University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering

ECE 120: Introduction to Computing

Instructions Illustrated

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How Do We Write Instructions?

Previously, we looked at some instruction bits and talked about executing instructions.

It's natural to wonder:

How did those bits get there?

Similarly, when making a peanut butter sandwich:

- Why was the bag closed?
- Where did the bread come from?
- Why was it whole wheat bread?

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Put Bits into Memory, Then Execute the Bits

All perfectly valid questions, but be patient!

Our model of programming:

- **Place bits into memory** locations (you'll see how in the lab, and later in class).
- Then **tell the LC-3 to interpret our bits** as instructions.

We **can also put data bits in memory**.

- But be careful!
- The **LC-3 can't tell the difference** between instructions and data. Both are bits.

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Let's Illustrate LC-3 Instruction Processing

Let's execute the LC-3 for a few cycles and see how it works.

We'll show a few pieces of the datapath:

- memory
- register file
- **PC** and **IR**
- **MAR** and **MDR**

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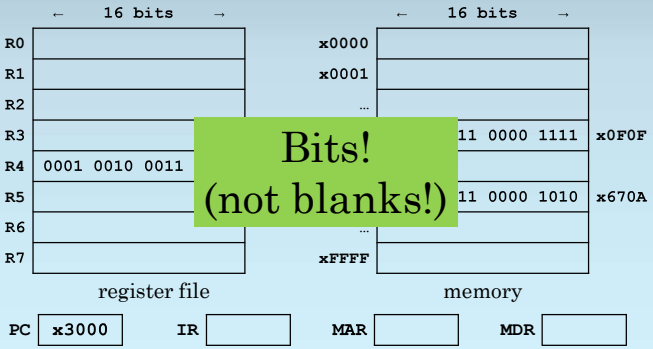
What's in the Blank Boxes?



Bits!
(not blanks!)

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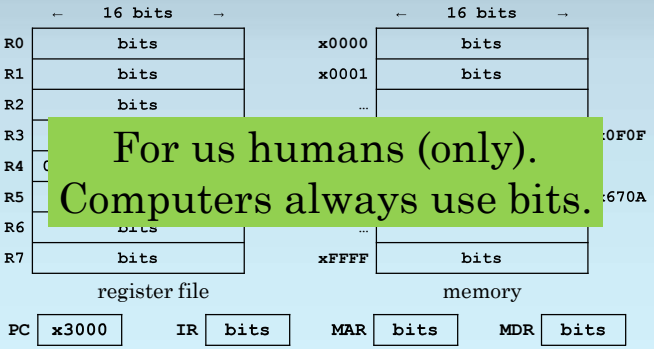
Why are Some Values in Hex?



For us humans (only).
Computers always use bits.

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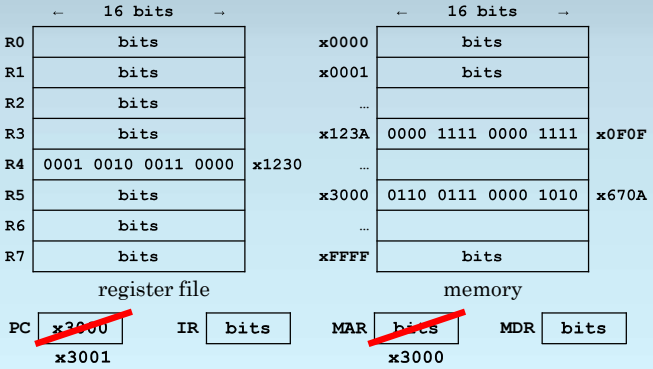
Fetch #1: MAR ← PC, PC ← PC + 1



