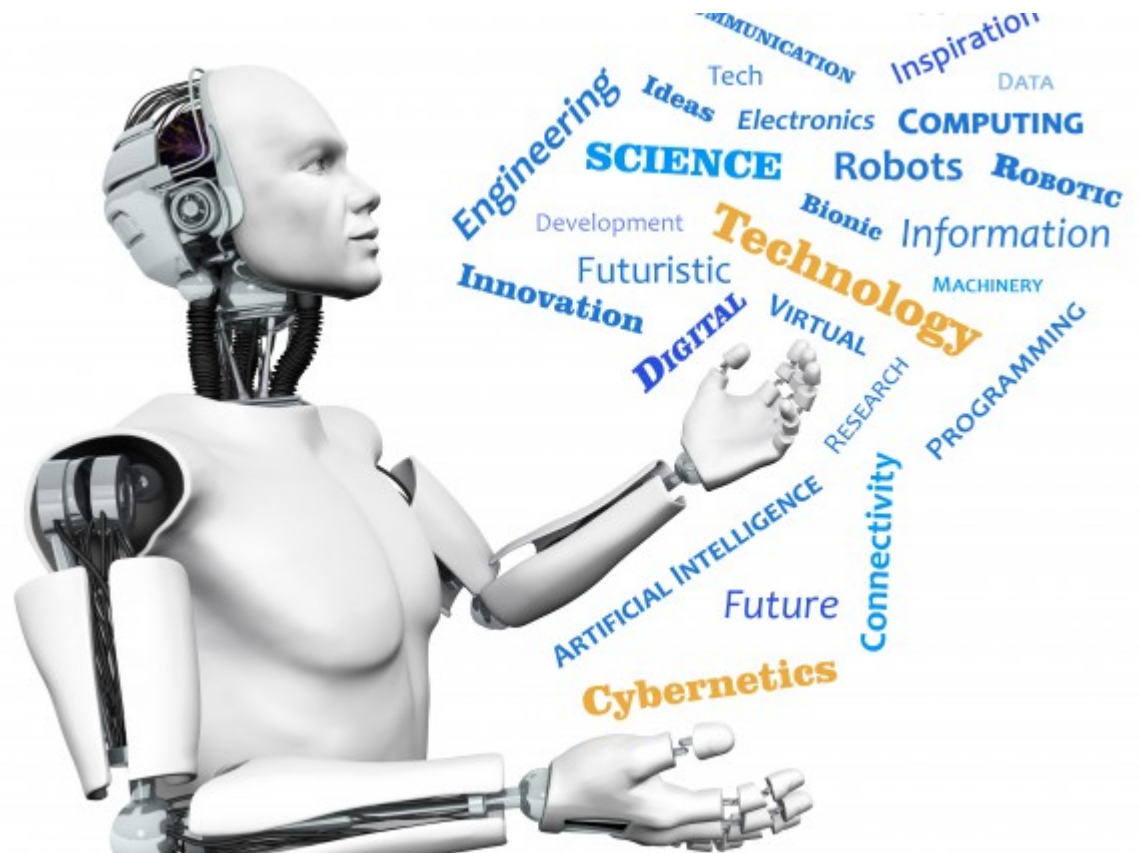


# 15-494/694: Cognitive Robotics

Dave Touretzky

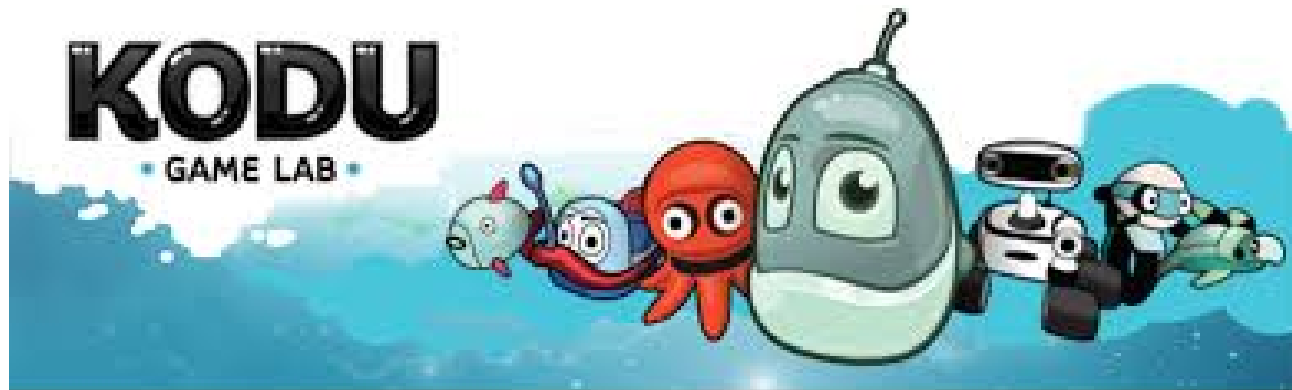
Lecture 17:

Calypso (Kodu for Robots)



# Microsoft's Kodu Game Lab

- Children's programming language: make your own computer games.
- Developed by Microsoft FUSE Labs.
- Released in 2009 for Xbox 360 and Windows.
- Inspired by behavior-based robotics.



# Kodu Worlds

Full 3D, with physics and sound effects.



