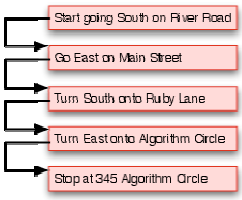
CHAPTER 4:
CONDITIONAL STRUCTURES

Introduction to Computer Science Using Ruby

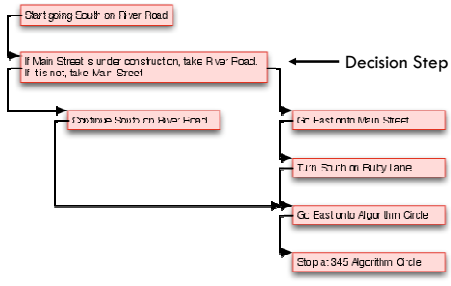
Flow of Execution

- Every algorithm has a **logic flow**
  - There is a start, steps that happen in chronological order, and an end
  - There is a **graphical way** to describe program flow
- Understanding **control flow** is essential to creating and testing an implementation of an algorithm

Figure 4.1:



This chart has a **one directional flow** (each step is performed once before the next), but some algorithms can have multiple possible execution flows



Flow of Execution: Multiple Path Logic Flow (Figure 4.2)

- **Conditional flow:** a certain condition must be met to perform the next step
  - After doing the first step, follow the path that matches the given condition, then the rest of the flow is one directional

Conditional Control

- A **condition** is an expression defined using **relational** and **Boolean** operators
  - A condition has a Boolean value, either **True** or **False**

```
irb(main):001:0> 5 == 5
  => true
irb(main):002:0> 5 == 6
  => false
irb(main):003:0> 5 <= 5
  => true
irb(main):004:0> 5 != 5
  => false
```

Relational Operators	Meaning
==	Is equal to
!=	Not equal to
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than of equal to

Relational Operators (Table 4.1)

Conditional Control

- The **"!" operator** is the **negation** of a condition or Boolean value
  - "!" can work on any true or false statement or conditional
  - Usually referred to as "not"
- Boolean operators operate on **Boolean values,** creating expressions that evaluate to True or False
  - Operators include: **and, or, not**
- The results of the operators are described by **truth tables**

A	B	A and B	A or B
		A && B	A || B
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

Truth Tables for "and" and "or" (Table 4.2)

Example: Boolean Expressions

```
irb(main) :001:0> !false
  =>true
irb(main) :002:0> !(true or false)
  => false
irb(main) :003:0> first = true
  => true
irb(main) :004:0> second = false
  => false
irb(main) :005:0> (first and second or
  !(first and second)
  => true
```

Conditional Flow: *If* Statements

- Ruby uses an *if* statement for basic conditional control flow (Example 4.3)

```
1 if (condition)
2 # section 1
3 end
```

Section 1 **is executed** when the condition evaluates to true or is **skipped** when the condition evaluates to false

- Input value of **11** (Example 4.4):

```
1# if a number is even, print out "Even"
2 puts "Enter a number"
3 number = gets.to_i
4 if (number % 2 == 0) # evaluates to false
5 puts "Even" # does not execute
6 end
```


Conditional Flow: *If-Then-Else* Statements

- Provides a **second flow option**
  - If the original condition is not met, then the second flow option is taken (Example 4.5)

```
1 if (condition)
2 # section 1 executes if true
3 else
4 # section 2 executes if false
5 end
```


Example of Program that Determines Prices of Movie Tickets (Example 4.6)

```
1 puts "Enter the customer's age: "
2 # Get an integer age value from the user
3 age = gets.to_i
4
5 # Determine the cost based on age
6 if (age < 12)
7 cost = 9
8 else
9 cost = 18
10 end
11
12 # Print out the final cost
13 puts "Ticket cost: " + cost.to_s
```


If-Else Statement Logic Flow

- To test the program, input one value for each logic flow option
- Test the edge or boundary conditions (most errors occur here)

