Fundamentals of Computing

Source Work:
Malone, Thomas. *15.561 Information Technology Essentials, Spring 2005*.
(MIT OpenCourseWare: Massachusetts Institute of Technology),
http://ocw.mit.edu/courses/sloan-school-of-management/15-561-information-technology-essentials-spring-2005
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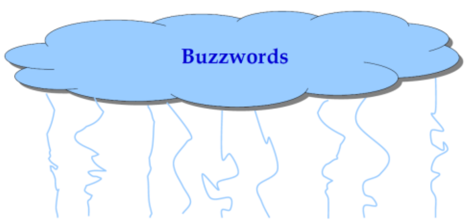
Course URL:
http://pinformatics.org/phpm631

Why bother?

Why should you, as a manager, care about information technology?

Do you know the language?



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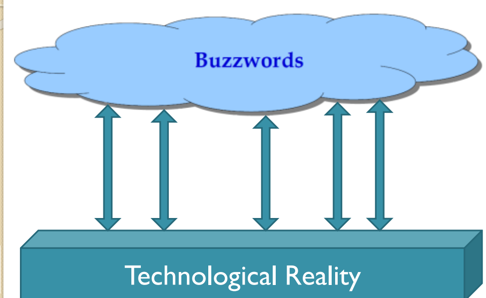
Do you know the language?



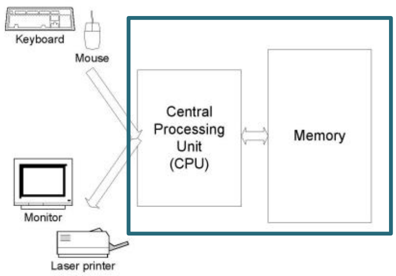
Main Course Objectives

- Become comfortable with the technologies that are shaping business today
- Acquire tools that will help you assess technological trends long after you have left school
  - Import to learn how to understand and think about technology, so that you can keep up
- Open up the blackbox
  - Under the hood

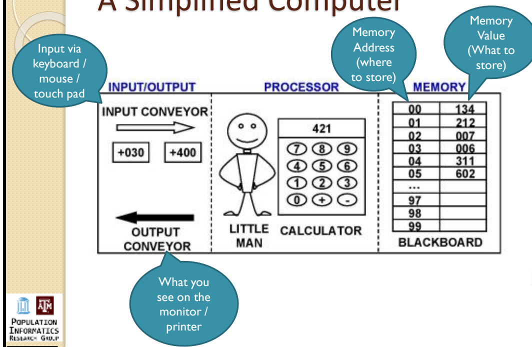
What is a computer?

- What are the important components?
- What does it do?

A Typical Computer



A Simplified Computer



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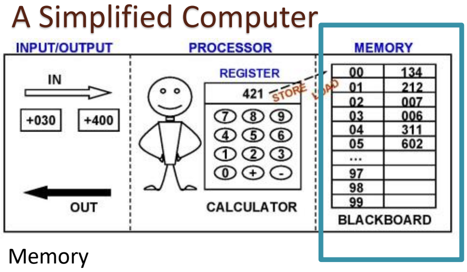
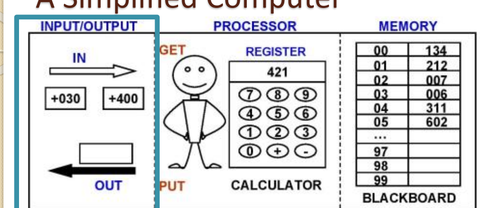


Memory

- There are 100 “locations” on the blackboard
- Each location has room for one 3-digit number
- LOAD moves number from blackboard to register. Example: LOAD 01
- STORE moves number from register to blackboard. Example: STORE 00

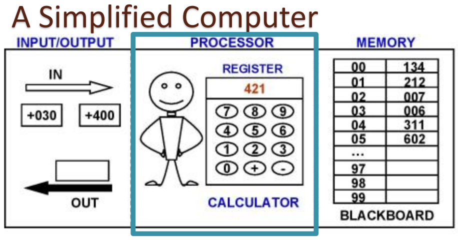
A Simplified Computer



Input/Output

- Input and Output conveyors hold 3-digit numbers.
- GET moves number from input to register.
- PUT moves number from register to output

A Simplified Computer



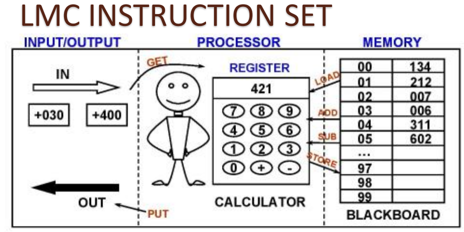
Processor/Calculator

- Register has room for one 3-digit number.
- Calculator can add and subtract numbers from memory to register.

