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TON DUC THANG UNIVERSITY

PROGRAMMING METHODOLOGY
(PHƯƠNG PHÁP LẬP TRÌNH)

UNIT 5: Selection Statements

Acknowledgement

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Recording of modifications

- Currently, there are no modification on these contents.

Unit 5: Selection Statements

Objectives:

- Using relational and logical operators
- Using selection statements to choose between two or more execution paths in a program
- Formulating complex selection structures to solve decision problems

Reference:

- Chapter 4 Lessons 4.1 – 4.6, Beginning Decision Making

Unit 5: Selection Statements (1/2)

1. Sequential vs Non-Sequential Control Flow
2. Selection Structures

   2.1 *if* and *if-else* Statements

   2.2 Conditions

   2.3 Truth Values

   2.4 Logical Operators

   2.5 Evaluation of Boolean Expressions

   2.6 Caution

   2.7 Short-Circuit Evaluation

   2.8 *if* and *if-else* Statements: Examples

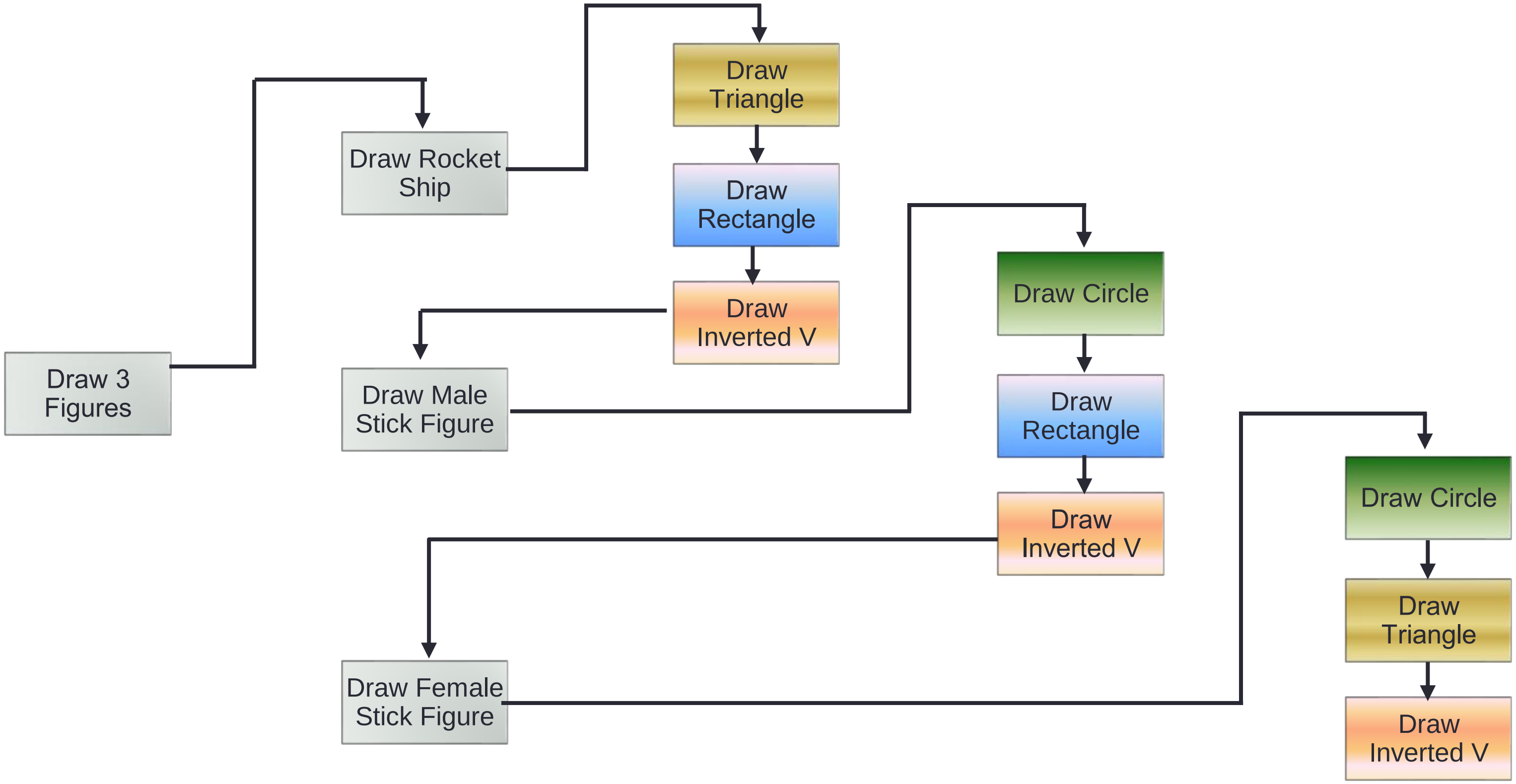
Unit 5: Selection Statements (2/2)

