The Nature of Computing

ICOM 4036
Lecture 2

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Some Inaccurate Yet Popular Perceptions of Computing

- Computing = Computers
- Computing = Programming
- Computing = Software

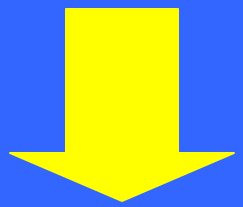
Computing = Computers

Computing is about solving problems using computers

A.K.A. The Computing Device View of Computing

Computing = Programming

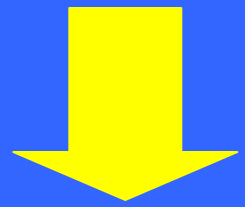
Computing is about writing
programs for computers



A.K.A. The Programming Language view of Computing

Computing = Software

Computing is not concerned with hardware design

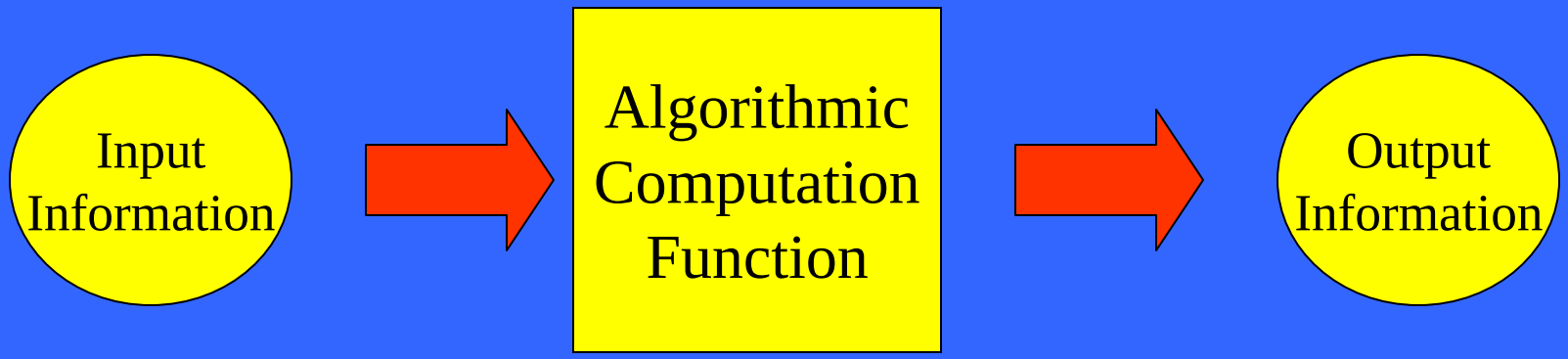


A.K.A. The “Floppy Disk” view of Computing

Part I - Outline

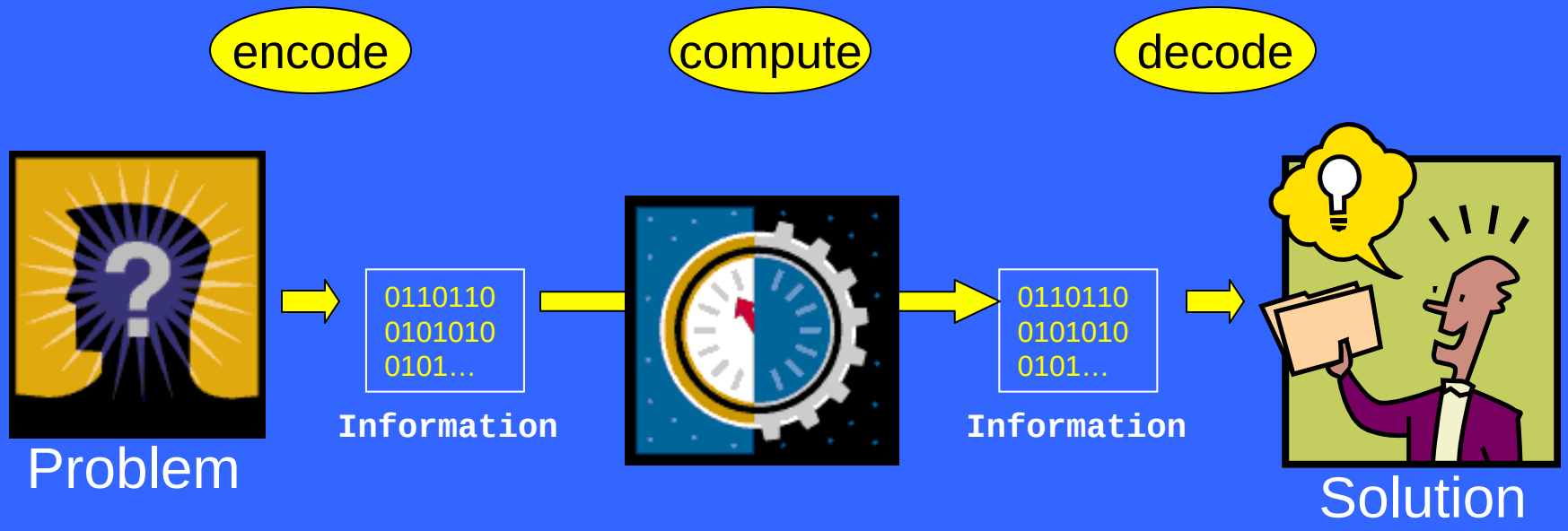
- What is Computing?
- Computing Models and Computability
- Interpretation and Universal Computers
- Church's Thesis

