

15-494/694: Cognitive Robotics

Dave Touretzky

Lecture 16:

Calypso (Kodu for Robots)

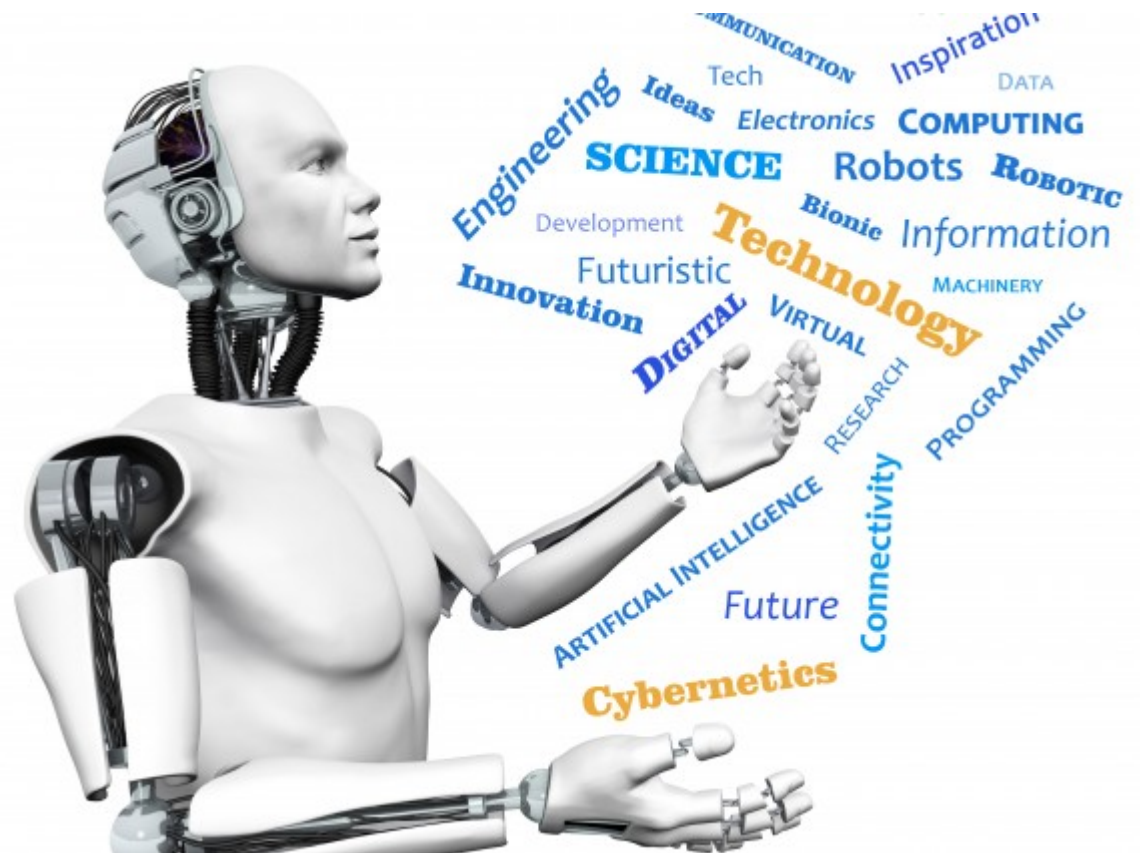
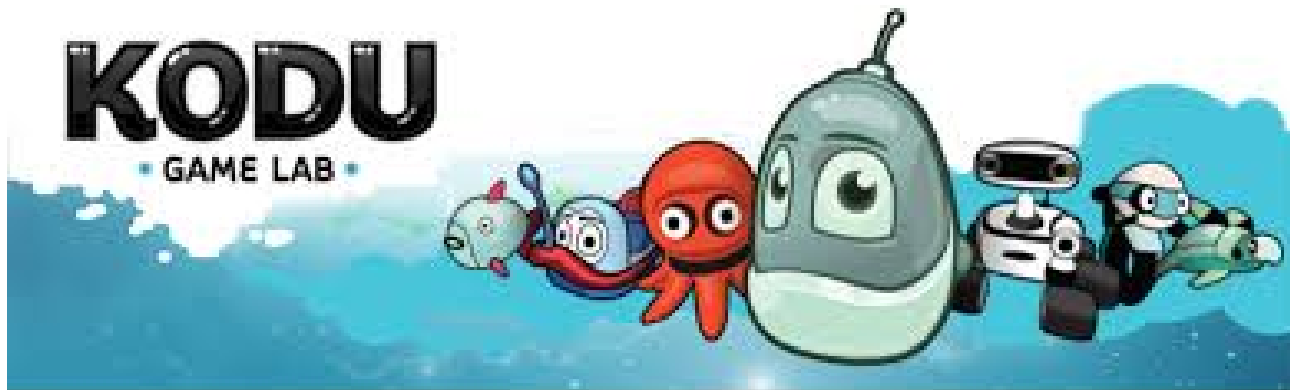