    Example: ADD 02

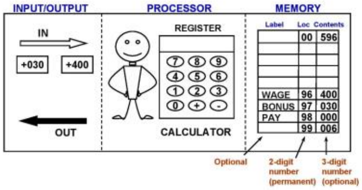
    SUBTRACT 03

LMC INSTRUCTION SET



1. Get
2. Put
3. Load x (Load 01)
4. Store x (Store 05)
5. Add x (Add 02)
6. Sub x (Sub 03)
7. Stop

SYMBOLIC LMC INSTRUCTIONS

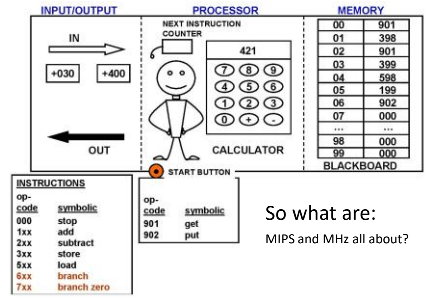


Software: Example Instruction Sequence

Calculate Pay = Wage + Bonus

1. Load Wage
2. Add Bonus
3. Store Pay
4. Stop

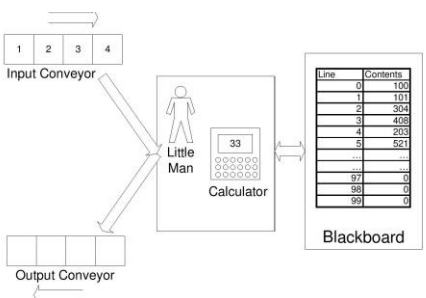
INSTRUCTION SEQUENCE



So what are:

MIPS and MHz all about?

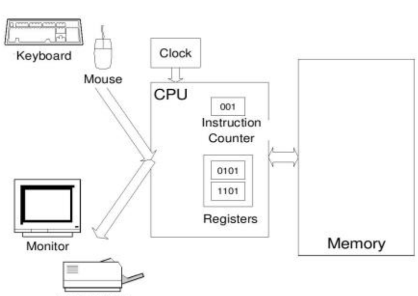
The Little Man Computer



Basic Facts to Ask About Any Computer LMC Answers

- MEMORY
  - BASIC UNIT: 3 DECIMAL DIGIT NUMBER
  - MAXIMUM SIZE: 100 LOCATIONS
- REGISTERS
  - HOW MANY: 1
  - NUMBERS: 3 DECIMAL DIGIT NUMBER
- INSTRUCTIONS
  - NUMBER: 7 INSTRUCTIONS

The 'Real' Computer



INTEL PENTIUM 4 ANSWERS

1. MEMORY
   a) BASIC UNIT — 8 BINATY DIGITS (BITS) = 1 BYTE
      8 BITS
      0 0 1 0 1 1 0 1
   b) MAXIMUM SIZE — 32 BITS = 4 BYTES
   c) TYPICAL SIZE — MEMORY RAM: 128 MB – 1GB
2. REGISTERS
   a) HOW MANY — ABOUT 50 REGISTERS
   b) NUMBERS — VARIOUS TYPES
3. INSTRUCTIONS
   a) NUMBER — ABOUT 500

Binary Computers

- Real computers don't store and calculate with 3-digit decimal numbers
- A bit (binary digit) distinguishes between two states
  - TRUE and FALSE
  - 1 and 0
- Bits are easier to implement in machines
  - Light bulbs on or off
  - High vs. low voltages (on wires)
  - Magnetized or not (computer hard disks, floppies, tapes)
  - Pit or no pit detected by a laser (compact discs)

