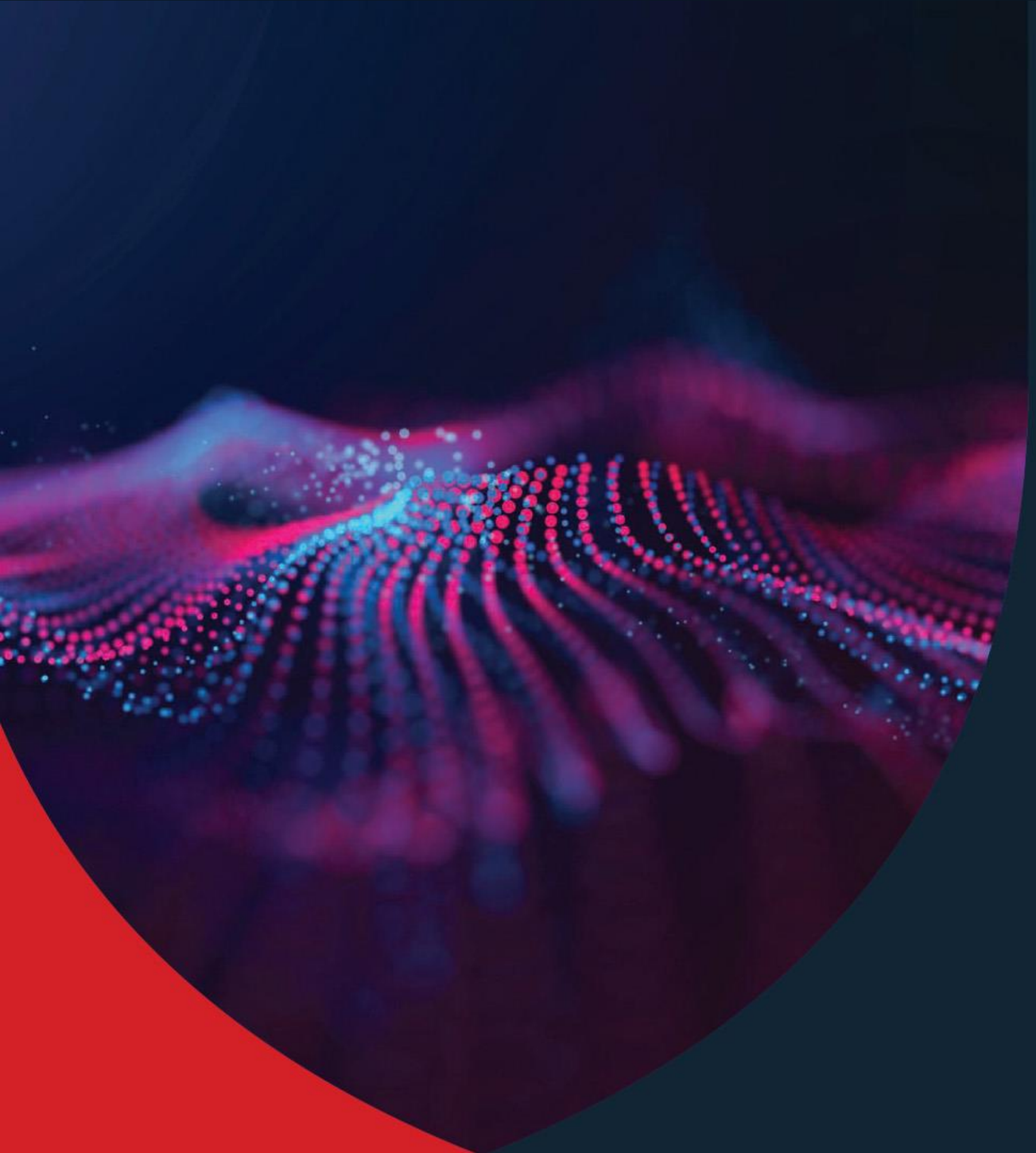

Computer Systems

Lecture 12: Virtual Machine
Review and Exercise

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Question 1 — 1 pts

Consider the following Hack Assember code:

```
(LOOP)
    @curr
    MD=M+1
    @last
    D=M-D
    @END
    D;JLE
    @curr
    A=M
    D=M
    @curr
    M=D
    @min
    D=D-M;
    @LOOP
    D;JMP
(END)
    @END
    0;JMP
```

Match entries that would appear in the Assember's symbol table for this code with their corresponding values.

Question 2 — 1 pts

The Hack Virtual Machine assumes values are represented in a particular way. Match the following to their representation or value.

integer	[Choose]
pointer	[Choose]
true	[Choose]
false	[Choose]
most negative integer value	[Choose]
largest integer value	[Choose]

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Question 3 — 1 pts

Why are stacks drawn growing downwards in the textbook and on the lecture slides?

- [ ] So that the text book and lecture slides are consistent.
- [ ] The stack in the Hack computer grows from high addresses to low addresses.
- [ ] Stacks in real computers grow from high addresses to low addresses.
- [ ] They are not drawn this way.