Image from <http://www.futuristgerd.com/2015/09/10>

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



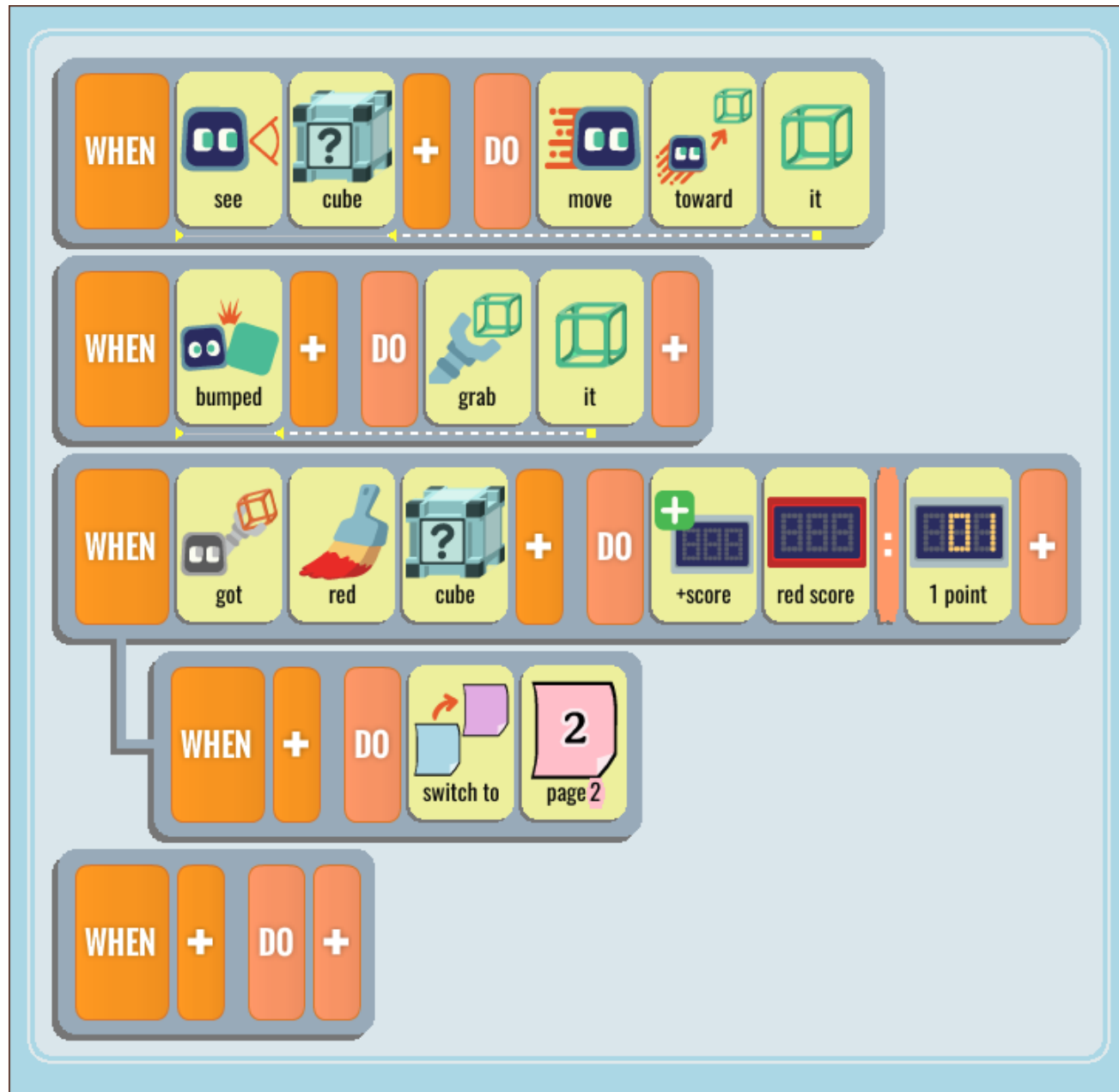
Menu Selection



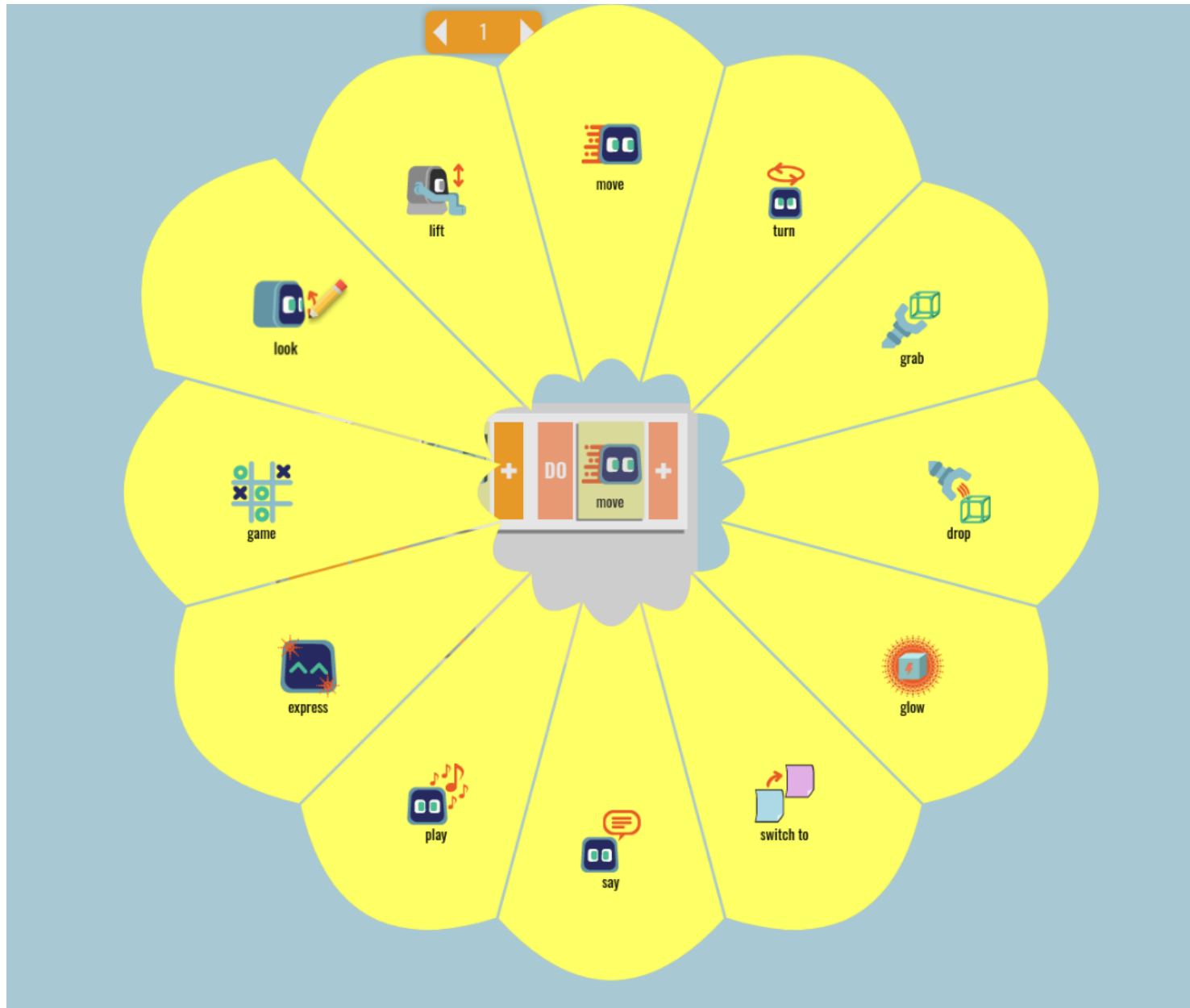
Calypso: Kodu for Robots



Sample Calypso Program



Context-Sensitive Petal Menus

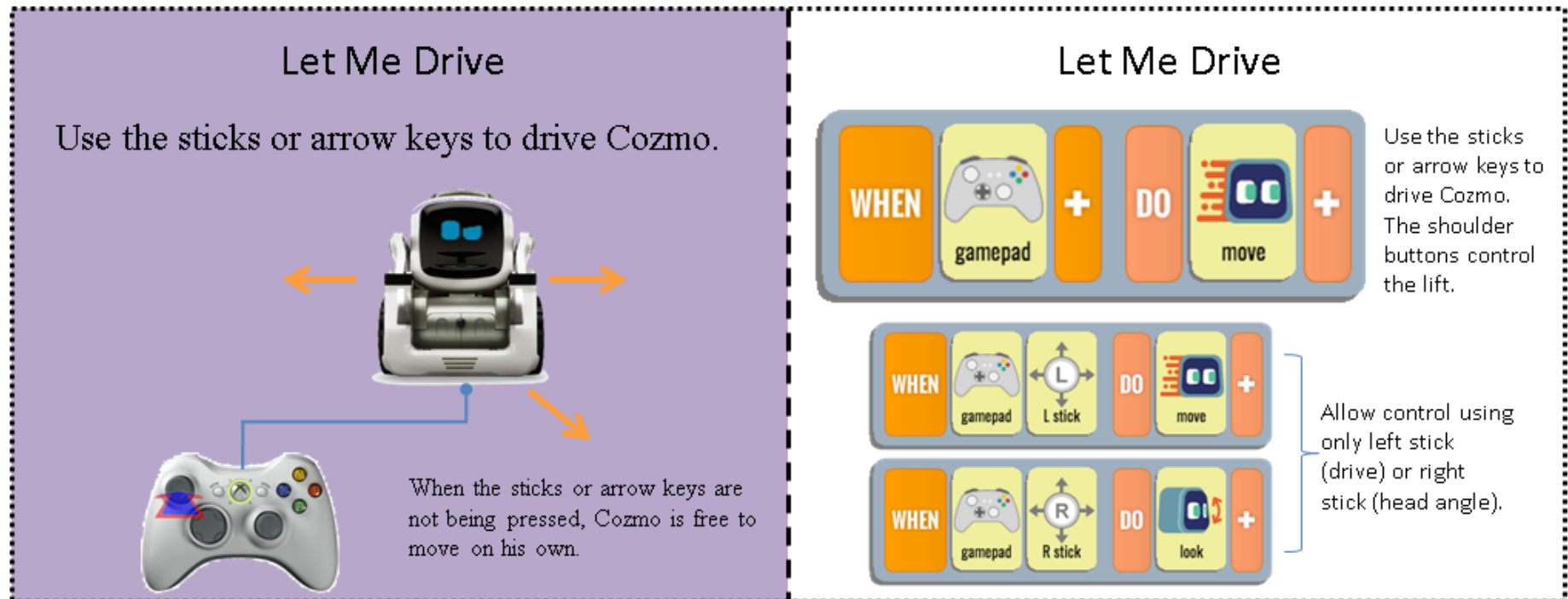


The Robot's World Map

The screenshot displays the Calypso 0.9.04 web interface. The top navigation bar includes a 'Settings' link and a tab for 'Calypso 0.9.04'. The browser address bar shows '127.0.0.1:43125/Calypso/index.html'. The main interface is divided into several sections:

- Left Panel:** Contains a 'Stop program' button and a list of keyboard shortcuts: 'Ctrl ↑ State machine view', 'Ctrl ← → Switch characters', 'Ctrl ↓ Map editor view', 'Esc Stop program', and 'Scroll up/down'.
