Basic Program Structure

Repetition (Looping)

Lesson Objectives

At the end of this lesson, you should be able to:

- Explain the need for repetition in programming
- Familiarize with the structure of a loop
- Apply the loop design strategy when developing loops
- Distinguish between counter-controlled loop and sentinel-controlled loop

Topic Outline

The Structure of a Loop

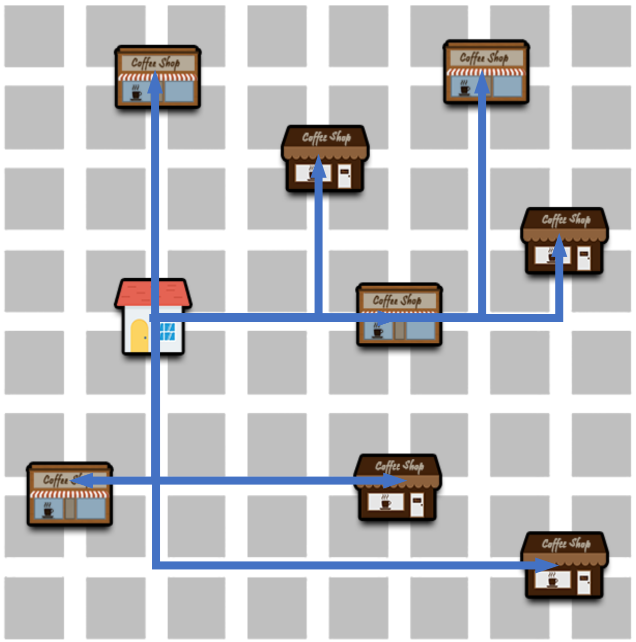
The Loop Design Strategy

Counter-Controlled Loop

Sentinel-Controlled Loop

Recall: Finding Distance Between Two Points

What if there were many coffee shops?



If we only have a *sequence*… ⇒ Tedious

We need to **repeat certain instruction(s).**

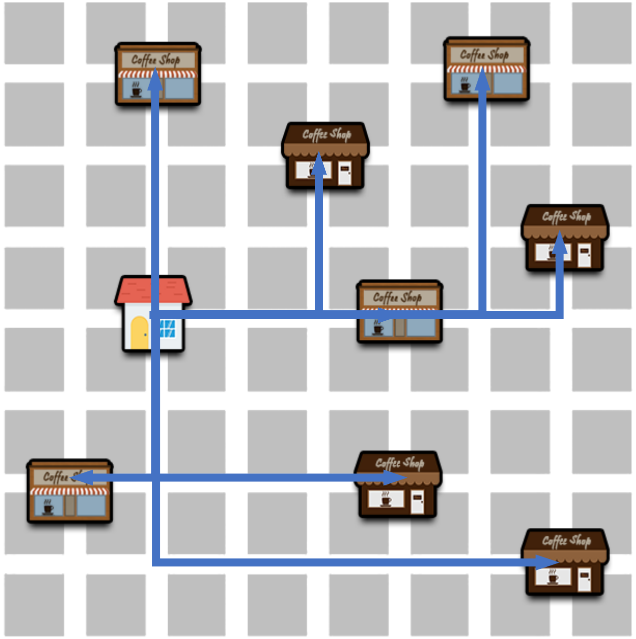
E.g., calculate the travel distance between two points **exactly *N* times**, where ***N*** is the total number of coffee shops.

***N* times**

```
Read horizonDist
Read vertDist
dist = horizonDist + vertDist
Display distance traveled between these two points
Read horizonDist
Read vertDist
dist = horizonDist + vertDist
Display distance traveled between these two points
⋮
```

Recall: Finding Distance Between Two Points

What if there were many coffee shops?



If we only have a *sequence*…

⇒ **Not reusable**

Example

Different users have different numbers of coffee shops nearby.

Hence, the number to repeat the certain instruction has to be changed for different users.

