CURRENT_ORDER);
    accept SERVE(ICE_CREAM: out DESSERT_TYPE) do
        ICE_CREAM := BR.ICE_CREAM;
    end SERVE;
    exception
    when TASKING_ERROR => null;
        --customer not here
    end;
end loop;
end;
task body SERVOMATIC is
  NEXT_NUMBER : SERVOMATIC_NUMBERS :=
               SERVOMATIC_NUMBERS'first;

begin
  loop
    accept TAKE(A_NUMBER : out SERVOMATIC_NUMBERS) do
      A_NUMBER := NEXT_NUMBER;
      end TAKE;
      NEXT_NUMBER := (NEXT_NUMBER + 1) mod
                     SERVOMATIC_NUMBERS'last;
    end loop;
  end SERVOMATIC;
task body CUSTOMER_TASK is
  MY_ORDER : ORDER_TYPE := ... - some value;
  MY_DESSERT : DESSERT_TYPE;
  begin
    accept REQUEST ( ORDER : out ORDER_TYPE) do
      ORDER := MY_ORDER;
    end REQUEST;
    BR.SERVE(MY_DESSERT);
    -- eat the dessert, or do whatever
  end;

Service Requested: File Name
Service Provided: Print

Printer Task

Service Requested: Print
Service Provided: Virtual Print

Spooler Task

by Renaming Task Entry
Action-"Hides" The Print Spooler
Printer Package

"Lets Hide The Spooler Task"

Scenario IV

Ada Tasking
Package PRINTER_PACKAGE is

... task SPOOLER is
  entry PRINT_FILE (NAME : in STRING;
  PRIORITY : in NATURAL);
  entry PRINTER_READY;
end SPOOLER;
...

procedure PRINT (NAME : in STRING;
  PRIORITY : in NATURAL := 10)
  renames SPOOLER.PRINT_FILE;
end PRINTER_PACKAGE;

Package Body PRINTER_PACKAGE is

... task PRINTER is
  entry PRINT_FILE (NAME : in STRING);
end PRINTER;
...
...
end PRINTER_PACKAGE;
task body SPOOLER is
begin
loop
select
accept PRINTER_READY do
    PRINTER_PRINT_FILE ( REMOVE (QUEUE) );
    -- Remove would determine the next job and
    -- send it to the actual printer
    end PRINTER_READY;
else
    null;
end select;
select
accept PRINT_FILE ( NAME : in STRING;
    PRIORITY : NATURAL ) do
    INSERT ( NAME, PRIORITY);
    -- put name on queue or queues according
    -- to priority
    end PRINT_FILE;
else
    null;
end select;
end select;
end loop;
end SPOOLER;
task body PRINTER is
begin
  loop
    SPOOLER.PRINTER_READY;
    accept PRINT_FILE ( NAME : in STRING ) do

      if NAME'length /= 0 then .......
        --print the file
      else
        delay 10.0 * seconds;
      end if;

    end PRINT_FILE;
  end loop;
end PRINTER;
with PRINTER_PACKAGE;

procedure MAIN is

loop
    --process several files
    PRINTER_PACKAGE.PRINT (A_FILE, A_PRIORITY);

end loop;

end MAIN;
APPLICATIONS FOR TASKS

- CONCURRENT OPERATIONS
- ROUTING MESSAGES
- SHARED RESOURCE MANAGEMENT
- INTERRUPT HANDLING
**MATRIX MULTIPLICATION**

\[
\begin{bmatrix}
1 & 1 & 1 \\
2 & 2 & 0
\end{bmatrix}
\times
\begin{bmatrix}
2 \\
1 \\
1
\end{bmatrix}
= 
\begin{bmatrix}
4 \\
6
\end{bmatrix}
\]

type ROW_OR_COL is array (integer range <>) of integer;
type PTR is access ROW_OR_COL;

task type PARTIAL is
  entry SEND (ROW, COL : ROW_OR_COL);
  entry RECEIVE (RESULT : out integer);
end PARTIAL;