# “Parallel” WHEN-DO Rules



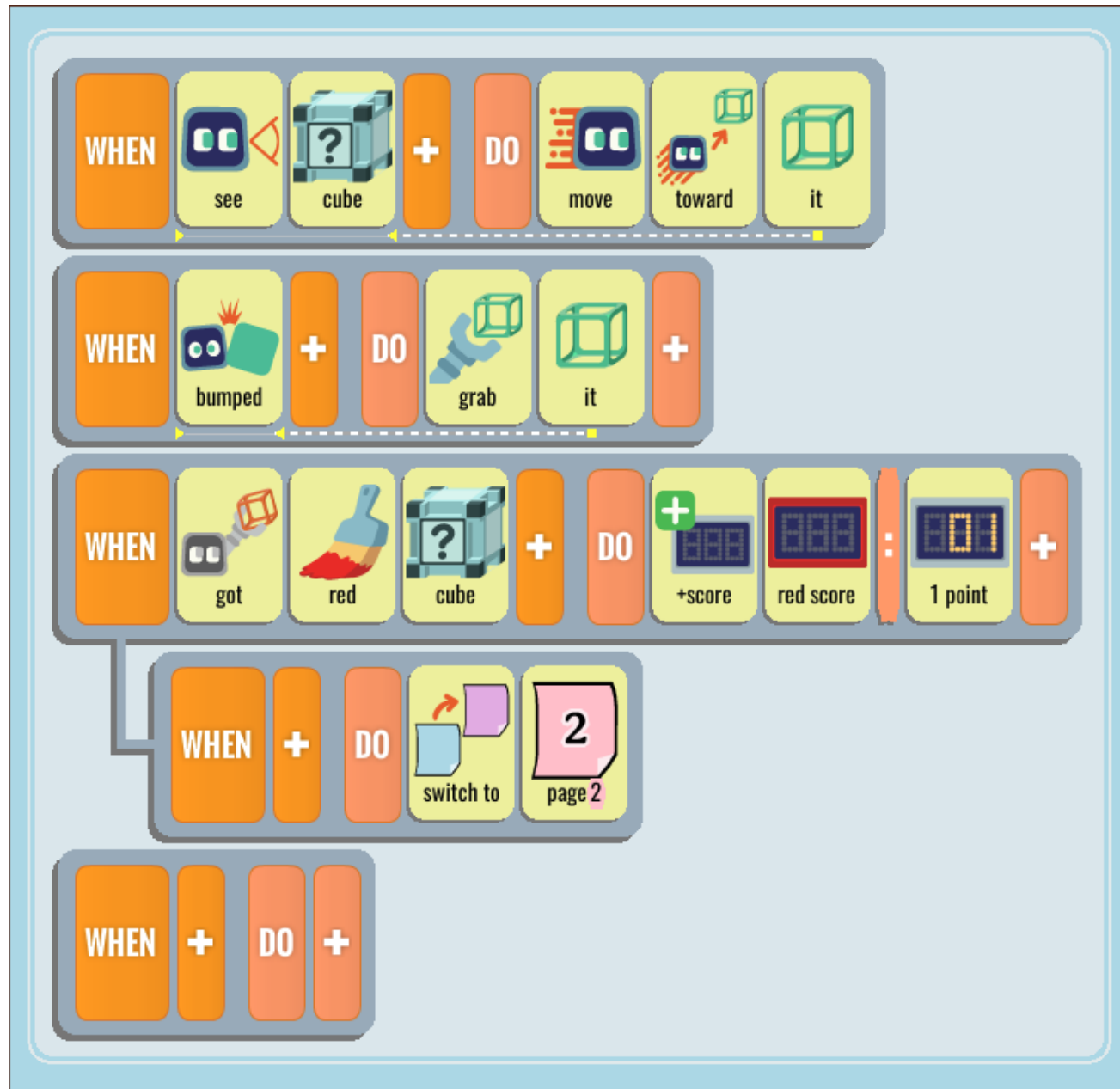
# Menu Selection



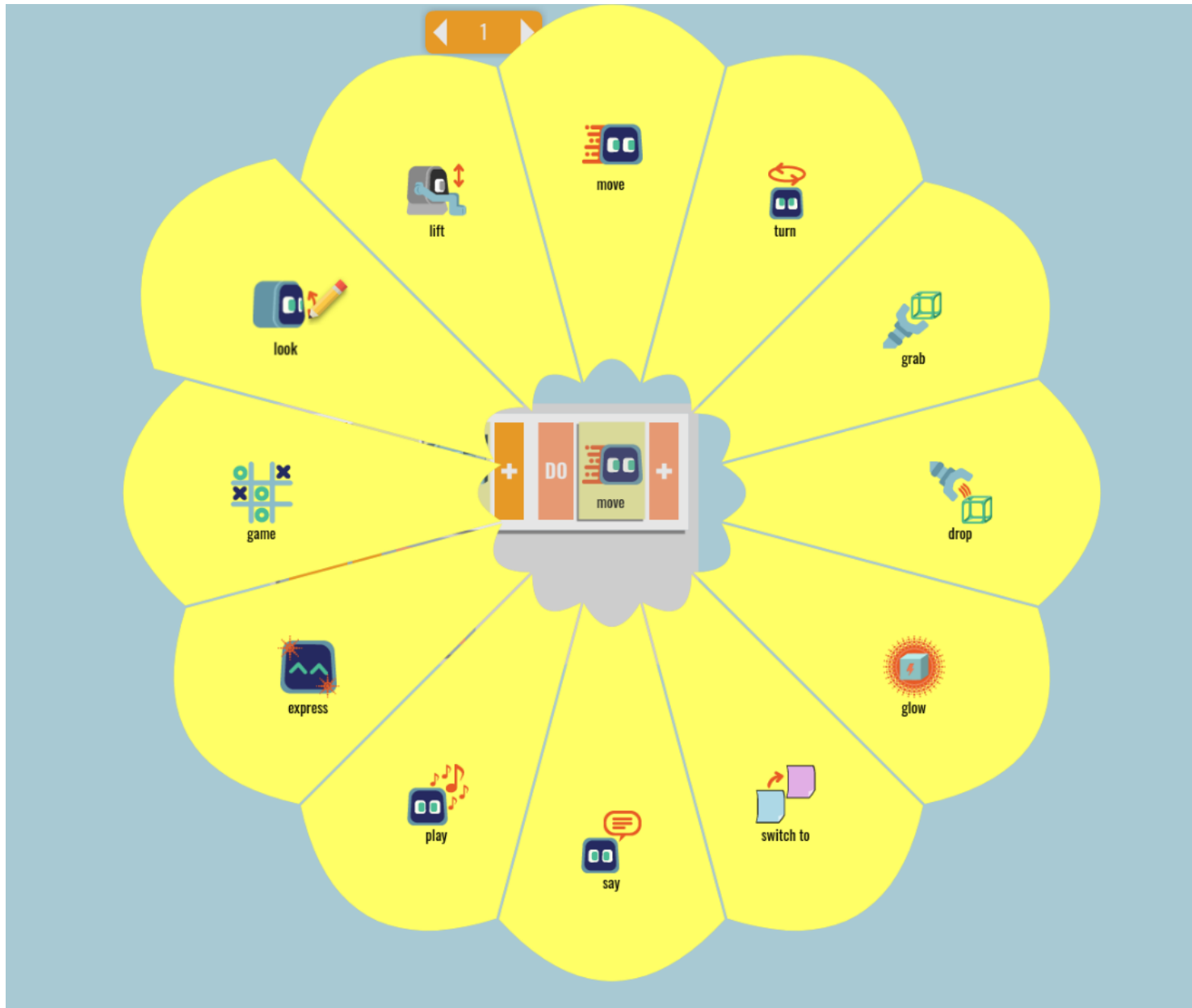
# Calypso: Kodu for Robots



# Sample Calypso Program



# Context-Sensitive Petal Menus





# The Robot's World Map

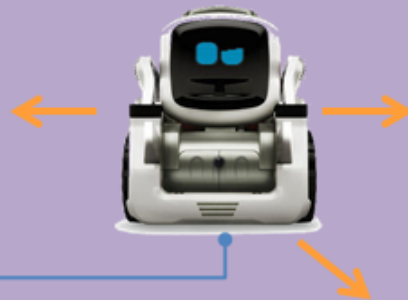
The screenshot displays the Calypso 0.9.04 web interface. The browser address bar shows the URL `127.0.0.1:43125/Calypso/index.html`. The interface is divided into several sections:

- Left Panel:** Contains a menu with the following items:
  - Stop program
  - Ctrl ↑ State machine view
  - Ctrl ← → Switch characters
  - Ctrl ↓ Map editor view
  - Esc Stop program
  - Scroll up/down
- Center Panel:** Displays a visual programming interface with two rows of blocks:
  - Row 1: WHEN (orange) → see (robot icon) → cube (cube icon) → + → DO (orange) → move (robot icon) → toward (arrow icon) → it (cube icon)
