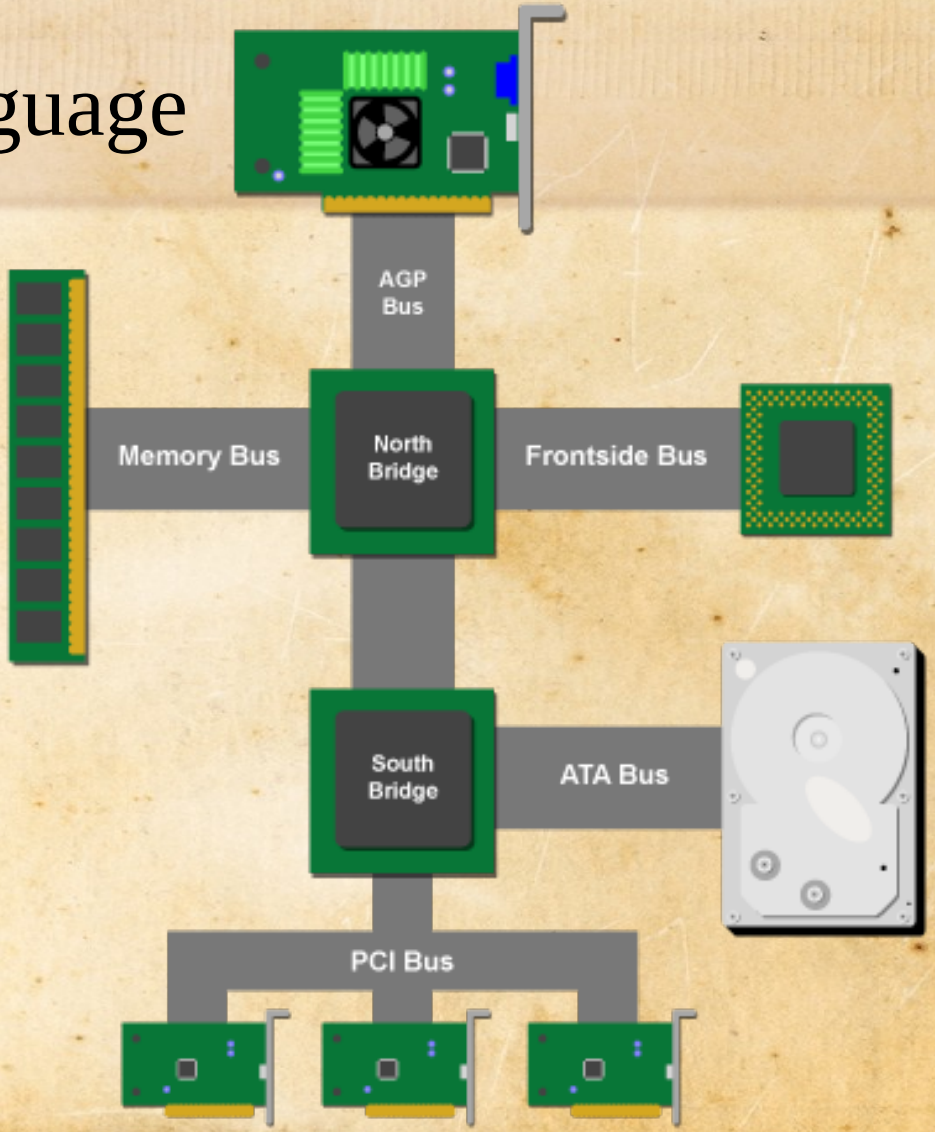
Introduction

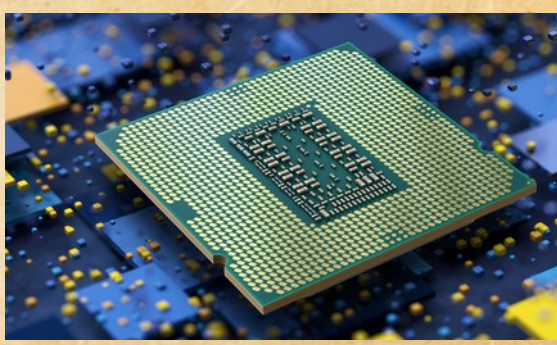
Programming Languages

Lecture Contents

- Languages
  - Machine Language (1st Generation)
  - Assembly Language (2nd Generation)
  - High-Level Programming Languages (3rd Generation)
    - Subroutine (FORTRAN, BASIC)
    - Procedural / Functional (Pascal, C)
    - Object Oriented (C++, Java)
- Compilers and Interpreters
- Java