MAIN

begin
  -- send row and col
  -- receive partial product
  end
task: body PARTIAL is

PRODUCT : integer := 0;
ROW_PTR : PTR;
COL_PTR : PTR;

begin

accept SEND (ROW,COL : ROW_OR_COL) do
    ROW_PTR := new ROW_OR_COL'(ROW);
    COL_PTR := new ROW_OR_COL'(COL);
end SEND;

for I in ROW_PTR.all'range loop
    PRODUCT := PRODUCT +
        ROW_PTR(I) * COL_PTR(I);
end loop;

accept RECEIVE (RESULT : out integer) do
    RESULT := PRODUCT;
end RECEIVE;

end PARTIAL;
procedure MAIN is

COLS : constant := 10;
ROWS : constant := 10;
type MATR IX is array (1 .. ROWS) of
ROW OR COL (1 .. COLS);

MAT : MATR IX;
VECTOR : ROW OR COL (1 .. COLS);
FINAL : ROW OR COL (1 .. ROWS);

....
declare

WORKER : array (1 .. ROWS) of PARTIAL; -- tasks

begin

for I in 1 .. ROWS loop
   WORKER(I).SEND(ROW => MAT(I),
      COL => VECTOR);
end loop;

for I in 1 .. ROWS loop
   WORKER(I).RECEIVE (FINAL(I));
end loop;

end; -- block
- Write task specifications to send an integer from task A to task B.
* WRITE SPECIFICATIONS AND BODIES FOR THE FOLLOWING SYSTEM. TASK C WILL REPEATEDLY GET AN INTEGER FROM TASK A AND SEND IT ON TO TASK B.
type PRIORITY is (LOW, MEDIUM, HIGH);

task SWITCH is
   entry SEND (PRIORITY)
      (M : in string);
   end SWITCH;

   task body SWITCH is
      begin
         loop
            select
               accept SEND(HIGH) do ... end SEND;

               or

               when SEND(HIGH)'count = 0 =>
                  accept SEND(MEDIUM) do ... end SEND;

               or

               when SEND(HIGH)'count = 0 and
                  SEND(MEDIUM)'count = 0 =>
                  accept SEND(LOW) ... end SEND;

               end select;
         end loop;
      end SWITCH;
task SYNCHRONIZER is
  entry PUT (ITEM in SOME_TYPE),
  entry GET (ITEM out SOME_TYPE);
end SYNCHRONIZER;

task body SYNCHRONIZER is

  SPOT : SOME_TYPE;

begin

  loop

    accept PUT (ITEM : in SOME_TYPE) do
      SPOT := ITEM;
    end PUT;

    accept GET (ITEM : out SOME_TYPE) do
      ITEM := SPOT;
    end GET;

  end loop;

end SYNCHRONIZER;
CONTROLLING RESOURCES

- Several concerns are present when dealing with parallelism that are not present when dealing in a purely sequential mode.

- It is important to be able to assure that a value is not being changed by one user at the precise moment that it is being referenced by another user.

- Ada provides a pragma 'shared' which can help:

      INDEX integer;
      pragma SHARED(INDEX);

- Enforces mutually exclusive access.

- Available for scalar and access types only.
task SEMAPHORE is
  entry SEIZE;
  entry RELEASE;
end SEMAPHORE;

task body SEMAPHORE is
  IN_USE : boolean := false;
begin
  loop
    select
      when not IN_USE =>
        accept SEIZE do
          IN_USE := true;
          end SEIZE;
      or
      when IN_USE =>
        accept RELEASE do
          IN_USE := false;
          end RELEASE;
    end select;
  end loop;
end SEMAPHORE;
ENCAPSULATING A DATA ITEM

task PROTECTED is
   entry SET (OBJ : in integer),
   entry GET (OBJ : out integer),
end PROTECTED,

   task body PROTECTED is
      LOCAL : integer;
      begin
         loop
            select
               accept SET (OBJ : in integer) do
                  LOCAL := OBJ;
               end SET;

            or

               accept GET (OBJ : out integer) do
                  OBJ := LOCAL;
               end GET;

            end select;
         end loop;
end PROTECTED;
task PUMP;

task SENDER is
   entry WRITE (ITEM : out SOME_TYPE);
end SENDER;

task RECEIVER is
   entry READ (ITEM : in SOME_TYPE);
end RECEIVER;

task body PUMP is
   THE_ITEM : SOME_TYPE;
begin
   loop
      SENDER.READ(THE_ITEM);
      RECEIVER.WRITE(THE_ITEM);
   end loop;
end PUMP;

task body SENDER is separate;
task body RECEIVER is separate;
HARDWARE INTERRUPTS

