# LECTURE 15: MIPS (FOR LAB 10)

## Computer Systems and Networks

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# MIPS Partner Workout (for class problems only)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Steve** | **Richard** | **Tejpal** | **Kenny** | **Kevin** | **Terry** | **Yode** | **Beau** | **Miguel** |
| Jason L | Rakan | Cassidy | Jose | Angela | Greg | Sonali | Alex | Andrew |
| Hoang | Thor | Carl | George | Jerry | Janet | Jason VB | Lovejot | Colton |

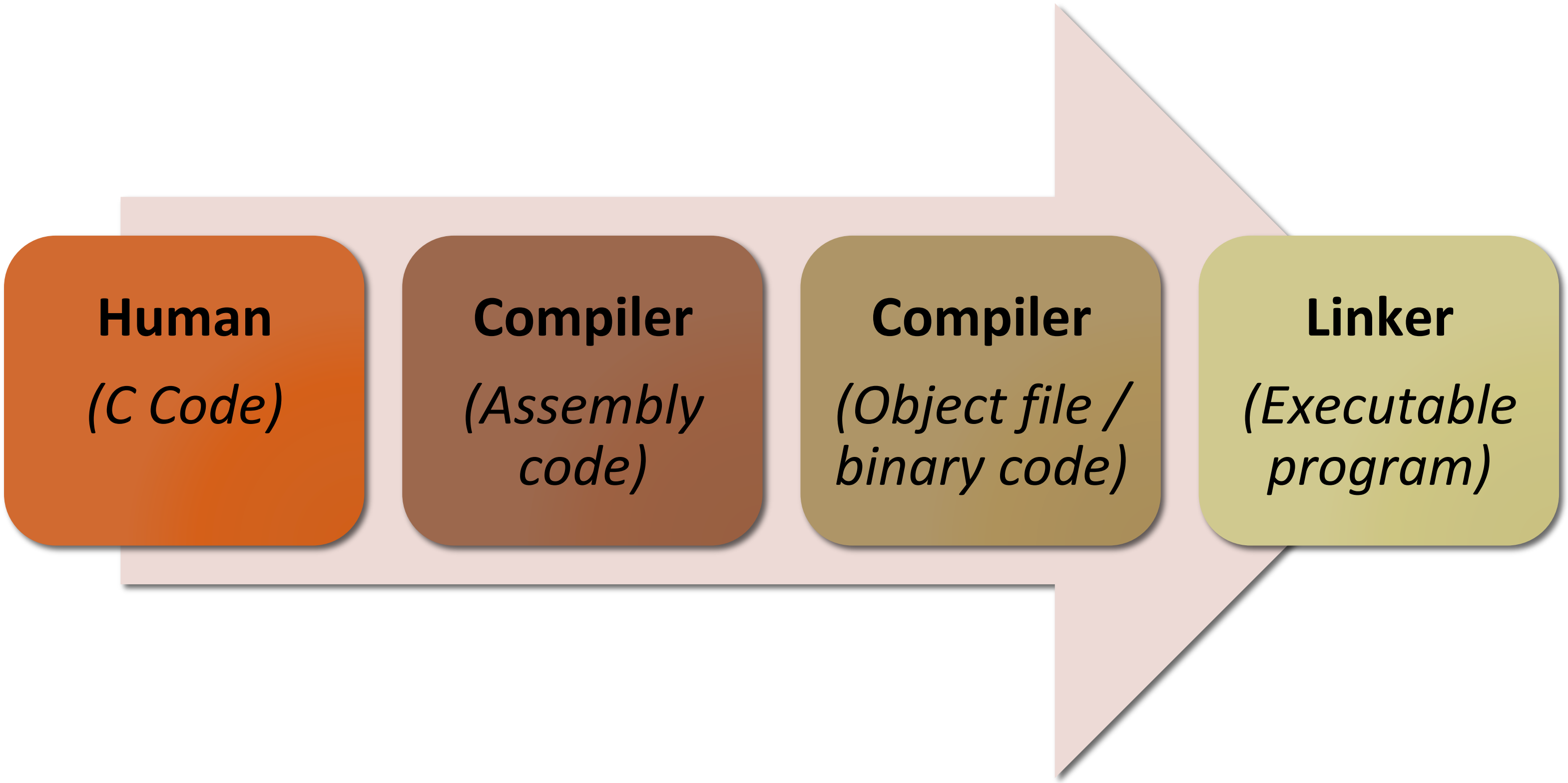
whiteboard

Performance on the next three worksheets will lead to a max. of 5 points credit on Labs 10, 11, and 12. Points awarded = function(overall team performance)