  - Row 2: WHEN (grey) → bumped (robot icon) → cube (cube icon) → + → DO (grey) → grab (robot icon) → it (cube icon) → +
- Right Panel:** Shows a 2D world map with a robot icon and a red line indicating its path or position.
- Bottom Left:** A video feed showing the robot's perspective. Two lightcubes are visible, labeled "Lightcube 2 id=1" and "Lightcube 2 id=2".
- Bottom Right:** A status bar showing battery levels:
  - Cozmo's battery 4 volts
  - Cube1 batt 1.28V (56%)
  - Cube3 batt 1.08V (16%)

# Calypso Idioms (Design Patterns)

## Let Me Drive

Use the sticks or arrow keys to drive Cozmo.



When the sticks or arrow keys are not being pressed, Cozmo is free to move on his own.

## Let Me Drive



Use the sticks or arrow keys to drive Cozmo. The shoulder buttons control the lift.

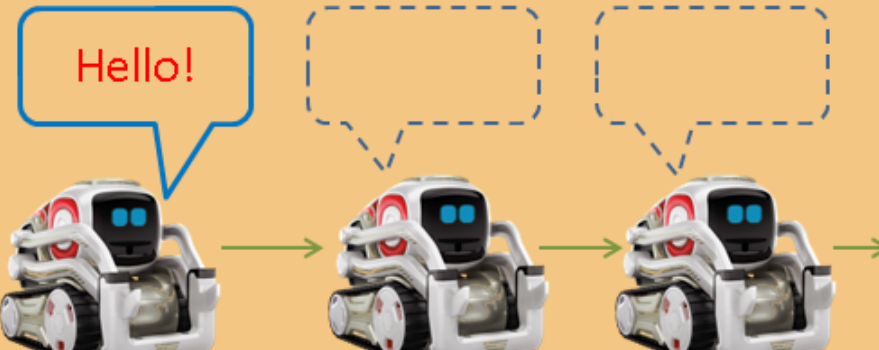


Allow control using only left stick (drive) or right stick (head angle).

# Calypso Idiom: Once Is Enough

### Once Is Enough

Do something one time instead of repeatedly.