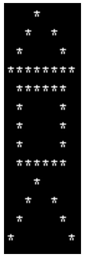
3. Nested *if* and *if-else* Statements
4. Style Issues
5. Common Errors
6. The *switch* Statement
7. Testing and Debugging

1. Sequential Control Flow

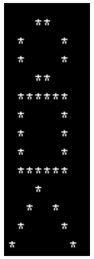
- Recall Simple “drawing” problem in Unit 4:

  Write a program to draw a rocket ship, a male stick figure, and a female stick figure.

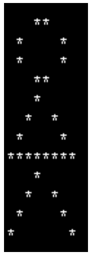



```
   *
  *  *
 *    *
********
 ******
 *    *
 *    *
 *    *
 ******
   *
  *  *
 *    *
*      *
```

rocket


```
   **
 *    *
 *    *
   **
 ******
 *    *
 *    *
 *    *
 ******
   *
  *  *
 *    *
*      *
```

male

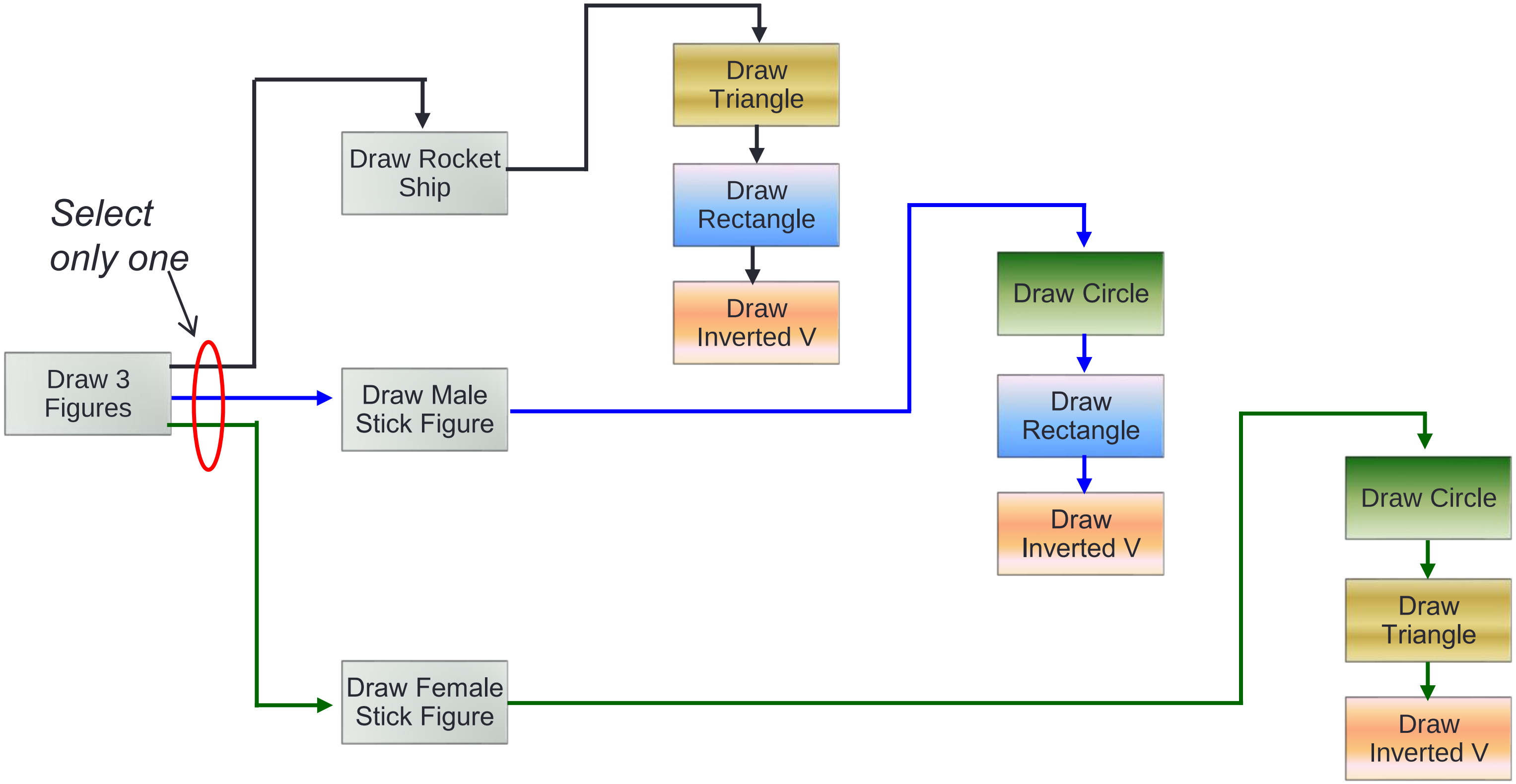

```
   **
 *    *
 *    *
   **
   *
  *  *
 *    *
********
   *
  *  *
 *    *
*      *
```