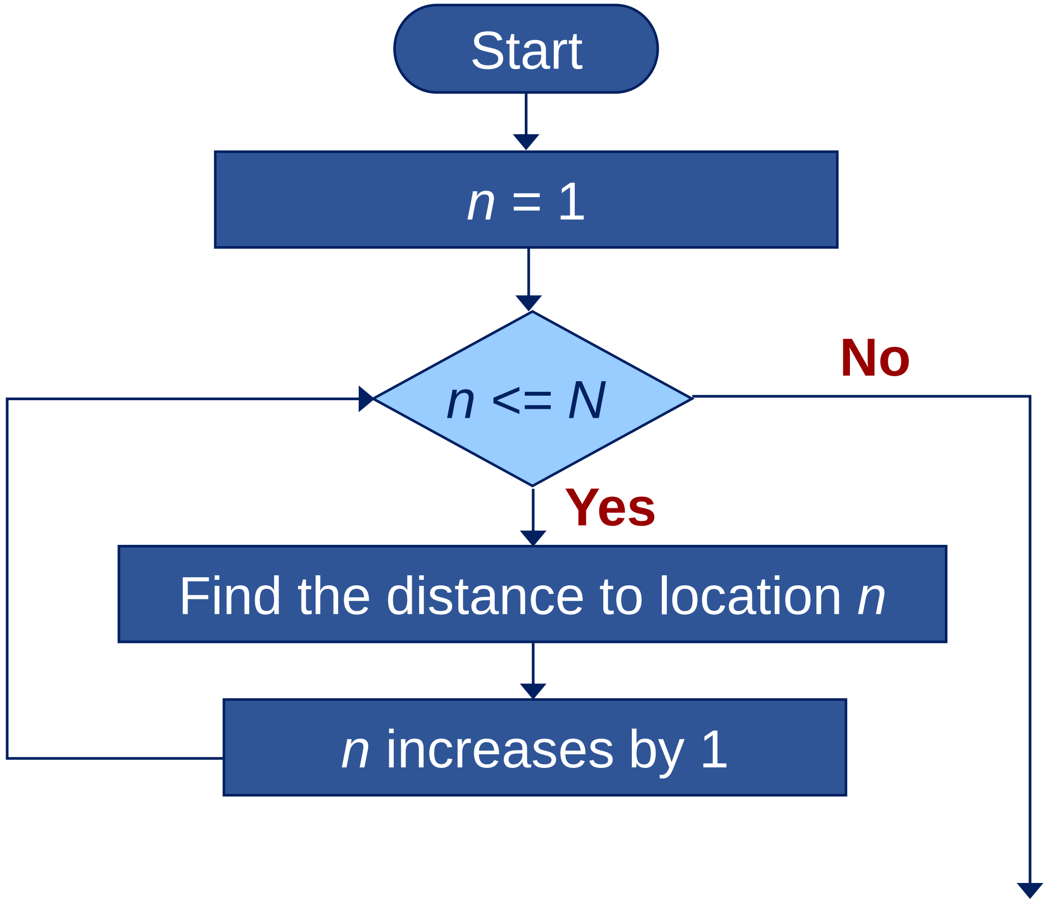
Solution: Looping

Looping

A computer program **can dynamically** choose how many times it repeats certain instruction(s) during the programme runtime.

Program instructions can be repeated dynamically.

- Sometimes three times, sometimes 1,000 times, or sometimes not even repeat at all.



Solution: Looping (Cont’d)

The program is the same for different users (it doesn’t need to change for different numbers of repetitions).

Pseudocode

```
Count = 1
WHILE count <= N
      Read horizonDist
      Read vertDist
      dist = horizonDist + vertDist
      Display distance traveled between two points
      Increase count by 1
END WHILE
```