What is computing then?



Computing is the study of Computation:
the process of transforming information

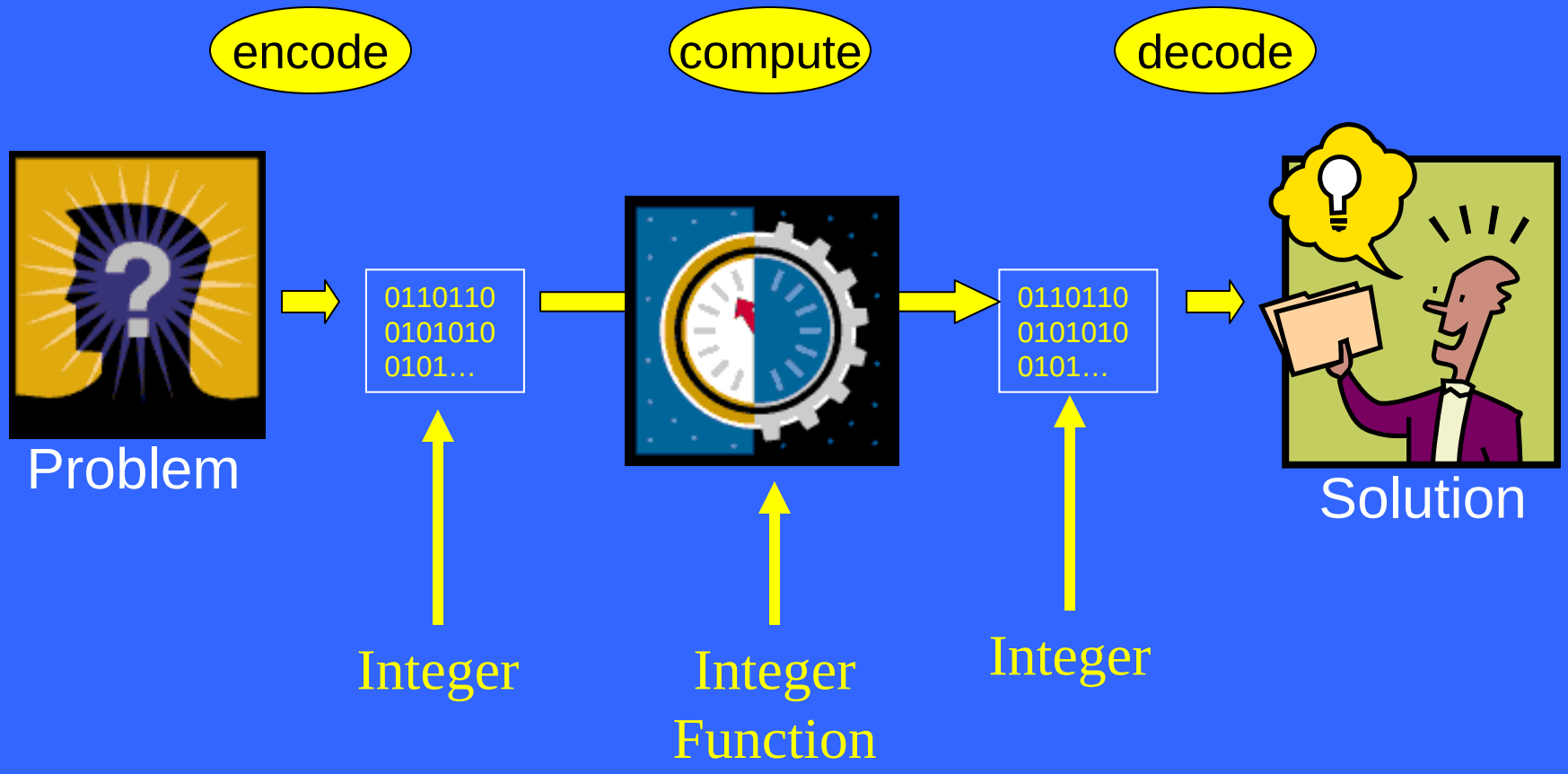
The Computation Process



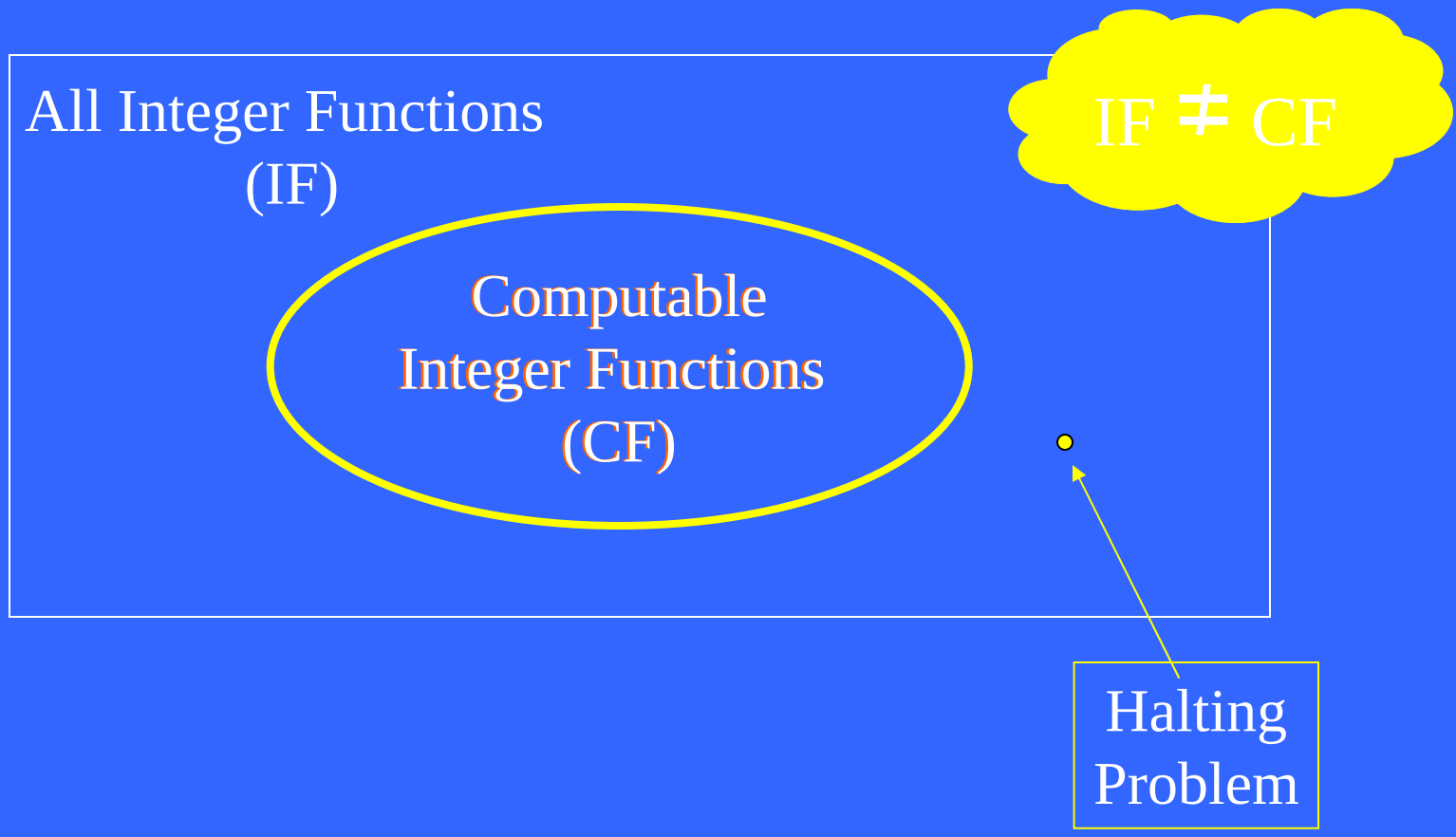
Fundamental Questions Addressed by the Discipline of Computing

- What is the nature of computation?
- What can be computed?
- What can be computed efficiently?
- How can we build computing devices?

