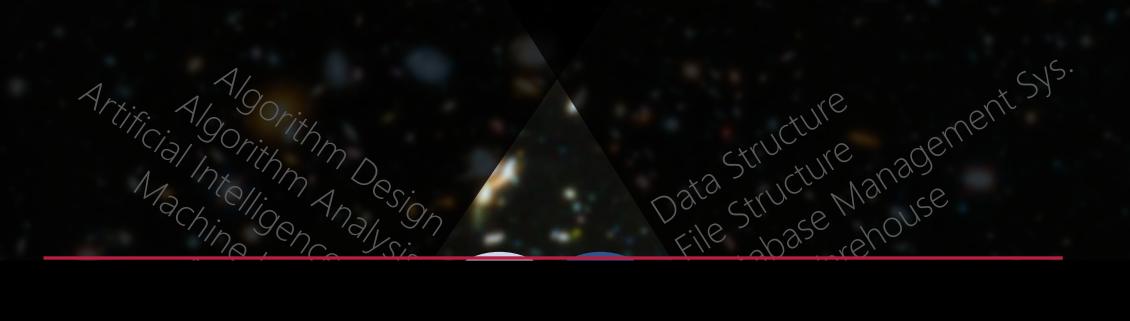


Database Management Sys. Algorithm Design Artificial Intelligence (AI) Algorithm Analysis DataStructure FileStructure Machine Learning Data Warehouse Data Mining Big Data Alga Data Cloud Vaccille



this course, System Programming, is in which space?





John von Neumann

(<u>/vpn 'nɔɪmən/</u>) 1903 –1957

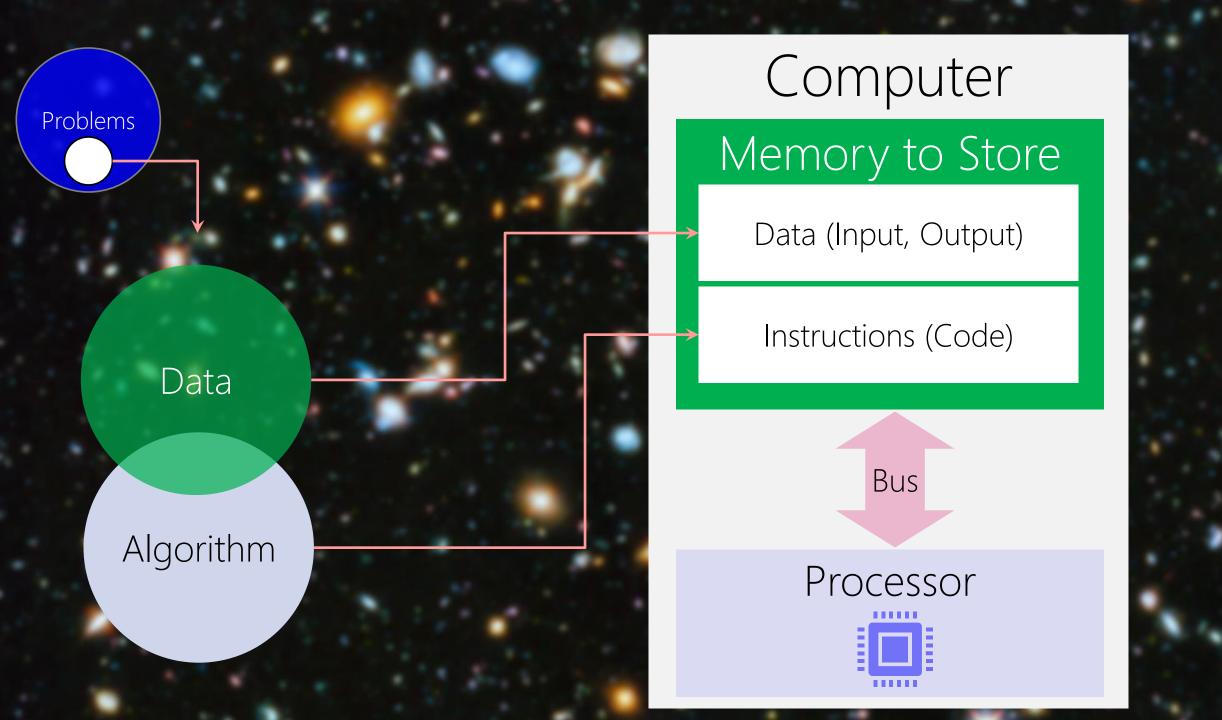
Mathematician, Physicist, Computer Scientist, Engineer

Polymath

He integrated pure and applied sciences. He made major contributions to many fields, including:

- Mathematics
- Physics
- Economics (game theory)
- Computing
- Statistics





von NEUMANN ARCHITECTURE

- 1. Data and instructions are all in the memory
- 2. The memory is addressable by location (regardless of what is stored in that location)
- 3. Instructions are executed sequentially unless the order is explicitly modified

Computer System

Input/Output Devices



Computer

Memory to Store

Data (Input, Output)

Instructions (Code)