female

1. Non-Sequential Control Flow

- New requirement:

  Write a program to allow user to select only ONE of the following options: Draw a (1) rocket ship, (2) male stick figure, or (3) female stick figure.



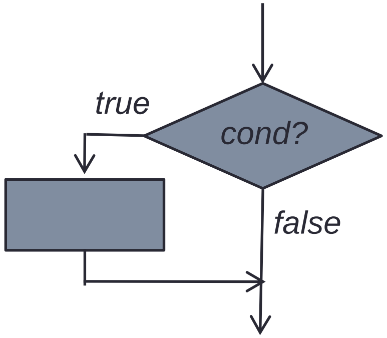
2. Selection Structures

- C provides two control structures that allow you to select a group of statements to be executed or skipped when certain conditions are met.

if … else …

switch

2.1 *if* and *if-else* Statements

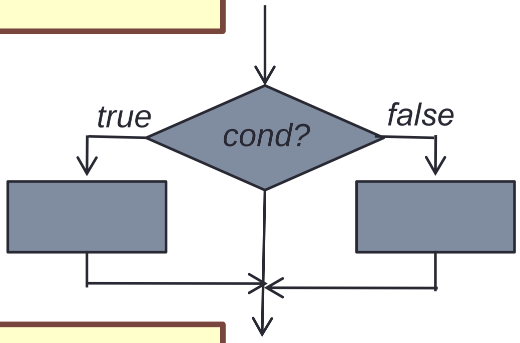


- *if* statement

How are conditions specified and how are they evaluated?

```
if ( condition ) {
    /* Execute these statements if TRUE */
}
```

Braces { } are optional only if there is one statement in the block.



- *if-else* statement

```
if ( condition ) {
    /* Execute these statements if TRUE  */
}
else {
    /* Execute these statements if FALSE */
}
```

2.2 Condition

- A condition is an expression evaluated to *true* or *false*.
- It is composed of expressions combined with relational operators.
  - Examples: (a <= 10), (count > max), (value != -9)

Relational Operator	Interpretation
<	is less than
<=	is less than or equal to
>	is greater than
>=	is greater than or equal to
==	is equal to
!=	is not equal to

2.3 Truth Values

- Boolean values: true or false.
- There is no boolean type in ANSI C. Instead, we use integers:
  - 0 to represent false
  - Any other value to represent true (1 is used as the representative value for true in output)
- Example:

Unit5_TruthValues.c

```
int a = (2 > 3);
int b = (3 > 2);

printf("a = %d; b = %d\n", a, b);
```

```
a = 0; b = 1
```

2.4 Logical Operators

- Complex condition: combining two or more boolean expressions.
- Examples:
  - If temperature is greater than 40C or blood pressure is greater than 200, go to A&E immediately.
  - If all the three subject scores (English, Maths and Science) are greater than 85 and mother tongue score is at least 80, recommend takinf Higher Mother Tongue.
- Logical operators are needed: && (and), || (or), ! (not).

