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Intro to Computer Organization
Johns Hopkins
Final Exam

1. As described by Hennessy and Patterson ,the modern computer is composed of five classic hardware components. Given one, list the other four:

Input, Output (given), Memory, Datapath and Control

2. The hardware above provides the four basic functions that every computer performs. What are these functions ?

Inputting Data, Outputting Data, Processing Data, Storing Data

3. The integer word length and register size of the MIPS machines is

B) 32 bits

4. How are negative integer numbers represented on the MIPS machines ?

C) 2's Compliment

5. Today, assembly language programs are more efficient than compiled high-level language programs, such as C++, for the same large accounting applications.

TRUE (in terms of runtime, if written by a skilled developer)

6. 1,099,511,627,776 bytes is known as:

A) Terabyte

7. MIPS subroutines generally have PROLOG code. What is the purpose of this code ?

The purpose of the prolog code is to preserve the data in existing registers. Most procedures will save the return address in $ra since most procedures exist to be called and return. Prolog code will also commonly save the registers that the procedure uses. The tail of the procedure is used to reverse the calls in the procedure and add a jr to return

8. Match these people with their noted accomplishments :

L0pht:	D) – Internet Security
Alan Turing:	C) – Computing Theory
Vinton G. Cerf:	B) – TCP / IP
J Presper Eckert	A) – ENIAC

9. What is the purpose of each of the following MIPS assembler directives:

.globl: specify a global variable (visable to other files)
.text : the next line contrains instructions
.word: store 32 bit quantities in successive memory words
.asciiz: stores a null terminated string within memory

10. Convert 0.715 to a binary fraction (total of 8 bits) For example 0.75 = 0.1100 0000

The best you can do with 8 bits is 0.10110111, which evaluates to .714844 (off by .00016)

11. Given this hexadecimal representation of a 16-bit One's Complement number: 753B Is the value

753B = 0111 0101 0011 1011
C) greater than 0

12. The MIPS multiply hardware stores the 64 bit product in two registers, HI and LO. What does it mean when the value in the HI register is minus one (-1) ?

The operation was NaN

13. Which of the following must be performed by every assembler :

C) Assign machine memory addresses to symbol labels.

14. Floating point arithmetic has problems different from integer arithmetic. Which of these floating point arithmetic statements are True and which are False?
    A) Multiplication of a positive and a negative number will never overflow.
    FALSE
    B) Addition of a positive and a negative number will never overflow.
    TRUE
    C) Addition of two positive numbers will never overflow
    FALSE

15. What is the primary reason a two-pass assembler is necessary rather than a one-pass assembler?

D) Symbols may be used as operands before they are defined

16. Computer Arithmetic has a problem called 'Overflow'. Simply what is this problem ?

Overflow occurs when there are insufficient bits in a binary number representation to properly account for a number. For example, the number 20 is represented as 10100. But if you only have four bits of memory that is not enough space to store the 5 bits you need to store the value 20. An arithmetic operation whose result cannot be portrayed by the number of bits set aside for the result, then, results in overflow.

17. Generate the hexadecimal object machine code for each line in the following MIPS source program. (Use the Green reference card) Values are decimal numbers. Show work. (For example: sub $s4, $s2, $s1 = 0251 A022)

```
.text 1020
.globl strcpy # subroutine for memory copy of a string from A to B
strcpy: add $t0, $zero, $zero # index to the next character to copy
loop: add $s1, $t0, $a0 # s1 has address of A
lb $t2, 0($s1) # get the next character
add $s3, $t0, $a1 # s3 has the address of B
sb $t2, 0($s3) # copy it
beq $t2, $zero, finish # if it is null character, then finished
addi $t0, $t0,1 # increment the index
 j loop # continue the copy finish:
jr $ra # return from the subroutine
```

assume strcpy resolves to address 0008
assume loop resolves to address 000c
assume finish resolves to address 0024

R-Type rd:8(t0), op:0 -> 00004020
R-Type rs:17(s1), rt:10(t2), rd: 17(s1) op:0 ->01048820
I-Type rs:17(s1), rt:10(t2), op:32 -> 822a0000
R-Type rs:8(t0), rt:5(a1), rd:19(s3), op:0 -> 01059820
I-Type rs:19(s3), rt:10(t2), op:40 -> a26a00010
I-Type rs:10(t2), rt:0(zero), op:4 -> 11400001
R-Type rs:8(t0), rt:8(t0) op:8 -> 21080001
J-Type to: 0000000c, op:2 ->08000003
R-Type rs:31(ra), op:0 -> 03e000008

18. Write the MIPS Assembler pair of hardware instructions for this pseudoinstruction:
    BGE $s6, $t9, REPEAT

slt $at, $t9, $s6
bne $at, $zero, REPEAT

19. The MIPS hardware does not have a subtract immediate instruction. Why ?

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Because there is addi, and you can simply addi a negative number using 2’s compliment representation

20. The MIPS architecture has five Addressing Modes. For each of the modes, give an example of an instruction that uses each.

