Introduction to Programming
CS101

Spring 2012

Lecture #10

Roadmap

Last week we learned

- Files
  - reading from a file
  - writing to a file
- break
- continue

This week we will learn

- Controlling hardware with software

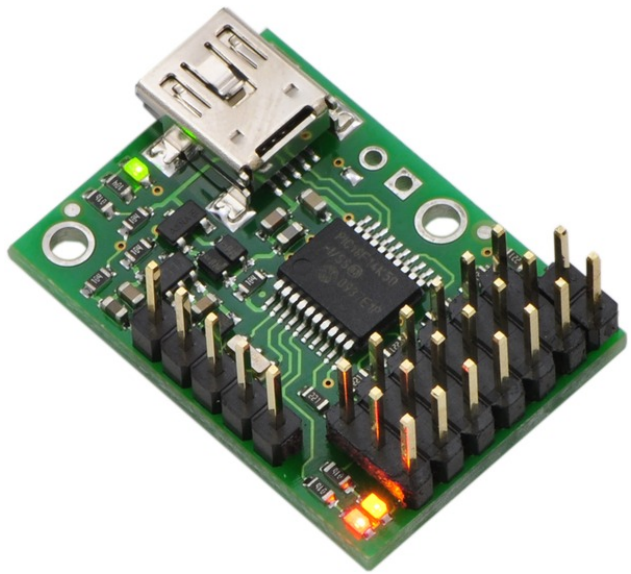
Controlling hardware

A large portion of today's programming is for embedded microprocessors. Every dish-washer, alarm clock, washing machine, car, phone, etc. has one or more microprocessors inside.

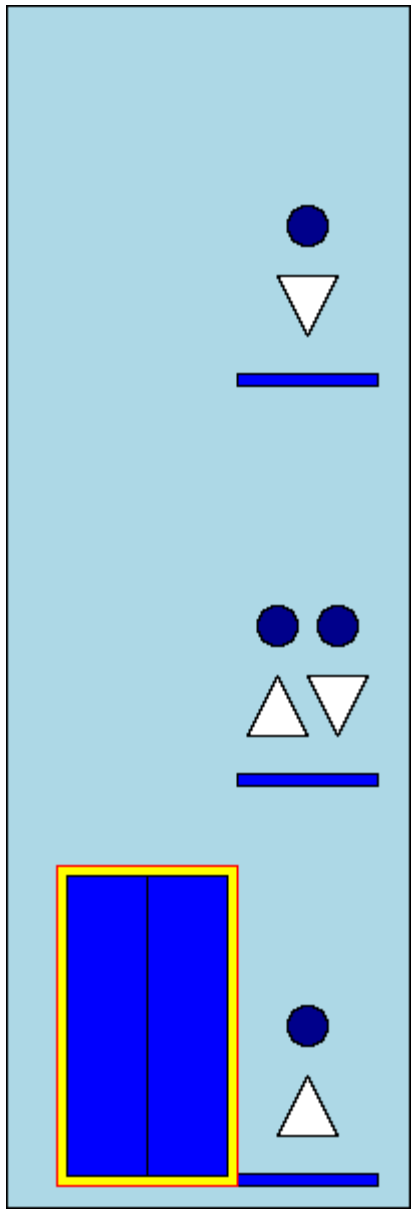
Some decades ago, an elevator was controlled by relays. Today, there is a small computer that does everything.

Electrical engineers spend a lot of time programming embedded devices.

You can buy off-the-shelf devices that allow you to control hardware using a USB connection.



Elevator



An elevator for three floors.

Hardware: Elevator motor, three floor sensors, four call buttons, four call lights, elevator door.

Software interface:

```
from elevator import *
init_hardware()
set_motor(speed)        # -127..127
set_light(num, state) # num 0..3
open_door()
close_door()
get_button(num)         # num 0..3
get_sensor(floor)       # floor 1..3
```

Controlling the motor

When the motor is running, we have to continuously check the floor sensors to stop the motor when we arrive at the right floor (or the elevator will shoot out of the shaft and fall off the roof).

```
def up_to_two():
  set_motor(40)
  while not get_sensor(2):
    pass
  set_motor(0)

def move_to_floor(speed, floor):
  set_motor(speed)
  while not get_sensor(floor):
    pass
  set_motor(0)
```

First attempt

```
# Elevator is at this floor
current_floor = 1

def goto_floor(floor):
  global current_floor
  if floor == current_floor:
    return
  speed = 80
  if floor < current_floor:
    speed = -80
  move_to_floor(speed, floor)
  current_floor = floor
```

Checking buttons and sensors

When a call button is pressed, the call light should go on immediately, even if the computer is currently "busy" monitoring the elevator movement.