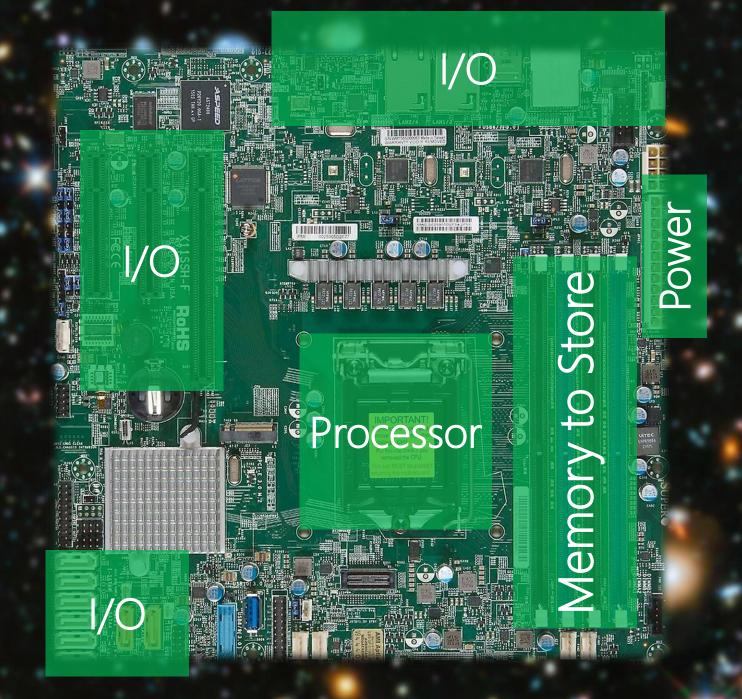
Processor

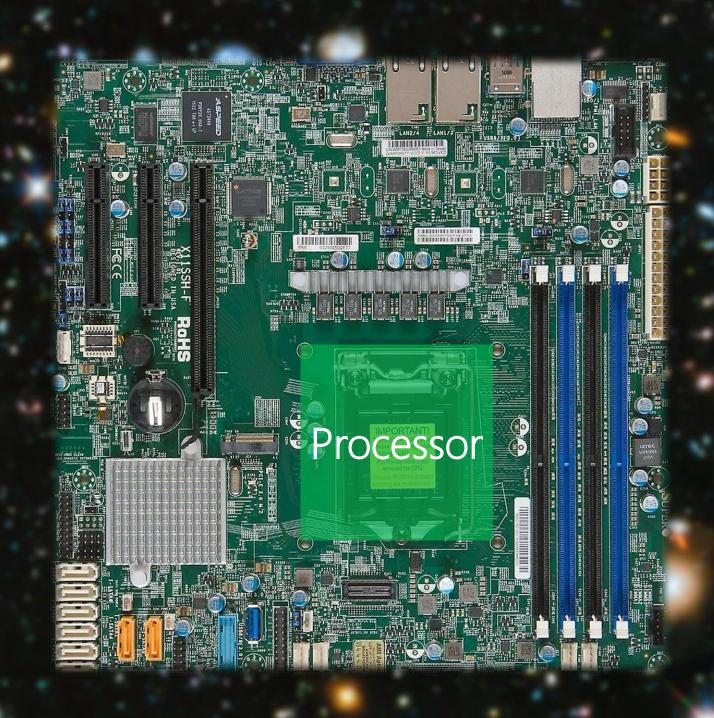




Permanent Storage







PROCESSOR

- 1. Cannot instruct a processor to do whatever we want!
- 2. Processors have limitations.
 - Some can only do addition,
 - Some can do both addition and subtraction, but no division

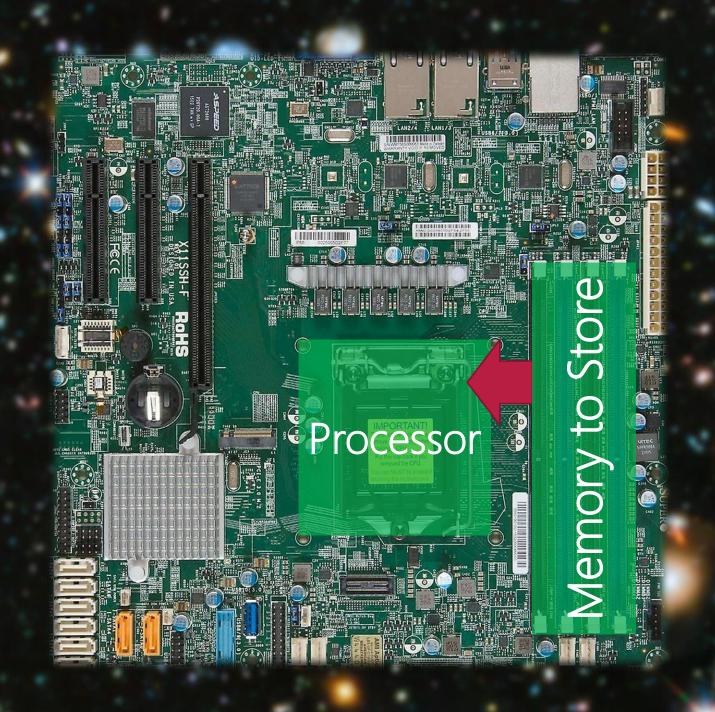
RISC vs. CISC /'sisk/

Small but optimized set of instructions e.g., integer calculation vs.