- Center Panel:** Features a '1' button and two rows of action blocks. The top row includes 'WHEN see cube + DO move toward it'. The bottom row includes 'WHEN bumped cube + DO grab it +'. Each block contains a small icon representing the action.
- Right Panel:** Displays a 'World Map' showing a robot's path and a red line indicating a specific action or state.
- Bottom Panel:** Shows a video feed of the robot's environment. Two yellow boxes highlight specific objects, labeled 'Lightcube 2 id=1' and 'Lightcube 2 id=2'.
- Status Bar:** At the bottom, it displays 'Cozmo's battery 4 volts' and 'Cube1 batt 1.28V (56%), Cube3 batt 1.08V (16%)'.

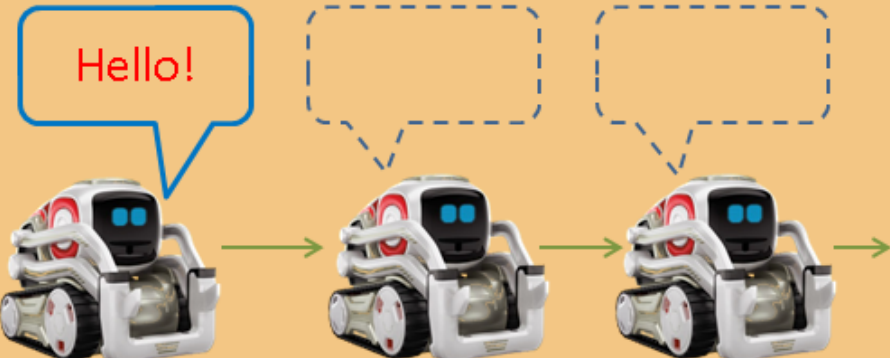
Calypso Idioms (Design Patterns)



Calypso Idioms (Design Patterns)

Once Is Enough

Do something one time instead of repeatedly.

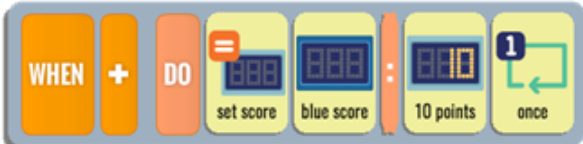


WHEN DO say "Hello!" **once**


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:



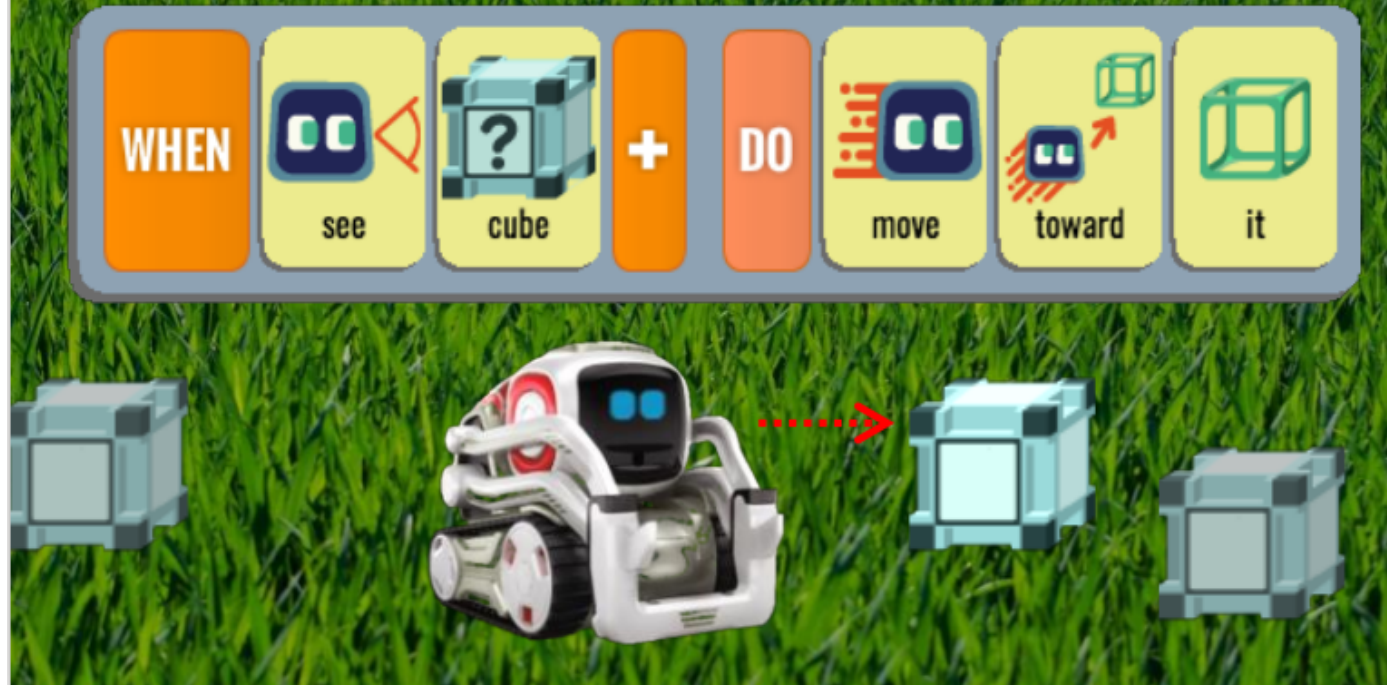
Score one point when you go from "no cube visible" to seeing a cube:



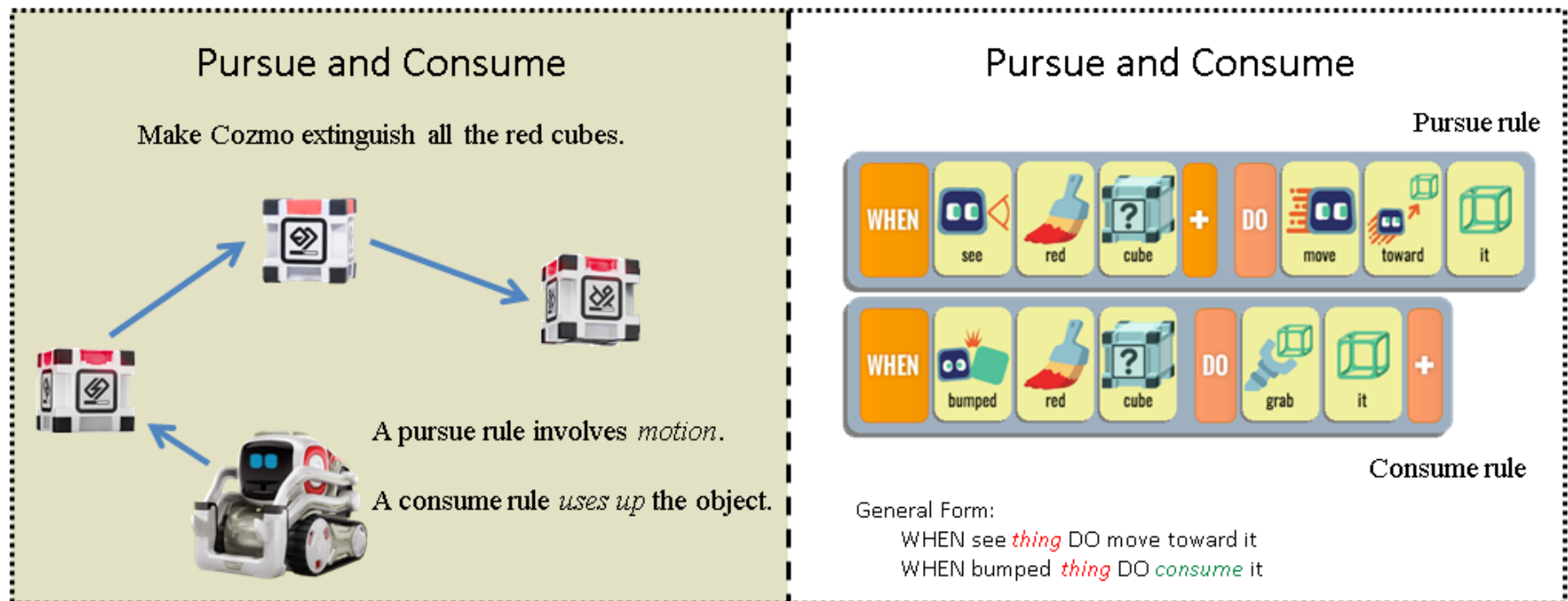
First Law of Calypso

First Law of *Calypso*

Each rule picks the closest matching object.