A	B	A && B	A || B	!A
False	False	False	False	True
False	True	False	True	True
True	False	False	True	False
True	True	True	True	False

Note: There are bitwise operators such as & , | and ^, but we are not covering these in CS1010.

2.5 Evaluation of Boolean Expressions (1/2)

- The evaluation of a boolean expression is done according to the precedence and associativity of the operators.

Operator Type	Operator	Associativity
Primary expression operators	( ) [ ] . -> expr++ expr--	Left to Right
Unary operators	* & + - ! ~ ++expr --expr (typecast) sizeof	Right to Left
Binary operators	* / %	Left to Right
	+ -	
	< > <= >=	
	== !=	
	&&	
	||	
Ternary operator	?:	Right to Left
Assignment operators	= += -= *= /= %=	Right to Left

2.5 Evaluation of Boolean Expressions (2/2)

See Unit5_EvalBoolean.c

- What is the value of x?

```
int x, y, z,
    a = 4, b = -2, c = 0;
x = (a > b || b > c && a == b);
```

x is true (1)

gcc issues warning (why?)

- Always good to add parentheses for readability.

```
y = ((a > b || b > c) && a == b);
```

y is false (0)

- What is the value of z?

```
z = ((a > b) && !(b > c));
```

z is true (1)

2.6 Caution (1/2)

- Since the values 0 and 1 are the returned values for false and true respectively, we can have codes like these:

```
int a = 12 + (5 >= 2); // 13 is assigned to a
```

(5 >= 2) evaluates to 1; hence a = 12 + 1;

```
int b = (4 > 5) < (3 > 2) * 6; // 1 assigned to b
```

* has higher precedence than <.
(3 > 2) evaluates to 1, hence (3 > 2) * 6 evaluates to 6.
(4 > 5) evaluates to 0, hence 0 < 6 evaluates to 1.

```
int c = ((4 > 5) < (3 > 2)) * 6; // 6 assigned to c
```

(4 > 5) evaluates to 0, (3 > 2) evaluates to 1, hence
(4 > 5) < (3 > 2) is equivalent to (0 < 1) which evaluates to 1.
Hence 1 * 6 evaluates to 6.

- You are certainly <u>not encouraged</u> to write such convoluted codes!

2.6 Caution (2/2)

- Very common mistake:

```
int num;

printf("Enter an integer: ");
scanf("%d", &num);

if (num = 3) {
   printf("The value is 3.\n");
}
printf("num = %d\n", num);
```

- What if user enters 7?
- Correct the error.

2.7 Short-Circuit Evaluation

- Does the following code give an error if variable a is zero?

```
if ((a != 0) && (b/a > 3))
    printf(. . .);
```

- Short-circuit evaluation
  - expr1 || expr2: If expr1 is true, skip evaluating expr2 and return true immediately, as the result will always be true.
  - expr1 && expr2: If expr1 is false, skip evaluating expr2 and return false immediately, as the result will always be false.

2.8 *if* and *if-else* Statements: Examples (1/2)

if statement without *else* part

```
int a, b, t;
. . .
if (a > b) {
  // Swap a with b
  t = a; a = b; b = t;
}
// After above, a is the smaller
```

if-else statement

```
int a;
. . .
if (a % 2 == 0) {
  printf("%d is even\n", a);
}
else {
  printf("%d is odd\n", a);
}
```

2.8 *if* and *if-else* Statements: Examples (2/2)

- Move common statements out of the *if-else* construct.

```
if (cond) {
   statement-a;
   statement-b;
   statement-j;
   statement-x;
   statement-y;
}
else {
   statement-a;
   statement-b;
   statement-k;
   statement-x;
   statement-y;
}
```

```
statement-a;
statement-b;
if (cond) {
   statement-j;
}
else {
   statement-k;
}
statement-x;
statement-y;
```

3. Nested *if* and *if-else* Statements (1/2)

- Nested *if* (*if-else*) structures refer to the containment of an *if* (*if-else*) structure within another *if* (*if-else*) structure.
- For example:
  - If it is a weekday, you will be in school from 8 am to 6 pm, do revision from 6 pm to 12 midnight, and sleep from 12 midnight to 8 am.
  - If it is a weekend, then you will sleep from 12 midnight to 10 am and have fun from 10 am to 12 midnight.