Large and NOT optimized set of instructions e.g., integer and floating-point calculations

x86, x64

By Intel and AMD instruction set size: ~981
How Many x86-64 Instructions Are There Anyway?



Instruction Decoder

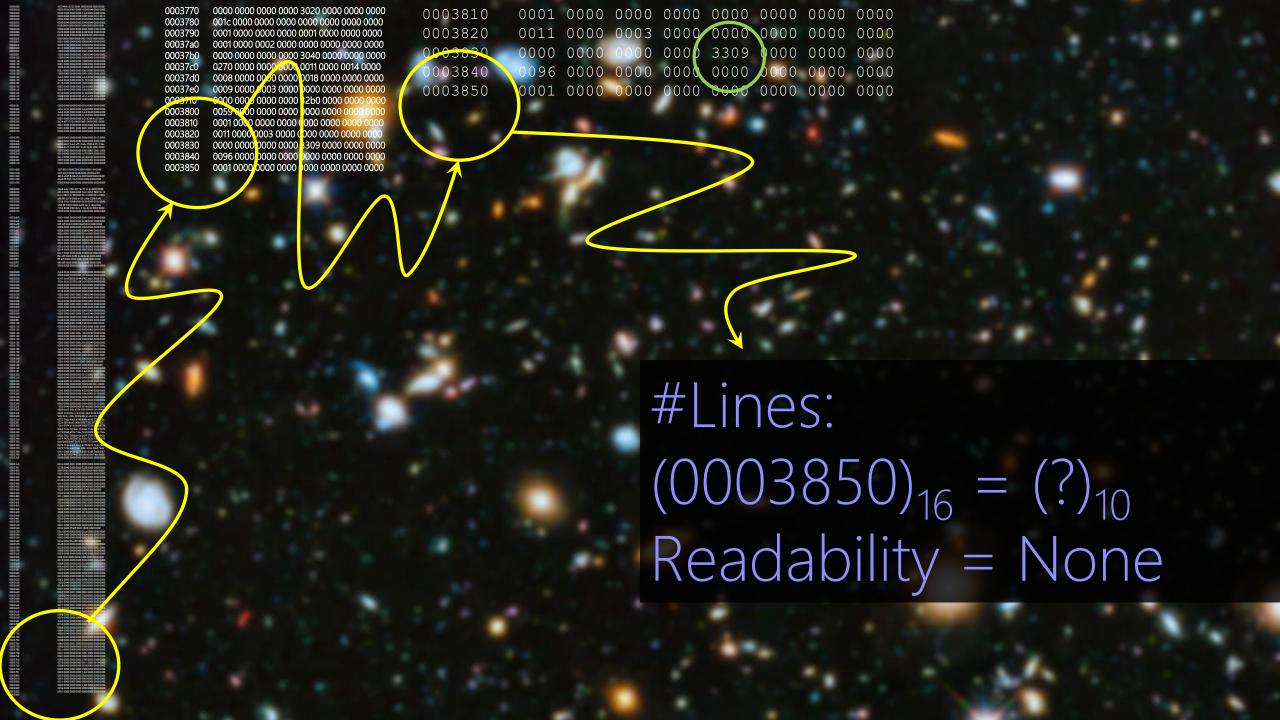
Operation Code (OP Code)	01001000 XXXX YYYY ZZZZ
What to do?	 Fetch the first operand from memory at XXXX address Store the first operand inside somewhere (AX) Fetch the second operand from memory at YYYY address Store the first operand inside somewhere else (BX) Use the n-bit Adder to add AX and BX Store the result inside somewhere else (CX) Push CX to memory at ZZZZ address

extremely simplified version!

Hello world!







ASSEMBLY

Instruction Decoder

Assembly	ADD [XXXX], [YYYY], [ZZZZ]
Operation Code (OP Code)	01001000 XXXX YYYY ZZZZ
What to do?	 Fetch the first operand from memory at XXXX address Store the first operand inside somewhere (AX) Fetch the second operand from memory at YYYY address Store the first operand inside somewhere else (BX) Use the n-bit Adder to add AX and BX Store the result inside somewhere else (CX) Push CX to memory at ZZZZ address