Interpretation of a decimal number

3 7 9

3x100 + 7x10 + 9x1

$3 \times 10^2 + 7 \times 10^1 + 9 \times 10^0$

Interpretation of a binary number

1 1 0 1 1

$1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

1x16 + 1x8 + 0x4 + 1x2 + 1x1

27

Integer Number Representations

conversion functions `intmin, intmax`

int8 8-Bit Integer (sign; bits 8 … 1): $[-2^7, +2^7-1] = [-128, +127]$

uint8: $[0, +2^8-1] = [0, +255]$

int16 16-Bit Integer (sign; bits 16 … 1): [-32,768 +32,767]

uint16: [0 65,535]

int32 32-Bit Integer (sign; bits 32 … 1): $[-2^{31}, +2^{31}-1]$

uint32: $[0, +2^{32}-1]$

int64 64-Bit Integer (sign; bits 64 … 1)

uint64

Integer Issues: Overflow

- **Overflow**, expression tries to create an integer value larger than allowed valid range [min,max]
  - X = 1111 (4 bit)
  - X = X + 1 : 10000 (?)
  - Y= 0000 (4 bit)
  - Y=Y-1
- **Truncation**, fractions not supported
  - `int16(23)/int16(5) = 5` not `4.6`
  - Rounds result to nearest whole number

Scientific Notation

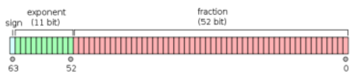
- $3457.2 = 3.4572 * 10^3$
  - Sign: +
  - Exponent: 3
  - Mantissa: 3.4572
- $-0.0564 = -5.64 * 1/100 = -5.64 * 10^{-2}$
  - Sign: -
  - Exponent: -2
  - Mantissa: 5.64

Real Number Representations

IEEE 754 Floating point standard

- **Reals** (http://kipirvine.com/asm/workbook/floating_tut.htm)
  - Sign bit *(1 bit) : + / -*
  - Exponent *(7 or 11 bits) : biased by 127 = exp-127*
  - Mantissa (fraction) *(23 bits or 52 bits):* $\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\ldots$
  - *(+/-) (1+fraction) * 10 $^{(exp-127)}$ = + (1.01) * 10 $^{(124-127)}$*
    *= (1.01)*10 $^{(-3)}$ = (0.00101)=1/8+1/32=0.15625*
  - **Single**

  - **Double**



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  - *(+/-)*
  - **Singl**
  - **Doubl**

Binary Numbers

1001	1 0 0 1
8 4 2 1	1/2 1/4 1/8 1/16
8*1+1*1=9	0.5+0.0625=0.5625

Real Number Representations

IEEE 754 Floating point standard

- **Reals** (http://kipirvine.com/asm/workbook/floating_tut.htm)
  - Sign bit *(1 bit) : + / -*
  - Exponent *(7 or 11 bits) : biased by 127 = exp-127*

Decimal fraction to Binary fraction

Lose precision

0.200000000000

= .00110011001100110011001

+ **remainder 0.000000071526**

Real Issues (single, double)

- **Precision Error** $Error = |actual - representation|$
  - Most numbers don't get represented exactly
  - Finite precision of IEEE floating point
  - Represented by nearest real number
  - Separation between two closest numbers varies over entire range
- **Numeric Stability** (does error overwhelm?)
  - Truncation Errors $Error = |true\_answer - computed|$
  - Accumulated error from repeated calculations
- **Don't compare real numbers**
  - 3.0 == 3.0 (NOT GOOD)

The CPU

- CPU = Central Processing Unit
- Internal clock ticks very fast (e.g. 1.6GHz = 1.6 billion ticks per second)
  - Activities are synchronized to start on a clock tick
  - Some activities take more than one clock tick
- Instruction execution is automatic
  - (tick) find memory address of next instruction
  - (tick) retrieve instruction from memory
  - (tick) decode the instruction
  - (tick) fetch argument from memory if necessary
  - (tick) execution instruction
  - (tick) store result in memory if necessary