The Computation Process

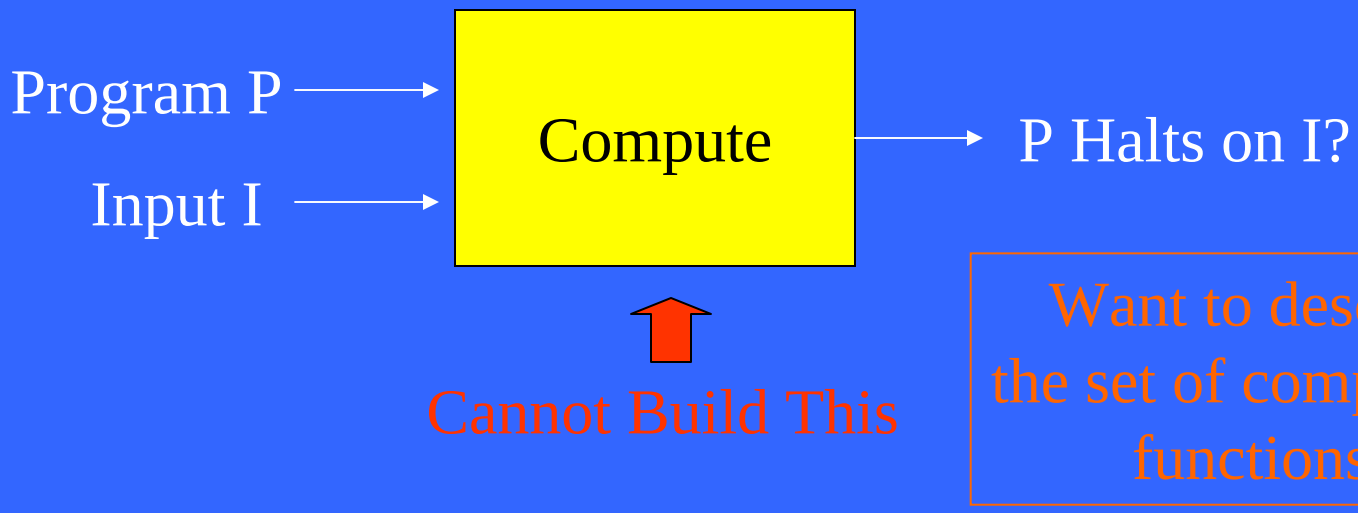


Computability



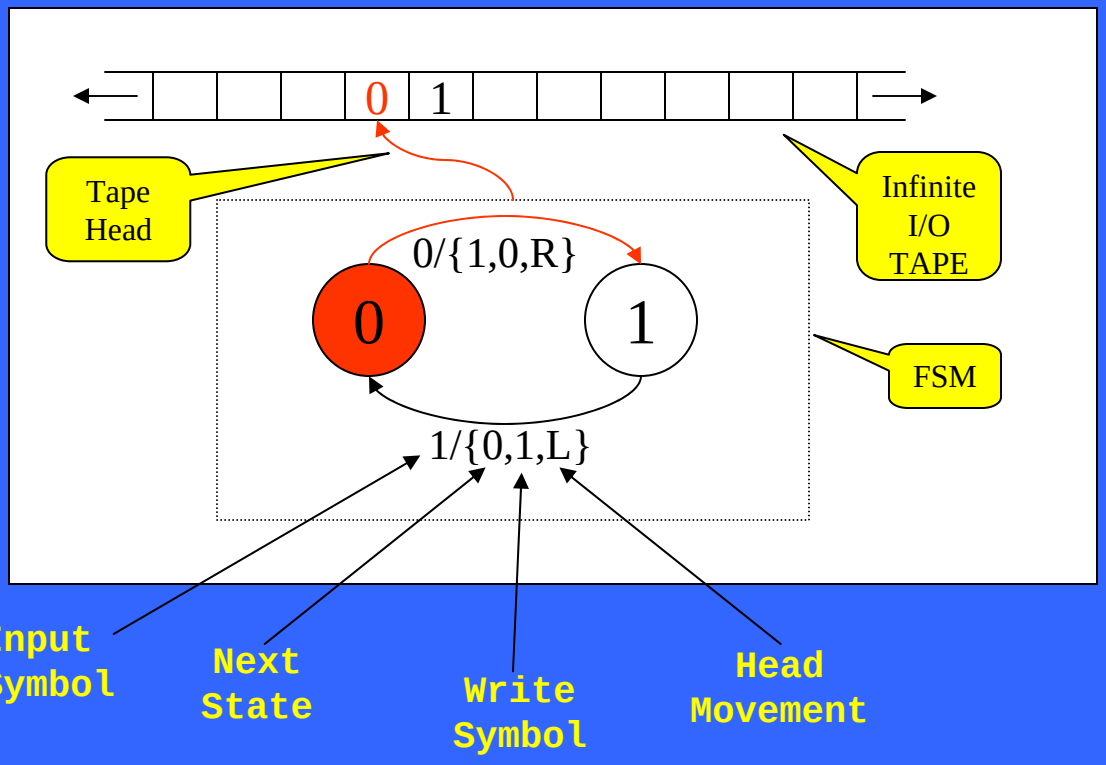
The Halting Problem
(Alan Turing 1936)

Given a program and an input to the program, determine if the program will eventually stop when it is given that input.