Machine Language





Machine Language (1st Generation)

- This is the language the computer understands
  - For a hypothetical computer, instructions could be

0000	Stop			**Machine Code**
0001	Add	3+4	→	0001 0011 0100
0010	Subtract	7-5	→	0010 0111 0101
0011	Multiply	2x3	→	0011 0010 0011
0100	Divide	6÷2	→	0100 0110 0010
0101	Square	3x3	→	0101 0000 0011

Assembly Language (2nd Generation)

- It is more human-readable, but corresponds directly to the machine code (one assembly instruction → one machine language instruction)
  - It is specific to each type of computer chip

Assembly Code		Machine Code
add 3,4	→	0001 0011 0100
sub 7,5	→	0010 0111 0101
mul 2,3	→	0011 0010 0011
div 6,2	→	0100 0110 0010
sqr 3	→	0101 0000 0011
stop		0000 0000 0000

  - Translated into machine code by an ***assembler***.

High-Level Languages (3rd Generation)

- Much more human-readable
- Languages are becoming more abstract with time
  - less abstract languages such as BASIC, C
  - more abstract languages such as Java and Python
- High-Level languages are translated into ***machine code*** by either a ***compiler*** or an ***interpreter*** (or a combination or them).
- One ***statement*** in a high-level language may become many ***machine code*** instructions.

High Level Languages

- BASIC

```
10 FOR I = 1 TO 10
20 GOSUB 100
30 NEXT I
40 END
100 PRINT "hello hackaday!"
110 RETURN
```

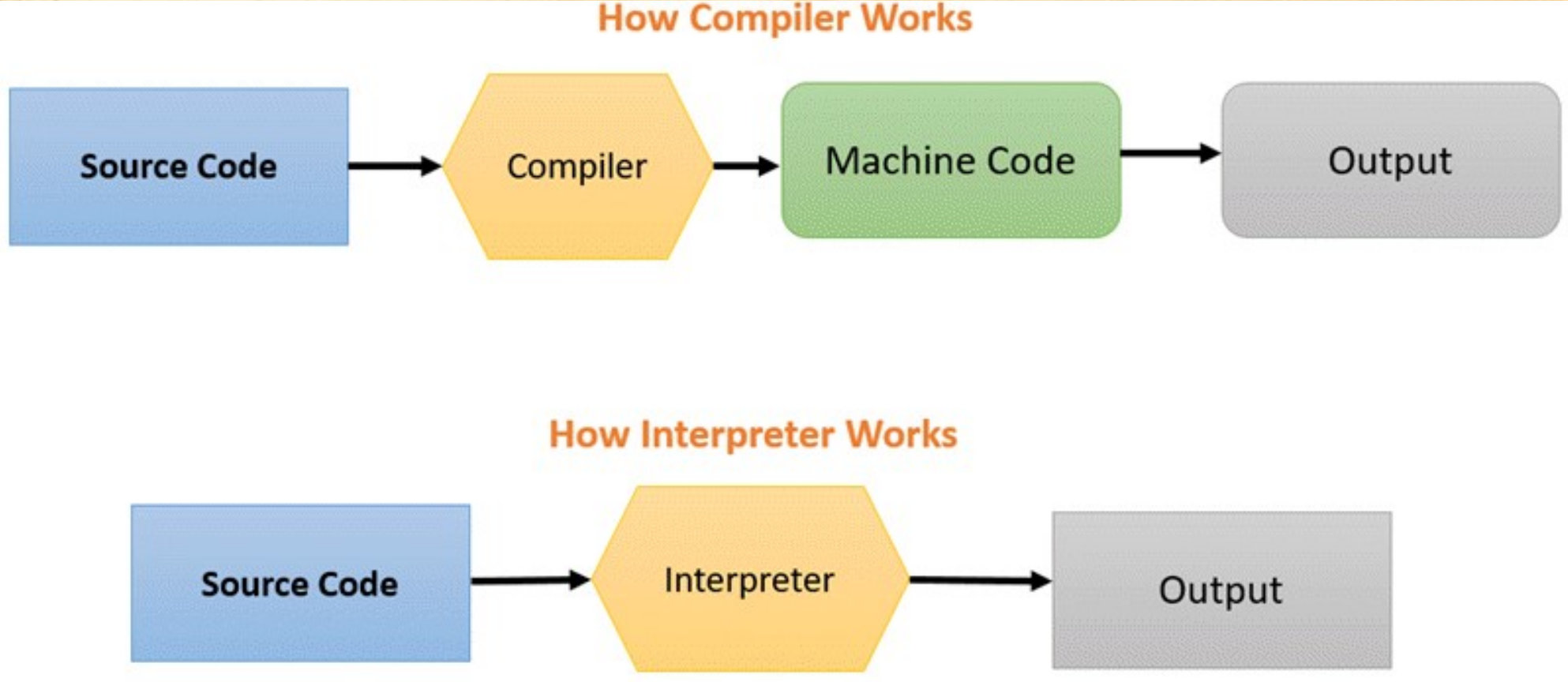
```
main:   let b2 = 15          ; set b2 value
        gosub flsh           ; call sub-procedure
        let b2 = 5           ; set b2 value
        gosub flsh           ; call sub-procedure
        end                  ; stop accidentally falling into sub

flsh:   for b0 = 1 to b2     ; define loop for b2 times
          high B.1           ; switch on output 1
          pause 500          ; wait 0.5 seconds
          low B.1            ; switch off output 1
          pause 500          ; wait 0.5 seconds
        next b0              ; end of loop
        return               ; return from sub-procedure
```

