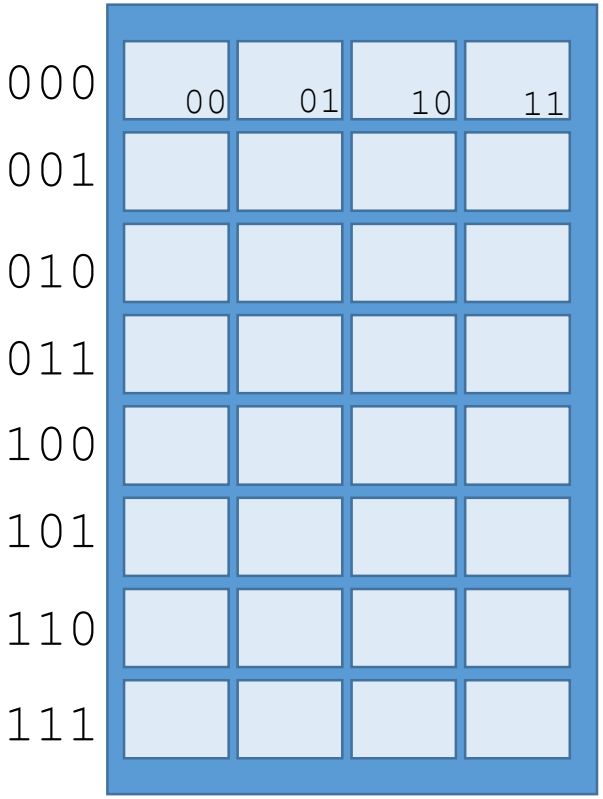
Microprocessor Architecture from the bottom - up

Session 2.2

PH435

Address spaces – at what "address" in physical memory is data / program stored



This 'memory' IC has 4x8=32 D registers, each stores a single bit

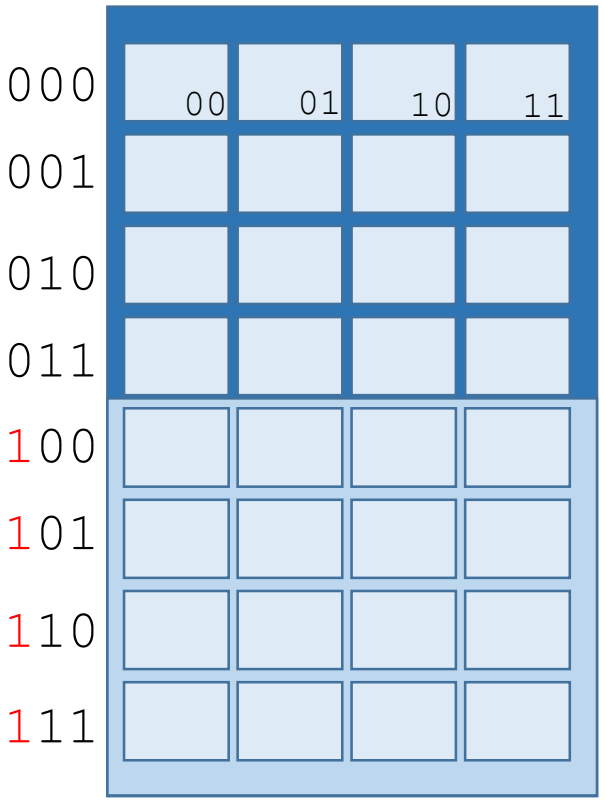
We build this IC on a breadboard with 32 individual D registers