Mathematical Computers: The Turing Machine (1936)

Alan Turing



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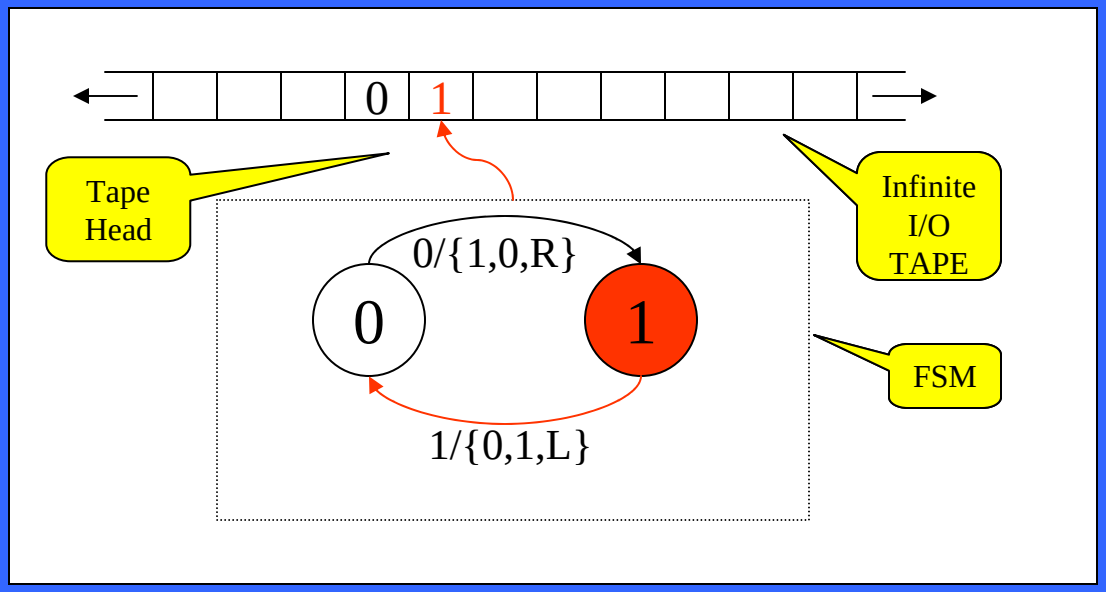
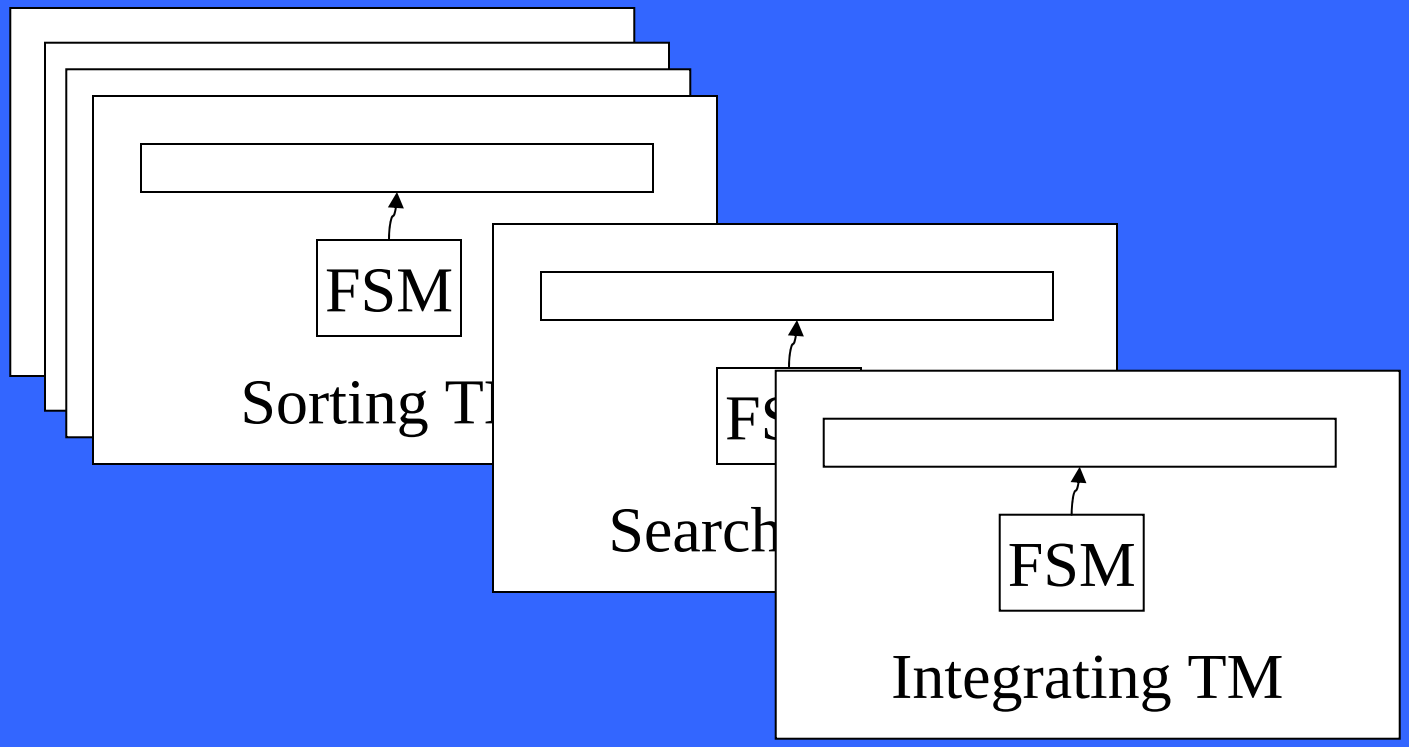