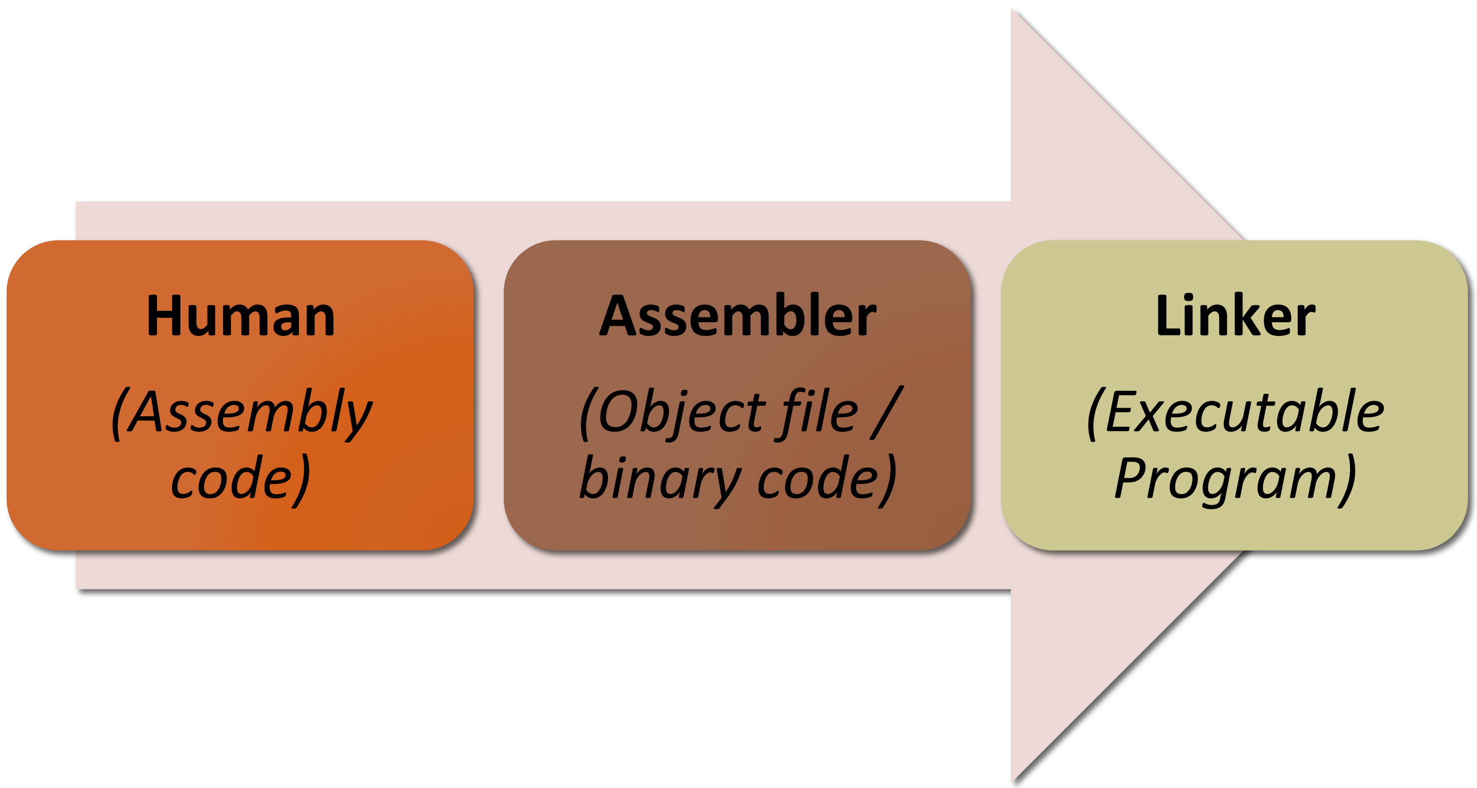
# Class Today

MIPS Practice for Lab 10

# Class to Date



# Class Now


Human
(Assembly code)
Assembler
(Object file / binary code)
Linker
(Executable Program)

# MIPS Background

**M**icroprocessor without **I**nterlocked **P**ipeline **S**tages

**Embedded devices**

- Cisco/Linksys routers
- Cable boxes
- MIPS processor is buried inside *System-on-a-Chip (SOC)*

**Gaming / entertainment**

- Nintendo 64
- Playstation, Playstation 2, PSP

# MIPS Design

RISC – **What does this mean?**

- **R**educed **I**nstruction **S**et **C**omputing
- Simplified design for instructions
- Use more instructions to accomplish same task
  - But each instruction runs much faster!