3. Nested *if* and *if-else* Statements (2/2)

- Drawing task in Unit 4

```
int main(void) {
   draw_rocket();
   printf("\n\n");
   draw_male();
   printf("\n\n");
   draw_female();
   printf("\n\n");

   return 0;
}
```

- Draw only 1 figure

```
int main(void) {
   char resp;

   printf("(R)ocket, ");
   printf("(M)ale, or ");
   printf("(F)emale? ");
   scanf("%c", &resp);

   if (resp == 'R')
      draw_rocket();
   else if (resp == 'M')
      draw_male();
   else if (resp == 'F')
      draw_female();

   return 0;
}
```

4. Style Issues: Indentation (1/6)

- Once we write non-sequential control structures, we need to pay attention to indentation.

Acceptable

```
if (cond) {
    statements;
}
else {
    statements;
}
```

```
if (cond) {
    statements;
} else {
    statements;
}
```

```
if (cond)
{
    statements;
}
else
{
    statements;
}
```

Do you remember which vim command to auto-indent your program?

Non-acceptable

```
if (cond)
{
statements;
}
else
{
statements;
}
```

No indentation!

```
if (cond) {
    statements; }
else {
    statements; }
```

Closing braces not aligned with if/else keyword!

4. Style Issues: Indentation (2/6)

- Note that appropriate indentation of comments is just as important.

Correct

```
// Comment on the whole if
// construct should be aligned with
// the 'if' keyword
if (cond) {
    // Comment on the statements in
    // this block should be aligned
    // with the statements below
    statements;
}
else {
    // Likewise, comment for this
    // block should be indented
    // like this
    statements;
}
```

Incorrect

```
    // Compute the fare
if (cond) {
// For peak hours
    statements;
}
else {
        // For non-peak hours
    statements;
}
```

4. Style Issues: Indentation (3/6)

- Sometimes we may have a deeply nested *if-else-if* construct:

```
int marks;
char grade;
. . .
if (marks >= 90)
   grade = 'A';
else
   if (marks >= 75)
      grade = 'B';
   else
      if (marks >= 60)
         grade = 'C';
      else
         if (marks >= 50)
           grade = 'D';
         else
           grade = 'F';
```

- This follows the indentation guideline, but in this case the code tends to be long and it skews too much to the right.

4. Style Issues: Indentation (4/6)

- Alternative (and preferred) indentation style for deeply nested *if-else-if* construct:

```
int marks;
char grade;
. . .
if (marks >= 90)
   grade = 'A';
else
   if (marks >= 75)
      grade = 'B';
   else
      if (marks >= 60)
         grade = 'C';
      else
         if (marks >= 50)
            grade = 'D';
         else
            grade = 'F';
```

Alternative style

```
int marks;
char grade;
. . .
if (marks >= 90)
   grade = 'A';
else if (marks >= 75)
   grade = 'B';
else if (marks >= 60)
   grade = 'C';
else if (marks >= 50)
   grade = 'D';
else
   grade = 'F';
```

4. Style Issues: Naming ‘boolean’ variables (5/6)

- Here, ‘boolean’ variables refer to int variables which are used to hold 1 or 0 to represent true or false respectively.
- These are also known as boolean flags.
- To improve readability, boolean flags should be given descriptive names just like any other variables.
- In general, add suffices such as “is” or “has” to names of boolean flags (instead of just calling them “flag”!)
  - Example: isEven, isPrime, hasError, hasDuplicates

```
int isEven, num;
. . .
if (num % 2 == 0)
   isEven = 1;
else
   isEven = 0;
```

4. Style Issues: Removing ‘if’ (6/6)

- The following code pattern is commonly encountered:

```
int isEven, num;
. . .
if (num % 2 == 0)
   isEven = 1;
else
   isEven = 0;
```

- In this case, the *if* statement can be rewritten into a single assignment statement, since (num % 2 == 0) evaluates to either 0 or 1.
- Such coding style is common and the code is shorter.

```
int isEven, num;
. . .
isEven = (num % 2 == 0);
```

5. Common Errors (1/2)

- The code fragments below contain some very common errors. One is caught by the compiler but the other is not (which makes it very hard to detect). Spot the errors.