Turing demonstrated how to solve several problems using his computing model

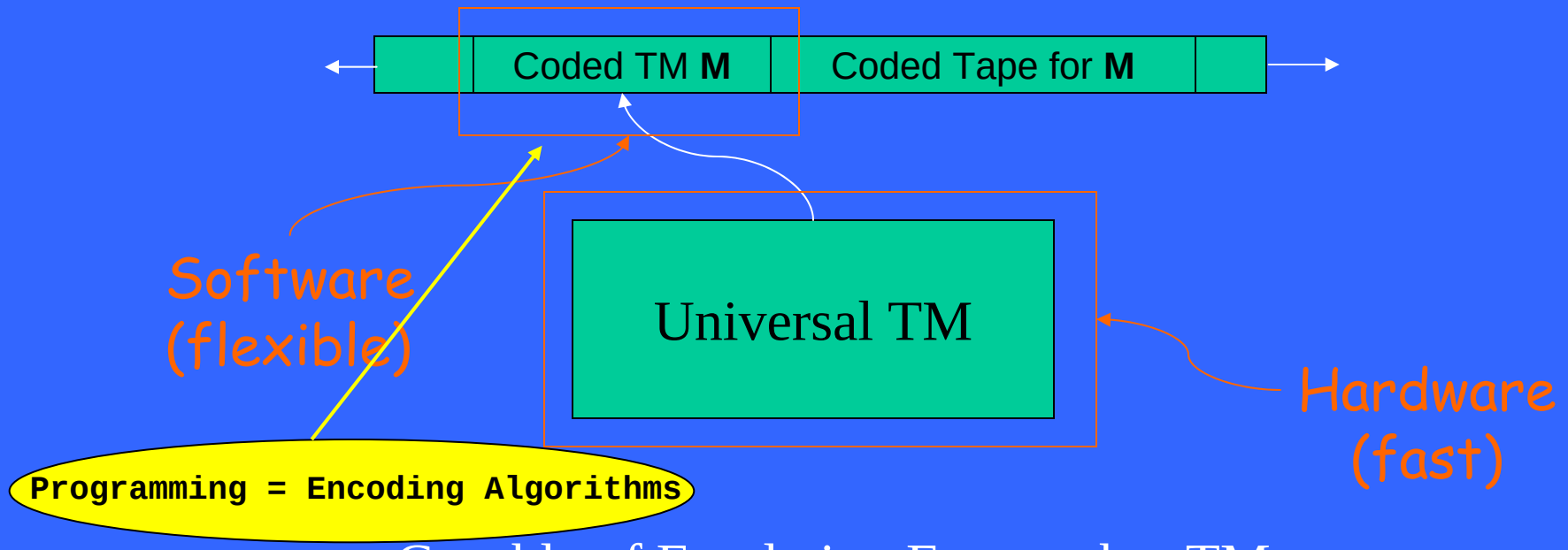
Ad-hoc Turing Machines



Can we build a general purpose TM?