32 bits (originally) – **What does this mean?**

- 1 “word”= 32 bits
- Size of data processed by an integer add instruction
- New(er) MIPS64 design is 64 bits, but we won’t focus on that

# Why should I learn MIPS?

**Computer Science majors --** Compilers optimize assembly to improve performance. One day, you'll develop such efficient compilers

**ECPE majors --** Assembly language will help you design Microcontroller applications. One day, you may be the coder for a microcontroller that goes on a space mission

**CS and ECPE majors --** You will collaborate and develop the next-generation processors

# ISA Definition

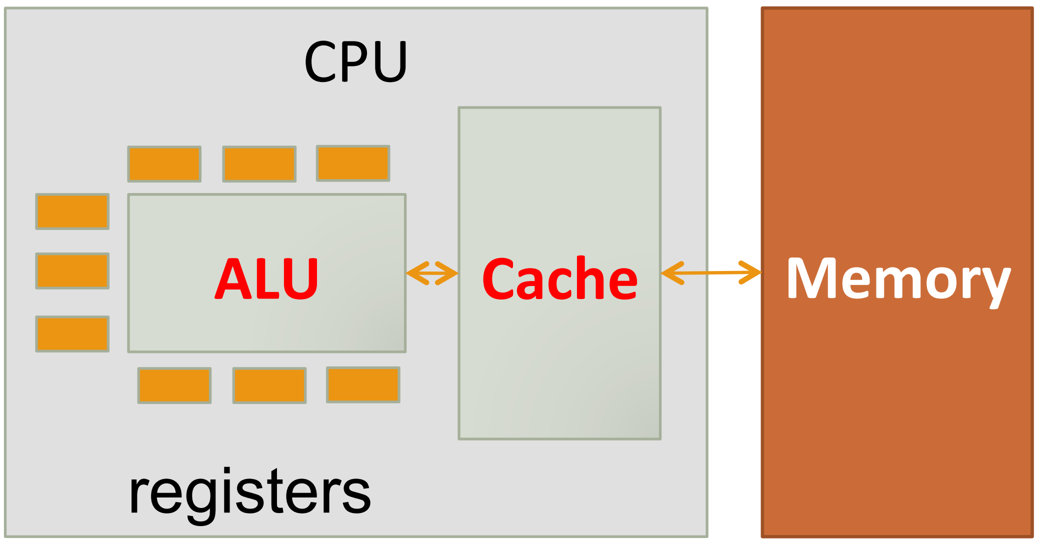
**Instruction Set Architecture** is an interface between hardware and software

**Instruction Set Architecture** defines format for arithmetic/ logic instructions, addressing instructions, and branching instructions. We will broadly divide ISA into these classes:

- **Arithmetic** instructions
- **Branching** instructions
- **Addressing** instructions

# Recap of a typical Processor

We will actively use registers to fetch data and perform ALL arithmetic and logic computations




Load values into registers and try performing everything with them

1. **Registers**
   - On the CPU itself
   - Very close to ALU
   - Tiny
   - Access time: 1 cycle
2. **Memory**
   - Off-chip
   - Large
   - Access time: 100+ cycles

# Registers in MIPS

MIPS design: **32 integer registers**, each holding **32 bits**

- "Word size" = 32 bits

| Name | Use |
|---|---|
| `$zero` | Constant value: ZERO |
| `$s0-$s7` | Local variables |
| `$t0-$t9` | Temporary registers |

**This is only 19 – where are the rest of the 32?**

- Reserved *by convention* for other uses
- We'll learn a few more later…

# Arithmetic Instructions

# Add Instructions

Add (perform addition using registers)

```
add <destination> <source 1> <source 2>
E.g.:
     add $t0, $s1, $s2  #t0 = s1 + s2
     add $s1, $s1, $s2 #s1 = s1 + s2
```