Interpreters and Compilers

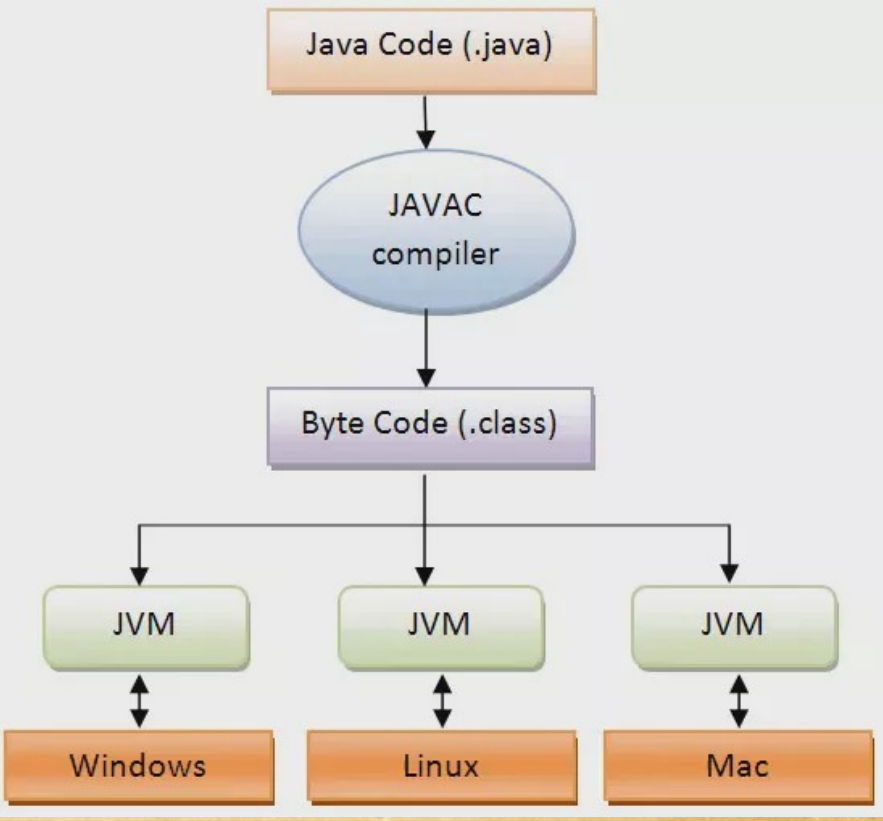
- Computers only understand ***machine code***
  - Specific to each computer chip family (X86, ARM, RISC-V)
- ***Assembler***: assembly language → machine code
- ***Interpreter***:
  - Line by line, executing instructions at the same time.
- ***Compiler***: high-level language → machine code (“object code”)
  - Entire program to generate an executable file that can be run again and again.