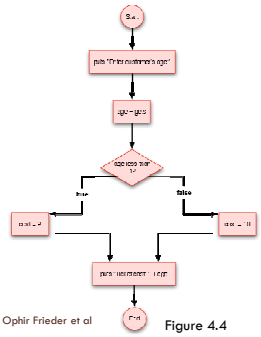


Figure 4.4

Movie Ticket Example: Input Value of 8 (Example 4.6)

```
1 puts "Enter the customer's age: "
2 # Get an integer age value from the user
3 age = gets.to_i
4
5 # Determine the cost based on age
6 if (age < 12) # evaluates to true
7 cost = 9 # so the If portion Executes
8 else
9 cost = 18  # This portion DOES NOT
10 end
11
12 # Print out the final cost
13 puts "Ticket cost: " + cost.to_s
```


Movie Ticket Example: Input Value of 25 (Example 4.6)

```
1 puts "Enter the customer's age: "
2 # Get an integer age value from the user
3 age = gets.to_i
4
5 # Determine the cost based on age
6 if (age < 12)# Evaluates to false
7 cost = 9   # This DOES NOT execute
8 else
9 cost = 18   # Executes
10 end
11
12 # Print out the final cost
13 puts "Ticket cost: " + cost.to_s
```

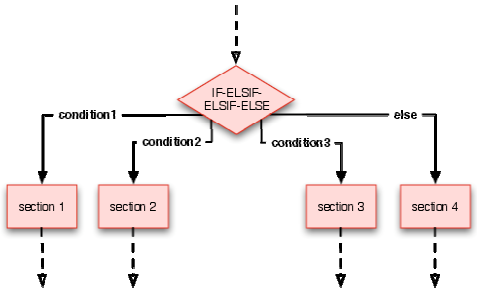

Movie Ticket Example: Input Value of 12 (Figure 4.9)

```
1 puts "Enter the customer's age: "
2 # Get an integer age value from the user
3 age = gets.to_i
4
5 # Determine the cost based on age
6 if (age < 12) # Evaluates to false
7 cost = 9
8 else
9 cost = 18 # Executes
10 end
11
12 # Print out the final cost
13 puts "Ticket cost: " + cost.to_s
```

The correct outcome should be **9** because a child is considered 12 or under, so the program is **incorrect**. To correct the error (“**bug**”), the conditional test in the program needs to be “*age <= 12*”

Elsif Statements

- Conditional flow can have more than two flow options
- There are various ways to implement a **multi-flow control**
  - One of them is using an ***elsif* statement**



Elsif Statement Logic Flow (Figure 4.5)

Only the **first** condition that evaluates to true gets executed

Program that Discounts Tickets for Children & Senior Citizens (Example 4.9)

```
1 puts "Enter the customer's age: "
2 # Get an integer age value from the user
3 age = gets.to_i
4
5 # Determine the cost based on age
6 if (age <= 12)
7 cost = 9
8 elsif (age >= 65)
9 cost = 12
10 else
11 cost = 18
12 end
13
14 # Print out the final cost
15 puts "Ticket cost: " + cost.to_s
```

Note: The program needs another condition for senior citizens

Review: Original Movie Ticket Program (Example 4.6)

```
1 puts “Enter the customer's age:”
2 # Get an integer age value from the user
3 age = gets.to_i
4
5 # Determine the cost based on age
6 if (age <= 12)
7 cost = 9
8 else
9 cost = 18
10 end
11
12 # Print out the final cost
13 puts "Ticket cost: " + cost.to_s
```


Alternatives

Alternative Syntax

```
1 puts "Enter the customer's age:”
2 # Get an integer age value from the user
3 age = gets.to_i
4 cost = 18
5 # Determine the cost based on age
6 if (age <= 12)then cost = 9 end
7 # Print out the final cost
8 puts "Ticket cost: " + cost.to_s
```