Add Immediate

```
addi <destination> <source 1> <signed value>
E.g.:
     addi $s0, $s1, -2  #s0 = s1 - 2
     addi $s1, $s1, 1 #s1++
     addi $t1, $zero, 6 # t1 = 6
```

# Sub Instructions

Sub (perform addition using registers)

```
sub <destination> <source 1> <source 2>
E.g.:
     sub $t0, $s1, $s2  #t0 = s1 - s2
     sub $s1, $s1, $s2 #s1 = s1 - s2
```

# Problem 1: Convert this snippet to assembly

```
g = 15;
h = 20;
i = 5;
j= 18;
f = (g + h) – (i+j);
```

**Assume Map:**

$s0 = g
$s1 = h
$s2 = i
$s3 = j
$s4 = f

Currently, your computer only knows add and sub instructions!

# Branching Instructions

ASSEMBLY FOR IF-ELSE, FOR, WHILE, AND SUCH..

# How would you explain this to a 2nd grader?

if-else statements and loops result in branching of control

```
if((A>=B) || A>6)
     C=A;
else
     C=B-A;
//outside if-else
```

# Branching Instructions

**Branch on equal:**

`beq <register 1>, <register 2>, label` #if `register 1` is equal to `register 2`, then branch to label.

**Branch on not equal:**

`bne <register 1>, <register 2>, label` #if `register 1` is not equal to `register 2`, then branch to label.

**Branch on greater than:**

`bgt <register 1>, <register 2>, label` #if `register 1` is greater than `register 2`, then branch to label.

# Branching Instructions

**Branch on greater than equal to:**

bge <register 1>, <register 2>, label #if register 1 is greater than or equal to register 2, then branch to label.

**Branch on less than:**

blt <register 1>, <register 2>, label #if register 1 is less than register 2, then branch to label.

**Branch on less than or equal to:**

ble <register 1>, <register 2>, label #if register 1 is less than or equal to register 2, then branch to label.

# Branching Instructions

**Unconditional jump to a label:**

`j label` #just jump to this label and proceed there onwards

# Problem 2: Convert the following to Assembly

```
if((A>=B) || A>6)
     C=A;
else
     C=B-A;
```

Currently, your computer only understands add, sub, and some branching.

**Assume Map:**

\$s0 = C

\$s1 = A

\$s2 = B

# Problem 3: Convert the following to Assembly

```
sum=0;
for(i=0;i<10;i++)
{
      sum+=i;
}
```

Currently, your computer only understands add, sub, and some branching.

**Assume Map:**

$s0 = sum

$t0 = i

# Problem 4: Convert the following to Assembly

```
sum=0;
for(i=0;i<10;i++)
{
        j=i;
        while(j<2*i)
        {
                sum=sum+j;
                j++;
        }
}
```

Currently, your computer only understands add, sub, and some branching.

**Assume Map:**

$s0 = sum

$s1 = i

$s2 = j

# In-Class Participation: 10 minutes

Use as many registers

```
while(1)
{
      sum=sum+i;
      i--;
      if(i<=0)
            break;
      else
            continue;
}
```

Currently, your computer only understands add, sub, and some branching.

**Assume Map:**

$s0 = sum

$s1 =i

# You are prepared for Lab 10 Parts 1, 2, and 3

MAKE PROGRESS ON THESE UNTIL NEXT CLASS

# USE THIS CODE AS A STUB. Also on Lab 10 Page (a link)

```
        # Declare main as a global function
        # Pound is for comments
        .globl main
        # All program code is placed after the
        # .text assembler directive
        .text
# The label 'main' represents the starting point
main:
        #fill out main here

# Exit program by syscall
         li $v0, 10 # select exit syscall
         syscall # Exit the program
 Assembler directive .data
         .data
# Reserves space in memory for word with initial value 0
# used to store Z in memory
value:  .word 0
```

# Storing a value in Memory

In the end of the stub, note a `.data` section

E.g.:

```
.data
value: .word 0 # a word set to zero
msg: .asciiz "Hello World!\n” #a string
pow2: .word 1, 2, 4, 8, 16, 32, 64, 128
#an initialized array of integers
```

# Next Class – MIPS for Labs 10 and 11

Arrays and memory accesses in Assembly

Writing Functions in assembly

# For Next Class

Carefully go through MIPS example programs (see Lab 10 page). Teach yourself:

- `printf` in MIPS
- `scanf` in MIPS

Finish SPIM tutorial on Lab 10 page. In the next class, I will assume you know your way around SPIM