Base: lw
Register: jr
Immediate: addi
Pseudo Direct: j
Program Counter: bne

21. Floating point numbers are stored in Normalized format. Give three reasons :

A) Simplifies exchange of data that included floating point number
B) Simplifies floating point arithmetic algorithms to know that numbers will always be in that form
C) Increases the accuracy of the numbers that can be stored in a word since unnecessary 0’s are replaced by real digits to the right of the decimal point

22. From the discussion readings: What was the first Internet ‘killer app’?

Email

23. What decimal value does this bit pattern : 0000 0000 0000 0000 0000 0000 0000 0000 represent (exactly) in the IEEE 754 format ?

0.0000000

24. Convert the following decimal value to its MIPS floating point binary value: (IEEE 754 32-bit format) Show result as hex digits. Show work. -9876.5

sign bit: 1
9876.5 = 19753 / 2
19753 / 2 -> 100110100101001 / 2 -> 1. 00110100101001 E 13
13 + 127 = 140 -> 10001100 = exponent
11000110000110100101001000000000 = fraction
Binary representation = 1100 0110 0001 1010 0101 0010 0000 0000

25. Identify which of these Assembly process functions would most likely occur in
    1) Pass one or 2) Pass two of a two-pass assembler
    2 - Translate mnemonic operation codes to machine codes
    1 - Save addresses assigned to labels
    1 - Scan for label definitions
    2 - Write object code

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26. Match the statements (a - e) with the most appropriate Object Program record type :
    T) Text Segment -> a) Object instruction code
    R) Relocation -> b) Relative address of global symbol.
    S) Symbol -> c) Modification information.
    H) Header -> d) Program name.
    D) Data Segment -> e) Data values.
27. Does the MIPS assemble language allow for arithmetic with 1-byte and 2-byte operands? Yes / No ? Why ?

Yes, you can perform arithmetic on 1-byte and 2-byte operands indirectly. lb and lh can be used load 1-byte and 2-byte operands into registers, and you can perform arithmetic operations on those registers

28. Natural languages are clear and concise, and therefore suitable for use as programming languages. (True / False)

FALSE

29. Register $t5 contains a negative 32-bit value in sign magnitude form. After performing a 1-bit sll instruction, followed by a 1-bit srl instruction. Register $t5 would contain the absolute value of the original value. (True / False)

TRUE

30. The IEEE 754 floating point standard includes these objects. What they are, and how they are used ??

Guard Bit : An extra bit of precision used in arithmetic calculations
Round Bit : A second bit of precision used in arithmetic calculations
Sticky Bit : An indication of what could be extra significant bits that are not kept. If the sticky bit ever is converted to a value of 1, the sticky bit remains at 1 despite further shifting
NaN : Not a Number. Any opereation on NaN produces NaN (e.g. 0/0, infinity/infinity, infinity * 0. etc.)

31. What is RAID 1 ?

RAID is a redundancy system which helps a storage unit safely store data in case of disk failure. RAID 1 relies on all data being stored on a mirroring, redundant disk which allows the data to be saved if a disk goes down

32. Which of the following is a primary characteristic of System Software ?

c) Supports the operations of a specific computer

33. What is the primary purpose of Pass One of the Two-pass Linker/Loader ?

Pass one assigns addresses to all external symbols so that the second pass can perform the actual loading, relocation and linking.

