# CSCI 1106
# Lecture 10

Debugging

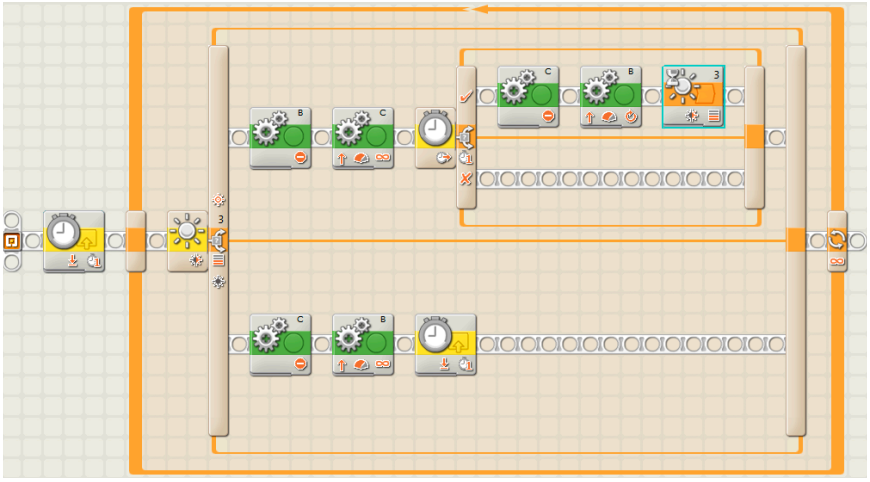
## Announcements

- Today's Topics
  - Motivation
  - Asking the right questions
  - Where to start
  - The "printf" method
  - Divide and conquer

# The Bearable Heaviness of Bugs

- Fact: Most programs have bugs
  - Design flaws
  - Typos
  - Bad assumptions
- Fact: Bugs cause programs to misbehave
  - Crash
  - Have incorrect behaviour
  - Corrupt data
  - Can cause loss of life, limb, and property
- Fact: Buggy programs must be debugged (fixed)

# This Program Does Not Work… Why?



## Asking the Right Questions

- Why? Because the program has a bug…
- Assumption: Most of the program is correct
- Observation: The bug's location is the point in the program where it starts to misbehave
- Conclusion: So, we ask *where* is the bug?

- Corollary 1: We ask *when* does the bug appear?
- Corollary 2: We ask *how* does the bug manifest?

## The When and the How

- Question: Why do we care about
  - *When* the bug manifests?
  - *How* the bug manifests?
- Answer:
  - Programs are large and complicated
  - Want to restrict our bug search to part of the program
  - This makes debugging easier, but …
- Still need to find the bug

## Where to Start …

- Recall: We assume that program misbehaviour begins shortly after bug is encountered
- Goal: Narrow our search for the bug
- Idea: Determine the first instance of program misbehaviour

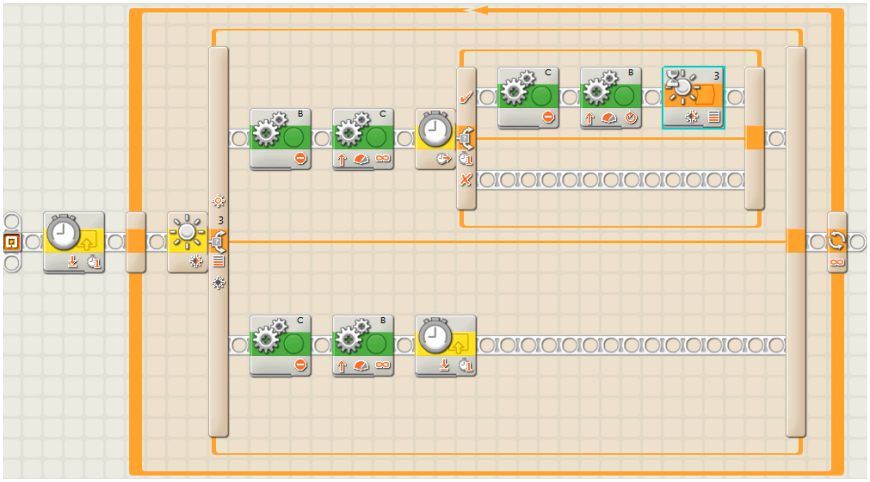
- So… where in the program do things go wrong?