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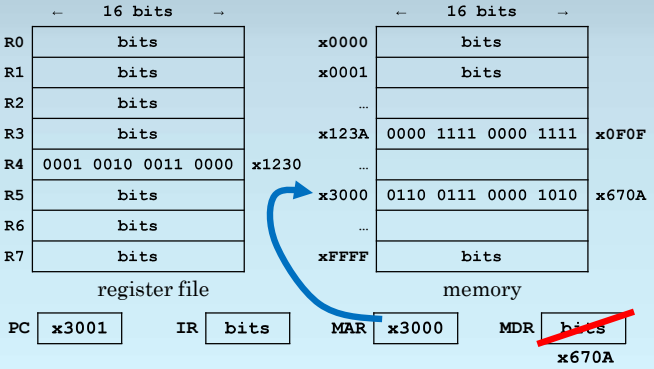
Fetch #2: MDR ← M[MAR]



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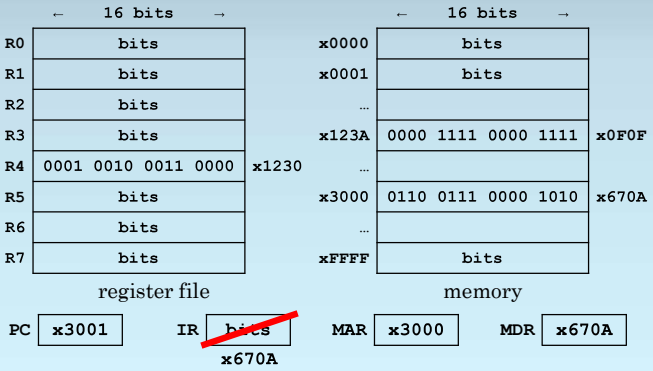
Fetch #3: IR ← MDR



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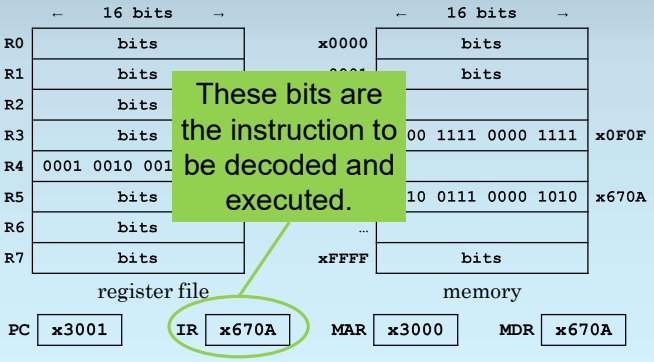
DECODE, then EXECUTE



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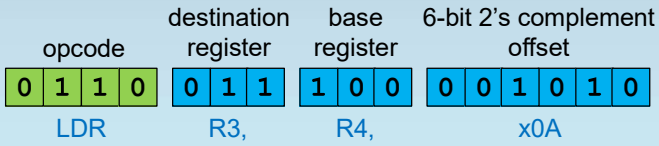
Let's Decode the Instruction

The **IR** has **x670A**. In bits, that's



Which means what? Let's decode it.

R3 ← M[R4 + x000A]

What is the memory address?

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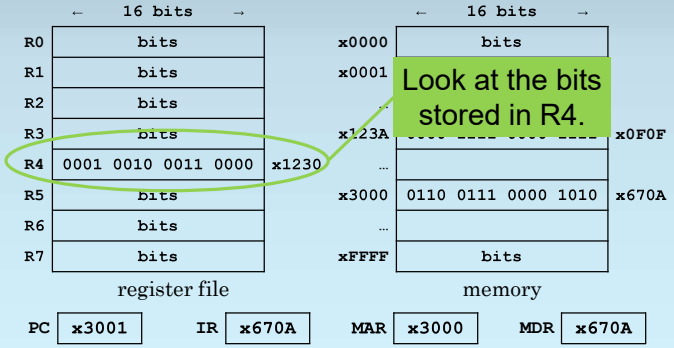
The LC-3 Reads the Bits from R4



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Let's Calculate the Memory Address

R3 ← M[R4 + x000A]

R4 is **x1230**.

Adding **x000A**, we obtain … ? **x123A**

What is stored at memory address x123A?