34. A process that is BLOCKED must wait for an event to occur before it can resume processing. (True/False)

TRUE

37. The Grammar describes the (A) SEMANTICS or (B) SYNTAX of the programming language.

B) SYNTAX

40. Given this binary bit pattern, what is the MIPS instruction as Assembly Language code:
0010 0011 0000 1010 0000 0000 1011 0101

addi $t8 $t2

42. Given This Intermediate File of a Compiler :

```
( 1 ) : = #1 Indx
( 2 ) JGT Indx #25 (20)
 ( 3 ) - Indx #1 t1
 ( 4 ) * t1 #10 t2
( 5 ) * #2 MLK t3
( 6 ) - t3 #1 t4
( 7 ) - t4 #1 t5
( 8 ) + t2 t5 t6
( 9 ) * t6 #4 t7
( 10 ) - Indx #1 t8
( 11 ) * t8 #10 t9
( 12 ) * #2 MLK t10
( 13 ) - t10 #1 t11
( 14 ) + t9 t11 t12
( 15 ) * t12 #4 t13
 ( 16 ) : = ZYX[t13] CBA[t7]
( 17 ) + #1 Indx t14
 ( 18 ) : = t14 Indx
( 19 ) JMP ( 2 )
( 20 )
```

Change the following lines to:

```
(10) := t1 t8             # t1 has the same value as t8, assigns are faster than arithmatic
(11) :=t2 t9              # t2 has the same value as t2
(12) := t3 t10            # t3 has the same value as t10
(13) := t4 t11            # t4 has the same value as t11
(14) addi t6 #1 t12       # t12 is equal to t6 + 1, addi is faster than arithmetic
(15)addi t7 #4 t13        # t13 is equal to t7 + 4
(17)addi t1 #2 t14        # t14 is equal to t1 + 2
```

additionally, lines (5) (6) (7) (12) and (13) can be moved out of the loop since they do not require the Indx variable to calculate

optimize the code by getting rid of redundant/repeated arithmetic as well as simplifying equations to reduce total processing cost

43. In a few phrases, describe these components of a compiler.

SCANNER – Sees a string of characters seen by the computer and identifies tokens based on the grammar
PARSER – Builds the parse tree for the program. This can be either top-down, bottom-up, or a combination of the two. Works to set the order of operations based on the code grammar
CODE GENERATOR – Convert information previously recognized by the parser to convert to three address code, sometimes referred to as quadruples

44. From the discussion readings: What is Ubuntu?

Ubuntu is a complete linux operating system which is free to access which is generally popular

45. Machine independent code optimization uses many techniques. List two of the methods discussed in the presentation that you did not use in problem #42

1. folding: folding is a method where arithmetic involving multiple factors is combined into fewer operations
2. loop jamming: loop jamming is a method used when multiple loops iterate over the same index and the loops are combined into one loop

51. Is it ever safe (you do not lose data values) for a MIPS user program to use registers $k0 or $k1?

$k0 and $k1 are reserved for the operating system in the event of an exception, therefore should not be used by the operator. The information stored in these registers can be changed at any time in the process, therefore are highly unreliable.

52. The Textbook, page 36, discusses the Classic CPU Performance Equation. Fill in the blanks:

$$CPU\ Time = \frac{seconds}{program} = \frac{instructions}{program}\ x\ \frac{clock\ cycles}{instruction}\ x\ \frac{seconds}{clock\ cycle}$$

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53. Given the following Simplified Pascal grammar :

< stmt-list > : : = < stmt > { ; < stmt > }
< stmt > : : = < assign > | < read > | < write > | < for >
< assign > : : = id : = < exp >
< exp > : : = < term > { + < term > | - < term > }
< term > : : = < factor > { * < factor > | DIV < factor > }
< factor > : : = id | int | (< exp >)

Modify the above Grammar to include the exponentiation operation. Make exponentiation the highest priority arithmetic operation.

< stmt-list > : : = < stmt > { ; < stmt > }
< stmt > : : = < assign > | < read > | < write > | < for >
< assign > : : = id : = < exp >
< exp > : : = < term > { + < term > | - < term > }
< term > : : = < factor > { * < factor > | DIV < factor > } | exponent
< exponent > : : = exponent ^ factor | factor
< factor > : : = id | int | (< exp >)

54. Create quadruples of the form we have used in class for the following statement:

ZEE := 3 * EX – 5 * WHY + EX / WHY;

* #3 EX i1
* #5 WHY i2
/ EX WHY i3
- i1 i2 i4
+ i3 i4 i5
:= i5   ZEE

55. The Optical Mouse includes an embedded processor

TRUE

56. Data Security consists of a number of methods and techniques. Name two.

1. Password Requirements
2. Privileged Accounts
3. File Access Control
4. Memory Access Protection
5. Privileged Input/Output Channels
6. Supervisor Modes

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57. Please complete the online Course Evaluation Survey. It is the only method to provide the feedback for improving the course

Done