- For architectures that 'jump' to a certain hardware address upon receipt of an interrupt
- A task entry is associated with the address
- Priority is higher than any user-defined

```
task INTERRUPT_HANDLER is
  entry DONE;
  for DONE use at 16*40*;
end INTERRUPT_HANDLER;

task body INTERRUPT_HANDLER is
begin
  accept DONE do
      ...
  end DONE;
end INTERRUPT_HANDLER;
```
A cyclic executive might deal with several levels of processing:

- Event driven processing (high priority, perhaps interrupt handling)
- Periodic (cyclic) processing
- Background processing (low priority)
procedure EXECUTIVE is

  task TASK_1 is
    pragma PRIORITY (10);
    entry EVENT;
  end TASK_1;

  task TASK_2 is
    entry EVENT;
    for EVENT use at 16/110;  -- one tick per cycle
  end TASK_2;

  task BACKGROUND is
    pragma PRIORITY (0);
  end BACKGROUND;

  task PERIODIC is
    pragma PRIORITY (5);
    entry TICK;
  end PERIODIC;

  task body PERIODIC is
    ...
    begin
      loop
        accept TICK;
        ...  -- process a frame
      end loop;
  end PERIODIC;

  -- bodies (or stubs) of other tasks go here

end EXECUTIVE,
Tutorial on Ada® Exceptions

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9 June 1987

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References


Outline

=> Overview

- Naming an exception
- Creating an exception handler
- Raising an exception
- Handling exceptions
- Turning off exception checking
- Tasking exceptions
- More examples
Overview

- What is an exception
- Ada exceptions
- Comparison
  - the American way
  - using exceptions
What Is an Exception

- A run time error
- An unusual or unexpected condition
- A condition requiring special attention
- Other than normal processing
Ada Exceptions

- An exception has a name
  - may be predefined
  - may be declared

- The exception is raised
  - may be raised implicitly by run time system
  - may be raised explicitly by raise statement

- The exception is handled
  - exception handler may be placed in any frame
  - exception propagates until handler is found
  - if no handler anywhere, process aborts
package Stack_Package is

    type Stack_Type is limited private;

    procedure Push (Stack : in out Stack_Type;
                    Element : in Element_Type;
                    Overflow_Flag : out boolean);

    ...

end Stack_Package;

with Text_IO;
with Stack_Package; use Stack_Package;
procedure Flag_Waving is

    ...
    Stack : Stack_Type;
    Element : Element_Type;
    Flag : boolean;
begin
    ...
    Push (Stack, Element, Flag);
    if Flag then
        Text_IO.Put ("Stack overflow");
        ...
    end if;
    ...
end Flag_Waving;
package Stack_Package is

    type Stack_Type is limited private;
    Stack_Overflow,
    Stack_Underflow : exception;

    procedure Push (Stack : in out Stack_Type;
        Element : in Element_Type);
    -- may raise Stack_Overflow

    end Stack_Package;

with Text_IO;
with Stack_Package; use Stack_Package;
procedure More_Natural is

    Stack : Stack_Type;
    Element : Element_Type;

    begin
        ...
        Push (Stack, Element);
        ...
    exception
        when Stack_Overflow =>
            Text_IO.Put ("Stack overflow");
            ...
    end More_Natural;
Outline

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Naming an Exception

- Predefined exceptions
- Declaring exceptions
- I/O exceptions
Predefined Exceptions

- In package STANDARD (also see chap 11 of LRM)

- CONSTRAINT_ERROR

  violation of range, index, or discriminant constraint...