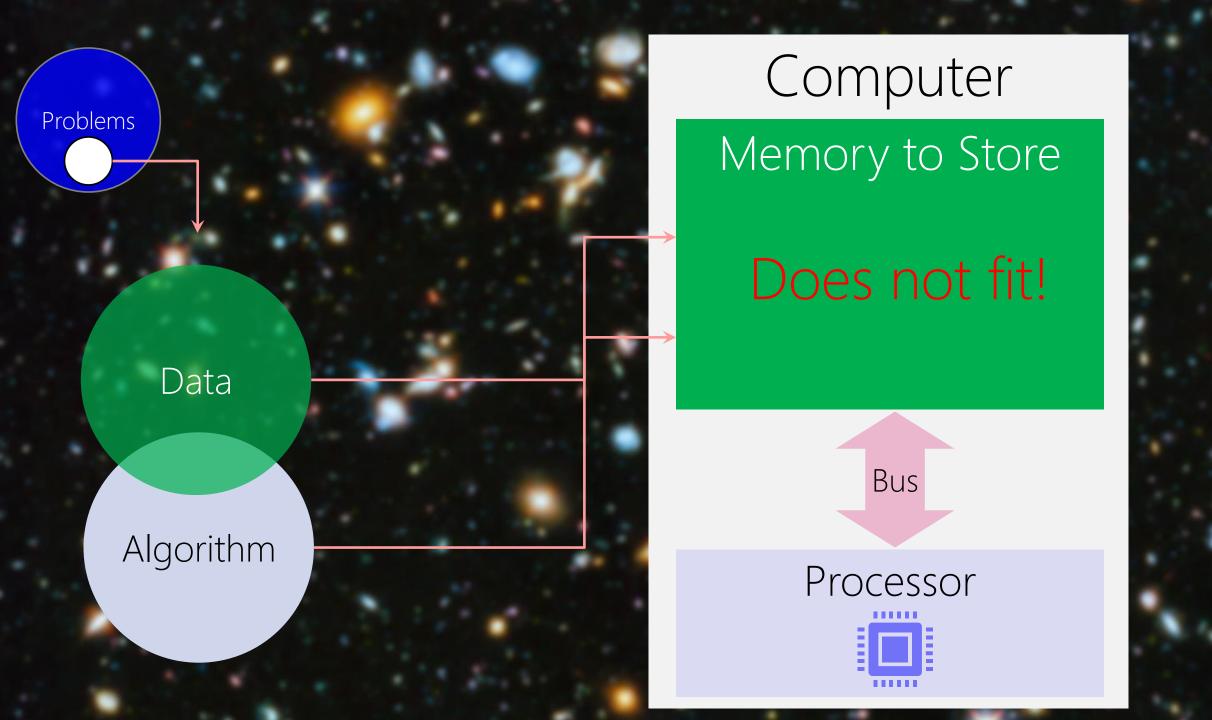
extremely simplified version!

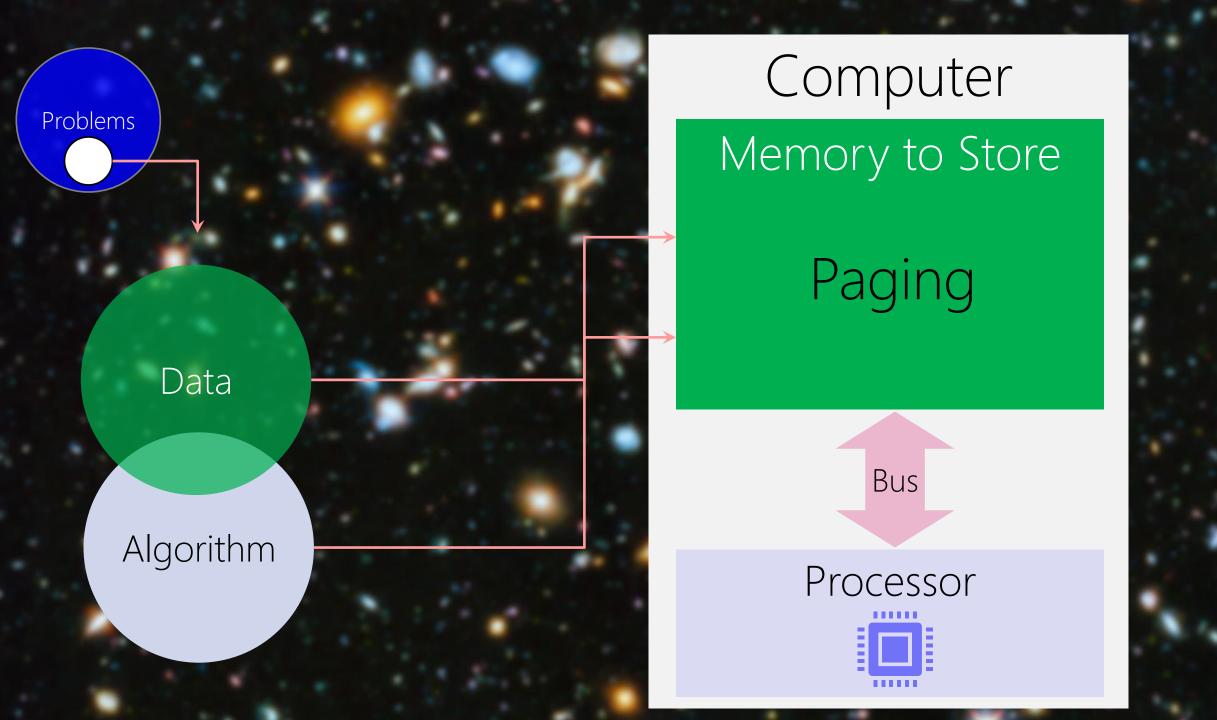
Hello world!

