1

Embedded Systems

Which one of the following first three statements is FALSE regarding embedded systems? If all three are true, choose the fourth option.

Select one alternative:

- Correct results arriving after the deadline are useless in hard real-time embedded systems
- An embedded system is designed to run only a few applications
- Embedded systems are usually not programmable by the end user
- All of the above are true ✔

2

ISA

Which of the following is defined by Instruction Set Architecture (ISA)?

Select one alternative:

- The register width (i.e. the number of bits in a register) ✔
- The number of pipeline stages
- The number of sets in the cache
- The cache miss latency

3

Assembly programming

Consider the following array of integers:

int arr[10];

Assuming that the register r1 holds the address of *arr[0]*, what is the correct way of loading *arr[4]* to register r2 if the memory is byte addressable:

NOTE: Assume that an integer occupies 32-bits in memory.

Select one alternative:

- ldr r2, [r1, #3]
- ldr r2, [r1, #4]
- ldr r2, [r1, #5]
- ldr r2, [r1, #16] ✔

4 Assembly programming

Find bugs in the following ARM Thumb-2 assembly code that should follow the ARM function calling conventions (the corresponding C code is also provided).

Note1: r15 is PC and r14 is Link Register

Note2: ARM function calling conventions are defined by ARM Application Binary Interface

C Code:	**Assembly code:**

int addNum(int a, int b, int c) {
  return a+b+c;
}
 	
main () {
  int x=5, y=10, z=15;
  addNum(x, y, z);
}
	addNum:
	  add r3, r0, r1
	  add r4, r3, r2
	  mov r0, r4
	  mov r15, r14
	
	main:
	  mov r0, #5
	  mov r1, #10
	  mov r2, #15
	  bl addNum

Select one alternative:

- Register r2 cannot be used for passing parameters to a function, the third parameter should be passed via stack
- The value of register r4 needs to be preserved by the callee but addNum is not doing that ✔
- Both above are bugs
- There is no bug in the code

5 DMA

What does DMA (Direct Memory Access) enable?

Select one alternative:

- DMA allows CPU to access memory directly by bypassing the caches
- DMA allows CPU to access hard disk directly
- DMA allows input/output devices to access memory without CPU intervention ✔
- All of above

6

Processor design

Which one of the following first three statements is FALSE? If all three are true, choose the fourth option.

Select one alternative:

- Single-cycle processor design does not require hazard detection and prevention mechanisms.
- Ideally, a pipelined processor is N times faster than a single-cycle processor, where N is the number of pipeline stages.
- A pipelined processor operates on a higher frequency than a single cycle processor.
- All of the above are true ✔

7

Processor design

A Branch Predictor uses the program counter of a conditional branch instruction to predict its direction (taken/not-taken) before the branch is executed. Which processor design is most likely to benefit (i.e. achieve better performance) from a branch predictor?

Select one alternative:

- Single-cycle processor design
- Pipelined processor design ✔
- Both single-cycle and pipelined design are likely to benefit equally

8

Memory technologies

Why is DRAM slower than SRAM?

Select one alternative:

- Because DRAM uses only one access transistor per cell whereas SRAM uses two transistors
- Because DRAM cells are smaller than SRAM cells.
- Because DRAM uses capacitors to store bits. ✔
- Because DRAM is cheaper than SRAM.

9

Set-associative caches

Which of the following is a valid number of ways in a set-associate cache?

Select one alternative:

- 3-way
- 5-way
- 8-way
- All of the above are valid number of ways. ✔

10

Cache Performance

Assume that a cache access requires 1 cycle on a cache hit and 5 cycles on a cache miss. If you want to achieve an average memory access time (AMAT) of at most 2 cycles, what should be the minimum cache hit rate?

Select one alternative:

- 70%
- 75% ✔
- 25%
- 80%

11

Virtual Memory

Select the correct access sequence. Hit/miss in the brackets indicates whether the access resulted in a hit or miss in that structure.

Select one alternative:

- TLB(hit) -> Page Table (hit) -> Cache (miss) -> Memory
- TLB(hit) -> Cache (miss) -> page table (hit) -> memory
- TLB(hit) -> Cache (miss) -> Memory ✔
- TLB(miss) -> Page table (hit) -> memory

12 Virtual Memory

If the physical memory size (in bytes) is doubled, how does the number of entries in the page table change? Assume a single-level page table, not a tree structured table.

Select one alternative:

- Number of entries remains same. ✔
- Number of entries doubles. (i.e 2x)
- Number of entries halves. (i.e. 0.5x)
- Number of entries quadruples. (i.e. 4x)

13 C programming

Which one of the following first three statements is FALSE regarding volatile variables in C? If all three are true, choose the fourth option.

