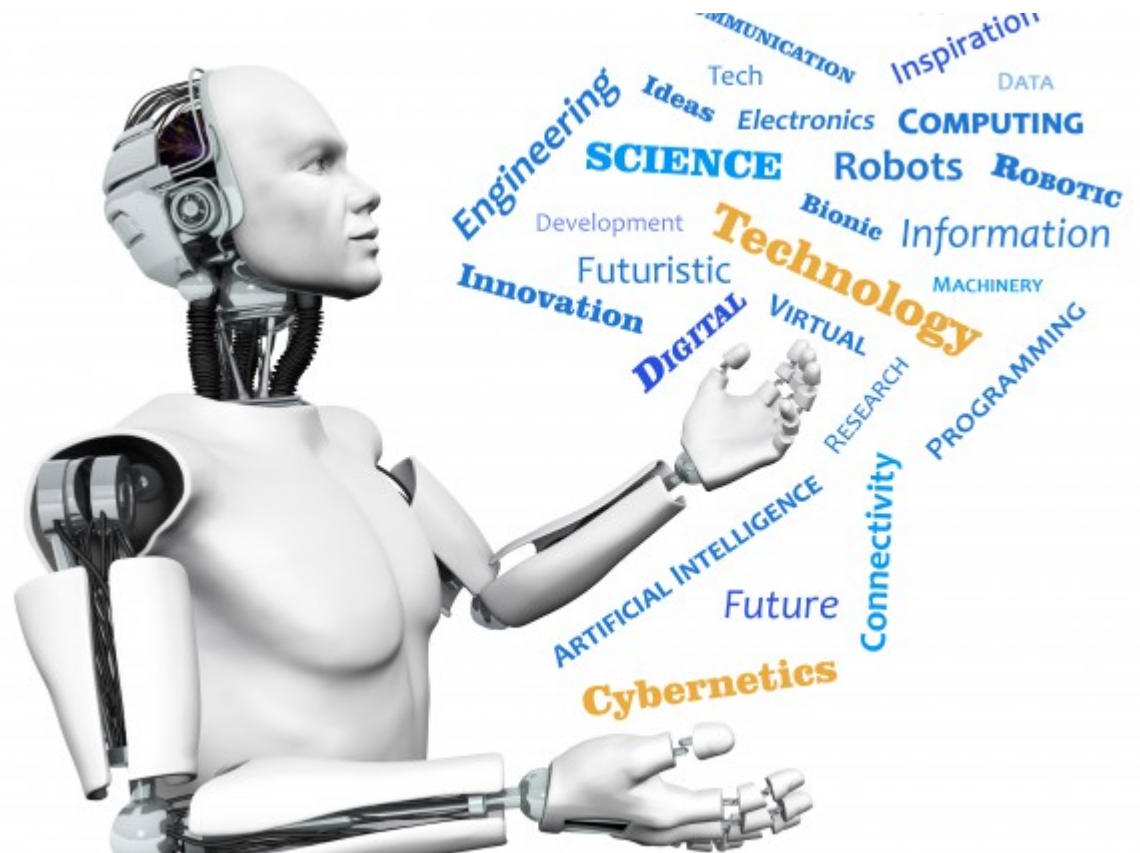


15-494/694: Cognitive Robotics

Dave Touretzky

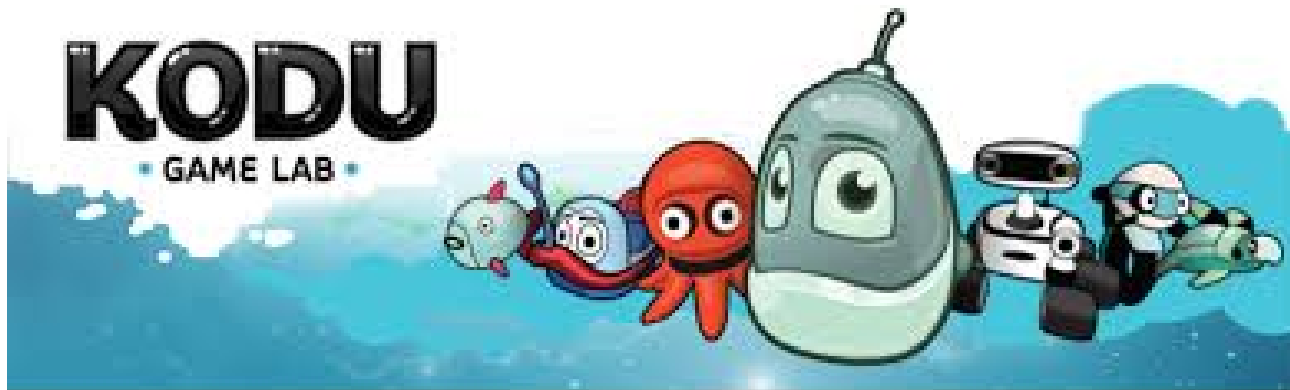
Lecture 17:

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



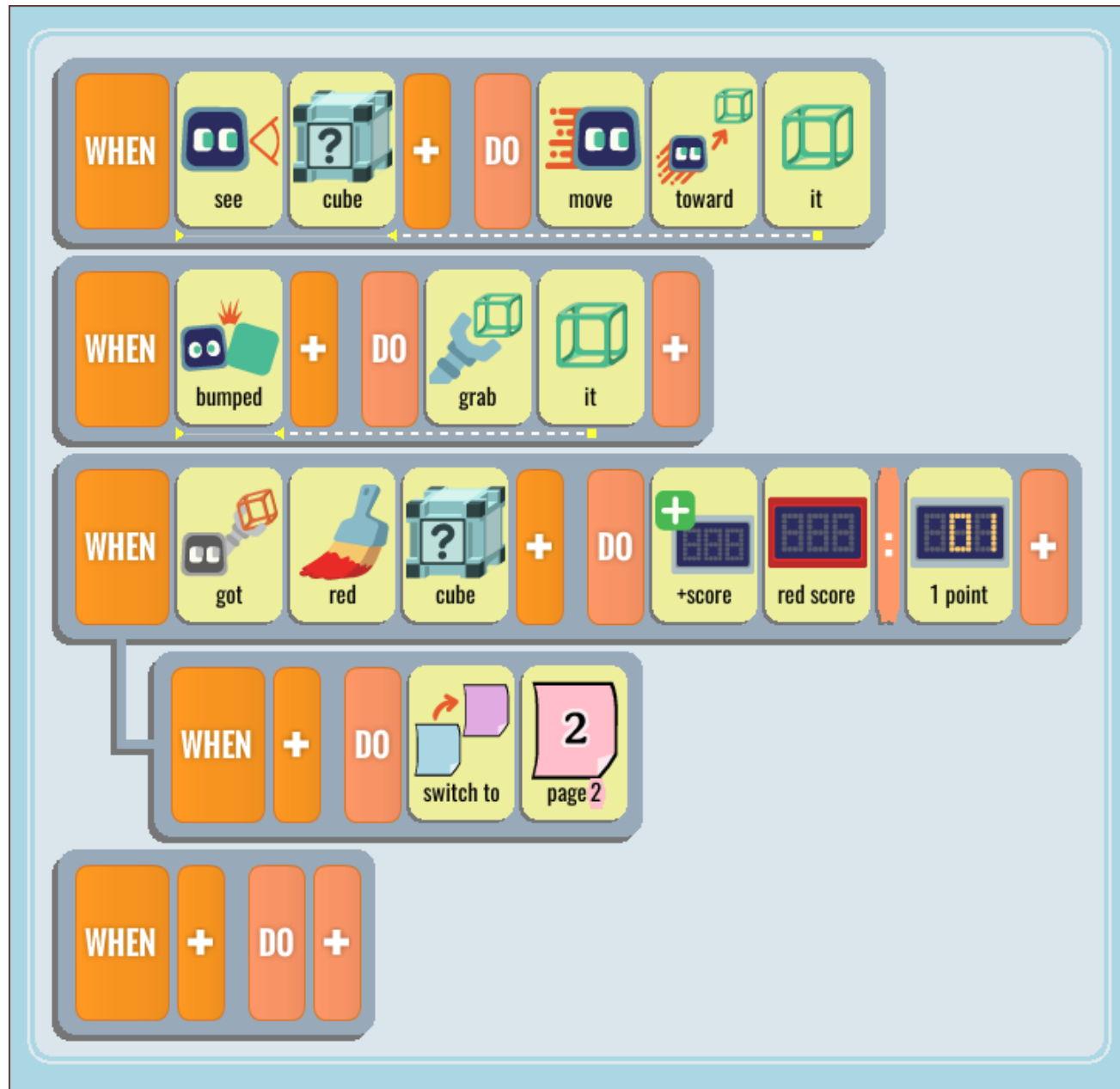
Menu Selection



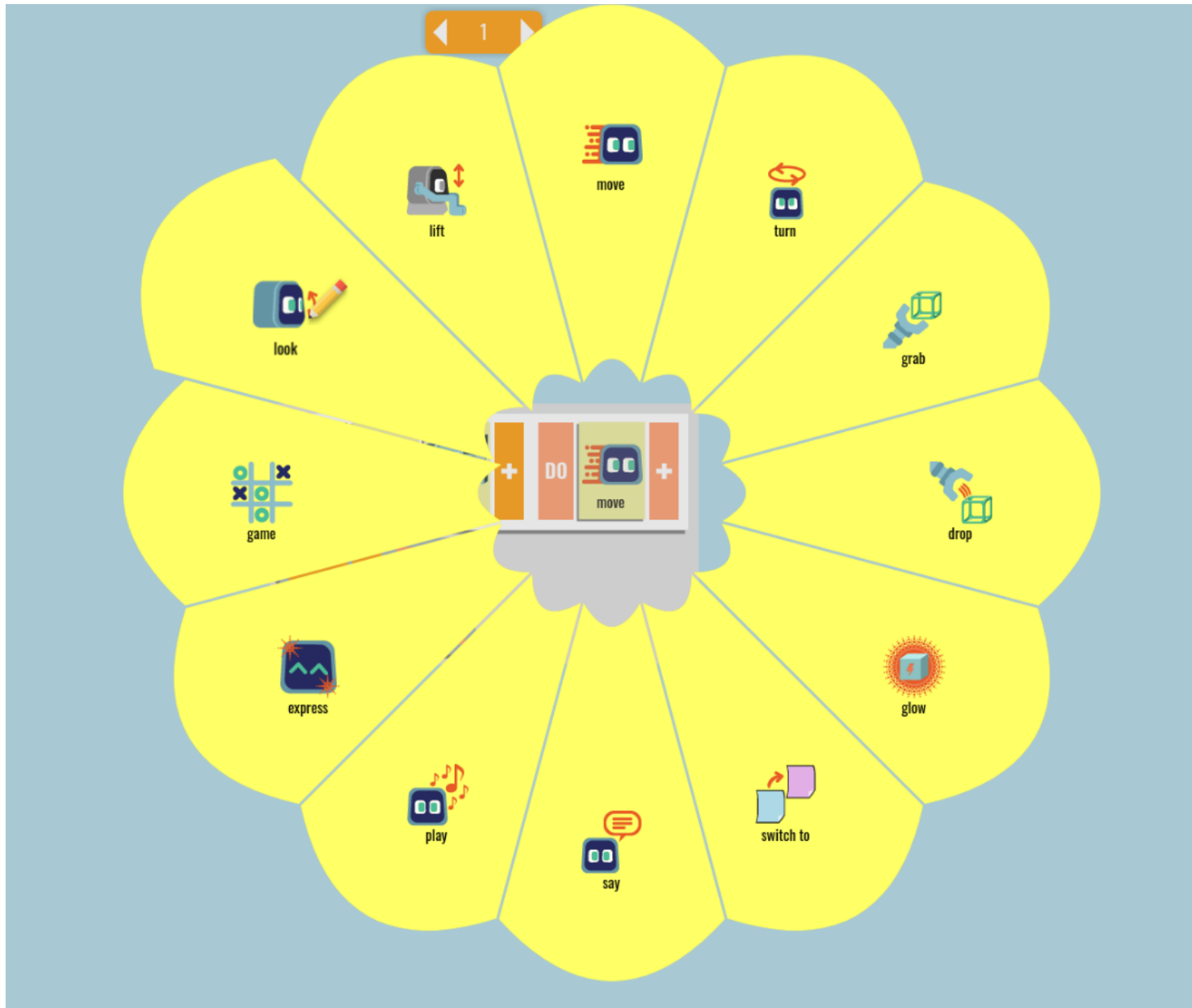
Calypso: Kodu for Robots



Sample Calypso Program



Context-Sensitive Petal Menus

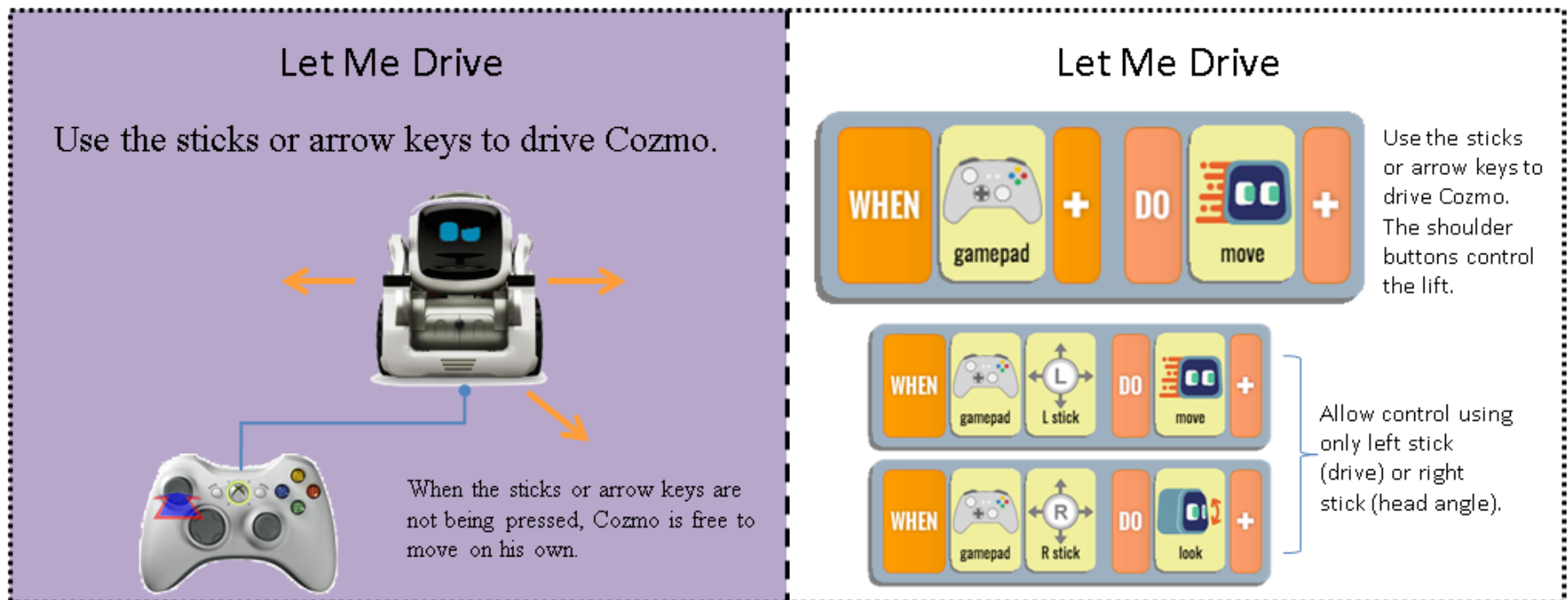


The Robot's World Map

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
- Map Editor:** A light blue area with a toolbar and a map. The toolbar includes:
 - WHEN** (orange button)
 - see** (robot icon)
 - cube** (cube icon with question mark)
 - +** (plus sign)
 - DO** (orange button)
 - move** (robot icon)
 - toward** (robot icon with arrow)
 - it** (cube icon)The map shows a robot icon and several cube icons. A red line connects the robot to one of the cubes.
- Video Feed:** A black and white camera view of the robot's environment. Two cubes are visible, labeled `Lightcube 2 id=1` and `Lightcube 2 id=2`.
- Status Bar:** Located at the bottom right, displaying battery levels:
 - Cozmo's battery 4 volts
 - Cube1 batt 1.28V (56%)
 - Cube3 batt 1.08V (16%)