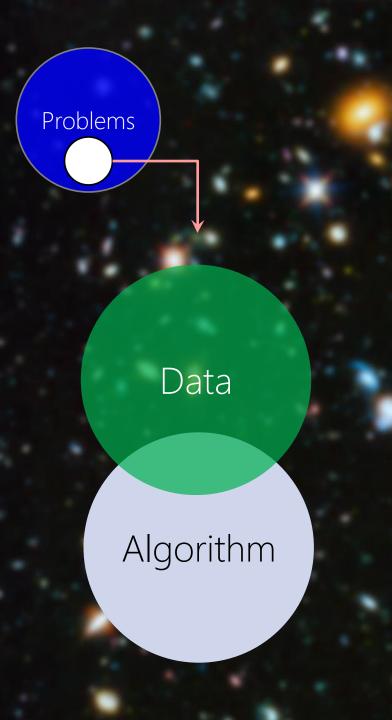
```
<.plt>:
pushq
        0x3002(%rip)
        *0x3004(%rip)
jmpq
        0x0(%rax)
nopl
<printf@plt>:
        *0x3002(%rip)
jmpq
        $0x0
pushq
        401000 <.plt>
jmpq
<main>:
push
        %rbp
        %rsp,%rbp
mov
        0xfd5(%rip),%rdi
lea
        $0x0, %eax
MOV
        401010 <printf@plt>
callq
nop
        %rbp
pop
retq
```

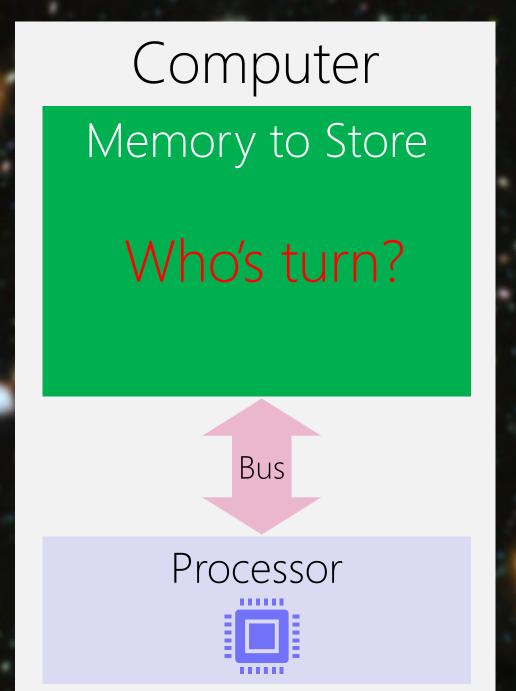
#Lines: 14-17 vs. 14416 opcodes Readability: Fair