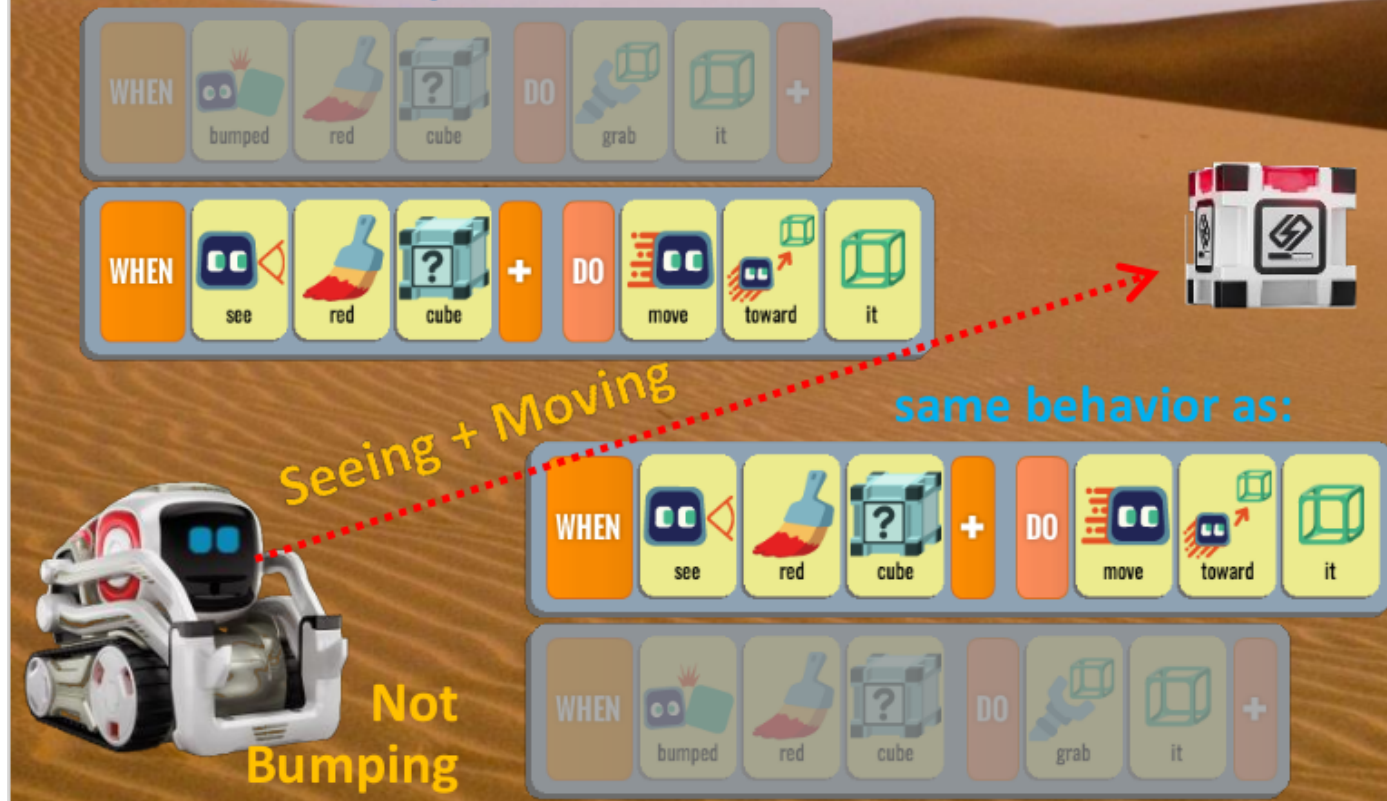


Calypso Idioms (Design Patterns)



Second Law of Calypso

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



Third Law of Calypso

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

The diagram illustrates the Third Law of Calypso, which states that when actions conflict, the earliest wins. It shows two sequences of actions in a game environment:


- Sequence 1 (Top):** WHEN see red cube + DO move toward it. This sequence is active, with the 'DO' button highlighted in orange.
- Sequence 2 (Bottom):** WHEN see blue cube + DO move toward it. This sequence is inactive, with the 'DO' button highlighted in grey.

Below the sequences, a robot is shown in a game environment. A blue dashed arrow points from the robot to a cube on the left, and a red dashed arrow points from the robot to a cube on the right, indicating a conflict in actions.

Calypso Idioms (Design Patterns)

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.

The diagram illustrates the Fourth Law of Calypso, which states: "An indented rule can run only if its parent's action succeeds." It shows three scenarios of a robot's actions and their outcomes:



- Scenario 1 (Left):** The robot bumps a green cube. The parent action (bumped) succeeds, so the indented action (grab it) runs. The robot then plays a beeper, resulting in a **Score: 5**.
- Scenario 2 (Middle):** The robot bumps a green cube. The parent action (bumped) fails (the cube is not green), so the indented action (grab it) does not run. The robot then plays a beeper, resulting in a **Score: 0**.
- Scenario 3 (Right):** The robot bumps a green cube. The parent action (bumped) succeeds, so the indented action (grab it) runs. The robot then plays a beeper, resulting in a **Score: 5**.

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

Calypso Idioms (Design Patterns)

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 Idioms (Design Patterns)