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Question 4 — 1 pts

Assume that we have a stack where the value of the top element is 5 and the second top element is 4. If the value 5 is stored at memory address 315, what is the value of the stack pointer and at what memory address is the value 4 stored?

Stack Pointer [Choose]

4 is stored at address [Choose]

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Question 5 — 1 pts

Assume that we have a stack where the value of the top element is 7 and the second top element is 3. If the VM command ***add*** is executed, and the value 3 is stored at memory address 768, what is the new value of the stack pointer?

- ○ 768
- ○ 769
- ○ 771
- ○ 767
- ○ 770
- ○ 0

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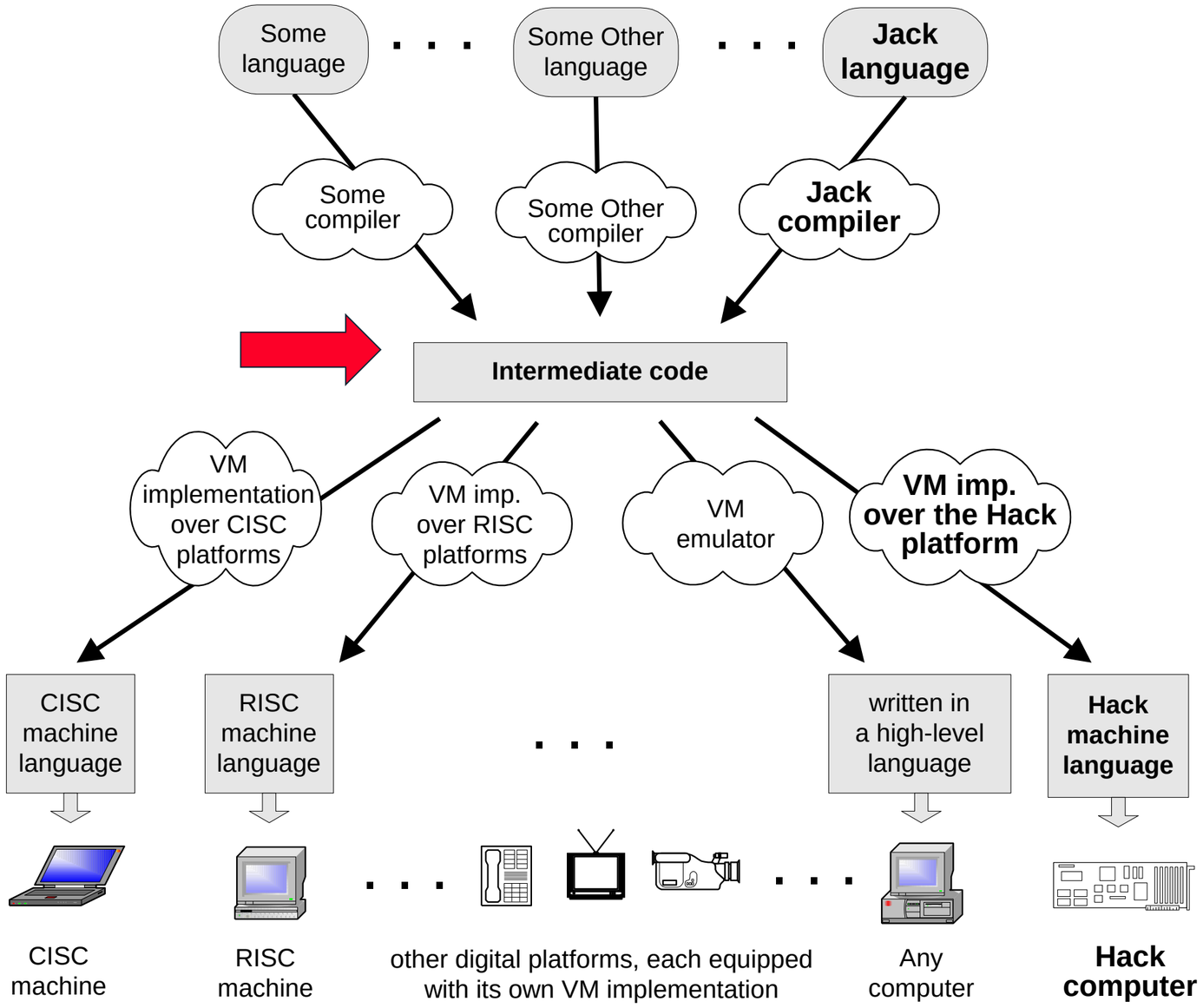
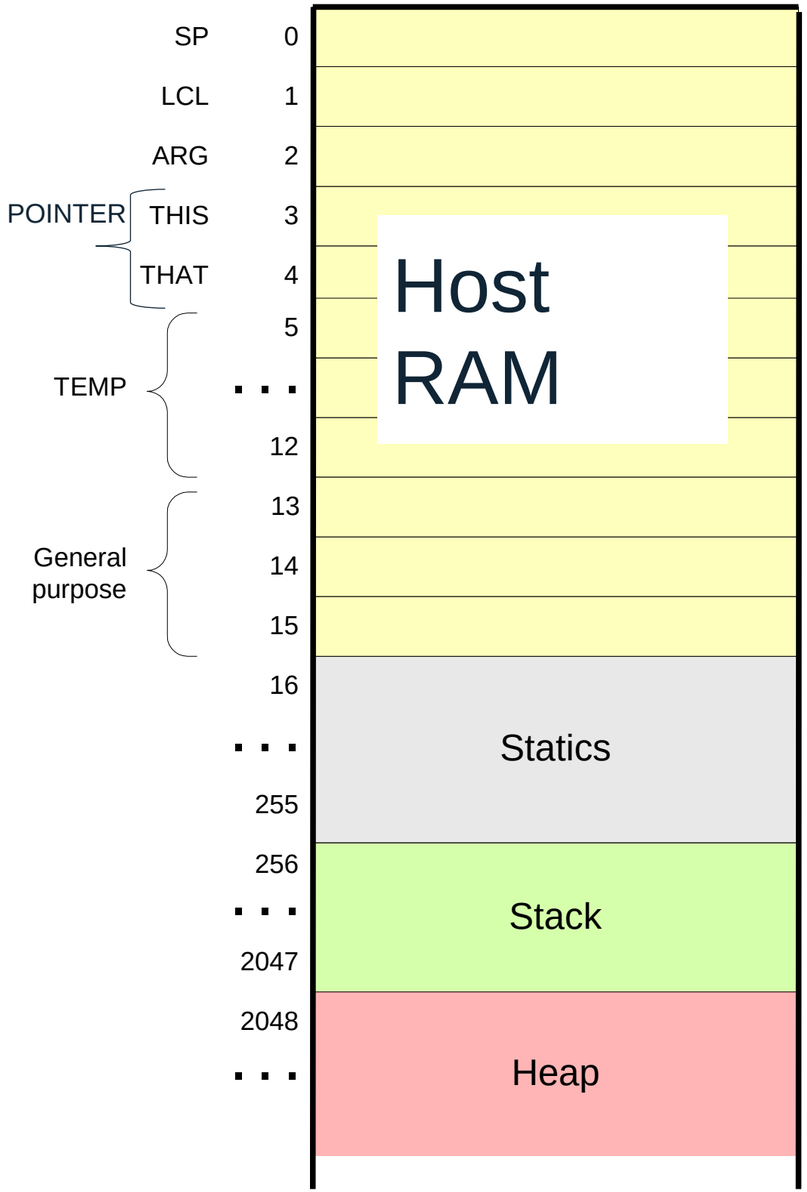
VM implementation on Hack platform