Select one alternative:

- Compiler does not reorder operations on a volatile variable
- Compiler does not optimize away volatile variables as dead code
- Volatile variables are not cached in processor caches ✔
- All above are true

14 Pointers in C

Consider the following C array:

int arr[20] = {0};

Which element of this array will be updated as a result of executing the following statement?

**(((short *)(&arr[2])) + 6) = 10;*

NOTE: a short occupies two bytes in memory and an integer occupies four bytes.

Select one alternative:

- arr[5] ✔
- arr[8]
- arr[12]
- arr[3]

15 **C programming**

Find bugs in the following C code.

```
void printNum() {
   for (int i = 0; i < 1000000000; i++)  {
      int *p = malloc(sizeof(int));
      if (p != NULL) {
         *p = i;
      }
      printf(“%d ”, *p);
   }
}
```

Select one alternative:

- The code results in a memory leak. (A memory leak happens when a program allocates memory and does not release it after use. As a result, the system might eventually run out of memory)
- The printf() statement can potentially dereference a NULL pointer.
- Both above are bugs ✔
- There is no bug in the code

16 **Bitmasks in C**

Which one of the following statements sets bit 3 of a variable declared as:

unsigned int bitmask;

Select one alternative:

- bitmask = bitmask[3] | 1;
- bitmask = bitmask | (1>>3);
- bitmask = bitmask | 3;
- bitmask = bitmask | (1<<3); ✔

17 Compiler optimizations

Machine dependent optimizations are aimed at a specific target architecture and may not be applicable across different architectures. Which of the followings is a machine dependent optimization?

Select one alternative:

- Dead code elimination
- Function inlining
- Loop unrolling
- All of the above are machine independent optimizations ✔

18 Compiler optimizations

Assume that a compiler repeatedly applies Dead Code Elimination, Constant Propagation, and Constant Folding (in this order) to the following code in Intermediate Representation. How many instructions will the optimized code have? **IMP:** Assume that "x" and "y" are the live outs of this code block and, therefore, cannot be eliminated as dead code. Also, assume that "f" is the input to this code.

1. a = 5
2. b = a + 2
3. c = 2 + 8
4. d = c * b
5. e = f * b
6. x = e + d
7. g = b + d
8. h = b + d
9. i = g * 1
10. y = i / h

Select one alternative:

- 3 ✔
- 5
- 2
- 4

19 Compiler

Given the following code in files File1.s and File2.s:

File1.s	**File2.s**
cmp r1, r2 bge **L1** bl **L2** **L1:** str r2, [r0]	**L2:** ldr r2, [r0] add r2, r1, r3

which of the following is responsible for resolving the label **L2** (i.e. replacing L2 with an address) in file File1.s:

Select one alternative:

- Assembler
- Linker ✔
- Pre-processor
- Both Assembler and Linker are equally capable of resolving L2

20 Operating System

Which of the following events causes a transition from the user mode to the kernel mode?

Select one alternative:

- Interrupt
- Syscall
- Exception
- All of above ✔

21

Operating System

Which of the following is FALSE about an Operating System?

Select one alternative:

- A thread can be a part of multiple processes. ✔
- An operating system provides services to user programs through syscalls, regardless of the programming language they are written in.
- Dual-mode operation allows the kernel to access memory of user processes, but prevents user processes from accessing memory of the kernel.
- Operating system must maintain a process's Program Counter, Stack Pointer, and Register values when the process is not running.

22

Operating System

The scheduler in an operating system (pick the best answer):

Select one alternative:

- Schedules a ready process based on a policy ✔
- Always schedules the highest priority ready process
- May schedule any process irrespective of the state (running, ready, blocked) of the process
- Schedules a process for execution as soon as it completes I/O

23

Power

Which of the following parameters has the biggest impact on dynamic power consumption?

Select one alternative:

- Activity factor
- Capacitance
- Voltage ✔
- Frequency

24 Code Testing

Which of the following can NOT be tested by a performance test:

Select one alternative:

- Execution speed
- Cache misses
- Memory usage (i.e number of page faults)
- Memory leaks ✔

25 Debugging embedded systems

You have a simple microcontroller that reacts to a motion sensor and turns lights on and off. The program running on it is sophisticated and uses all available flash and RAM. However, it has been reported that the system is not working correctly. Which of the following can be used to debug the issue?

Select one alternative:

- Manually add printf() statements to the code
- Use a stub debugger
- Use JTAG ✔
- All of the above mechanisms can be used