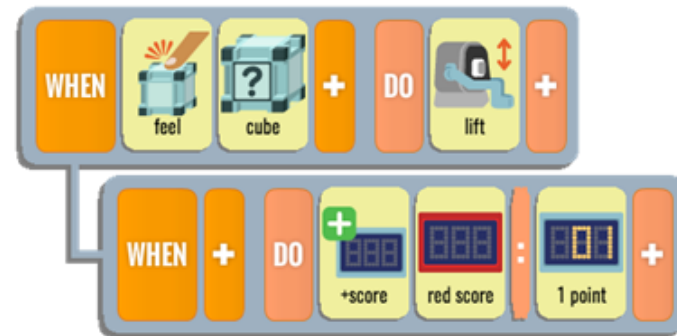
Count Actions

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

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

Count Actions

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

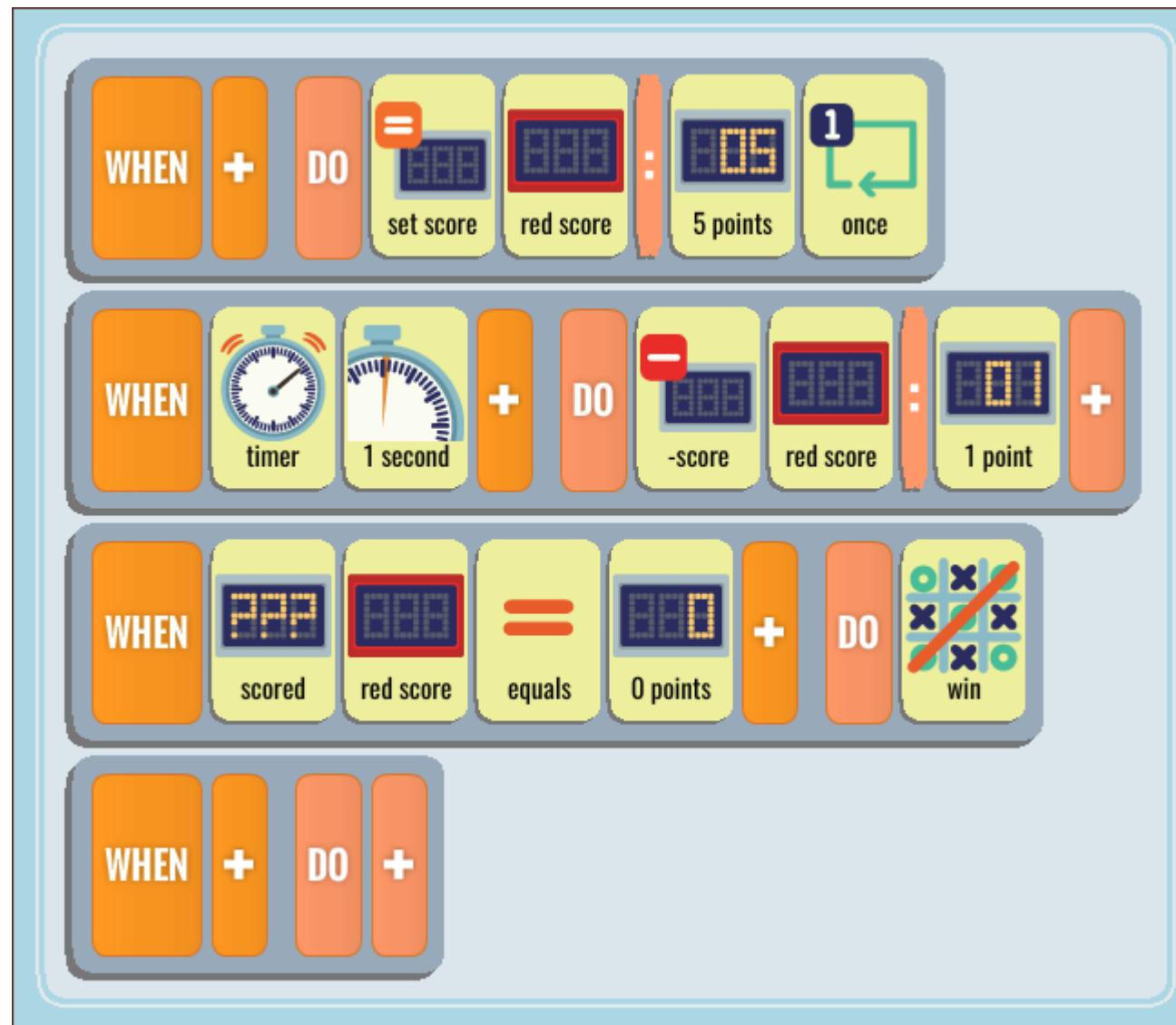


General Form:

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

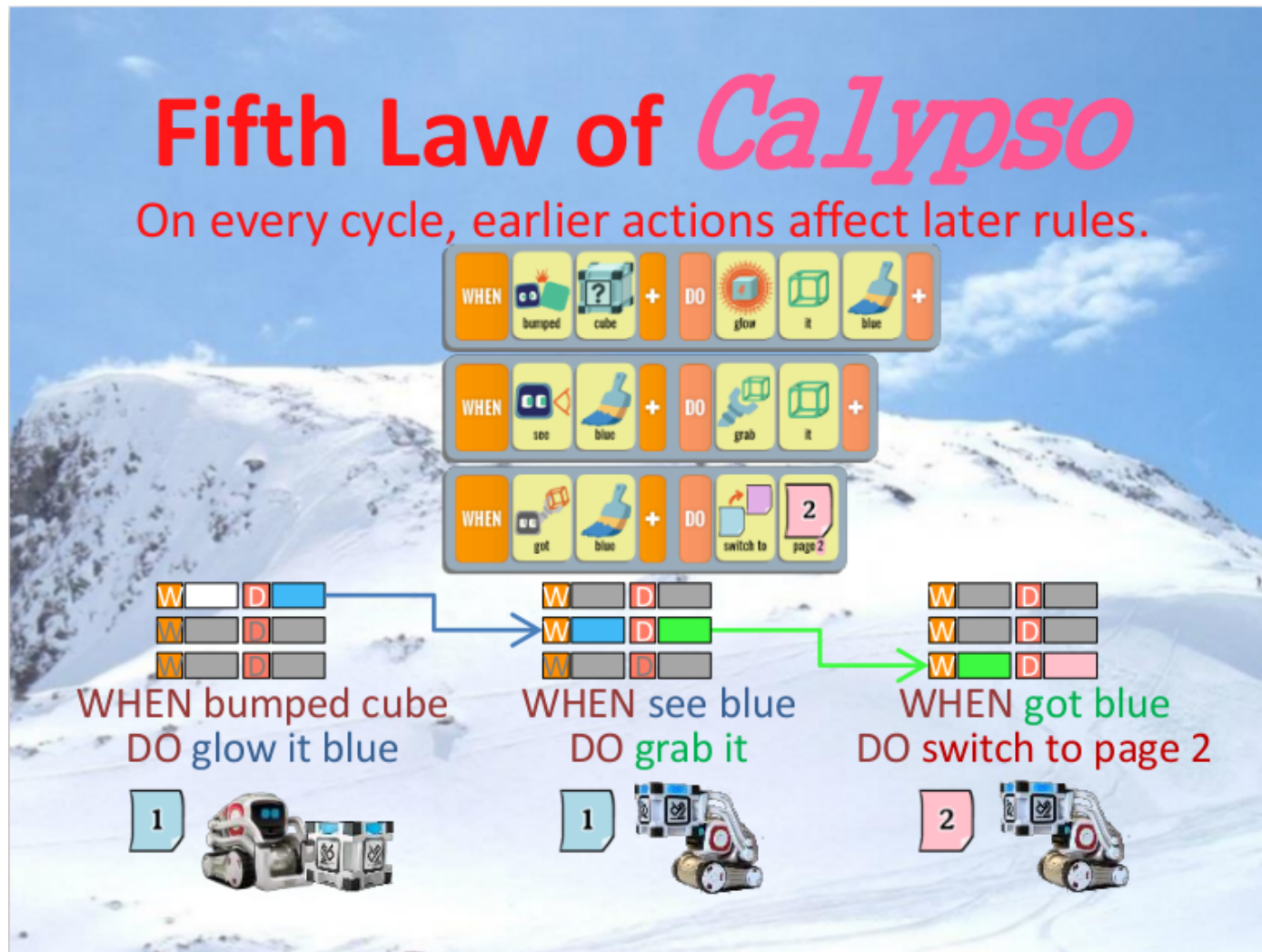
Scores are named by colors and displayed above the world map.

Parallel WHEN Evaluation?



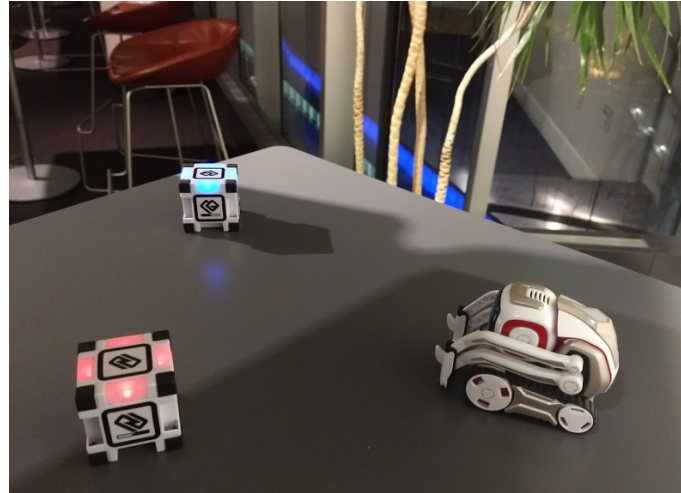
In Kodu this would exit immediately.