CPU Characteristics

- Family: Determines the set of instructions it understands
  - Intel 80386, 80486, Pentium, Pentium II, i5, i7…
  - Motorola: 68030, 68040
- Clock Speed
  - Pentium: 500 MHz – 2.2 GHz
- Data bus width: Size of data that can be manipulated at one time
  - 80486: 32 bits, Pentium: 64 bits
- Address bus width: Limits the amount of memory that can be installed in the computer
  - LMC: 3 decimal digits. Location 53 [0-99]
  - Pentium: 32 bits. Location 1001 1111 1010 1100 1001 1011 1011 1101
  - Itanium: 64 bits. Location
    - 1001 1111 1010 1100 1001 1011 0011 1101 1001 1001 1010 1100 1001 1011 1011 0001

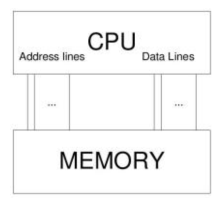
Positive feedback from last year

- *"I like this class because I have wanted to learn at least the basics of computer science for a long time. I enjoy the fact that most things are relevant i.e what is a computer, what is in a network and other things that are basic knowledge that we use daily…"*
- *"I have enjoyed learning many new things, and being able to understand how computers and webpages work a little better."*
- *"I liked learning about some of the inner workings of computers and networks. I find a lot of the small bits of trivia discussed really interesting…"*

Expressing Memory Capacity

- Measured in bytes (=groups of 8 bits)
- Each byte can store a binary number from 00000000 to 11111111 (255 = 2^8-1)
- More generally: n binary digits can store numbers from 0 to 2^n-1
- Frequently used multiples:
  - Kilobyte (KB) = 1,024 (2^{10}) bytes
  - Megabyte (MB) = 1024 KB = 1,048,576 (2^{20}) bytes
  - Gigabyte (GB) = 1,024 MB ~ 1 billion (2^{30}) bytes
  - Terabyte (TB) = (2^{40}) bytes
  - Petabyte (PB) = (2^{50}) bytes

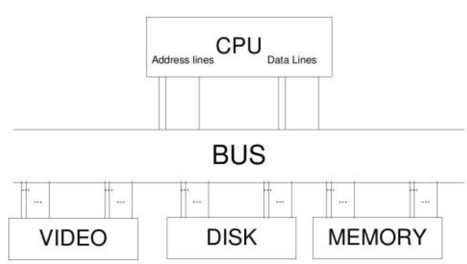
CPU and Memory Interaction



Buses: Connecting I/O to CPU

- One set of wires connect all devices and CPU
  - Transport of information is shared (public)
- Nearly all computers use a bus to connect CPU and I/O Devices
- Buses allow easy addition/replacement of I/O Devices
  - Modern PCs come equipped with expansions slots, directly connected to the bus
  - I/O Device controllers implemented as expansion cards
  - Examples: ISA, PCI PCMCIA, IEEE 1394 (FireWire)

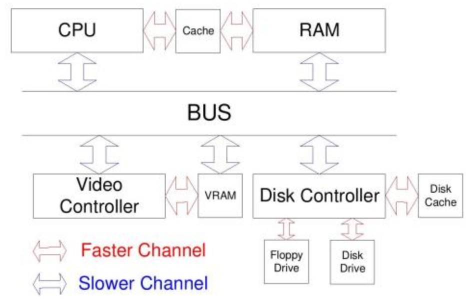
A simple bus architecture



Cache Memory: Motivation

- Cheap main memory is slower than CPU
  - Example: Pentium PCs
    - CPU 2ns (500MHz)
    - Main memory (100MHz SDRAM) 10ns
  - Instructions that access main memory take many more clock ticks than those that don't
- Solution:
  - Automatically keeps copies of most frequently used memory locations in fast (but expensive) memory = cache memory

A modern PC architecture (simplified)



I/O Devices

- Input
  - Keyboard
  - Mouse
  - Hard Disk
  - Floppy Disk
  - …
- Output
  - Printer
  - Screen
  - Speakers
  - …

Computer Displays

- Computer screen divided into small dots (pixels)
- Each pixel can be displayed in a different color
- Screen resolution: Number of pixels per screen
  - 640 x 480
  - 1024 x 768
- Color information for each pixel stored in memory, read and converted to video signal 60 times per second
  - To store information for a 1024 x 768 screen with 256 possible colors for each pixel we need ______ bytes
- Dimension (physical): 9/11/15 inch

Summary: A modern PC (2005)