## Manifestation, Location, Location

- Idea:
  - Bugs manifest in program misbehaviour
  - Misbehaviour corresponds to a program location
  - Need to match the manifestation to the location
- To do:
  - Identify the bug manifestation
    - How do we know that something is wrong?
  - Identify the manifestation location
    - Where in the code does this something occur?

# Bug Manifestation

This program stops while trying to find a lost line

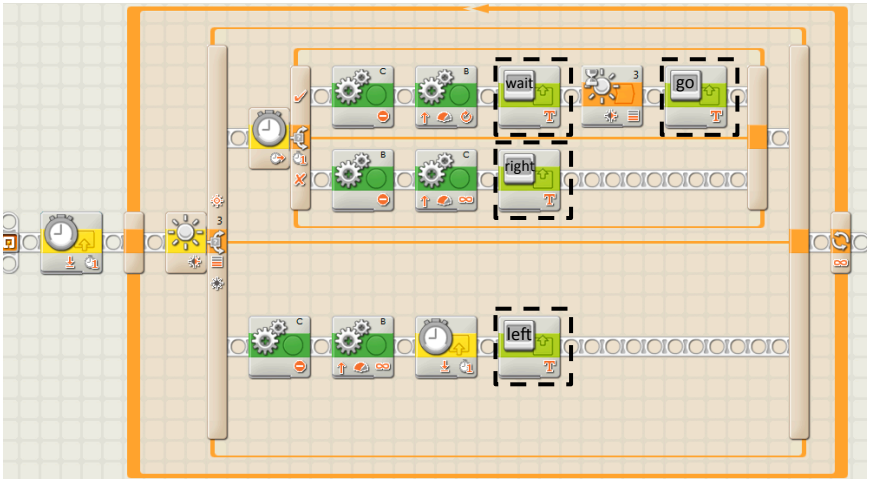


Where in the code does it stop?

# The "printf" Method

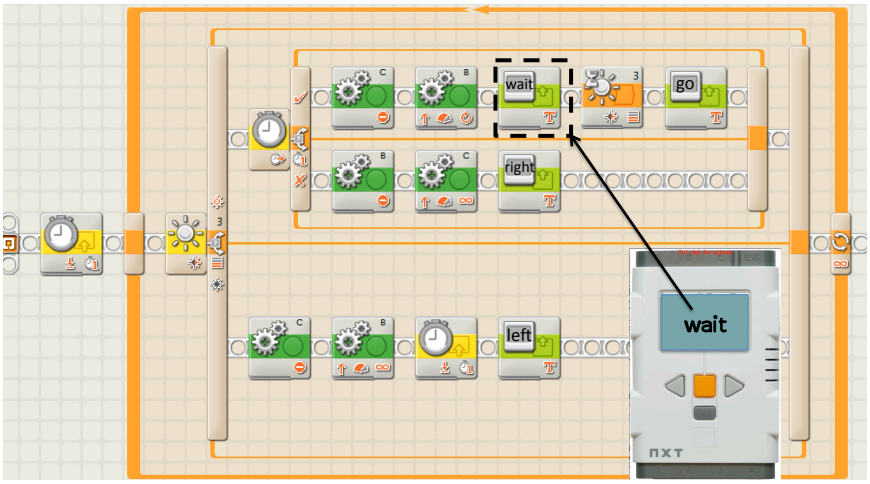
- We have two options:
  - Stare the code and guess at where the bug is
  - Use a mechanical procedure to narrow our search
- Goal:
  - Need to determine when we have reached specific locations in our program
  - Want the program to let us know when it has reached a specific location
- Idea:
  - "Print" to the screen when it has reached a given location in the program