- NUMERIC_ERROR

  execution of a predefined numeric operation cannot deliver a correct result

- PROGRAM_ERROR

  attempt to access a program unit which has not yet been elaborated...

- STORAGE_ERROR

  storage allocation is exceeded...

- TASKING_ERROR

  exception arising during intertask communication
Declaring Exceptions

```
exception_declaration ::= identifier_list : exception;
```

- Exception may be declared anywhere an object declaration is appropriate

- However, exception is not an object
  - may not be used as subprogram parameter, record or array component
  - has same scope as an object, but its effect may extend beyond its scope

Example:

```
procedure Calculation is

    Singular : exception;
    Overflow, Underflow : exception;

begin
    ...
end Calculation;
```
• Exceptions relating to file processing

• In predefined library unit IO_EXCEPTIONS
  (also see chap 14 of LRM)

• TEXT_IO, DIRECT_IO, and SEQUENTIAL_IO with it

package IO_EXCEPTIONS is

  NAME_ERROR  : exception;  -- attempt to use
  USE_ERROR   : exception;  -- invalid operation
  STATUS_ERROR: exception;  -- attempt to read
  MODE_ERROR  : exception;  -- beyond end of file
  DEVICE_ERROR: exception;  -- attempt to input
  END_ERROR   : exception;  -- wrong type
  DATA_ERROR  : exception;  -- for text processing
  LAYOUT_ERROR: exception;

end IO_EXCEPTIONS;
Outline

- Overview
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=> Creating an exception handler

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Creating an Exception Handler

- Defining an exception handler
- Restrictions
- Handler example
Defining an Exception Handler

- Exception condition is "caught" and "handled" by an exception handler

- Exception handler may appear at the end of any frame (block, subprogram, package or task body)

```
begin
  ...
  exception
    -- exception handler(s)
  end;
```

- Form similar to case statement

```
exception_handler ::= 
  when exception_choice { | exception_choice} =>
    sequence_of_statements

exception_choice ::= exception_name | others
```
Restrictions

- Exception handlers must be at the end of a frame

- Nothing but exception handlers may lie between exception and end of frame

- A handler may name any visible exception declared or predefined

- A handler includes a sequence of statements
  - response to exception condition

- A handler for others may be used
  - must be the last handler in the frame
  - handles all exceptions not listed in previous handlers of the frame (including those not in scope of visibility)
  - can be the only handler in the frame
procedure Whatever is

   Problem_Condition : exception;

begin
...

exception

   when Problem_Condition =>
       Fix_It;

   when CONSTRAINT_ERROR =>
       Report_It;

   when others =>
       Punt;

end Whatever;
Outline

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=> Raising an exception

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Raising an Exception

- How exceptions are raised
- Effects of raising an exception
- Raising example
How Exceptions are Raised

- Implicitly by run time system
  - predefined exceptions

- Explicitly by raise statement

```
raise_statement ::= raise [exception_name];
```

- the name of the exception must be visible at the point of the raise statement

- a raise statement without an exception name is allowed only within an exception handler
Effects of Raising an Exception

- Control transfers to exception handler at end of frame (if one exists)

- Exception is lowered

- Sequence of statements in exception handler is executed

- Control passes to end of frame

- If frame does not contain an appropriate exception handler, the exception is propagated
procedure Whatever is

Problem_Condition : exception;
Real_Bad_Condition : exception;

begin
  ...
  if Problem_Arises then
    raise Problem_Condition;
  end if;
  ...
  if Serious_Problem then
    raise Real_Bad_Condition;
  end if;
  ...
  exception
    when Problem_Condition =>
      Fix_It;
    when CONSTRAINT_ERROR =>
      Report_It;
    when others =>
      Punt;
  end Whatever;
Outline

- Overview
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=> Handling exceptions

- Turning off exception checking
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Handling Exceptions

- How exception handling can be useful
- Which exception handler is used
- Sequence of statements in exception handler
- Propagation
- Propagation example
How Exception Handling Can Be Useful

- Normal processing could continue if
  - cause of exception condition can be "repaired"
  - alternative approach can be used
  - operation can be retried

- Degraded processing could be better than termination
  - for example, safety-critical systems

- If termination is necessary, "clean-up" can be done first
Which Exception Handler Is Used

- If exception is raised during normal execution, system looks for an exception handler at the end of the frame in which the exception occurred.