This IC can store 32 1-bit numbers or 8 4-bit numbers

Program address space; Data address space

prog

data



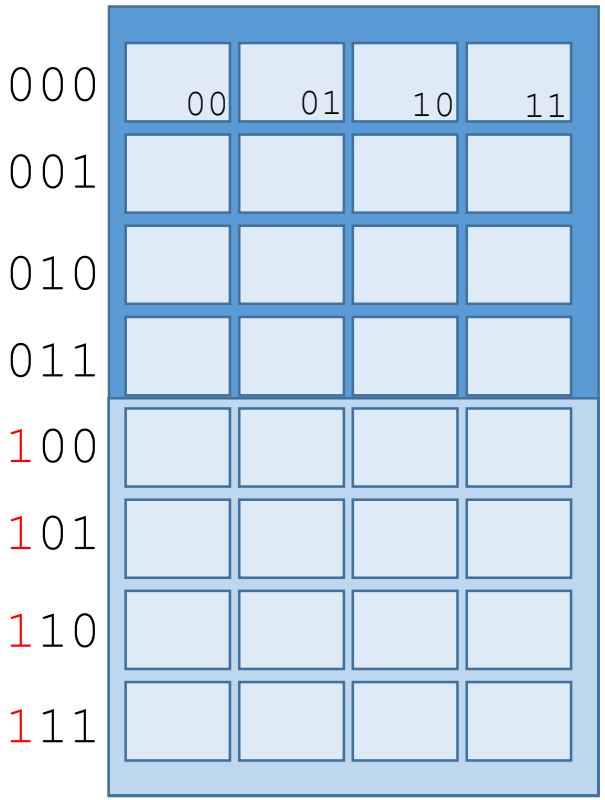
Let us agree to use 4-bit numbers

Let us also agree that the first 4 locations are reserved for program code (MSB=0 → prog)

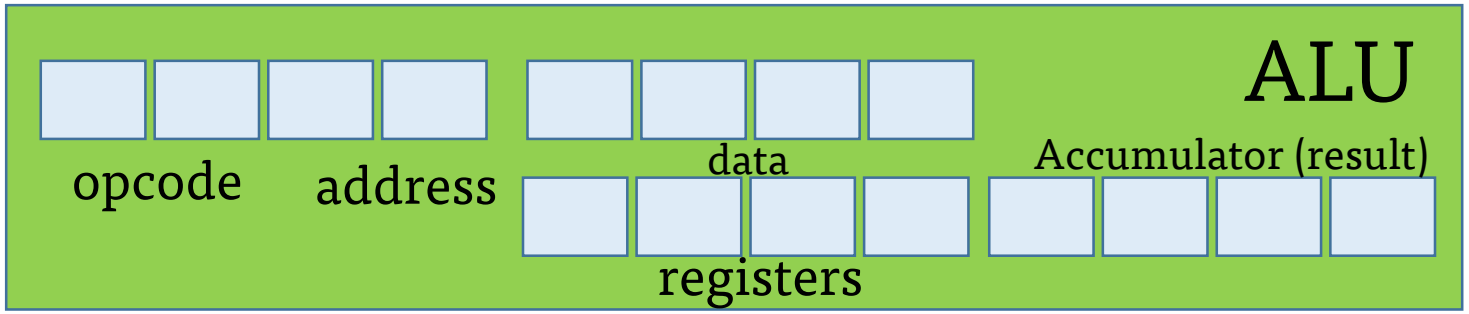
Latter 4 locations are reserved for data (MSB=1 → data

Big-endian / little-endian

ALU; COMPUTE UNIT, CPU



Let us build an ALU (compute unit)
That can perform 4 operations:
add, subtract, read, write
Opcodes: `00,01,10,11`