The Universal Turing Machine (UTM)

The Paradigm for Modern General Purpose Computers



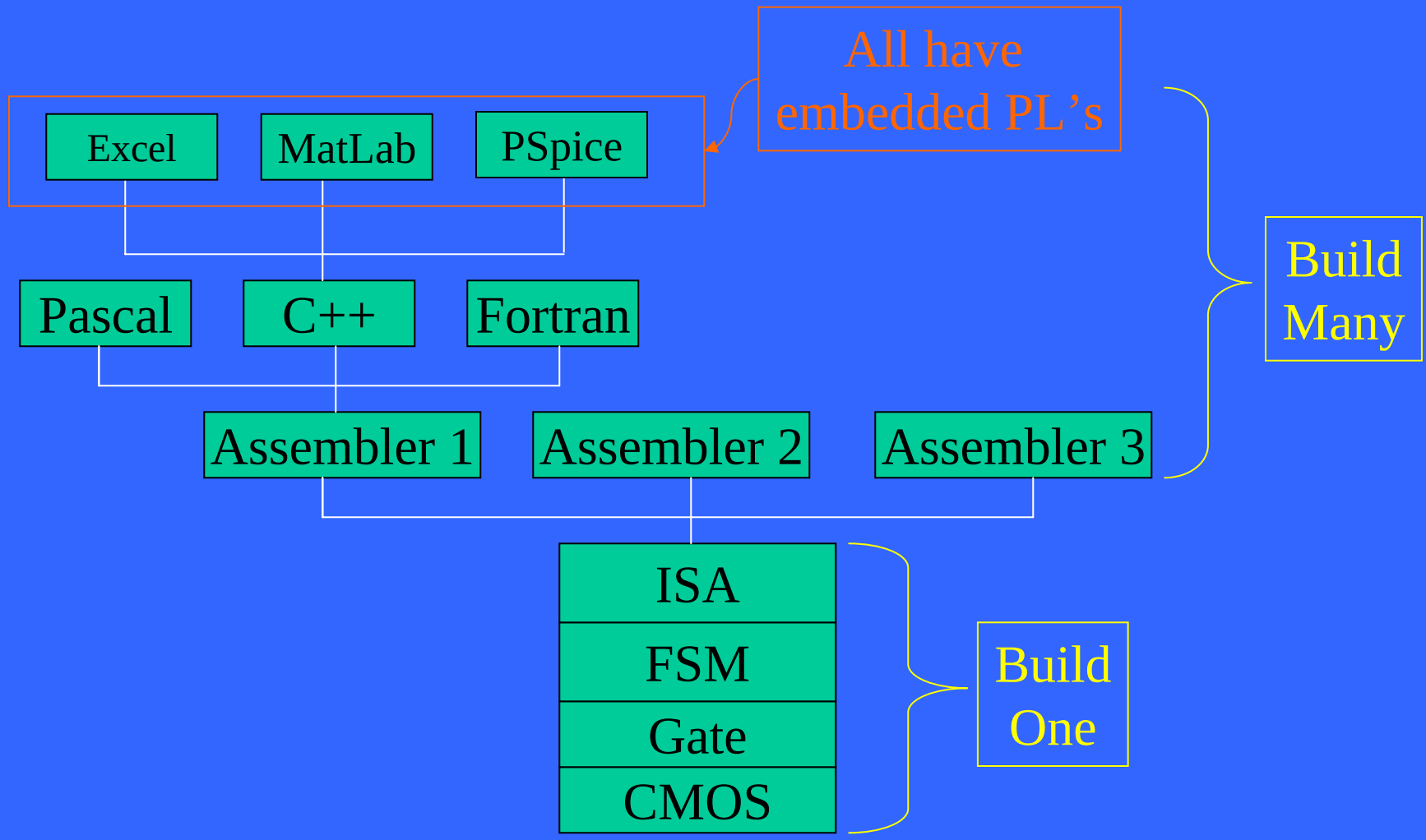
- Capable of Emulating Every other TM
- Shown possible by Alan Turing (1936)
- BIG IDEA: INTEPRETATION!!!

Other Familiar Models of Computation

- Combinational Circuits
- Sequential Circuits (FSM's)
- Pentium Instruction Set Architectures
- Lambda Calculus
- Recursive Functions
- C++

Can you tell which ones are Turing Universal?
That is, which ones can emulate any other Turing Machine?