General Structure of a Loop

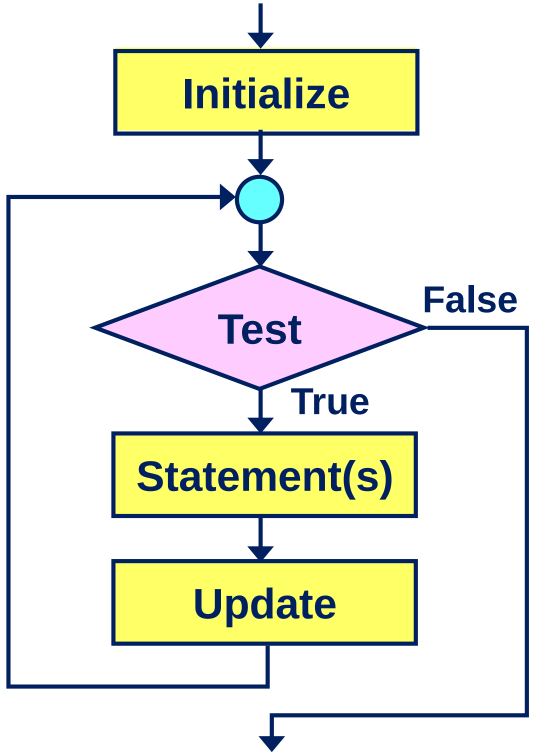
Four Steps

1. Initialize Loop control variable

2. Test Continue the loop or not?

3. Loop body Main computation being repeated

4. Update Modify the value of the loop control variable so that next time when we test, we may exit the loop



- Sometimes a loop may not have all of them. E.g., *Infinite loop* (Test condition is always true).
- A one-time execution of a loop body is referred to as an **iteration** of the loop.

General Structure of a Loop: More Application

Compute the Average Height of the Students in a Class

General Structure of a Loop: More Application (Cont’d)

Compute the Average Height of N Students in a Class

Pseudocode

```
    SET sum TO 0
1   SET counter TO 0                                 // Initialize
2   WHILE counter < N                                // Test
3       READ height                                  // Loop body
        ADD height TO sum
4       INCREMENT counter BY 1                       // Update
    END WHILE
    COMPUTE average = sum / counter
    PRINT average
```

Loop Design Strategies

Step 1

Identify the statements that need to be repeated

Step 2

Wrap these statements in a loop

```
while (true) {
Statements;
}
```

Step 3

Code the loop-continuation-condition and add appropriate statements for controlling loop

```
while (loop-continuation-condition) {
    Statements;
    Additional statements for controlling the loop;
}
```

Note: In designing loops, consider both the loop control structure and the loop body.

Two Kinds of Loops

Counter-Controlled Loop

The number of repetitions can be **known** before the loop body starts; just repeat the loop on each element in a preset sequence.

Sentinel-Controlled Loop

The number of repetitions is **NOT known** before the loop body starts.

- For example, a *sentinel value* (e.g. –1, different from normal data).

Counter-Controlled Loop: Application

Compute the Average Height of the Students in a Class

Pseudocode

```
sum = 0.0
REPEAT N times
  ASK user for next student's height
  sum += height
END of REPEAT
Average = sum / N
```

Assumption: The number of students is known before the start of the loop

Sentinel-Controlled Loop: Application

Compute the Average Height of the People Entering Canteen A in a Day

Are we able to know **beforehand** the number of people entering Canteen A before we start the loop body?

→ **NO**

Sentinel-Controlled Loop: Application (Cont’d)

Compute the Average Height of the People Entering Canteen A in a Day

A sentinel value is a special value that signifies the end of the loop.

Note: **Time** is the loop control variable.