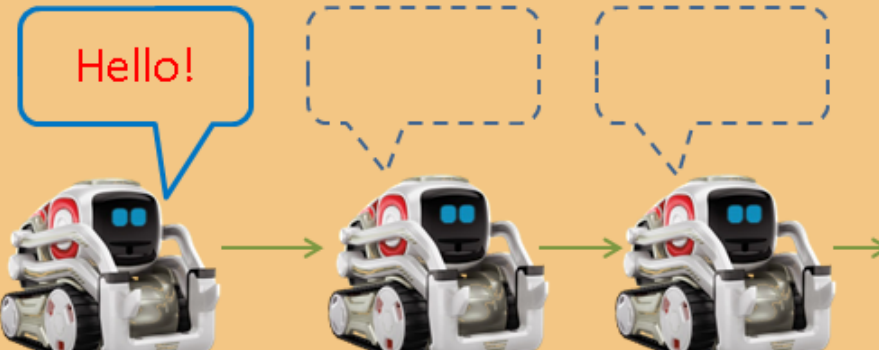
Calypso Idioms (Design Patterns)



Calypso Idiom: Once Is Enough

Once Is Enough

Do something one time instead of repeatedly.

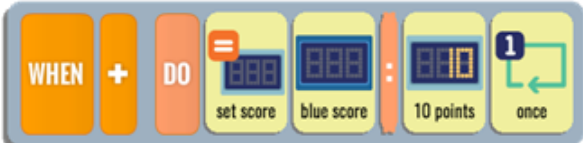


WHEN DO say "Hello!" once


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:



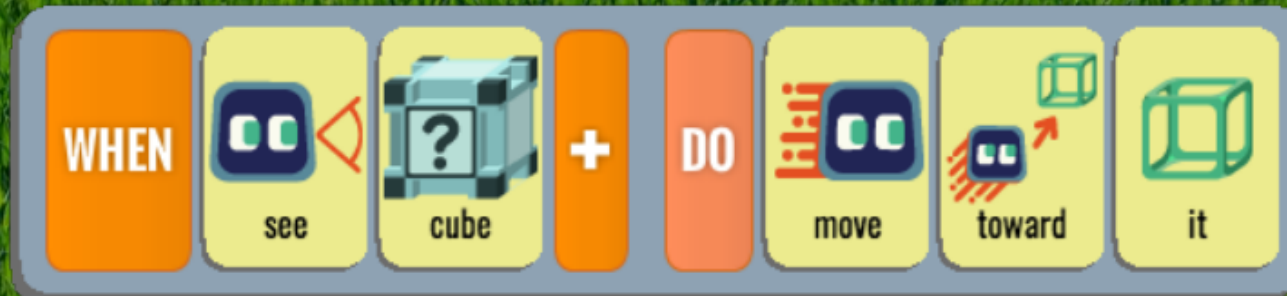
Score one point when you go from "no cube visible" to seeing a cube:



First Law of Calypso

First Law of *Calypso*

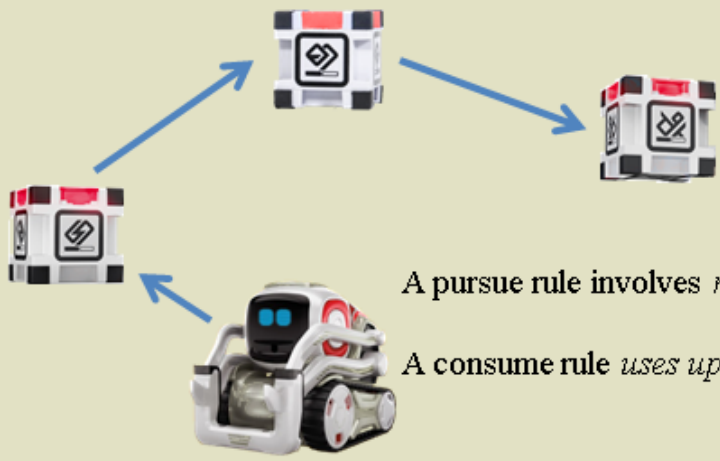
Each rule picks the closest matching object.



Calypso Idiom: Pursue and Consume

Pursue and Consume

Make Cozmo extinguish all the red cubes.

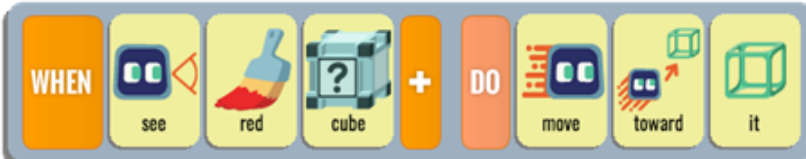


A pursue rule involves *motion*.


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

A red dotted arrow points from the middle rule block to the robot, labeled "Not Bumping".

The robot is a small, white, cube-shaped robot with a red and black top and a white bottom. It has a screen on its front showing two blue eyes.

Third Law of Calypso

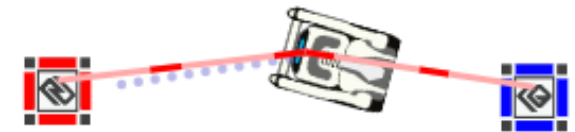
Third Law of *Calypso*
When actions conflict, the earliest wins.