# Add Print Blocks




Run the program …

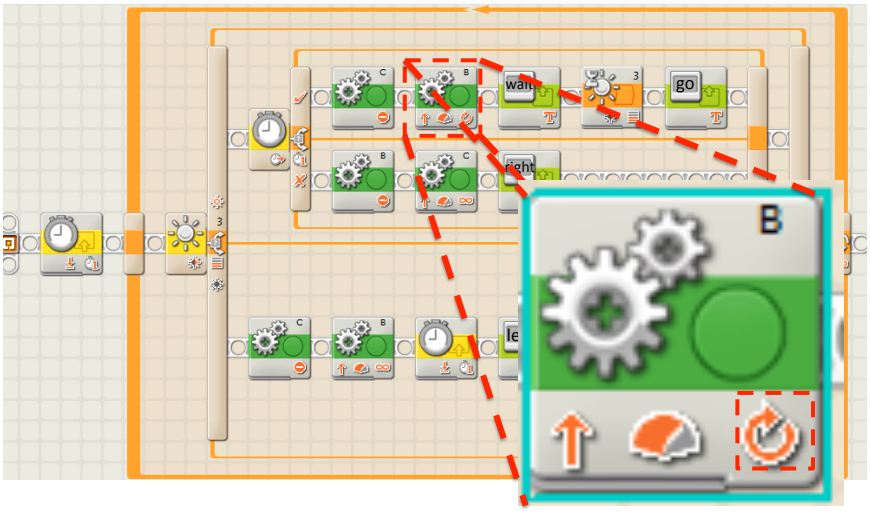
# Resulting Output when Program Stops



# Deduction

- Our program printed out “wait” hence
  - The program is currently doing what?
  - Why is it doing this?
  - Is this correct?
  - Why or why not?
- Assume: Bug is near by (not always the case)

# Where is the bug?

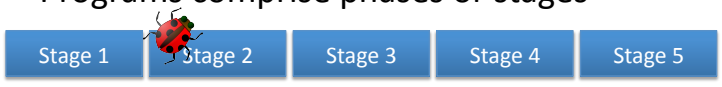


# Drowning in Complexity

- Observations:
  - This is a simple program
  - Yet, debugging it was not easy
  - Imagine what happens with more complex programs
- Question: How do we debug large programs?
  - Sometimes bugs are not near their manifestation
  - We cannot put output blocks everywhere
    - Too much output
    - Takes too long to do
  - We need to be selective
- We need a debugging strategy!

# Divide and Conquer

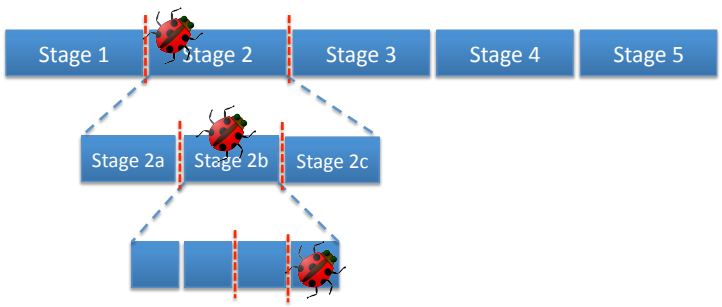
- Question: How do you search a phonebook?
- Idea: We can search a program for bugs in the same manner
- Observation:
  - Programs are linear entities
  - Programs comprise phases or stages




- Question: Does the bug occur before Stage 3?

# Finding the Bug

Key Idea: The partitions are where you place print blocks




Question: What happens if the program cannot be subdivided further?

# Discussion

- Debugging is an art, not a science
  - It's hard to do
  - A little different each time
  - Requires you to solve many small problems
  - Can take a long time
- There is no silver bullet (no quick fix)
- There systematic approaches to ease debugging
  - Use output to identify location of bug manifestation
  - Use "divide and conquer" to narrow your search
  - Have someone look over your shoulder (really!)