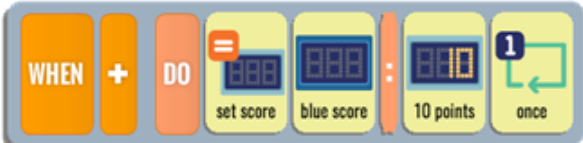


WHEN DO say "Hello!" once


WHEN **condition** DO **action** once

### Once Is Enough


Set the blue score to 10 once; don't try to change it after that:



Act playful when you first see a green cube:



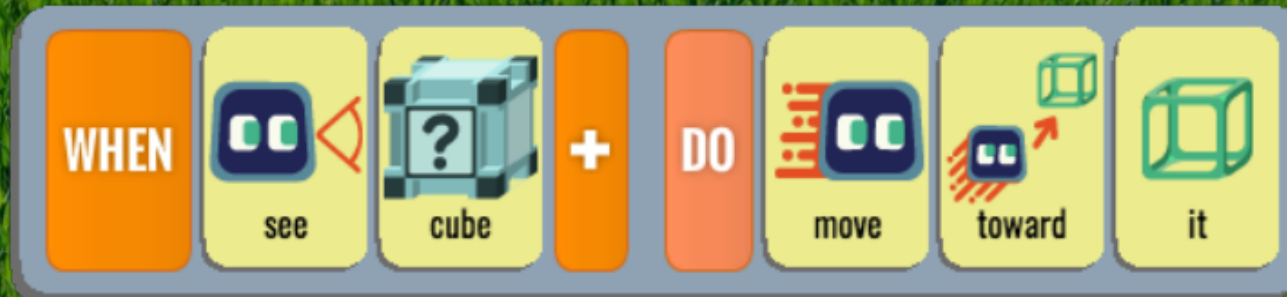
Score one point when you go from "no cube visible" to seeing a cube:



# First Law of Calypso

## First Law of *Calypso*

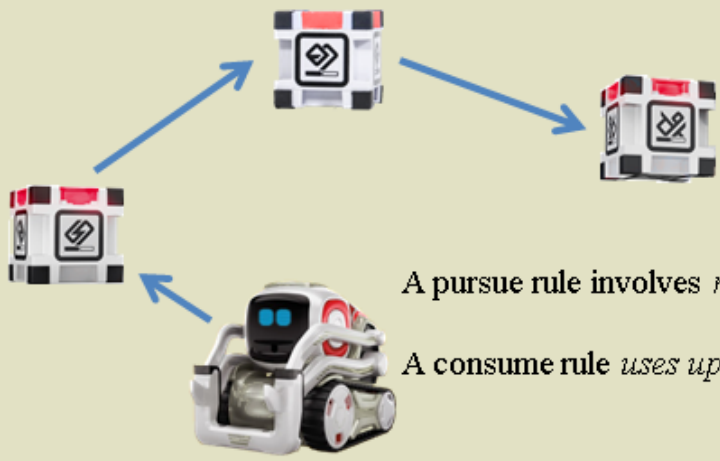
Each rule picks the closest matching object.



# Calypso Idiom: Pursue and Consume

### Pursue and Consume

Make Cozmo extinguish all the red cubes.

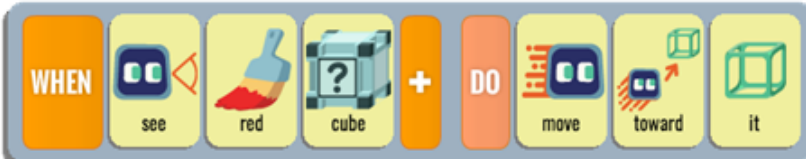


A pursue rule involves *motion*.


A consume rule *uses up* the object.

### Pursue and Consume

Pursue rule



Consume rule



General Form:  
WHEN see *thing* DO move toward it  
WHEN bumped *thing* DO *consume* it

# Second Law of Calypso

**Second Law of *Calypso***  
Any rule that can run, will run.

The diagram illustrates the Second Law of Calypso using a sequence of rule blocks and a robot. The background is a desert landscape with rolling hills.

- Top Rule Block (Grey):** WHEN bumped red cube DO grab it +
- Middle Rule Block (Orange/Yellow):** WHEN see red cube + DO move toward it
- Bottom Rule Block (Grey):** WHEN bumped red cube DO grab it +

A red dotted arrow points from the robot to the top rule block, labeled "Seeing + Moving".

A red dotted arrow points from the top rule block to the middle rule block, labeled "same behavior as:".

A small robot is shown in the bottom left corner, with the text "Not Bumping" next to it.

A small cube is shown in the top right corner.

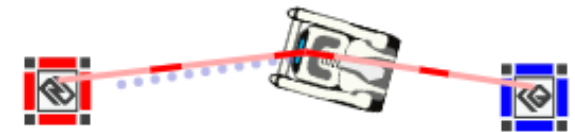
# Third Law of Calypso

**Third Law of *Calypso***  
When actions conflict, the earliest wins.

The diagram illustrates the Third Law of Calypso with two conflicting actions and a robot in a game environment. The top row shows a 'WHEN' condition (robot sees a red cube) followed by a '+' sign and a 'DO' action (robot moves toward the cube). The bottom row shows a 'WHEN' condition (robot sees a blue cube) followed by a '+' sign and a 'DO' action (robot moves toward the cube). The 'DO' actions in the bottom row are faded, indicating they are not executed because the top row's action is executed first. Below the text, a robot is shown in a game environment with two cubes: a blue cube on the left and a red cube on the right. A blue dashed arrow points from the robot to the blue cube, and a red dashed arrow points from the robot to the red cube.

# Third Law Visualization

The image shows a Scratch script editor with two event blocks. The first block is a 'WHEN GREEN FLAG CLICKED' block followed by a 'see red cube' block and a 'DO' block containing 'move it toward it'. The second block is a 'WHEN GREEN FLAG CLICKED' block followed by a 'see blue cube' block and a 'DO' block containing 'move it toward it'. A robot icon is visible in the top right corner of the editor.





# Calypso Idiom: Default Value

## Default Value

When the A button is pressed, glow red.  
Otherwise glow blue.