The diagram illustrates the Third Law of Calypso with two conflicting actions and a robot scenario. The top row shows a 'WHEN' condition (robot sees a red cube) followed by a '+' sign and a 'DO' action (robot moves toward it). The bottom row shows a 'WHEN' condition (robot sees a blue cube) followed by a '+' sign and a 'DO' action (robot moves toward it). Below the conditions, a robot is shown with a blue dashed arrow pointing left to a blue cube and a red dashed arrow pointing right to a red cube, representing conflicting actions.

WHEN	see	red	cube	+	DO	move	toward	it
WHEN	see	blue	cube	+	DO	move	toward	it

Robot scenario: Robot → (blue dashed arrow) → Blue cube | Robot → (red dashed arrow) → Red cube

Third Law Visualization



Action
suppression
indicator

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 robot playing a musical note). 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

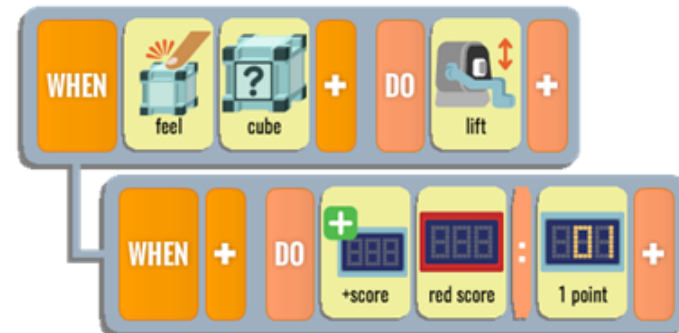
Make Cozmo keep a count of an action he takes.
This is a special case of Do Two Things.



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

Count Actions

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

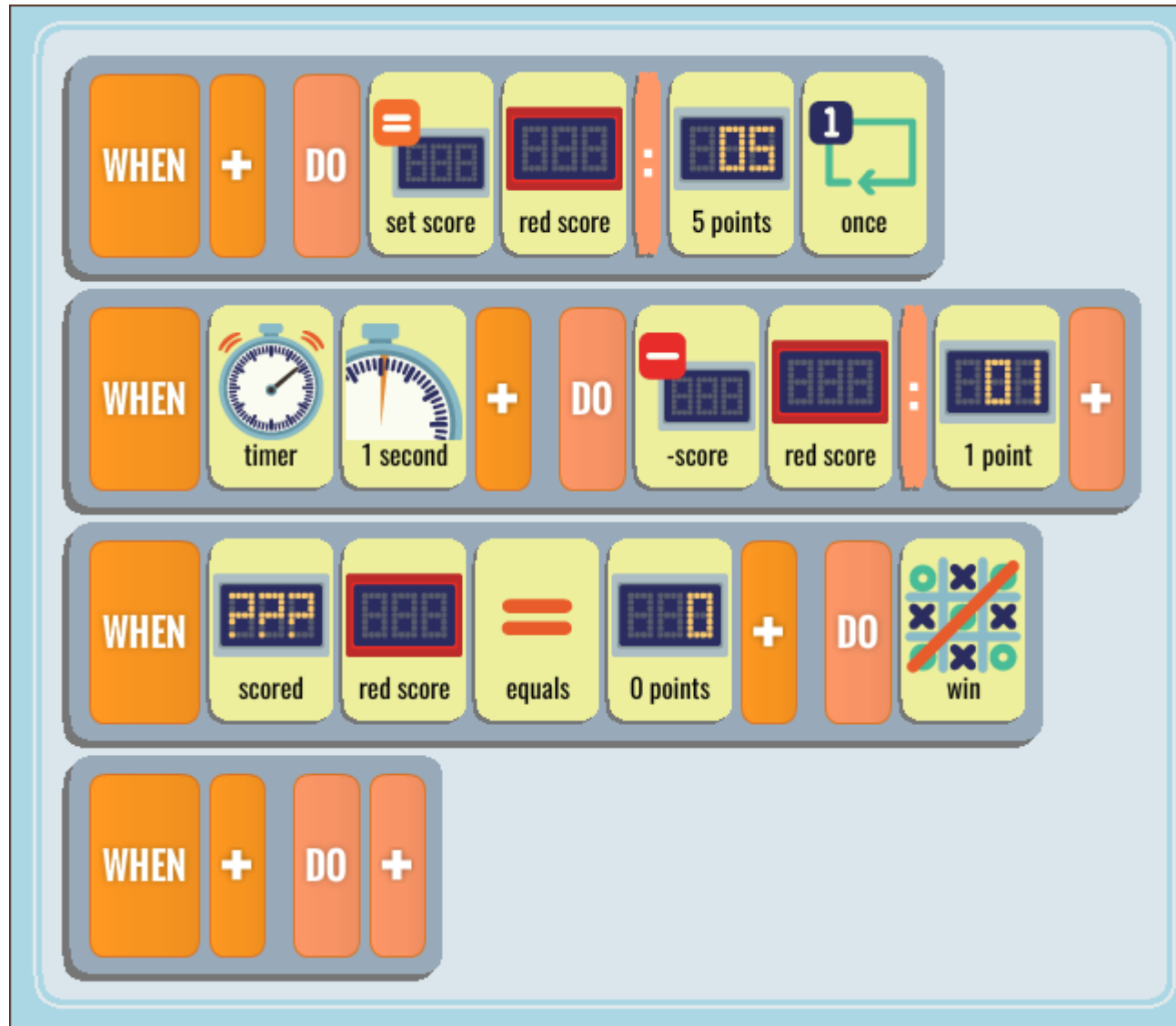


General Form:

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

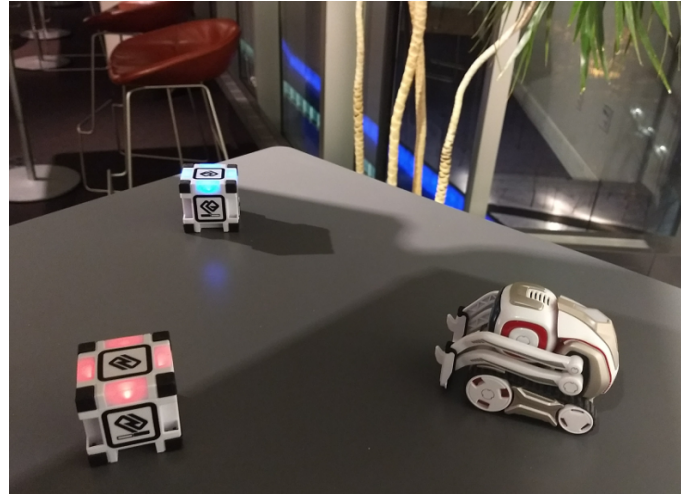
1

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:

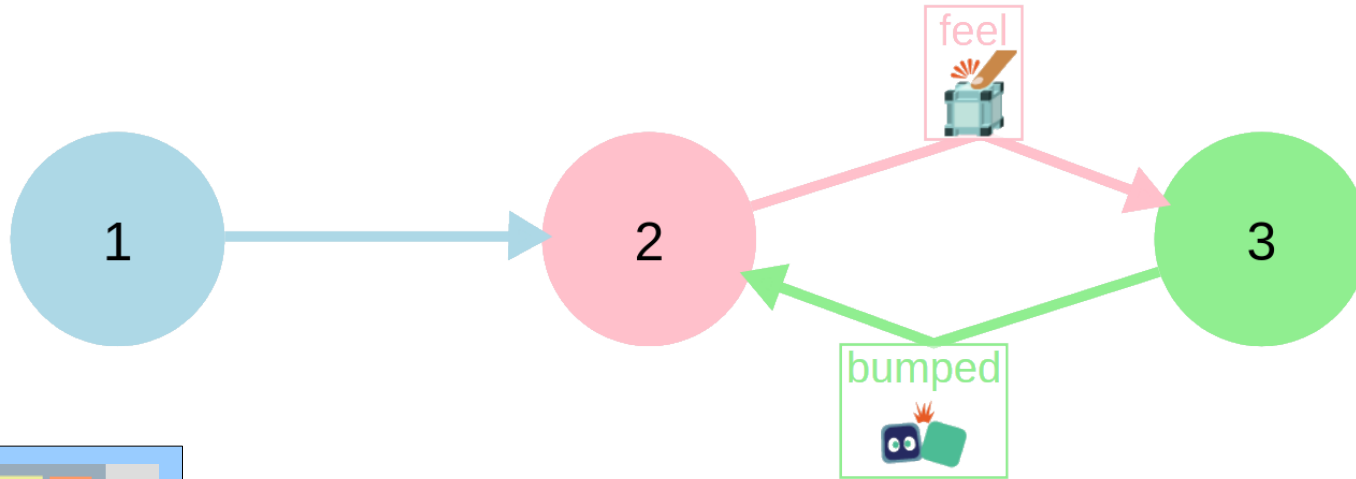
- Row 1: WHEN see red cube + DO move toward it
- Row 2: WHEN bumped red cube + DO switch to page 2
- Row 3: WHEN + DO turn wander

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

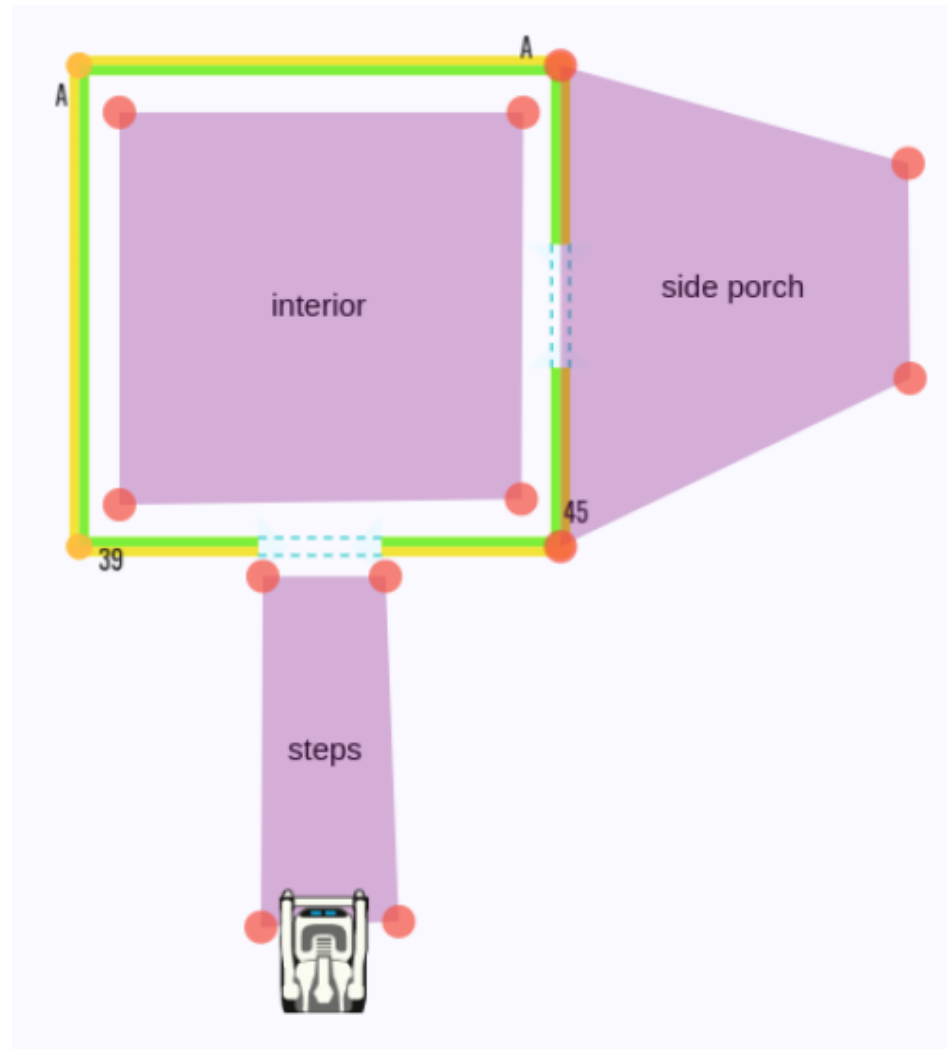
PAGE 2:

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

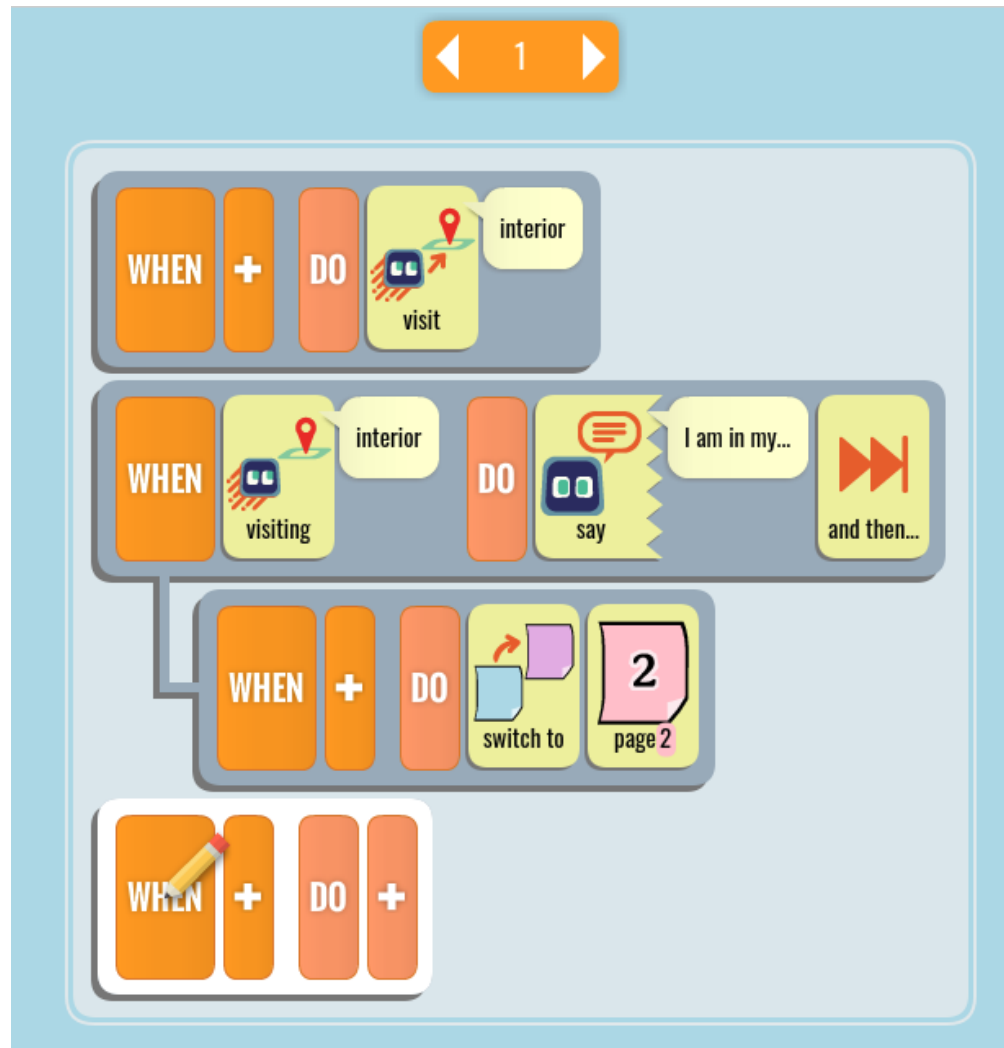
PAGE 3:

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 repeated across multiple rule cycles to make progress.
 - move toward, turn toward, visit