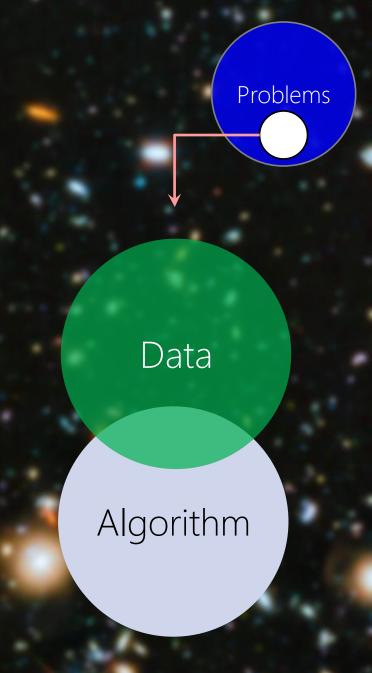


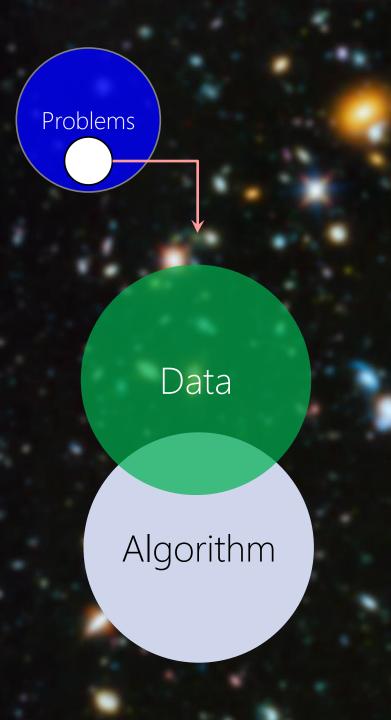


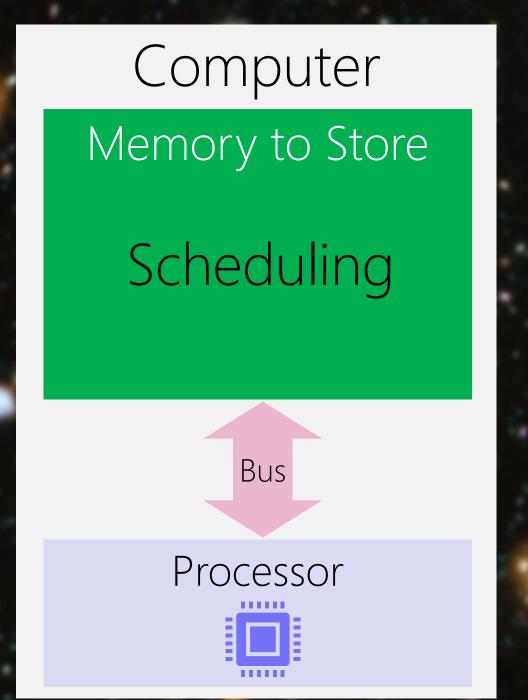


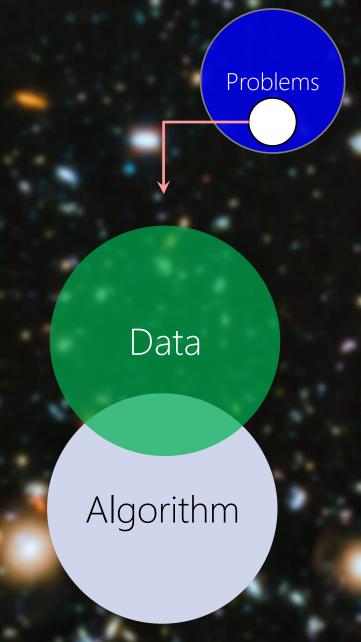






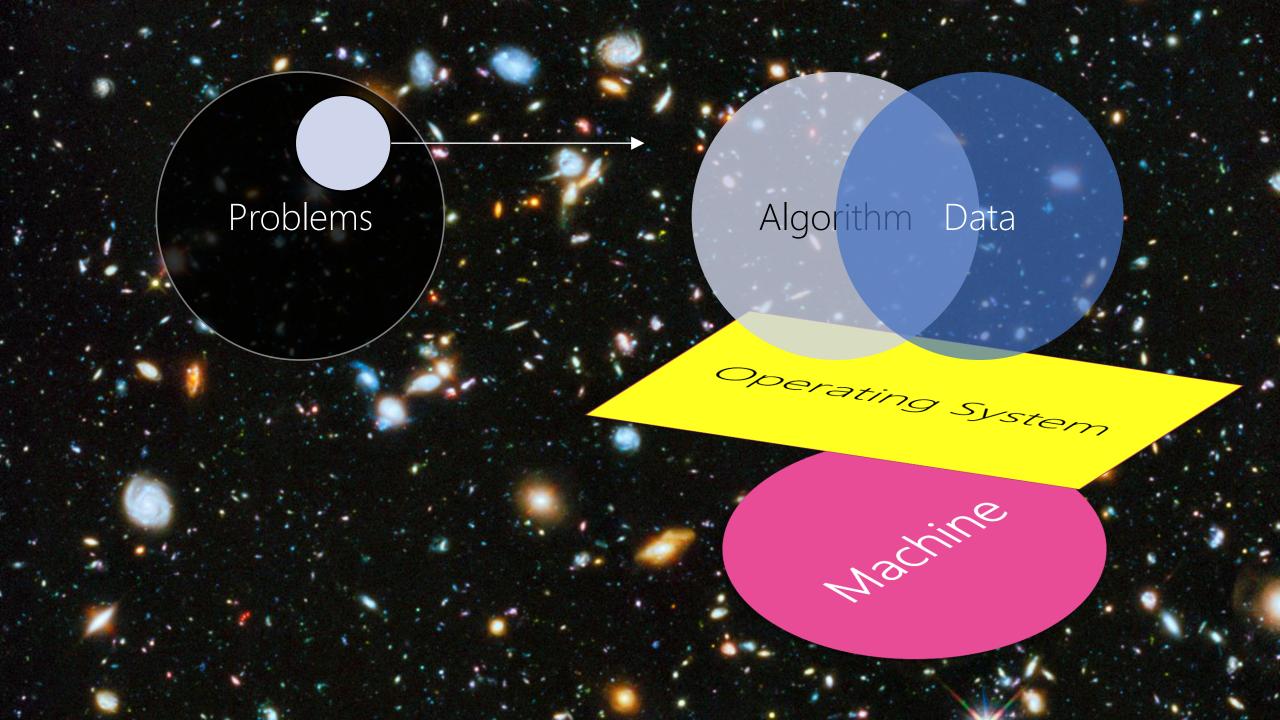






Operating System

A program for programs! System-level Program





UNIX

1969 in Assembly

New Language

C for UNIX

System-level Programing

The UNIX operating system's development started in 1969, and its code was *rewritten* in C in 1972. The C language was actually created to move the UNIX kernel code from assembly to a higher level language, which would do the same tasks with fewer lines of code.