*situation* → DO **action1** **value**  
*otherwise* → DO **action1** **default-value**

## Default Value

When the A button is pressed, glow red; otherwise glow blue.



General Form:

```
WHEN situation DO action1 value  
WHEN DO action1 default-value
```

The default case must come *after* the specific case. The action must be the same in both rules; only the value is different. For different actions, use the If-Then-Else idiom.

# Fourth Law of Calypso

## Fourth Law of *Calypso*

An indented rule can run only if its parent's action succeeds.

A Kodu block with a yellow background. It starts with a 'WHEN' block (orange) followed by three conditions: 'bumped' (robot bumping a green block), 'green' (a green block), and 'cube' (a white cube with a question mark). This is followed by a 'DO' block (orange) and two actions: 'grab' (a hand holding a cube) and 'it' (a cube). The block ends with a plus sign (+).

A Kodu block with a yellow background. It starts with a 'WHEN' block (orange) followed by three conditions: 'scored' (a digital display showing '222'), 'yellow score' (a digital display showing '000'), and 'greater' (a red greater-than sign). This is followed by a 'DO' block (orange) and two actions: '0 points' (a digital display showing '000') and 'play beeprobo' (a speaker icon with musical notes). The block ends with a plus sign (+).

A smaller version of the first Kodu block: WHEN bumped green cube DO grab it.

Score: 5



A smaller version of the second Kodu block: WHEN scored yellow score greater 0 points DO play beeprobo.

Score: 0



A smaller version of the second Kodu block: WHEN scored yellow score greater 0 points DO play beeprobo.

Score: 5





Actions don't fail in Kodu, but they do on real robots.

# Calypso Idiom: Do Two Things

## Do Two Things

Make Cozmo take two actions with one WHEN condition.

WHEN *something* ... DO **this**   
↳ *and also* → DO **that** 

## Do Two Things

When you feel a cube being tapped, move the lift *and also* play a sound.



General Form:

WHEN *something* DO *action1*

↳ WHEN DO *action2*

Indenting the second rule makes it dependent on the success of the action of the parent rule.

# Calypso Idiom: Count Actions

## Count Actions

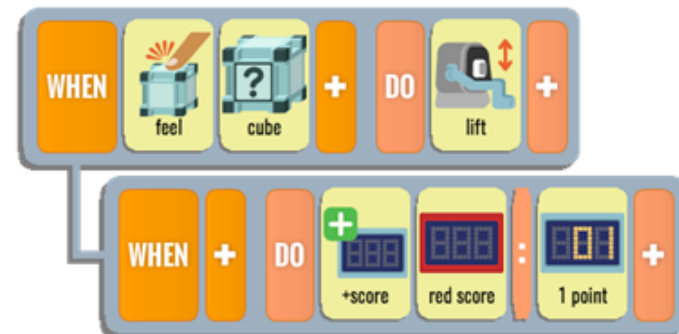
Make Cozmo keep a count of an action he takes.  
This is a special case of Do Two Things.



WHEN *something* DO **action**  
↳ *and also* score **color** 1 point

## Count Actions

When you move the lift, add one to the red score.