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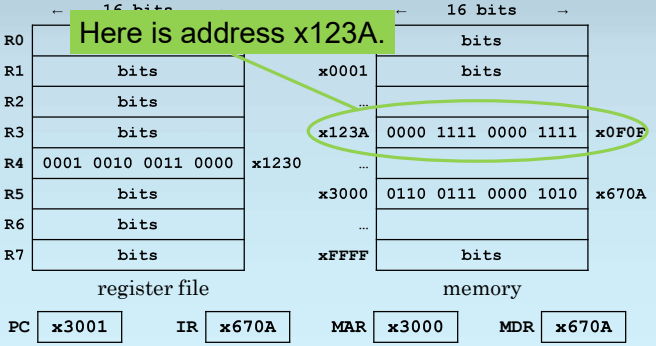
The LC-3 Reads Memory at x123A



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The LC-3 Stores x0F0F into R3

R3 ← M[R4 + x000A]

R4 is **x1230**.

Adding **x000A**, we obtain … ? **x123A**

What is stored at memory address x123A?

x0F0F

So the LC-3 stores **x0F0F** into **R3**.

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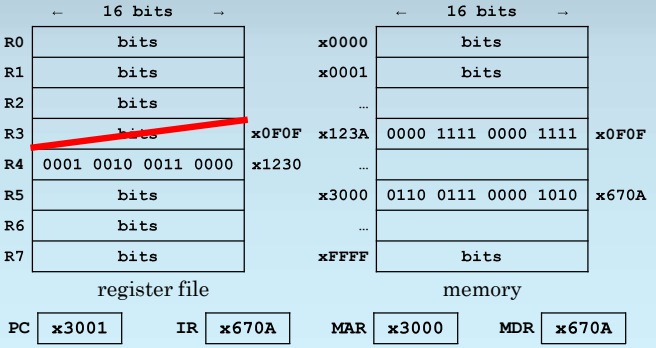
The LC-3 Stores x0F0F into R3



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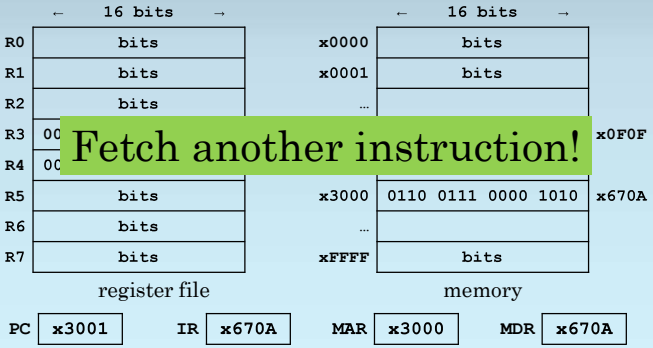
What's Next?



Fetch another instruction!

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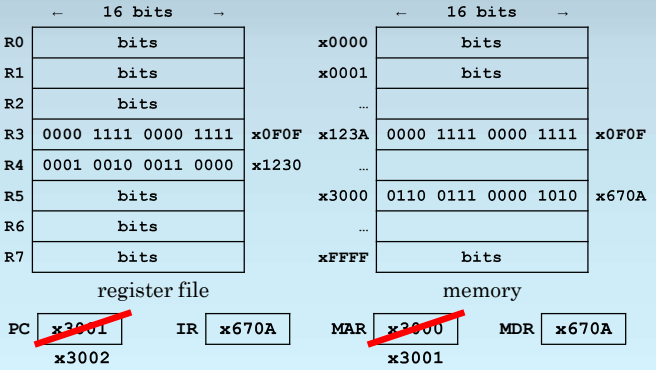
Fetch #1: MAR ← PC, PC ← PC + 1