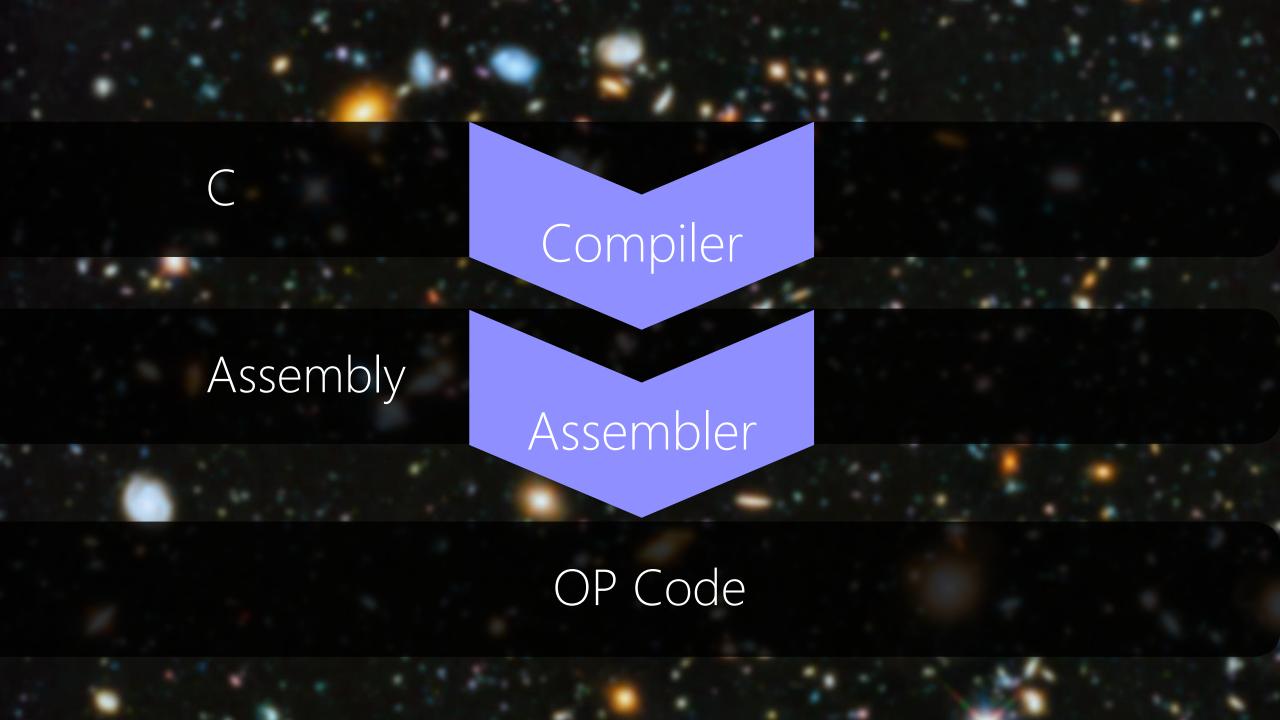
Instruction Decoder

C	C = a + b
Assembly	ADD [XXXX], [YYYY], [ZZZZ]
Operation Code (OP Code)	01001000 XXXX YYYY ZZZZ
What to do?	 Fetch the first operand from memory at XXXX address Store the first operand inside somewhere (AX) Fetch the second operand from memory at YYYY address Store the first operand inside somewhere else (BX) Use the n-bit Adder to add AX and BX Store the result inside somewhere else (CX) Push CX to memory at ZZZZ address

extremely simplified version!

```
#include <stdio.h>
void main() {
    printf("Hello world!");
}
```

#Lines: 4 vs. 14 Assembly Readability: Good!