Fifth Law of Calypso



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

Visiting Cubes in Sequence



PAGE 1:

Visual programming 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:

Visual programming 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)

State Machine View



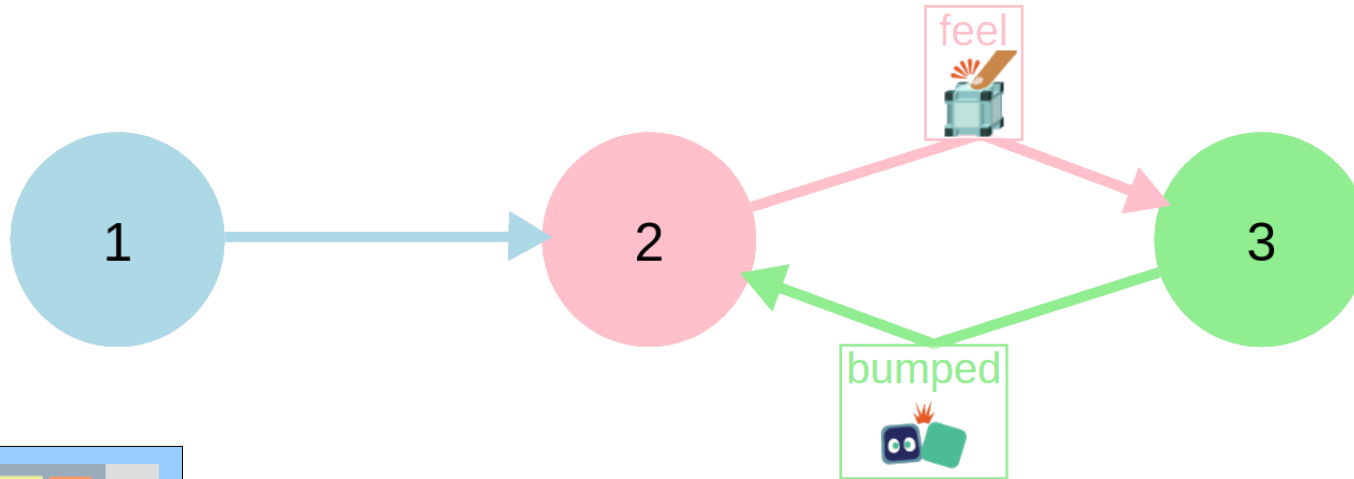
PAGE 1:



PAGE 2:



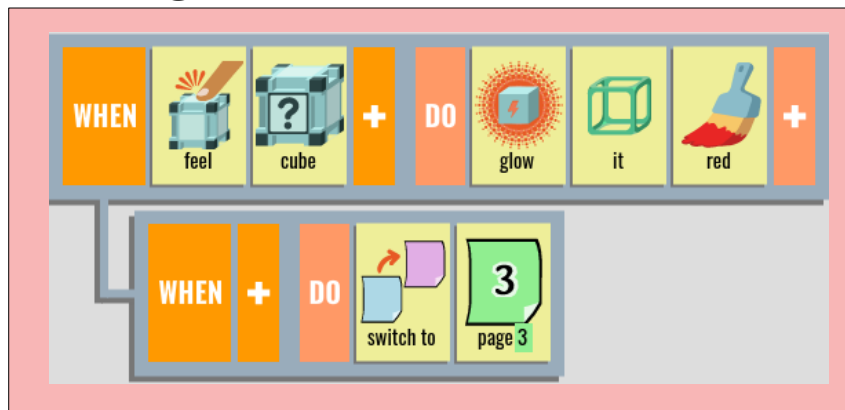
Loopy State Machine



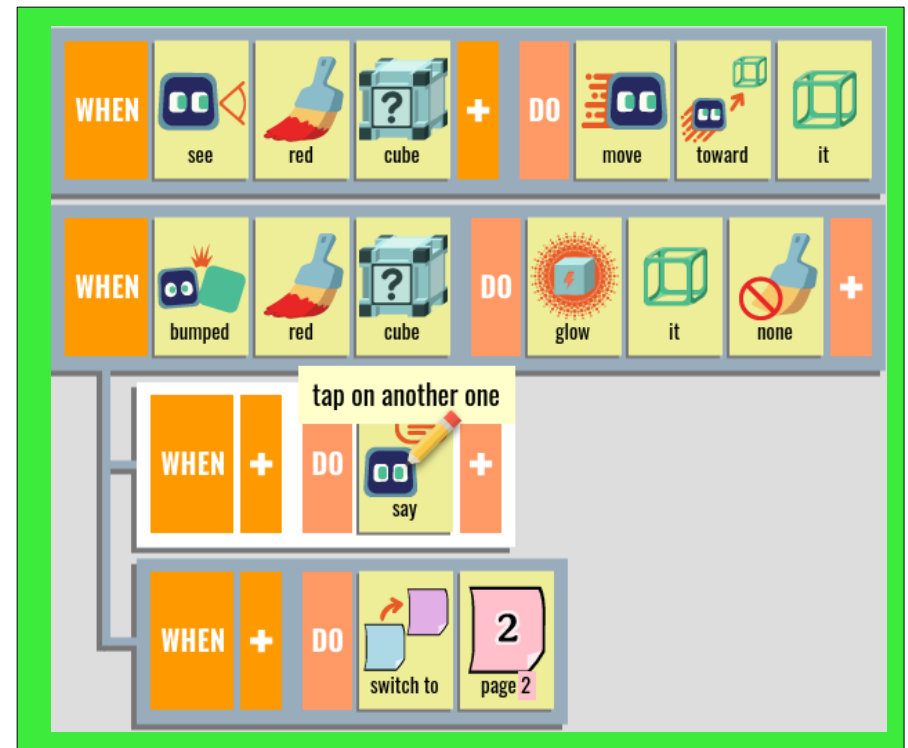
PAGE 1:



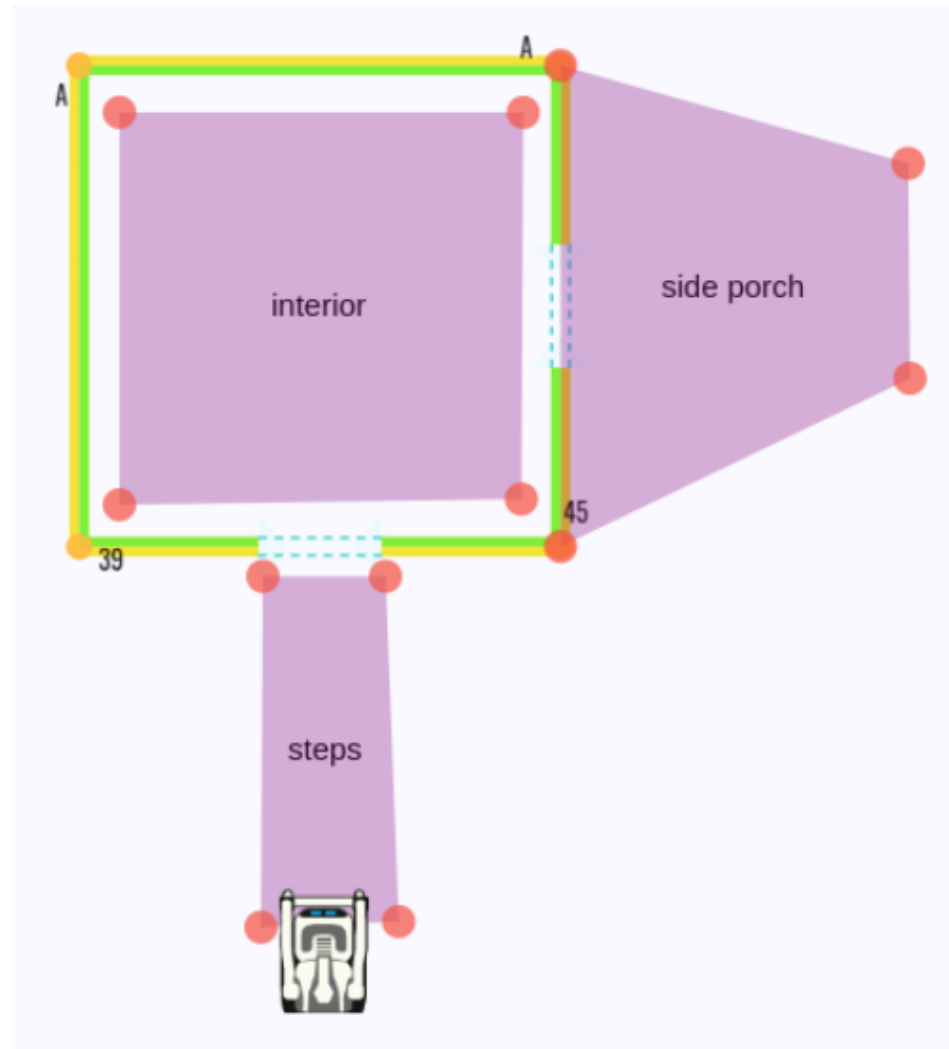
PAGE 2:



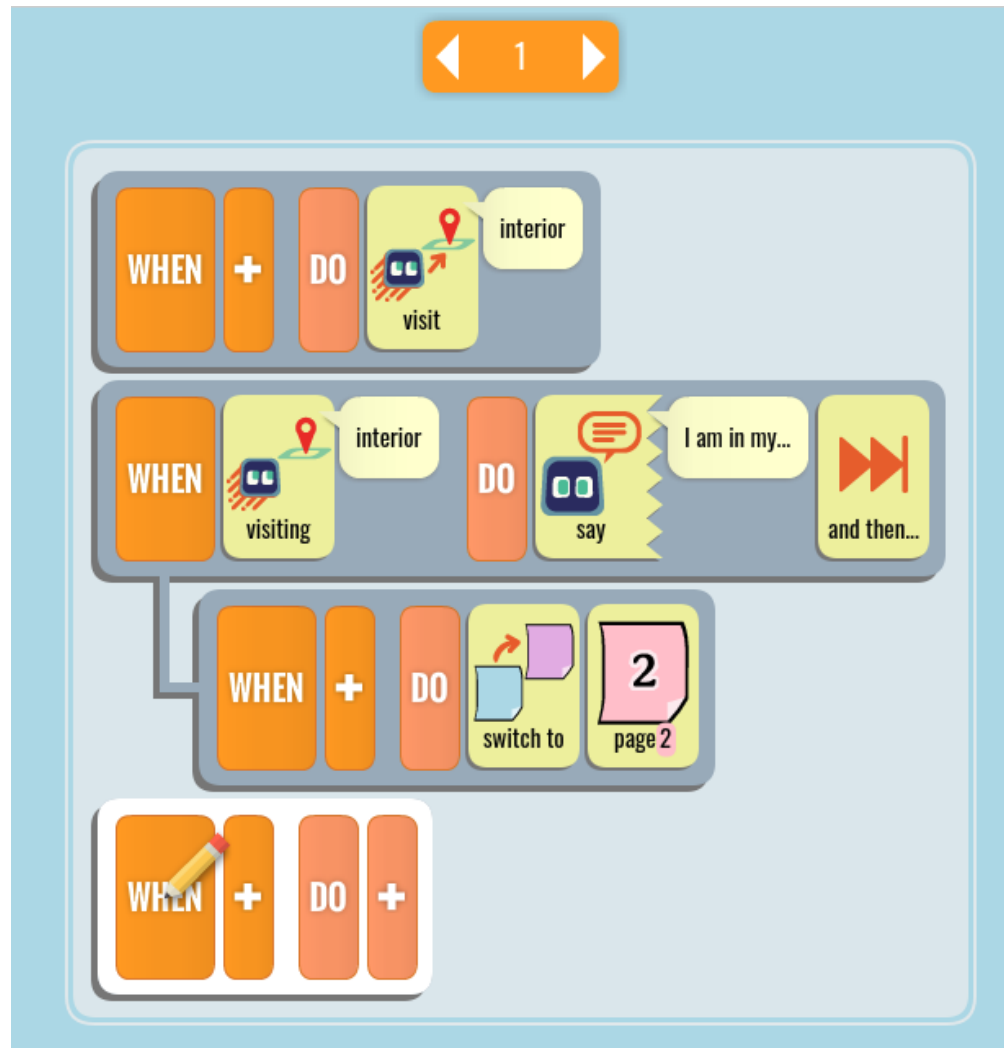
PAGE 3:



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

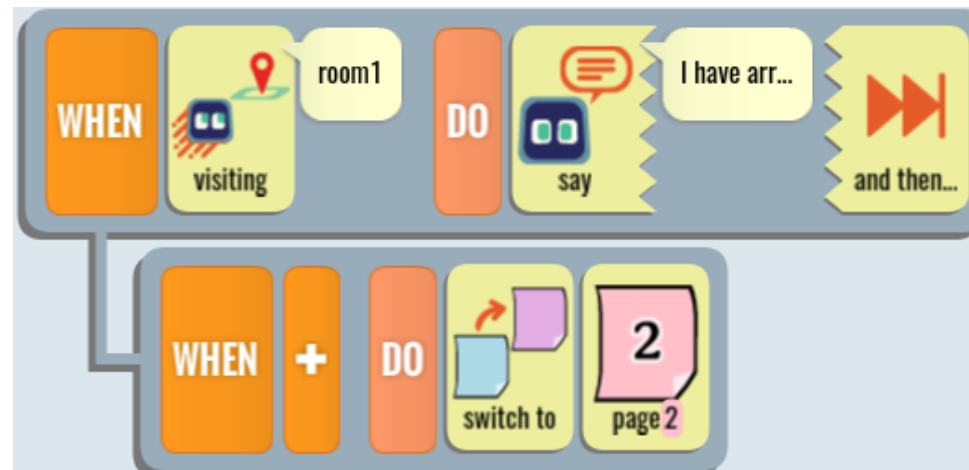
- Extended duration actions take time to complete but can run in parallel with other actions, so they don't suspend:
 - say, play, look, lift
- If we want to suspend execution of indented rules until these actions complete, we add an “and then...” tile.

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