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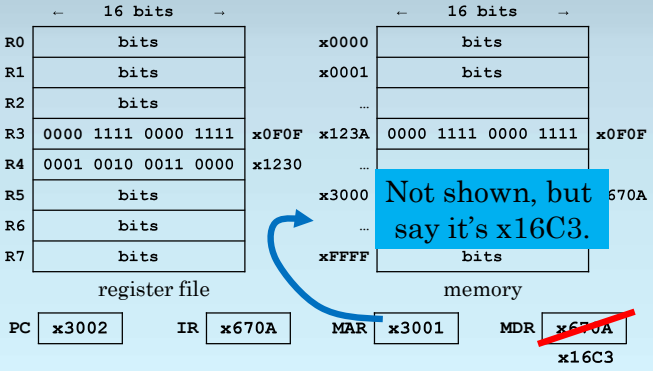
Fetch #2: MDR ← M[MAR]



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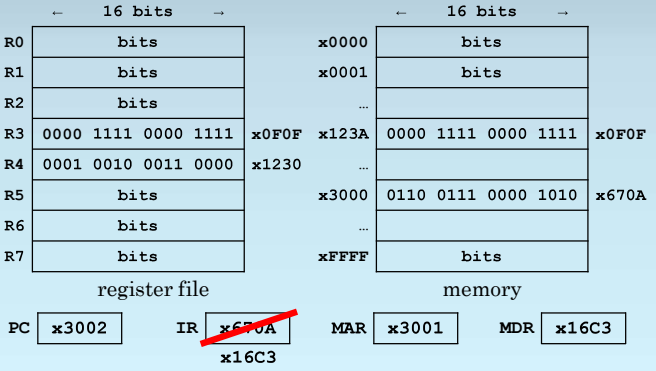
Fetch #3: IR ← MDR



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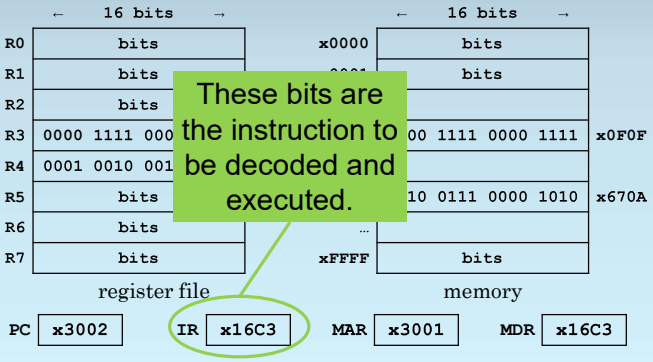
DECODE, then EXECUTE



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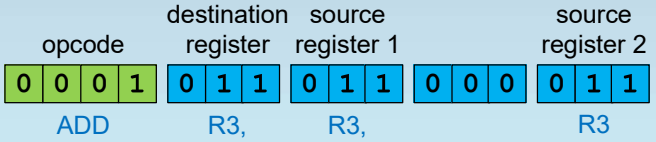
Let's Decode the Instruction

The **IR** has **x16C3**. In bits, that's



Which means what? Let's decode it.

R3 ← R3 + R3

Add **R3** to **R3**, storing the sum back into **R3**.

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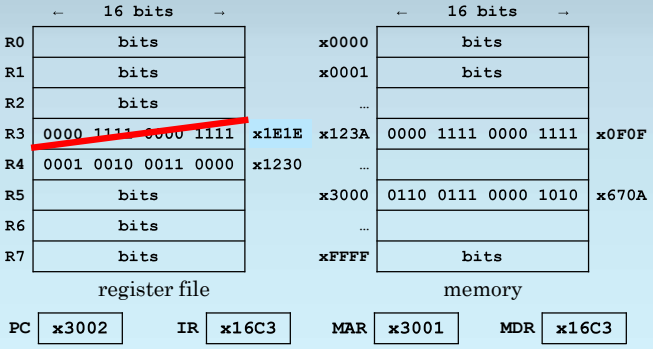
The LC-3 Stores x1E1E into R3