- Processor: Pentium (500 MHz - GHz)
- Main Memory: 64 MB – 4GB
- Floppy Drive: 1.44 MB (3.5-inch disks)
- Hard Drive 10 – 500 GB
- Graphics: 640 x 480 – 2048 x 1536, 256 to 16 million colors
- Video Memory: 32 – 256 MB

Summary: A modern PC (2015)

- Processor: i5, i7 (1.8 GHz, 2.4GHz)
- Main Memory: 4 GB – 32GB
- External Storage
  - Removable storage: Thumb drive
  - Cloud storage: dropbox, google drive, MS onedrive
- Internal Storage: 500 GB – 4 TB
  - Solid state disk (SSD)
- Graphics: full HD – 4K display (4096 x 2160), 256 to 16 million colors
  - A single graphics card support: 1-6 display
- Video Memory: 32MB – 4/6 GB
  - dual graphics card

Computers …

- Every few years,
  - computers will be able to support (or automate) more of the activities that go on in business.
  - Therefore, some of the most important technology opportunities won't involve making new technologies,
  - But in figuring out new ways to use technologies.
  - Finding (and exploiting) the most promising of these new opportunities can give you significant advantages
- Computer Systems can be
  - FAST, CHEAP, or RELIABLE
  - Choose any two

Exams

- 90% from 3 take away slides per lecture
  - Midterm
  - Final
- Other slides
  - Lots of details to help you understand the 3 main points
  - Will not go over some of them and only informational for those interested
    - Real number representation

Take Away 1

- There are many detailed facts about computers
- Many of them will change every year of your career
- You will never know them all
- That's okay
- What you need to know is
  - What kinds of questions to ask
  - How to make sense of the answers
- The basic concepts you have learned today will be useful for a long time
- Computer Systems can be
  - FAST, CHEAP, or RELIABLE
  - Choose any two

Take Away 2

Summary: A modern PC (2015)

- Processor: i5, i7 (1.8 GHz, 2.4GHz)
- Main Memory: 4 GB – 32GB
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- Graphics: full HD – 4K display (2048 – 1536), 256 to 16 million colors
  - A single graphics card support: 1-6 display
- Video Memory: 32MB – 4/6 GB
  - dual graphics card

Take Away 3

Binary Numbers and Computation Issues

- Binary Numbers
  - 1001 = 8*1+1*1=9
- Integer Issues:
  - **Overflow**, expression tries to create an integer value outside the valid range [min,max]
    - X = 1111 (4 bit)
    - X = X + 1 : 10000 (?)
  - **Truncation**, fractions not supported
    - `int16(23)/int16(5) = 5` not `4.6`
    - Rounds result to nearest whole number
- Real Issues:
  - **Precision**
  - **Numeric stability**

Agenda

- Fundamentals of Computing
- Video
- Discussion on Reading
- Break
- Introductions
- Lab

Future of Healthcare

- http://youtu.be/jZkHpNnXLB0?t=3m5s
- What technology do we need to get there?

Reading Log

- Dedicated class discussion time for readings (roughly 20 minutes)
- Forum on E-campus (blackboard)
  - Simple post before each class
    - 3 interesting points (facts you learned)
    - 1 opinion/thought
  - Will randomly pick a few and read together in class to prompt the discussion

Break

PHPM 631 Health Information Management Systems

Hye-Chung Kum
Population Informatics Research Group
http://research.tamhsc.edu/pinformatics/
http://pinformatics.web.unc.edu/

Course URL:
http://pinformatics.org/phpm631

Who am I ?

- PhD in Computer Science
  - Datamining
  - KDD (Knowledge discovery and datamining)
- MSW: Policy & Management Track
  - Certificate of nonprofit management
- ~15 years
  - School of Social Work, UNC-CH
  - Department of Computer Science, UNC-CH
  - Experience in teaching CS concepts to non majors (undergrads and grads)
- TAMU (2013)
  - Department of Health Policy and Management, School of Public Health
  - Department of Computer Science and Engineering
  - Department of Industrial and Systems Engineering
  - The Center for Remote Health Technologies and Systems (CRHTS)
- Teaching
  - I love teaching. I put a lot into it & I expect a lot from students
  - Slides are my personal notes so I wont forget (don't use as example of good presentations)
- Questions?