Interpreters and Compilers



Java

- Uses both a ***compiler*** and an ***interpreter***.
  - **`javac`** compiles Java *source code* into Java ***bytecode***.
  - Java ***bytecode*** is ***machine code*** for a ***Java Virtual Machine*** (**JVM**).
  - The command **`java`** runs the JVM.



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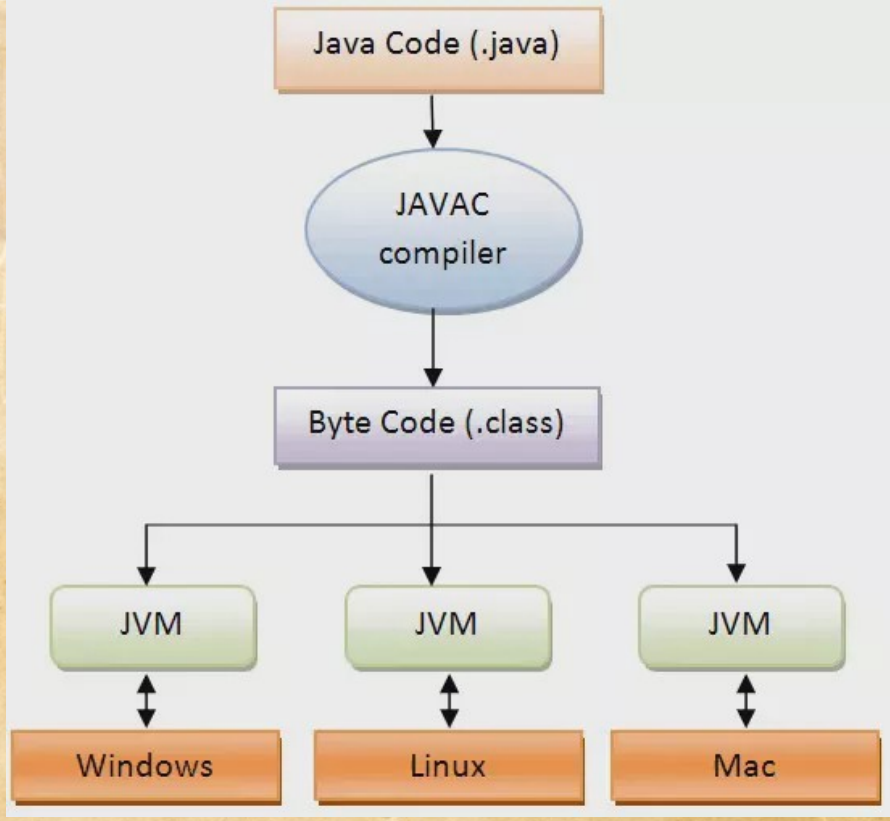
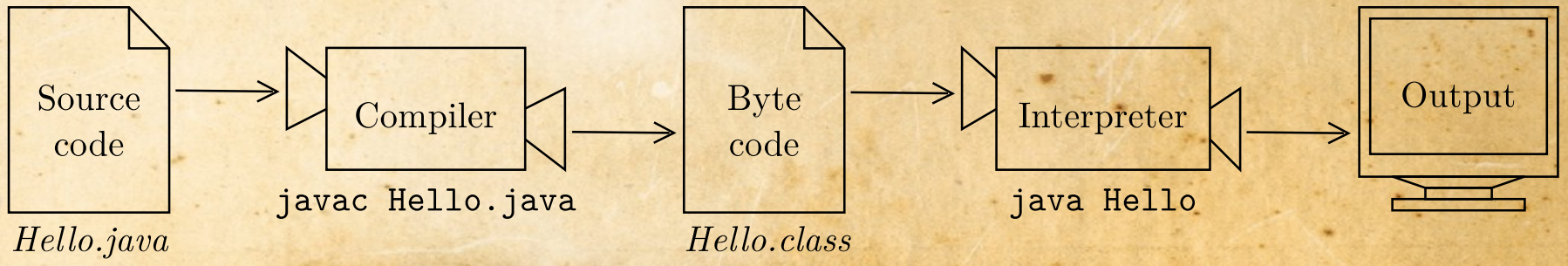