- If exception is raised during elaboration of the declarative part of a frame:
  - elaboration is abandoned and control goes to the end of the frame with the exception still raised.
  - exception part of the frame is not searched for an appropriate handler.
  - effectively, the calling unit will be searched for an appropriate handler.
  - if elaboration of library unit, program execution is abandoned.
    -- all library units are elaborated with the main program.

- If exception is raised in exception handler:
  - handler may contain block(s) with handler(s).
  - if not handled locally within handler, control goes to end of frame with exception raised.
Sequence of Statements in Exception Handler

- Handler completes the execution of the frame
  - handler for a function should usually contain a return statement

- Statements can be of arbitrary complexity
  - can use most any language construct that makes sense in that context
  - cannot use goto statement to transfer into a handler
  - if handler is in a block inside a loop, could use exit statement

- Handler at end of package body applies only to package initialization
Propagation

- Occurs if no handler exists in frame where exception is raised

- Also occurs if `raise` statement is used in handler

- Exception is propagated dynamically
  - propagates from subprogram to unit calling it
    (not necessarily unit containing its declaration)
  - this can result in propagation outside its scope

- Propagation continues until
  - an appropriate handler is found
  - exception propagates to main program (still with no handler) and program execution is abandoned
procedure Do_Nothing is
  --------------
procedure Has_It is
  Some_Problem : exception;
begins...
  raise Some_Problem;
  ...
exception
  when Some_Problem =>
    Clean_Up;
    raise;
end Has_It;
  --------------
procedure Calls_It is
begin...
  Has_It;
  ...
end Calls_It;
  --------------
begin -- Do_Nothing
  ...
  Calls_It;
  ...
exception
  when others => Fix_Everything;
end Do_Nothing;
Outline

- Overview
- Naming an exception
- Creating an exception handler
- Raising an exception
- Handling exceptions

=> Turning off exception checking

- Tasking exceptions
- More examples
Turning Off Exception Checking

- Overhead vs efficiency
- Pragma SUPPRESS
- Check identifiers
Overhead vs Efficiency

- Exception checking imposes run time overhead
  - interactive applications will never notice
  - real-time applications have legitimate concerns but must not sacrifice system safety

- When efficiency counts
  - first and foremost, make program work
  - be sure possible problems are covered by exception handlers
  - check if efficient enough - stop if it is
  - if not, study execution profile
    -- eliminate bottlenecks
    -- improve algorithm
    -- avoid "cute" tricks
  - check if efficient enough - stop if it is
  - if not, trade-offs may be necessary
  - some exception checks may be expendable since debugging is done
  - however, every suppressed check poses new possibilities for problems
    -- must re-examine possible problems
    -- must re-examine exception handlers
  - always keep in mind
    -- problems will happen
    -- critical applications must be able to deal with these problems
Improving the algorithm is far better - and easier in the long run - than suppressing checks
Pragma SUPPRESS

- Only allowed immediately within a declarative part or immediately within a package specification

```
pragma SUPPRESS (identifier [, [ ON =>] name]);
```

- identifier is that of the check to be omitted (next slide lists identifiers)

- name is that of an object, type, or unit for which the check is to be suppressed

  -- if no name is given, it applies to the remaining declarative region

- An implementation is free to ignore the suppress directive for any check which may be impossible or too costly to suppress