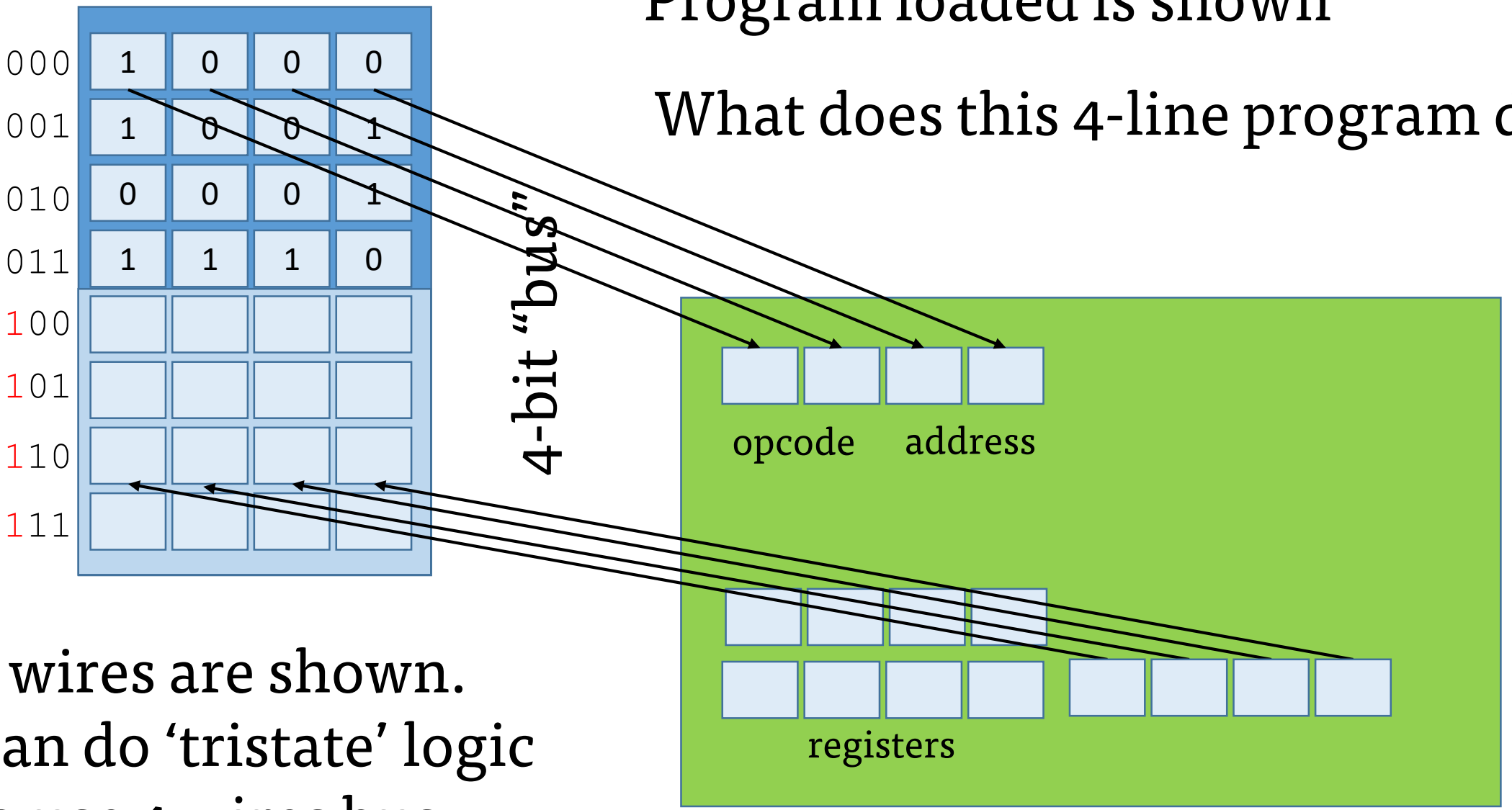
This ALU is hardware programmed i.e. its **firmware** [D.G, S.T] is setup to do the following:

```
At power on, execute opcode at prog address 000, then
001, 010, 011 and continue back at 000
```