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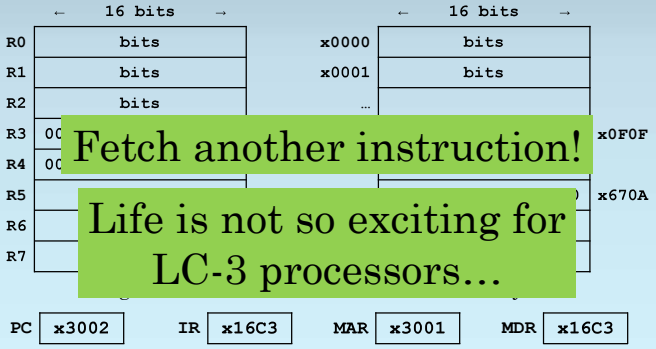
What's Next?



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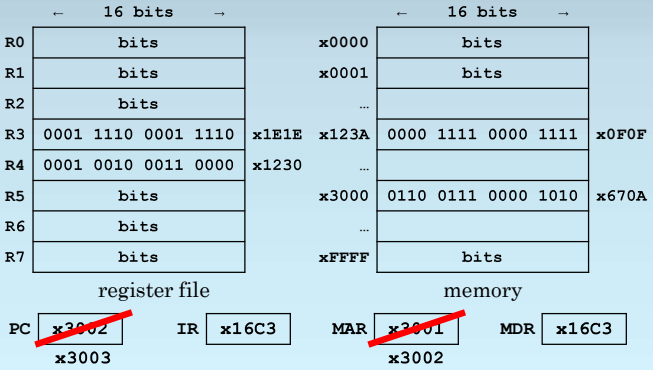
Fetch #1: MAR ← PC, PC ← PC + 1



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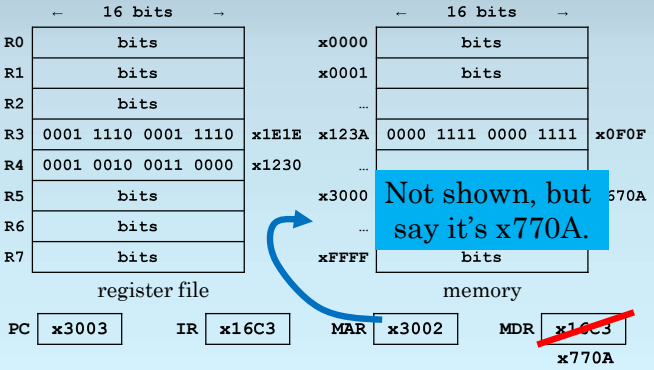
Fetch #2: MDR ← M[MAR]



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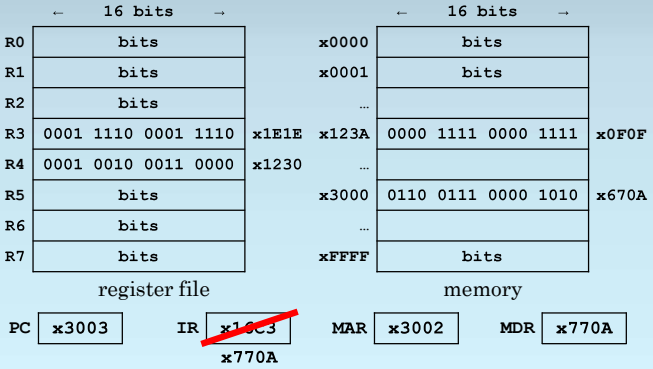
Fetch #3: IR ← MDR



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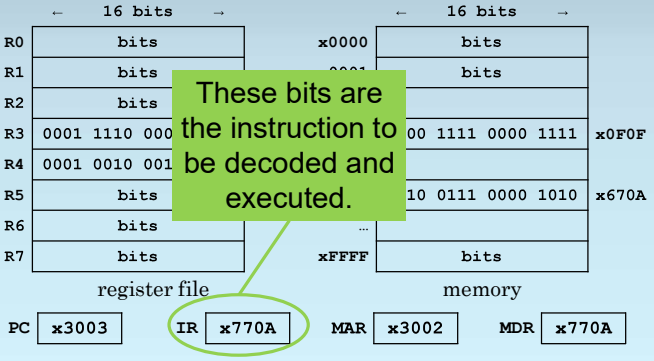
DECODE, then EXECUTE