We need to keep calling `get_button` during cabin moves:

```
def check_buttons():
  for i in range(4):
    if get_button(i):
      pending[i] = True
      set_light(i, True)

def move_to_floor(speed, floor):
  set_motor(speed)
  while not get_sensor(floor):
    check_buttons()
  set_motor(0)
```

A state machine

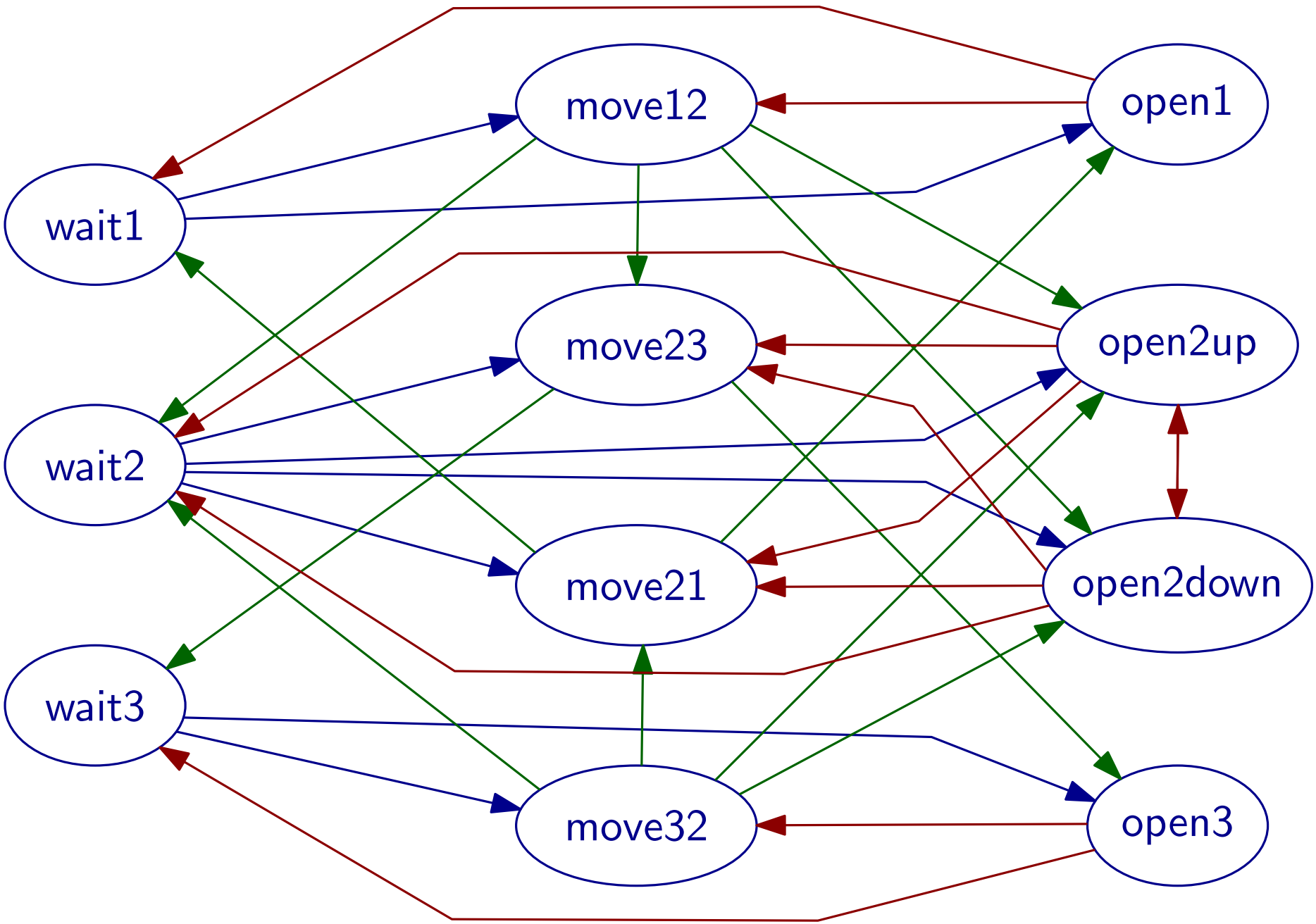
The target floor of a cabin move can change while the cabin is moving.

Let's start again at the beginning. At any time, the elevator is in one of the following eleven states:

wait1	move12	open1
wait2	move23	open2up
wait3	move21	open2down
	move32	open3

waiting at a floor moving between floors door open

State diagram



Implementing the state diagram

We write a handler function for each state. This function will be called repeatedly as long as the elevator is in this state. When the state changes, we start calling the next handler function.

The main loop has become very simple:

```
handler = [ wait1, wait2, wait3,
            move12, move21, move23, move32,
            open1, open2up, open2down, open3 ]

state = WAIT1
while True:
  handler[state]()
```

Handler functions

Each handler function must check all call buttons so that the elevator is responsive. It then checks if the state changes, and updates motor, lights, and doors correspondingly.

```
def move12():
  global state
  check_buttons()
  if not get_sensor(2): return
  if pending[2]:
    request_done(2)
    start_open(OPEN2UP)
  elif pending[3]:
    state = MOVE23
    return
  elif pending[0] or pending[1]:
    request_done(1)
    start_open(OPEN2DOWN)
  else:
    start_wait(WAIT2)
```