Computing in Perspective

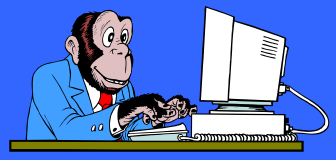


Interpreter Design Demands Programming Language Design

Why Abstraction Layers?

- Resilience to change:
  - Each layer provides a level of indirection
- Divide and Conquer Approach:
  - Can work on one small semantic gap at a time
- Building Block Approach:
  - Can build many higher layer on same l

Because we know of no other way of doing anything



Church's Thesis

Alonso Church

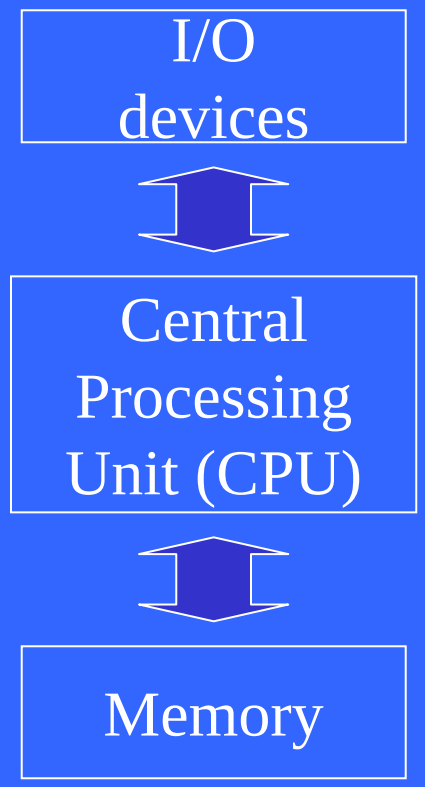
"Any realizable computing device can be simulated by a Turing machine"

"All the models of computation yet developed, and all those that may be developed in the future, are equivalent in power."

Issues not considered: Size, Programmability, Performance
But they must be considered if one is to build …

The (John) Von Neumann Architecture
(late 40's)


John von Neumann, 1950's



Allow communication with outside world

Interprets instructions

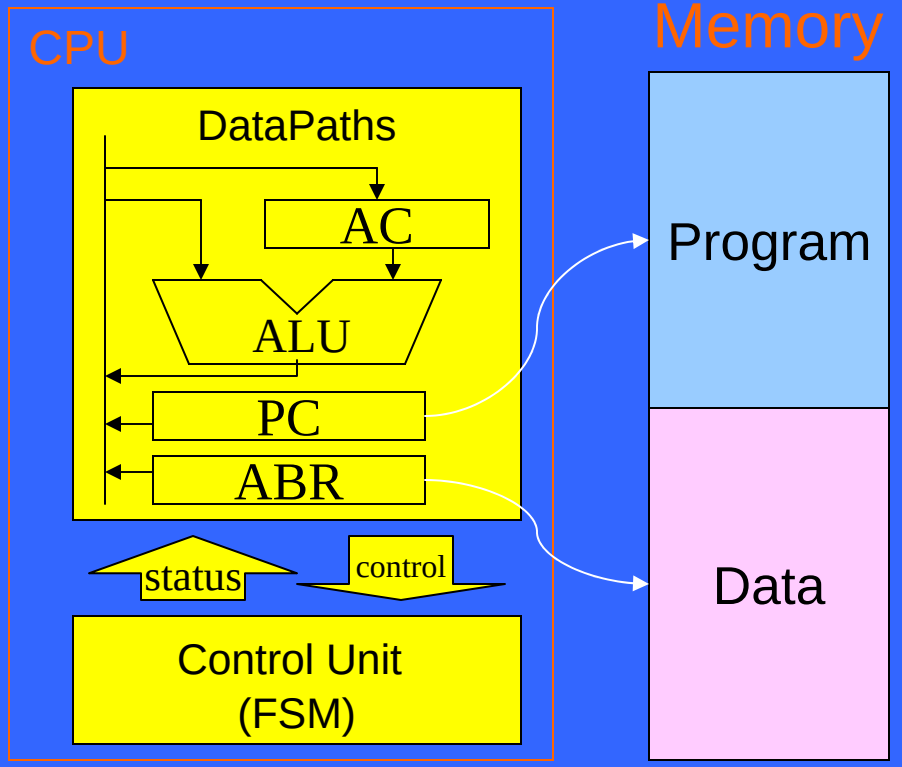
Stores both programs and data

After 60 years … most processors still look like this!

Practical Universal Computers

(John) Von Neumann Architecture (1945)


John von Neumann, 1950's



This looks just like a TM Tape

CPU is a universal TM

An interpreter of some programming language (PL)