Alternative Program

```
1 puts "Enter the customer's age:”
2 # Get an integer age value from the user
3 age = gets.to_i
5 # Determine the cost based on age
6 if (age<=12)then (cost=9)else (cost = 18 ) end
12 # Print out the final cost
13 puts "Ticket cost: " + cost.to_s
```

SYNTACTIC SUGAR IN ACTION:

Alternative syntax designed for **ease of programming and readability**

Case Statements

- The **case statement** handles multiple options
  - **Alternative** to *if-elsif* statements
  - Useful for a **large number** of options
- Case statements evaluate **in order**
  - Only the first **when** clause that evaluates to true gets executed
  - If none evaluates to true, then the else clause is executed

Figure 4.11:

```
case
when (expression1)
# section 1
when (expression2)
# section 2
else
# section 3
end
```


Movie Ticket Program: Rewritten Using a Case Statement (Example 4.12)

```
puts "Enter the customer's age: "
# Get an integer age value from the user
age = gets.to_i

# Determine the cost based on age
case
when (age <= 12)
cost = 9
when (age >= 65)
cost = 12
else
cost = 18
end

# Print out the final cost
puts "Ticket cost: " + cost.to_s
```


Debugging: Incorrect Movie Ticket Program (Example 4.13)

Example 1: The cost will always be 9

```
puts "Enter the customer's age: "
# Get an integer age value from the user
age = gets.to_i

# Determine the cost based on age
case
# '=' is assignment NOT equality test '=='
when (age = 12) then # Always evaluates to true
cost = 9
when (age >= 65) then
cost = 12
else
cost = 18
end

# Print out the final cost
puts "Ticket cost: " + cost.to_s
```


Debugging: Incorrect Movie Ticket Program (Example 4.14)

Example 2:

```
puts "Enter the customer's age: "
# Get an integer age value from the user
age = gets.to_i
# DEBUG
puts age

# Determine the cost based on age
case
# '=' is assignment NOT equality test '=='
when (age = 12) then
cost = 9
when (age >= 65) then
cost = 12
else
cost = 18
end
```

Debugging

- Uses **puts** statements to help identify errors.
  - Show **variable values** where they are not changing

Example 4.14 cont'd:

```
17 # DEBUG
18 puts age # Shows that age always equals 12
19
20 # Print out the final cost
21 puts "Ticket cost: " + cost.to_s
```


Debugging: Alternatives

- Programs can also be debugged using **constants**
- In each section, there is an ***if* statement** with a debugging constant as the **flag**
  - The flag determines whether a put statement is executed
- When a section is judged to be correct, the constant is set to **false**
  - There is no need to check variables
- The debug output should be fully descriptive
  - puts "debug – age" + age.to_s
  - ***NOT*** puts "age"

Debugging (Example 4.15)

```
 1 # Flag for debugging (change the false when finished debugging)
 2 DEBUG_MODULE_1 = true # Initialize and define a flag constant
     as true.
 3
 4 puts "Enter the customer's age: "
 5 # Get an integer age value from the user
 6 age = gets.to_i
 7
 8 # Determine the cost based on age
 9 if DEBUG_MODULE_1 # Changed to false if this section is correct
10 puts age # Prints age if the section is still # not debugged
11 end
12 case
13 # '=' is assignment NOT equality test '=='
14 when (age = 12) then
15 cost = 9
```


Debugging (Example 4.15 Cont'd)

```
16 when (age >= 65) then
17  cost = 12
18 else
19  cost = 18
20 end
21 if DEBUG_MODULE_1 # Changed to false if
                     # this section is correct
22  puts age # prints age if the section is
             # still not debugged incorrect
23 end
24
25 # Print out the final cost
26 puts "Ticket cost: " + cost.to_s
```

Summary

- Every program follows a **control flow**, which is determined by the **logic flow** of its algorithms
- Logic and control flow can often be **one directional** or **conditional**
- The **relational operators** are the key operators to creating conditional flows
- Another way to create conditional flow is by employing **if, elsif,** and **case statements**