Our “toy” microprocessor runs a program

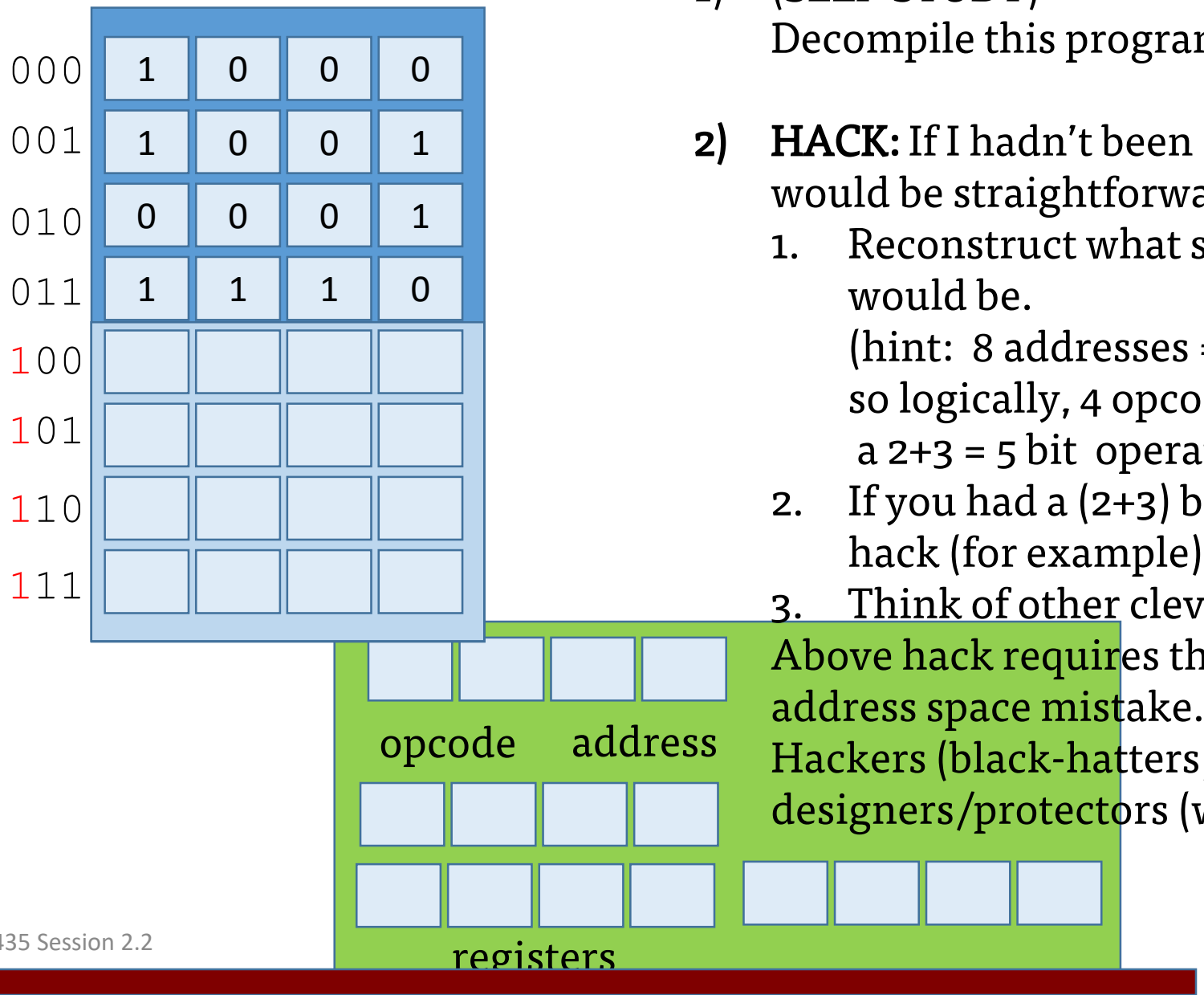
Program loaded is shown

What does this 4-line program do??



8 wires are shown.
Can do ‘tristate’ logic
to use 4 wires bus

Our “toy” microprocessor runs a program



Homework:

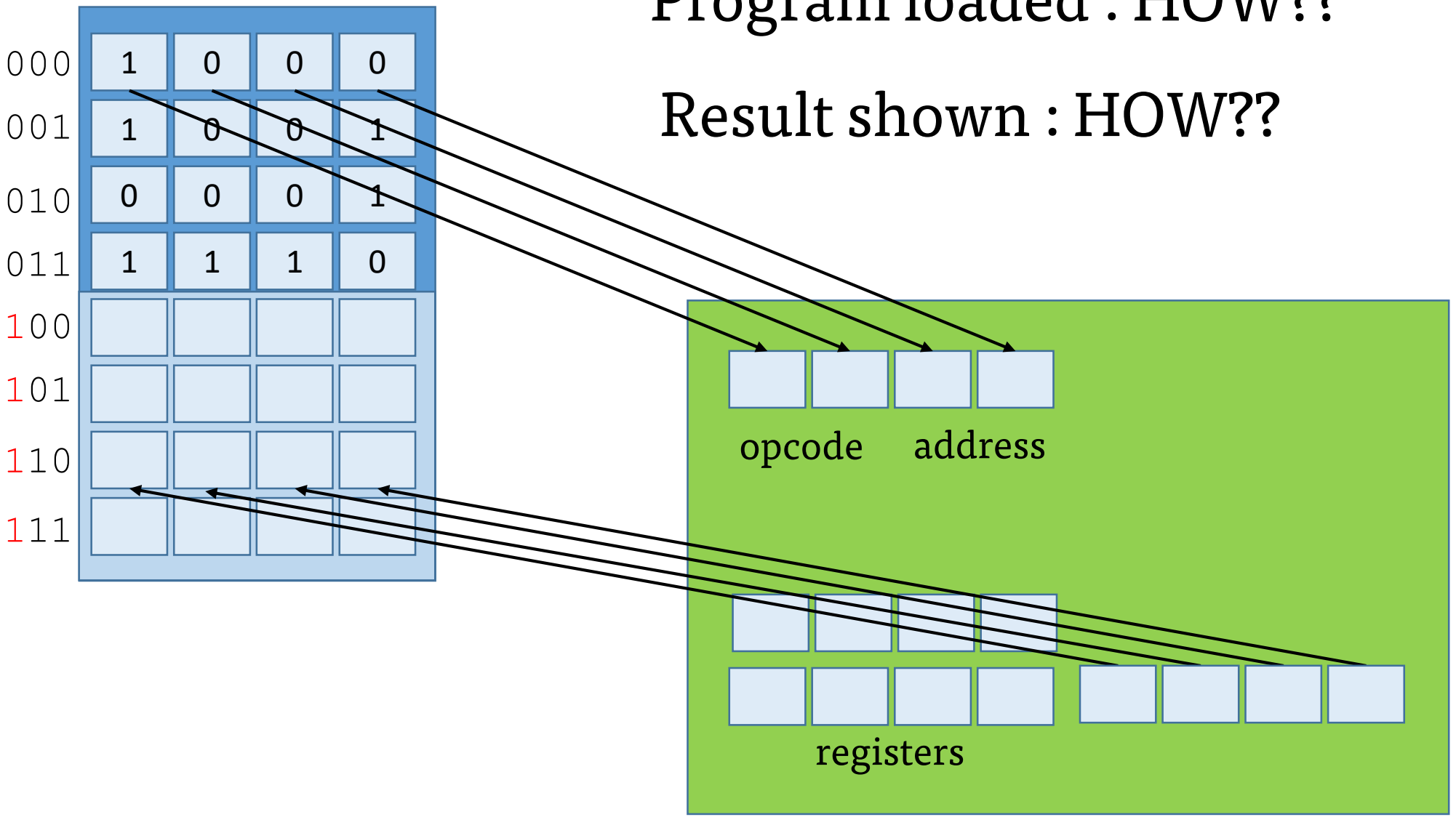
1) (SELF-STUDY)
   Decompile this program and state in words what it does.

2) **HACK:** If I hadn’t been careful in laying out this architecture, it would be straightforward to hack it. HOW?
   1. Reconstruct what such NON-careful architecture layout would be.
      (hint: 8 addresses = 3bits
      so logically, 4 opcodes + address register should be
      a 2+3 = 5 bit operation register
   2. If you had a (2+3) bit opcode register, what could you do to hack (for example) the US election?
   3. Think of other clever hacks too! There is no unique hack – Above hack requires the designer to have made a foolish address space mistake.
      Hackers (black-hatters) are always one step ahead of the designers/protectors (white-hatters)

Our “toy” microprocessor gets I/O component

Program loaded : HOW??