Extended Duration Actions

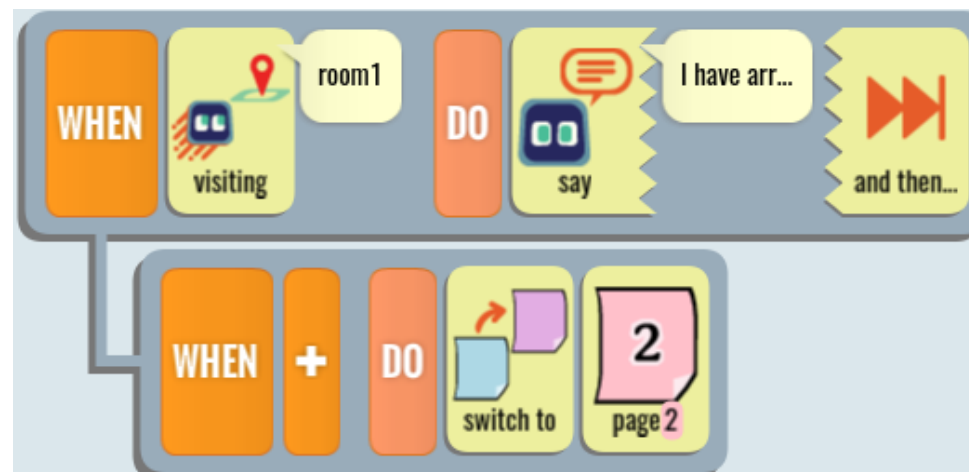
- Extended duration actions take time to complete but can run in parallel with other actions, so they don't suspend:
 - say, play, look, lift
- If we want to suspend execution of indented rules until these actions complete, we add an “and then...” tile.

Use of “And Then...”

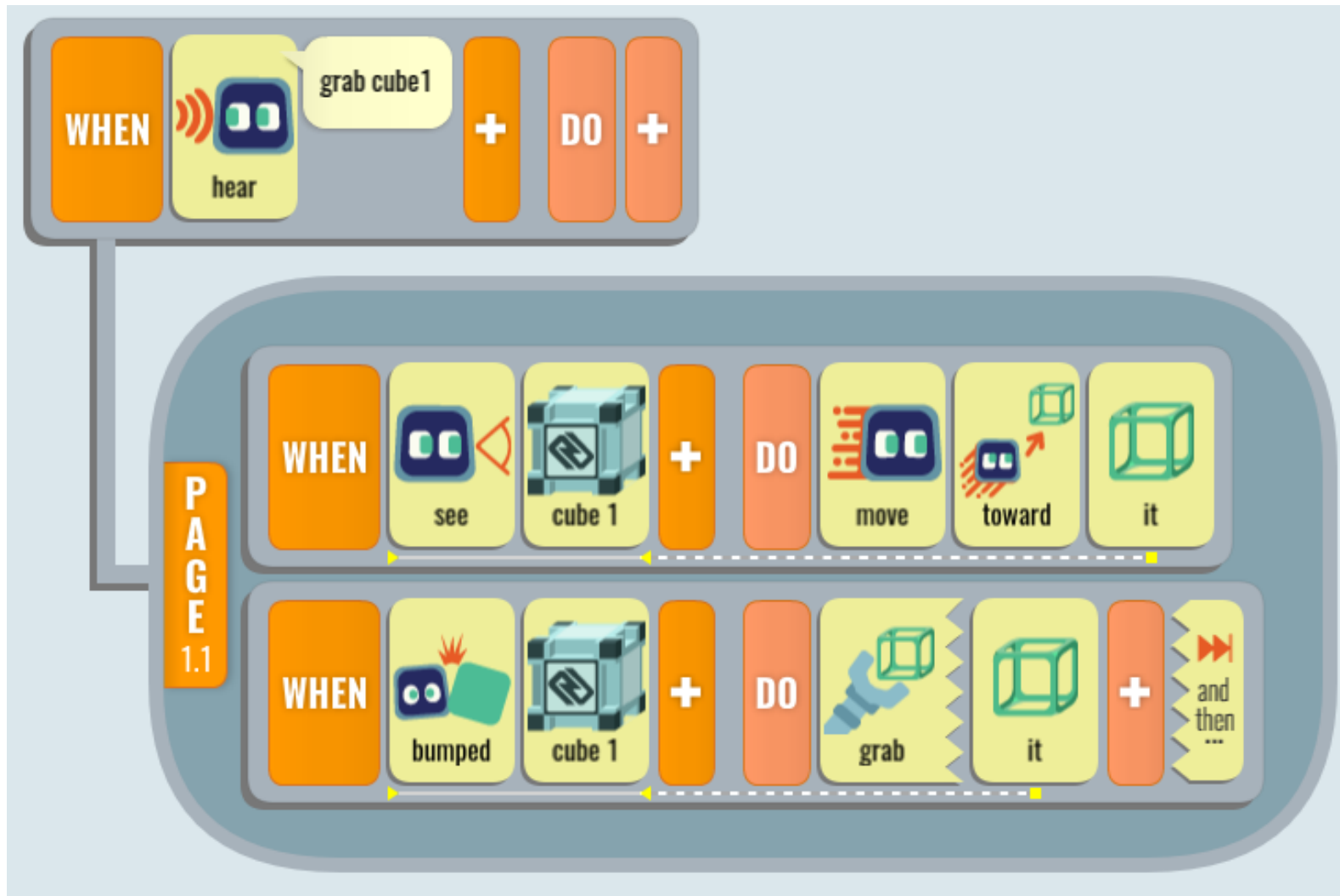
Switches pages as soon as the speech starts.



Switches pages after the speech completes.



Mini-Pages



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)
- Typed variables
- New object types:
 - Chips, Qubes, Containers
- Support for VEX AIM robot
- Multi-robot support