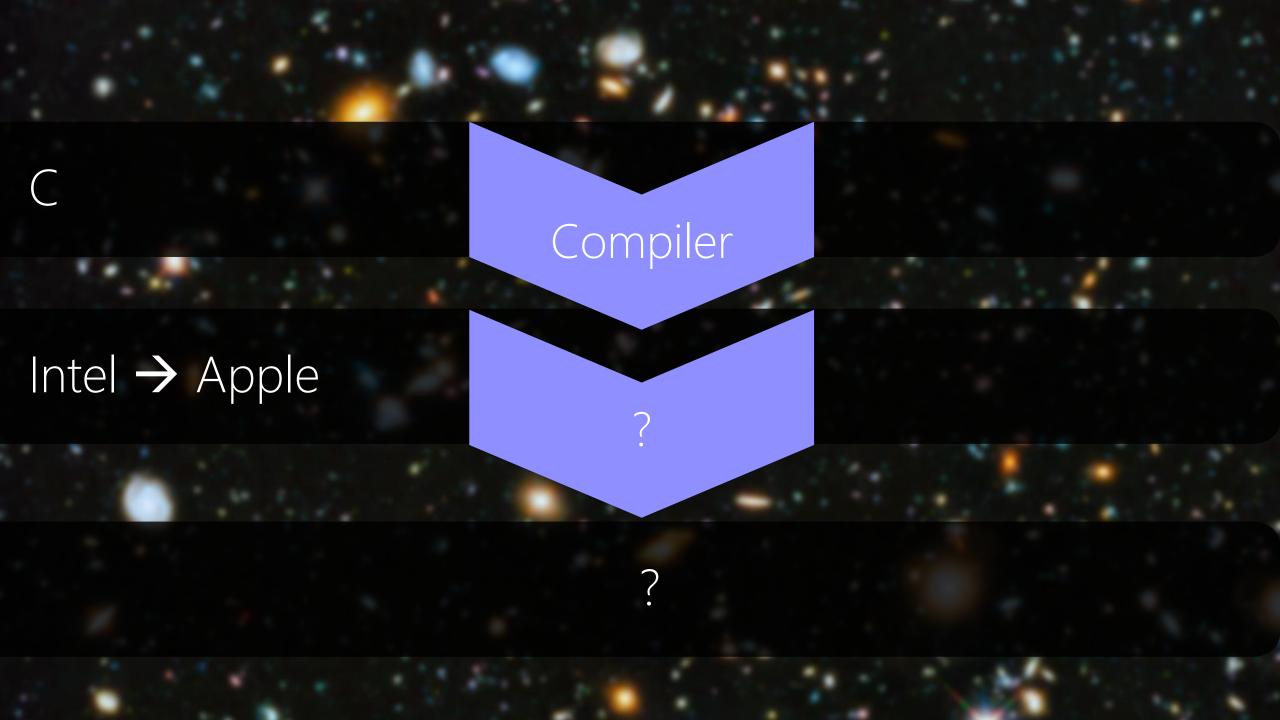
New Language

New Compiler

Assembly

Assembler

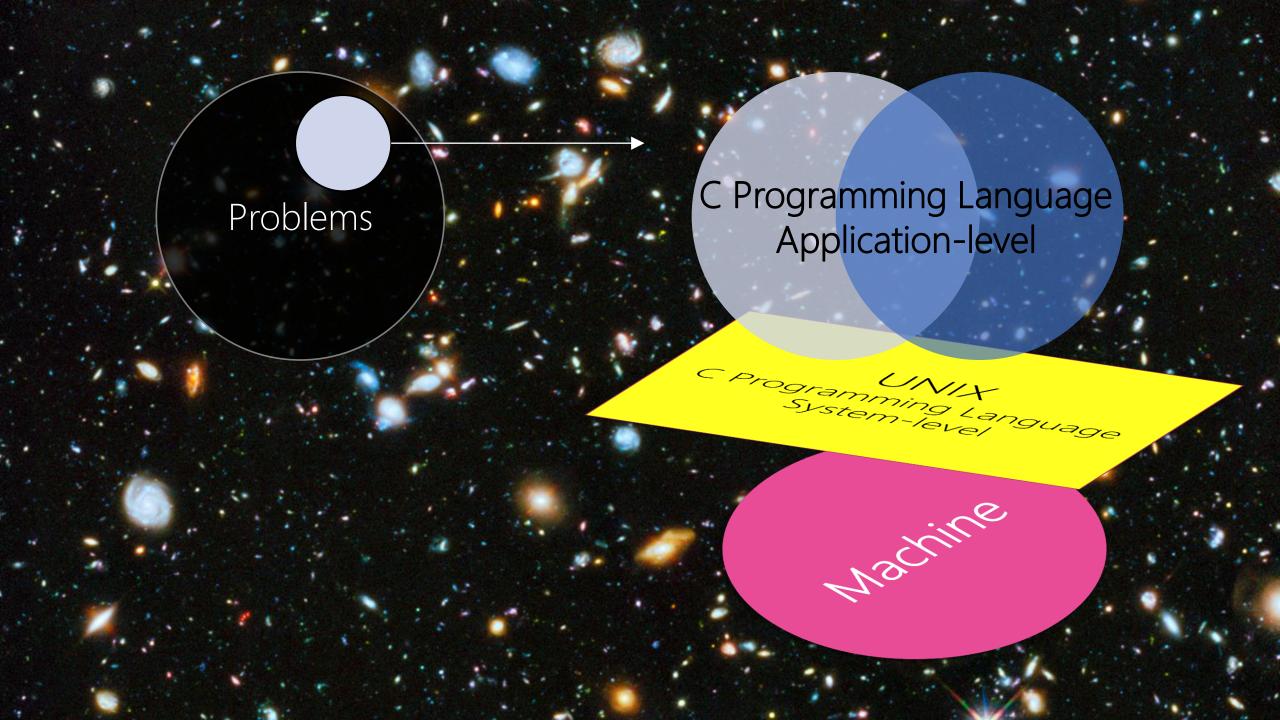
OP Code



Compiler Intel -> Apple New Assembler OP Code for Apple

C for ALL

Application-level Programing



We are not system-level programmer using C We are still application-level programmer using C

We want to know how OS execute our program!

We want to know how UNIX execute our program!

Why?