VM implementation on the Hack platform



Practice exercises

Now that we know how the memory segments are mapped on the host RAM, we can write Hack commands that realize the various VM commands.
for example, let us write the Hack code that implements the following VM commands:

- push constant 1
- pop static 7 (suppose it appears in a VM file named Bob.vm)
- push constant 5
- add
- pop local 2
- eq

Tips:

1. The implementation of any one of these VM commands requires several Hack assembly commands involving pointer arithmetic (using commands like A=M)
2. If you run out of registers (you have only two ...), you may use R13, R14, and R15.

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VM Translator Parsing

You will implement this in assignment

- **push constant 1**

```
@SP
AM=M+1
A=A-1
M=1
```

- **pop static 7 (in a VM file named Bob.vm)**

```
@SP
AM=M-1
D=M
@Bob.7
M=D
```

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VM Translator Parsing

You will implement this in assignment

- **push constant 5**

```
@5
D=A
@SP
AM=M+1
A=A-1
M=D
```

- **add**

```
@SP
AM=M-1
D=M
A=A-1
M=D+M
```

- **pop local 2**

```
@SP
AM=M-1
D=M
@LOCAL
A=A+1
A=A+1
M=D
```

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VM Translator Parsing

You will implement this in assignment

- **eq**

```
@SP
AM=M-1
D=M
@SP
AM=M-1
D=M-D
@labelTrue
D;JEQ
D=0
@labelFalse
0;JMP
(labelTrue)
D=-1
(labelFalse)
@SP
A=M
M=D
@SP
M=M+1
```

Exercise:

You will see similar question in exam

VM command **not** in hack assembly (3 lines):

Exercise:

You will see similar question in exam

Write the VM commands to compute **((a+b)+c)**:
Suppose **a**, **b** and **c** are in the local segment at offsets **4**, **5** and **6**.

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Exercise:

You will see similar question in exam

For the same computation **((a+b)+c)**, draw the top of the stack
Before and after each of the two **+** operation.
Suppose **a**, **b** and **c** are in the local segment at offsets **4**, **5** and **6**.

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This Week

- Review Chapters 6 & 7 of the Text Book (if you haven't already)
- Assignment 4 due this Friday (2nd September 2022)
- Assignment 5 Available Now – Due week 8.
- Review Chapter 8 of the Text Book before week 7.

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