Example:

```
pragma SUPPRESS (INDEX_CHECK, ON => Index);
```
Check Identifiers

- These identifiers are explained in more detail in chap 11 of the LRM

- Check identifiers for suppression of CONSTRAINT_ERROR checks
  
  ACCESS_CHECK
  DISCRIMINANT_CHECK
  INDEX_CHECK
  LENGTH_CHECK
  RANGE_CHECK

- Check identifiers for suppression of NUMERIC_ERROR checks
  
  DIVISION_CHECK
  OVERFLOW_CHECK

- Check identifier for suppression of PROGRAM_ERROR checks
  
  ELABORATION_CHECK

- Check identifier for suppression of STORAGE_ERROR check
  
  STORAGE_CHECK
Overview

- Naming an exception
- Creating an exception handler
- Raising an exception
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=> Tasking exceptions

- More examples
Tasking Exceptions

- Exception handling is trickier for tasks
- Exceptions during task rendezvous
- Tasking example
Exception Handling is Trickier for Tasks

- Rules are not really different, just more involved
  - local exceptions handled the same within frames

If exception is raised

- during elaboration of task declarations
  - the exception TASKING_ERROR will be raised at the point of task activation
  - the task will be marked completed

- during execution of task body (and not resolved there)
  - task is completed
  - exception is not propagated

- during task rendezvous
  - this is the really tricky part
Exceptions During Task Rendezvous

- If the **called** task terminates abnormally
  
  exception TASKING_ERROR is raised in **calling** task at the point of the entry call

- If the **calling** task terminates abnormally
  
  no exception propagates to the **called** task

- If an exception is raised in **called** task within an **accept** (and not handled there locally)
  
  the same exception is raised in the **calling** task at the point of the entry call
  (even if exception is later handled outside of the accept in the called task)

- If an entry call is made for entry of a task that becomes completed before accepting the entry
  
  exception TASKING_ERROR is raised in **calling** task at the point of the entry call
procedure Critical_Code is

Failure : exception;
-----------
task Monitor is
    entry Do_Something;
end Monitor;
task body Monitor is
...
begin
    accept Do_Something do
        ...
        raise Failure;
        ...
    end Do_Something;
...
exception  -- exception handled here
    when Failure =>
        Termination_Message;
end Monitor;
-----------

begin -- Critical_Code
...
    Monitor.Do_Something;
...
exception  -- same exception will be handled here
    when Failure =>
        Critical_Problem_Message;
end Critical_Code;
Outline

- Overview
- Naming an exception
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- Handling exceptions
- Turning off exception checking
- Tasking exceptions

=> More examples
Interactive Data Input

with Text_io; use Text_io;
procedure Get_Input (Number : out integer) is

    type Input_Type is integer range 0..100;
    package Int_io is new Integer_io (Input_Type);
    In_Number : Input_Type;

begin -- Get_Input

    loop      -- to try again after incorrect input

        begin -- inner block to hold exception handler

            put ("Enter a number 0 to 100");
            Int_io.get (In_Number);
            Number := In_Number;
            exit; -- to exit loop after correct input

        exception

            when DATA_ERROR | CONSTRAINT_ERROR =>
                put ("Try again, fat fingers!");
                Skip_Line;  -- must clear buffer

        end; -- inner block

    end loop;

end Get_Input;
package Container is
  procedure Has_Handler;
  procedure Raises_Exception;
end Container;

procedure Not_in_Package is
begin
  Container.Raises_Exception;
exception
  when others => raise;
end Not_in_Package;

package body Container is
  Crazy : exception;
  procedure Has_Handler is
begin
    Not_in_Package;
exception
  when Crazy => Tell_Everyone;
end Has_Handler;
  procedure Raises_Exception is
begin
  raise Crazy;
end Raises_Exception;
end Container;
begin
  Container.Has_Handler;
end;
Keeping a Task Alive

task Monitor is
  entry Do_Something;
end Monitor;

task body Monitor is
begin
  loop -- for never-ending repetition
    ...
    select
      accept Do_Something do
      begin -- block for exception handler
        ...
        raise Failure;
        ...
        exception
          when Failure => Recover;
      end; -- block
      end Do_Something; -- exception must be
        -- lowered before exiting
    ...
    end select;
    ...
  end loop;

exception
  when others =>
    Termination_Message;
end Monitor;
END DATE FILMED 5-88 FTC