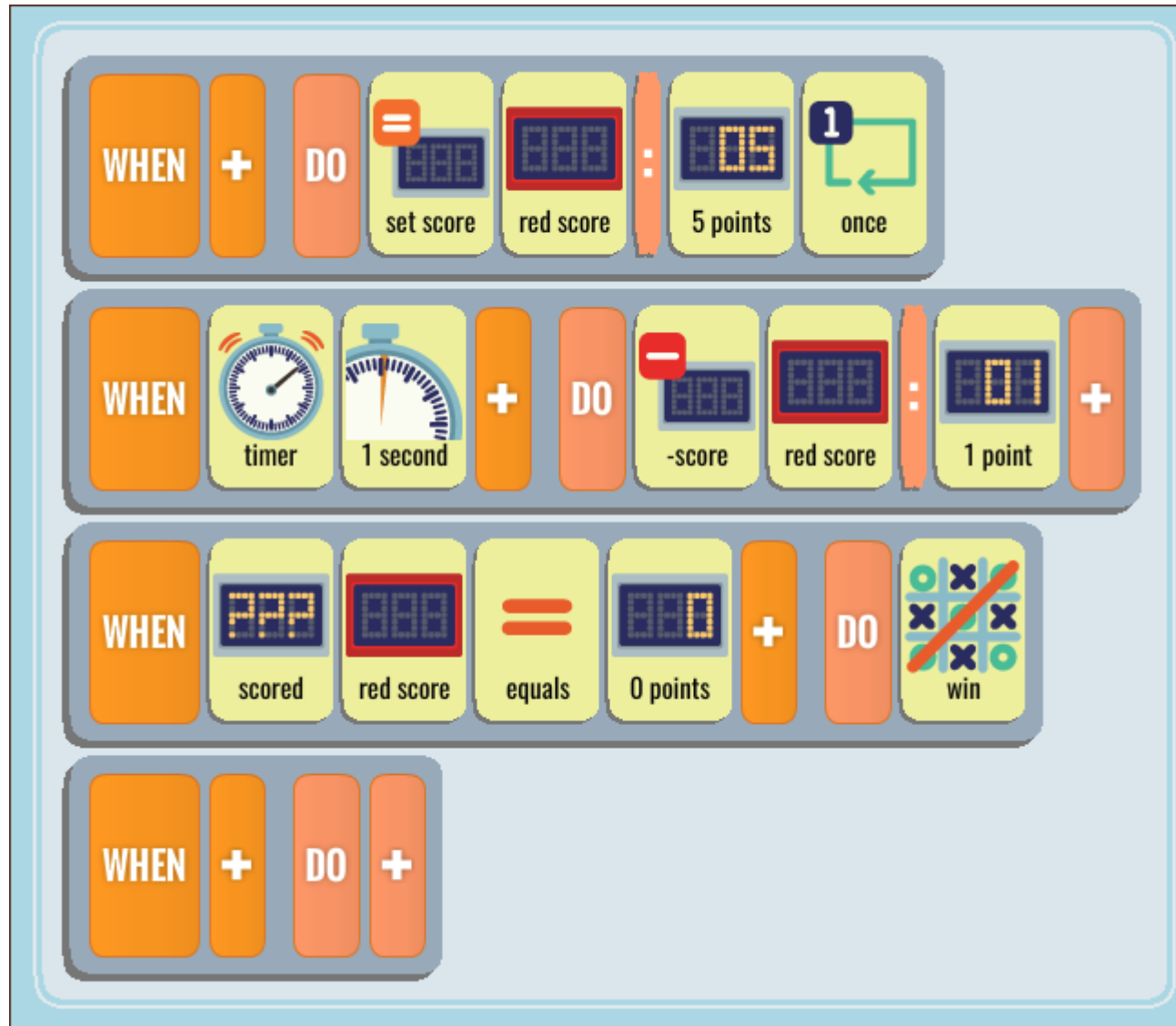


General Form:

WHEN *something* DO **action**  
↳ WHEN DO score **color** 1 point

Scores are named by colors and displayed above the world map.

# Parallel WHEN Evaluation?



In Kodu this would exit immediately.

# Fifth Law of Calypso

**Fifth Law of *Calypso***  
On every cycle, earlier actions affect later rules.

WHEN bumped cube + DO glow it blue

WHEN see blue + DO grab it

WHEN got blue + DO switch to page 2

1 WHEN bumped cube DO glow it blue

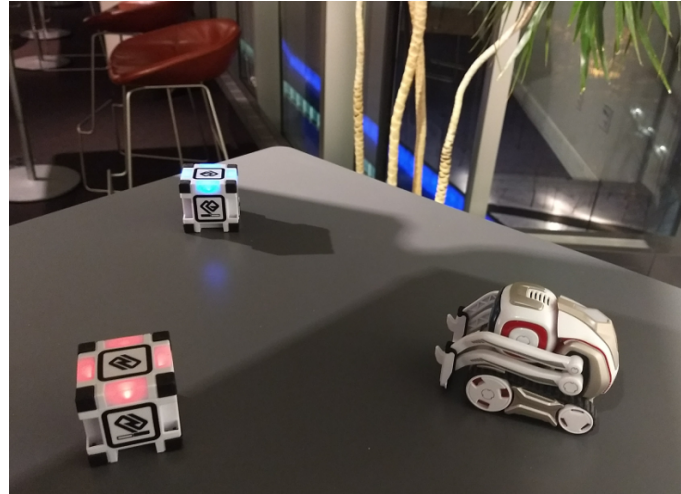
1 WHEN see blue DO grab it

2 WHEN got blue DO switch to page 2

Differs from Kodu, where all WHEN parts are evaluated simultaneously.

# Visiting Cubes in Sequence

Visit red cube and then blue cube.



PAGE 1:

WHEN see red cube + DO move toward it

WHEN bumped red cube + DO switch to page 2

WHEN + DO turn wander

PAGE 2:

WHEN see blue cube + DO move toward it

WHEN bumped blue cube + DO win

WHEN + DO turn wander

# State Machine View



PAGE 1:

Scratch code blocks for PAGE 1:

- Row 1: WHEN see red cube + DO move toward it
- Row 2: WHEN bumped red cube + DO switch to page 2
- Row 3: WHEN + DO turn wander

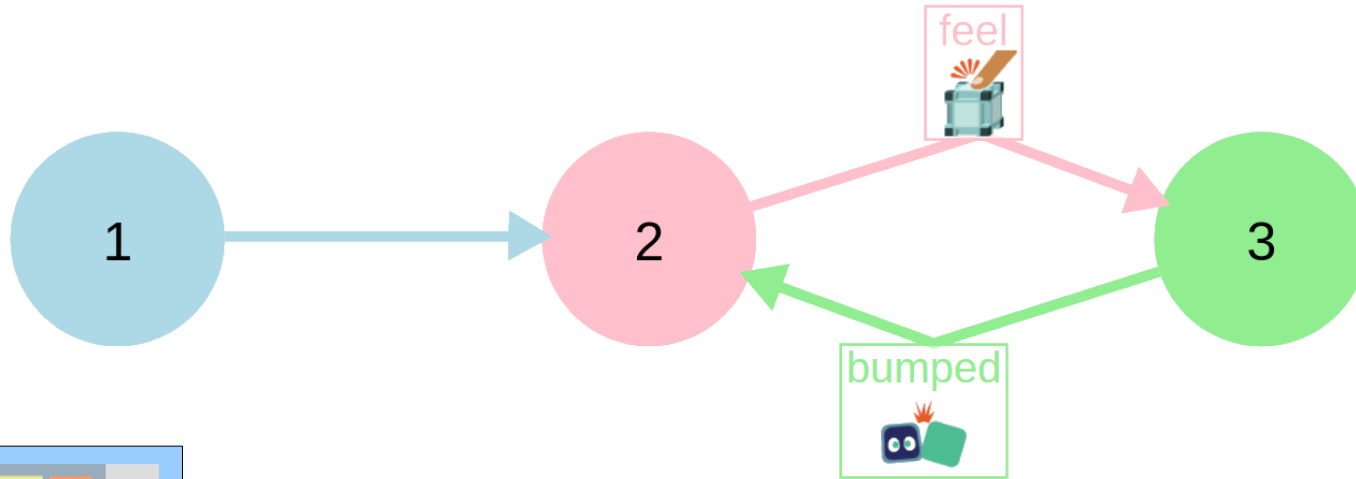
PAGE 2:

Scratch code blocks for PAGE 2:

- Row 1: WHEN see blue cube + DO move toward it
- Row 2: WHEN bumped blue cube + DO win
- Row 3: WHEN + DO turn wander



# Loopy State Machine



PAGE 1:

WHEN	+	DO	say	+
WHEN	+	DO	switch to	page 2

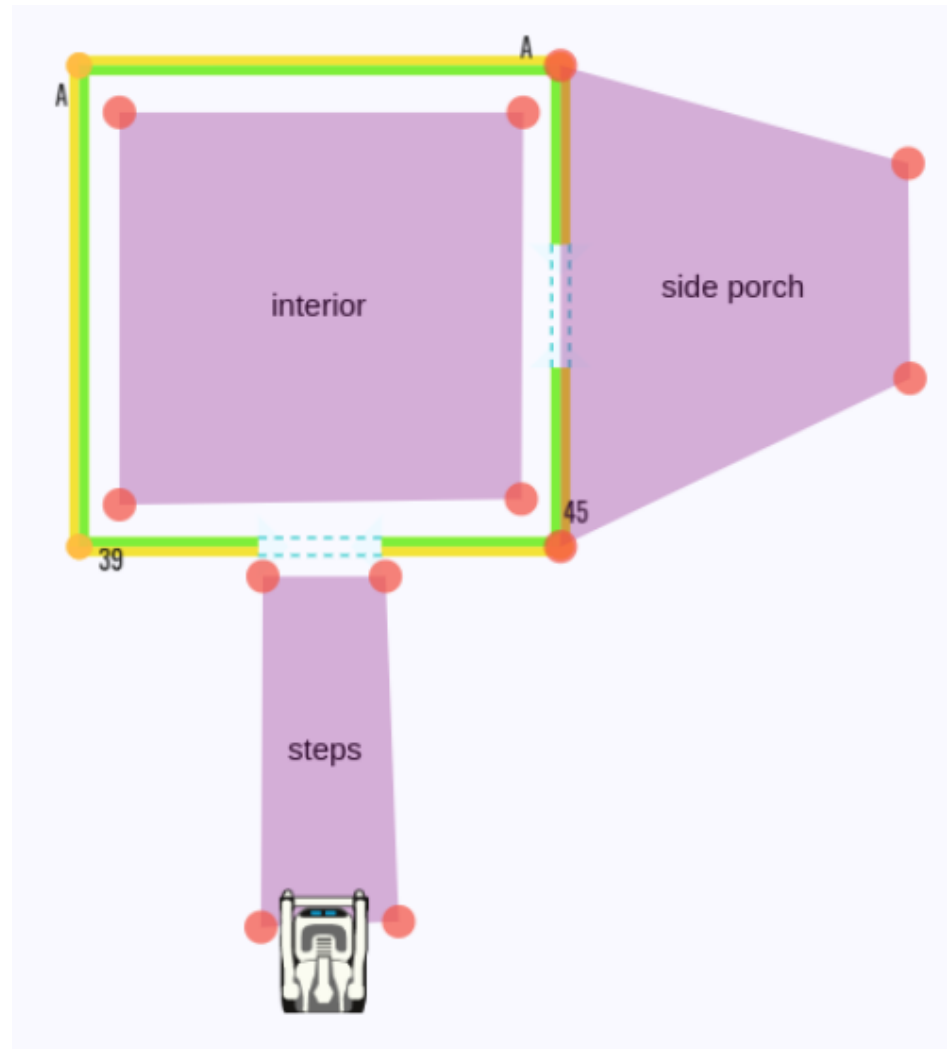
PAGE 2:

WHEN	feel	cube	+	DO	glow	it	red	+
WHEN	+	DO	switch to	page 3				

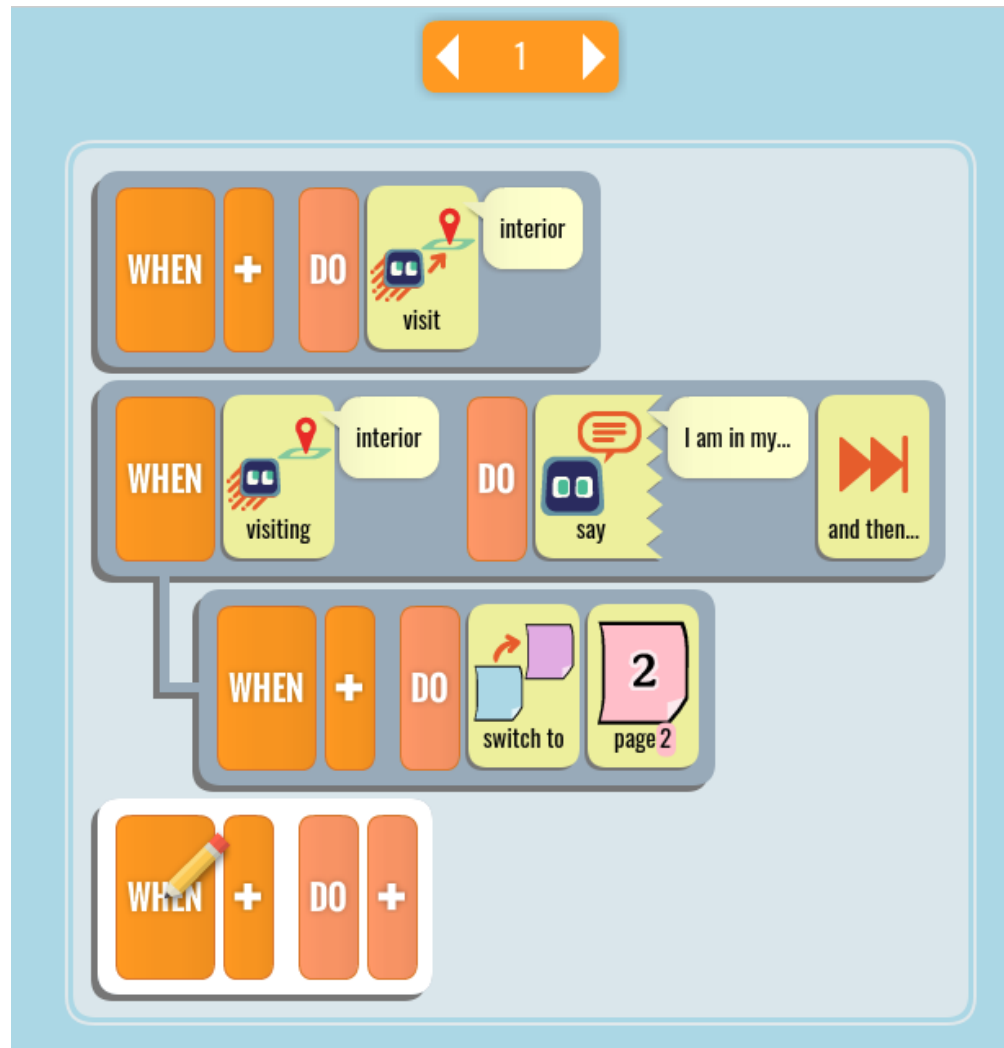
PAGE 3:

WHEN	see	red	cube	+	DO	move	toward	it
WHEN	bumped	red	cube	DO	glow	it	none	+
tap on another one								
WHEN	+	DO	say	+				
WHEN	+	DO	switch to	page 2				

# Walls and Rooms



# Visit Action and Visiting Predicate



# Suspending the Rule Interpreter

- Some actions require full control of the robot and take time to complete. They must suspend the rule interpreter until they succeed or fail:
  - Grab
  - Drop
  - Roll
  - Express
- Some of these actions can fail. We won't know if they succeeded until they complete.

# Four Types of Actions

1) Instantaneous: take effect immediately

- glow, +score, switch to page

2) Extended duration: take time to complete.

- say, play, move or turn by a fixed amount

3) Suspending: take control of the whole robot.

- grab, drop, roll, express

4) Incremental: take tiny steps. Must be repeat across multiple rule cycles to make progress.

- move toward, turn toward, visit

# Extended Duration Actions

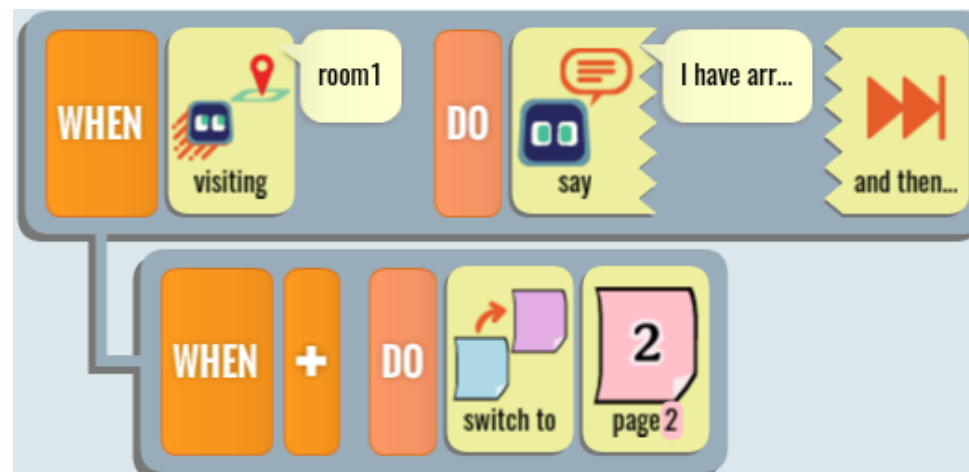
- Extended duration actions take time to complete but can run in parallel with other actions, so they don't suspend:
  - say, play, look, lift
- If we want to suspend execution of indented rules until these actions complete, we add an “and then...” tile.

# Use of “And Then...”

Switches pages as soon as the speech starts.



Switches pages after the speech completes.



# Cloud Calypso

- Runs in the browser.
- Uses *AWS* for authentication and storage.
- Simulated robot and world.
- Try it free at <https://calypso-robotics.com>





Testing  
With  
Real  
Kids

# Code Lab vs. Calypso (1/2)

Feature	Code Lab	Calypso for Cozmo
Free	✓	✗
Familiar to anyone who knows...	Scratch	Kodu Game Lab
Built in to the Cozmo app	✓	✗
Large display; runs on laptop or desktop	✗	✓
Camera viewer shows you what Cozmo is seeing	✗	✓
User-visible world map	✗	✓
Interpreter highlights rules that are running	✗	✓
Xbox game controller, mouse, or keyboard input	✗	✓

# Code Lab vs. Calypso (2/2)

Feature	Code Lab	Calypso for Cozmo
Voice commands	✗	✓
Simulator mode	✗	✓
Support for state machines	✗	✓
Detects failed actions	✗	✓
Free online curriculum	✗	✓

# Calypso Development Plans

- New primitives:
  - Trainable object recognition: done!  
(uses Google's Teachable Machine)
  - Visual search (in progress)
  - Line following
- New object types:
  - Chips
  - Qubes
  - Containers
- Multi-robot support