Who are you ?

- Program
  - MHA?
  - MPH?
  - Anyone else?
- Undergrad Majors
- Experience in IT
  - Experience in IT ?
  - Have any programming experience ?
- What would you like to get from this class

What is this class about

- Website
  - http://pinformatics.org/phpm631/
  - Very Important to check regularly! (readings)
- E-campus: Blackboard
  - HW submission
  - Grade posting
- Syllabus: online
- Schedule: online
- For an average student, on average 9h/week outside of class (readings & assignments)
- Study groups

Grading

- Assignments & In class work: 48%
  - On a 4 scale
    - 70% (70 points): Bad (√ --) Did NOT follow all instructions
    - 80% (80 points): Reasonable (√ -) Followed all instructions
    - 90% (90 points): Good (√) Followed all instructions, and did good work
    - 100% (100 points): Great (√ +) Followed all instructions and did great work
  - 3% (or 2%) for short assignments, 8% for long assignments
  - Class participation: 5%
    - Includes submission of in class activities (Labs)
    - Reading log on E-campus(blackboard) and class discussion participation
- Group Presentation: 7%
  - Email due by next week
  - Peer Review, Instructor, TA
- Exams: 45%
  - Midterm: 15%
  - Final: 30% (typo in syllabus updated)

	Date	Assignment Given	Assignment Due	Grade	Presentations (Grade: 7%)
1	1/23/2017	Assignment 1			GUEST LECTURE
2	1/30/2017	Assignment 2	Assignment 1 Email on Presentation	3%	
3	2/6/2017	Assignment 3	Assignment 2	3%	Group 1 (bonus 3 points)
4	2/13/2017				Group 2 (bonus 3 points)
5	2/20/2017	Assignment 4	Assignment 3	8%	Group 3
6	02/27/2017	Assignment 5	Assignment 4	3%	Group 4
7	3/6/2017				GUEST LECTURE
	3/13/2017	SPRING BREAK			
8	3/20/2017	Midterm		15%	
		Assignment 6	Assignment 5	8%	
9	3/27/2017				Group 5
10	4/3/2017	Assignment 7	Assignment 6	8%	Group 6
11	4/10/2017				GUEST LECTURE
12	4/17/2017	Assignment 8	Assignment 7	8%	Group 7
13	4/24/2017		Assignment 8	2%	Group 8
14	5/1/2017	Final		30%	

- Class participation: 5% (labs, reading log, discussion)

Grading in essence

- This class is about learning as much as you put into the class
- Being professional: Follow instructions and being on time
- Grading
  - A
    - Put in good effort on most assignments - 90
    - Participate in class – labs, reading log, discussion
    - Study for the final and get 90% on final
    - Do your part in the group presentation
  - B
    - Don't forget to turn in everything (whatever you are able to do. Follow instructions) - 75
    - Participate in class – labs, reading log, discussion
    - Pay attention to the review session and get 80% on final
    - Do your part in the group presentation
  - C
    - Skip some assignments (0 vs 75)
      - One late assignment allowed
    - Some class participation – labs, reading log, discussion
    - Do poorly on the finals
- Will work on an excel sheet together to track your grade (lab)

Group Presentation (7%)

- Go over the handout online
- Email due by next week
  - Form groups of 3
  - Pick a week to present
    - Bonus 3 points for first 2 weeks
  - Topic
- Schedule & Topic
- Peer Review and me
- Questions?

Class monitoring

- Collect data to make this class better
- Midterm, Final: submit review
- As we go, surveys about class reading, assignments, labs, guest lectures

WARNING: Be Prepared to Work Hard

- This was the only part of the class that will go at this nice pace
- There is a LOT of materials for me to cover
- You will not have another dedicated time to learn this, but things you learn in this class will be useful to you as you are looking for a job, and on the job.
- So I want to teach you as much as I can this semester.
- If you feel you are lost, please come talk to me. I will try to help. If majority of you come talk to me, I will slow down. If you don't give me input, I will assume the pace is fine.
- Much of this class is like a math class
  - You will get as much as you put into this class
  - In the end, either you will have learned it and know it or not
  - You will learn the most by doing (actively learning). Like learning to play an instrument.