Java

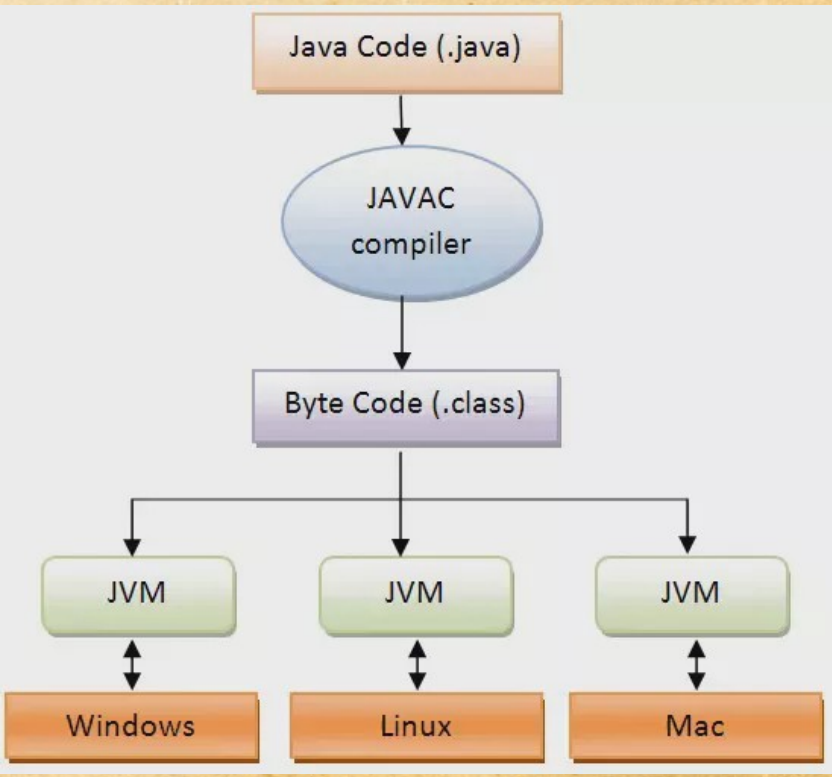
- Uses both a ***compiler*** and an ***interpreter***.

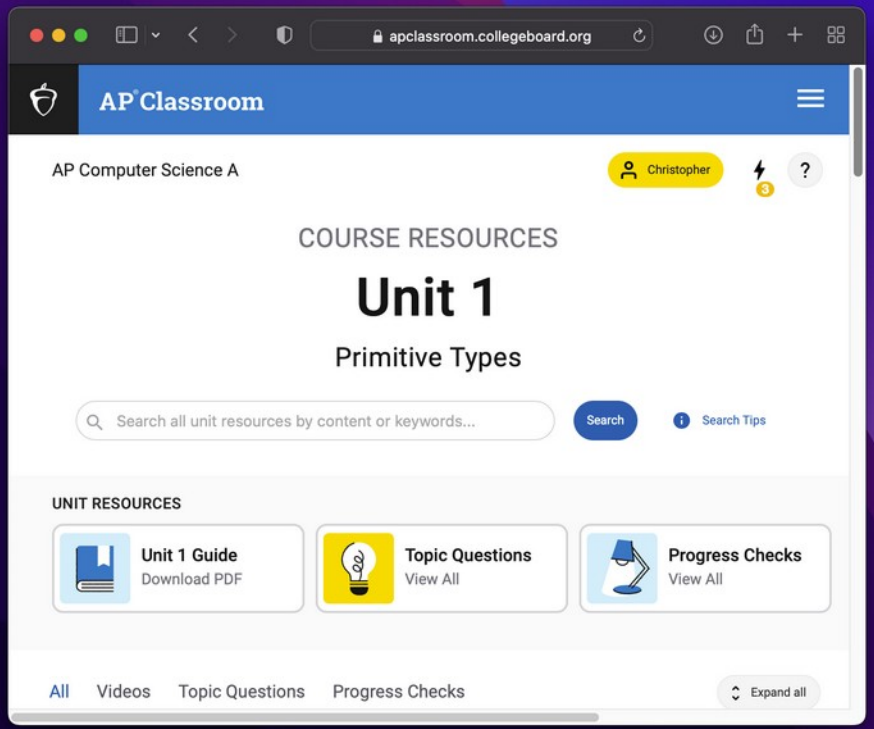
MyJavaProject — -zsh — 79×24

```
christophernielsen@Christophers-MacBook-Pro MyJavaProject % ls
MyClass.java
christophernielsen@Christophers-MacBook-Pro MyJavaProject % javac MyClass.java
christophernielsen@Christophers-MacBook-Pro MyJavaProject % java MyClass
Hello World!
christophernielsen@Christophers-MacBook-Pro MyJavaProject %
```