Unit5_CommonErrors1.c

```
int a = 3;
if (a > 10);
   printf("a is larger than 10\n");
printf("Next line.\n");
```

Unit5_CommonErrors2.c

```
int a = 3;
if (a > 10);
   printf("a is larger than 10\n");
else
   printf("a is not larger than 10\n");
printf("Next line.\n");
```

5. Common Errors (2/2)

- Proper indentation is important. In the following code, the indentation does not convey the intended purpose of the code. Why? Which *if* is the *else* matched to?

Unit5_CommonErrors3.c

```c
int a, b;
. . .

if (a > 10)
    if (b < 9)
        printf("Hello\n");
else
    printf("Goodbye\n");
```

6. The *switch* Statement (1/3)

- An alternative to *if-else-if* is to use the *switch* statement.
- Restriction: Value must be of discrete type (eg: int, char)

```
switch ( <variable or expression> ) {
   case value1:
       Code to execute if <variable or expr> == value1
       break;

   case value2:
       Code to execute if <variable or expr> == value2
       break;
   ...

   default:
       Code to execute if <variable or expr> does not
       equal to the value of any of the cases above
       break;
}
```

6. The *switch* Statement (2/3)

- Write a program that reads in a 6-digit zip code and uses its first digit to print the associated geographic area.

If zip code begins with	Print this message
0, 2 or 3	<zip code> is on the East Coast.
4 – 6	<zip code> is in the Central Plains.
7	<zip code> is in the South.
8 or 9	<zip code> is in the West.
others	<zip code> is invalid.

6. The *switch* Statement (3/3)

Unit5_ZipCode.c

```c
#include <stdio.h>
int main(void) {
   int zip;

   printf("Enter a 6-digit ZIP code: ");
   scanf("%d", &zip);

   switch (zip/100000) {

      case 0: case 2: case 3:
         printf("%06d is on the East Coast.\n", zip);
         break;
      case 4: case 5: case 6:
         printf("%d is in the Central Plains.\n", zip);
         break;
      case 7:
         printf("%d is in the South.\n", zip);
         break;
      case 8: case 9:
         printf("%d is in the West.\n", zip);
         break;
      default:
         printf("%d is invalid.\n", zip);

   } // end switch

   return 0;
}
```

7. Testing and Debugging (1/3)

- Finding the maximum value among 3 variables:

```c
// Returns largest among num1, num2, num3
int getMax(int num1, int num2, int num3) {
   int max = 0;
   if ((num1 > num2) && (num1 > num3))
      max = num1;
   if ((num2 > num1) && (num2 > num3))
      max = num2;
   if ((num3 > num1) && (num3 > num2))
      max = num3;
   return max;
}
```

Unit5_FindMax_v1.c

- What is wrong with the code? Did you test it with the correct test data?
- What test data would expose the flaw of the code?
- How do you correct the code?
- After correcting the code, would replacing the 3 *if* statements with a nested *if-else* statement work? If it works, which method is better?

7. Testing and Debugging (2/3)

- With selection structures (and next time, repetition structures), you are now open to many alternative ways of solving a problem.
- Alternative approach to finding maximum among 3 values:

```c
// Returns largest among num1, num2, num3
int getMax(int num1, int num2, int num3) {
   int max = 0;
   if (num1 > max)
      max = num1;
   else if (num2 > max)
      max = num2;
   else if (num3 > max)
      max = num3;
   return max;
}
```

Unit5_FindMax_v2.c

- What is wrong with this code? (There are more than one error.)
- What test data should you use to expose its flaw?

7. Testing and Debugging (3/3)

- The preceding examples will be discussed in class.
- Remember: Test your programs thoroughly with your own data.

Do NOT rely on CodeCrunch to test your programs!

Summary

- In this unit, you have learned about
  - The use of *if-else* construct and *switch* construct to alter program flow
  - The use of relational and logical operators
  - Style issues such as indentation, naming of boolean flags and replacing *if* statement with an assignment statement
  - How to test a selection construct with exhaustive test data, and to ensure that all alternative paths in the selection construct are examined

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