Pseudocode

Initialize

```
sum = count = 0
time = get current time
```

Test

```
WHILE time < Canteen A closing time
```

Loop body

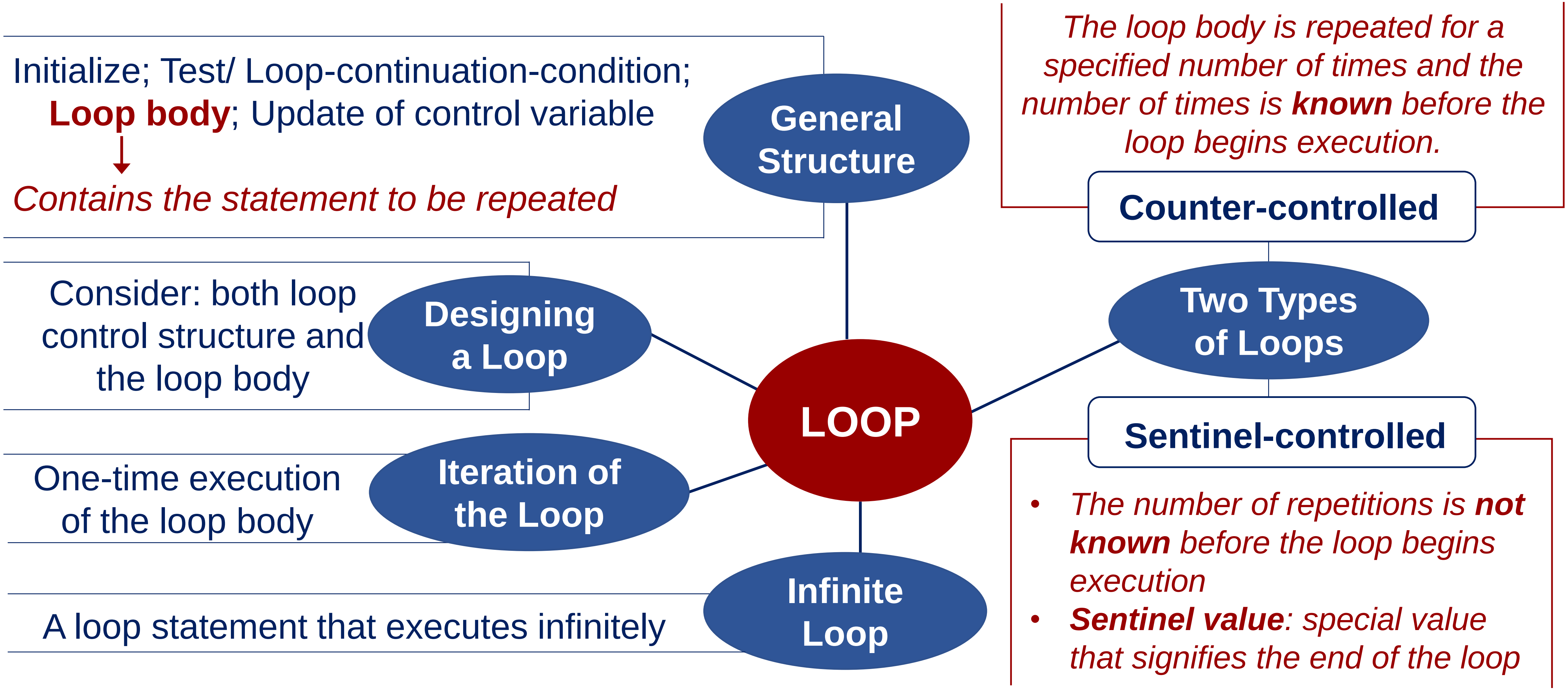
```
    height = get height of next guy
    sum += height
    count += 1
```

Update

```
    time = get current time
END WHILE
```

Loop-continuation-condition: *time is earlier than closing time*.

Summary



LOOP

General Structure

Initialize; Test/ Loop-continuation-condition; **Loop body**; Update of control variable

Contains the statement to be repeated

Designing a Loop

Consider: both loop control structure and the loop body

Iteration of the Loop

One-time execution of the loop body

Infinite Loop

A loop statement that executes infinitely

Two Types of Loops

Counter-controlled

*The loop body is repeated for a specified number of times and the number of times is **known** before the loop begins execution.*

Sentinel-controlled

- *The number of repetitions is **not known** before the loop begins execution*
- ***Sentinel value**: special value that signifies the end of the loop*

References for Images

No.	Slide No.	Image	Reference
1	6		Survey icon [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/survey-icon-survey-icon-2316468/.
2	13		By Arlington National Cemetery - Medal of Honor Day Bus Tour - loading bus, Public Domain, retrieved June 7, 2018 from https://commons.wikimedia.org/w/index.php?curid=63839066.
3	13		Alpha (2007). Queueing for Tian Tian Hainanese Chicken Rice-Maxwell Road Hawker Center [Online Image]. Retrieved June 16, 2018 from https://www.flickr.com/photos/avlxyz/2498427281.
4	15		Question problem [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/question-problem-think-thinking-622164/.