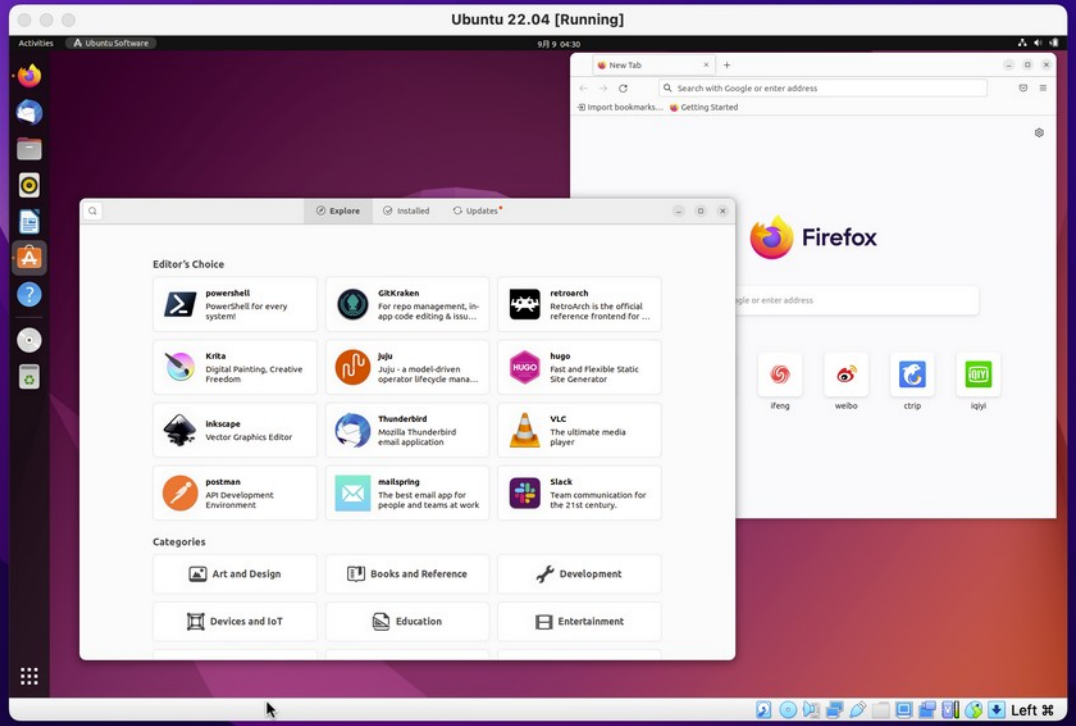
Java

- The big benefit of programming in Java:
  - A compiled java program can run without modification on any machine that has a JVM
    - Operating systems such as Windows, MacOS, Linux, Android, ...
    - Hardware architectures such as X86, ARM, PowerPC, MIPS, RISC-V, …
- It should be faster than other interpreted languages since *byte code* is very low level and requires little translation work





A virtual machine running the Linux operating system



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