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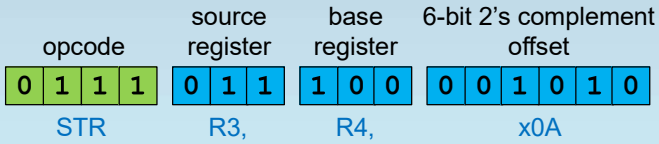
Let's Decode the Instruction

The **IR** has **x770A**. In bits, that's



Which means what? Let's decode it.

`M[R4 + x000A] ← R3`

What is the memory address?

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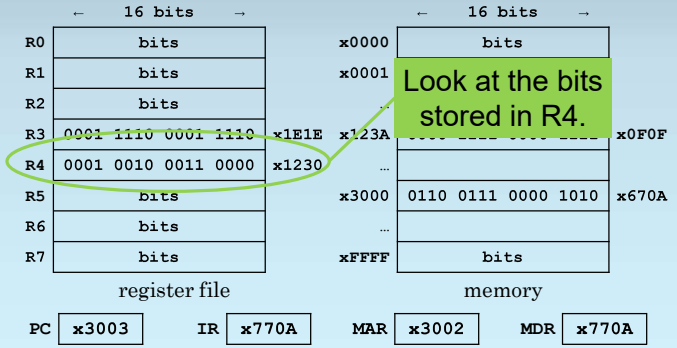
The LC-3 Reads the Bits from R4



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Let's Calculate the Memory Address

`M[R4 + x000A] ← R3`

R4 is **x1230**.

Adding **x000A**, we obtain … ? **x123A**

So the LC-3 stores the bits in R3 to memory address x123A.

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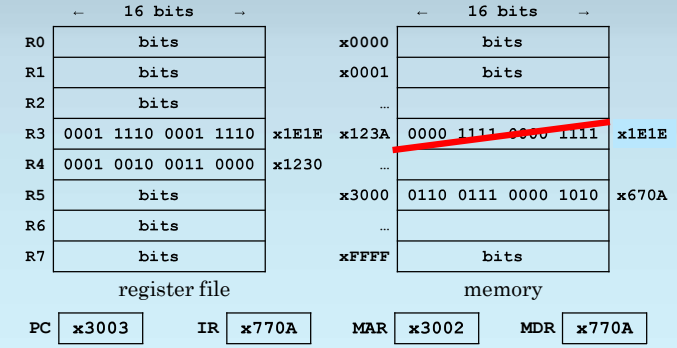
The LC-3 Writes x1E1E to Memory Address x123A



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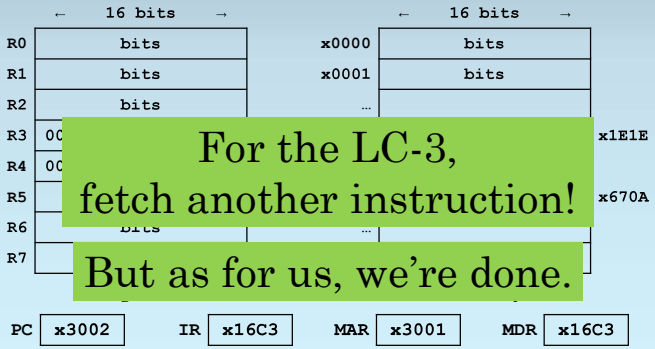
What's Next?



For the LC-3,
fetch another instruction!

But as for us, we're done.

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Computers Just Execute Instructions

What does that instruction sequence do?

Multiplies the value at address x123A by 2 (shifts it left by 1 bit).

What if R3 held something important before we executed those instructions?

Too bad. Those bits are gone.

The programmer controls the computer.

The **computer just does what it's told**.

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