Last thoughts

- This course is intended for students with little or no background in computer technology.
- The intent is not to train experts in computer technology, but to build enough understanding of the basics of the technology and data so that you can
  - manage IT projects (e.g., evaluate software products and consultants),
  - effectively communicate and collaborate with IT personnel,
  - use data effectively,
  - ultimately make good decisions about HIT
- All are key skills in health care management.

Lab 2: Talking to a Computer

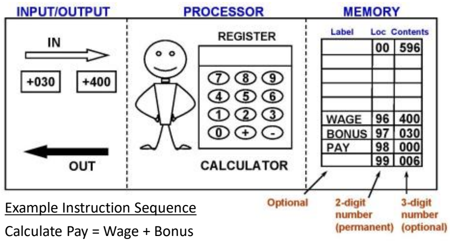
Lab

- How many can bring laptop?
- Mostly in class activity
- Submit whatever you have by due date
  - end of day
  - with assignment (part of assignment)

Trivia

- Text editors vs Word
- File Extension
- Root: where are your files?

SYMBOLIC LMC INSTRUCTIONS



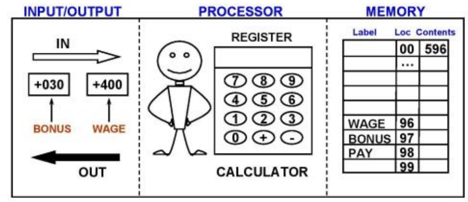
Example Instruction Sequence

Calculate Pay = Wage + Bonus

1. Load Wage
2. Add Bonus
3. Store Pay
4. Stop

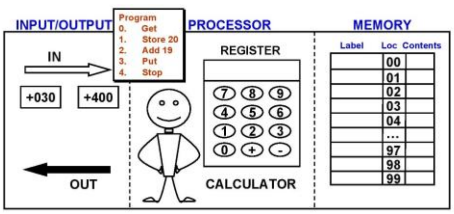
Program to: (NEXT WEEK LAB)

1) Read WAGE and BONUS amount from INPUT
2) Compute total PAY
3) Output total PAY



STEP	INSTRUCTION	STEP	INSTRUCTION
1.		5.	
2.		6.	
3.		7.	
4.		8.	

LMC STORED PROGRAM CONCEPTS

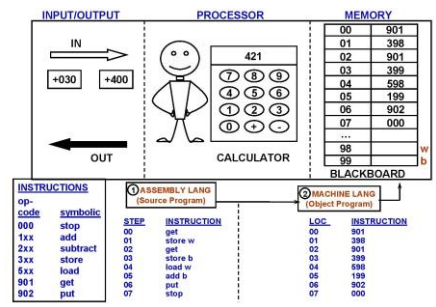


ISSUES:

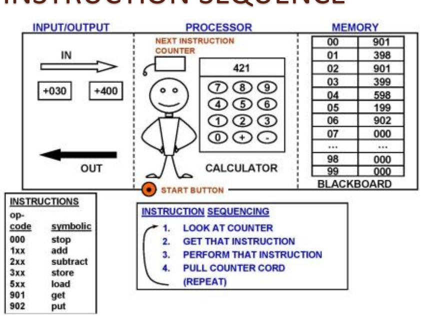
- Where is LMC program stored?
- How does LMC understand instructions like STOP? It only likes numbers.
- How does LMC handle symbolic labels like A, B, C

ANSWERS (Stored Program Concept):

LMC MACHINGE LANGUAGE AND ASSEMBLY LANGUAGE



INSTRUCTION SEQUENCE



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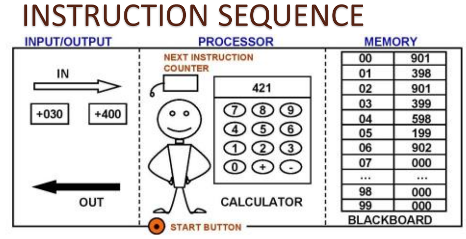

Control Flow

- BRANCH always puts a new address in the instruction counter.
- BRANCH ZERO puts a new address in the instruction counter if the REGISTER is 0. Otherwise it increases the instruction counter by 1.

Examples: BRANCH 02

BRANCH ZERO 06