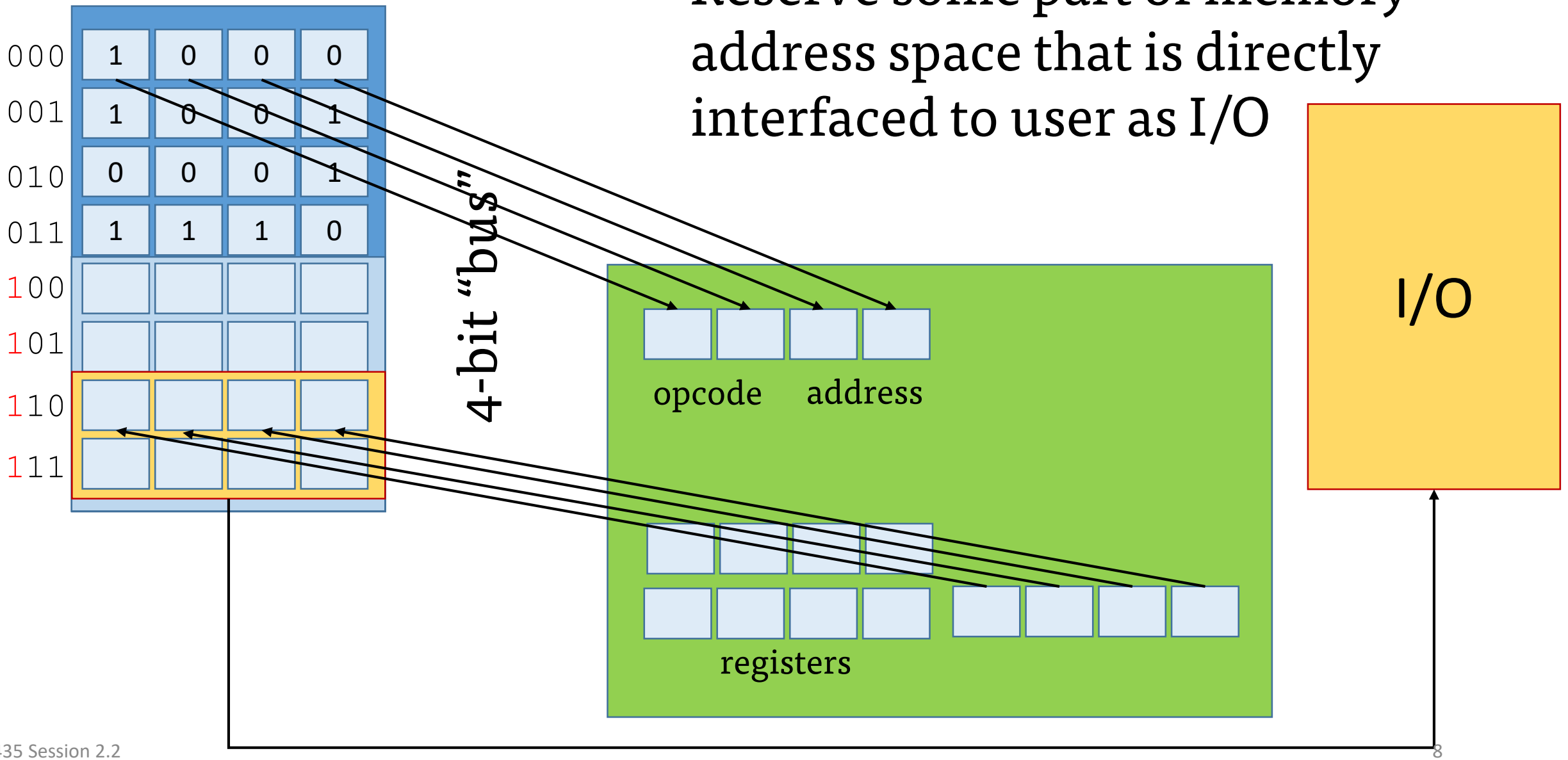
Result shown : HOW??



I/O

I/O system can be “memory mapped”

Reserve some part of memory address space that is directly interfaced to user as I/O



Note:

The theoretical concept of a computer had been developed earlier ~ 1930's by Alan Turing (also Cambridge + Princeton): **UNIVERSAL TURING COMPUTER**

Turing had also worked on a practical, mechanical device in UK which used pulleys and gears to decrypt German radio messages. Mostly mechanical, not electronic – the American ENIAC was the first Electronic computer using vacuum tubes.

Cf: Nice biopic movie 'The Imitation Game' (2014)
Also, the Nobel–equivalent prize in Computer Science is named the Turing Medal after A. Turing