Introduction to Embedded Systems Research
Midterm Exam

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28 February 2019

Closed book. Closed notes. No calculators or other computers.
If you write lightly with pencil, I may not see your answers or work.

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Sign below to acknowledge the Engineering Honor Code: "I have neither given nor received aid on this examination, nor have I concealed a violation of the Honor Code."

Solutions.

[5] 1. Why are there more competing embedded microcontroller companies than general-purpose CPU companies? Use at most one sentence.

Diverse application requirements lead to diverse microcontroller requirements.

[5] 2. What is the main reason designers do not generally tell a potential customer about a product idea during a customer discovery interview?

- ○ To avoid revealing trade secrets.
- ● To avoid revealing to the interviewee the types of answers the product designer wants to hear.
- ○ To keep the potential customer uncertain about the product and therefore excited.
- ○ To avoid boring the potential customer.

[2] 3. Are all cyberphysical systems wireless sensor networks? ○ Yes. ● No. some EPS are wired.

[2] 4. Are wireless sensor networks cyberphysical systems? ○ Yes. ● No.

May not control or actuate.

[5] 5. Indicate the application for which a set of periodic task graphs is the most appropriate way to represent functionality and timing requirements.

- ○ An event handling system that queues jobs when corresponding buttons are pressed.
- ○ An asynchronous serial bus interface.
- ● A 30 frame per second video signal processing system.
- ○ A wireless sensor network node that must detect flashes of light whose temporal occurrences are best modeled by a Poisson process.

[5] 6. Fill in the empty boxes. A Boltzmann trial implies that given a global temperature T, a solution with cost [k] beats a solution with cost [j] with probability $\frac{1}{1+e^{(j-k)/T}}$.

Do the math.

[5] 7. In the process of designing an embedded system, you suspect that you have encountered an $\mathcal{NP}$-complete scheduling problem. What should you do first?

First, determine what type of problem you have.

- ○ Design a heuristic.
- ○ Use exhaustive enumeration to solve the problem.
- ○ Use an general-purpose mixed integer-linear programming solver.
- ● Attempt to prove the problem is $\mathcal{NP}$-hard.
- ○ Attempt to prove that $\mathcal{P} = \mathcal{NP}$.

[5] 8. In the memory compression work by Yang et al., although the compression algorithm was very fast, compressing and writing a page was still substantially slower than simply writing the page. Use at most one sentence to explain why the impact on overall time and energy consumption was minimal?

Paging was infrequent.

[5] 9. When using Fourier's method to represent thermal circuits, which electrical component has no analogue?

○ Resistor ○ Capacitor. ● Inductor. ○ Voltage source. ○ Current source.

[5] 10. For a MICAz mote, how many word arithmetic operations can be done per word wireless communication transfer? I don't expect you to remember the exact number, so the answers are intentionally very widely spaced.

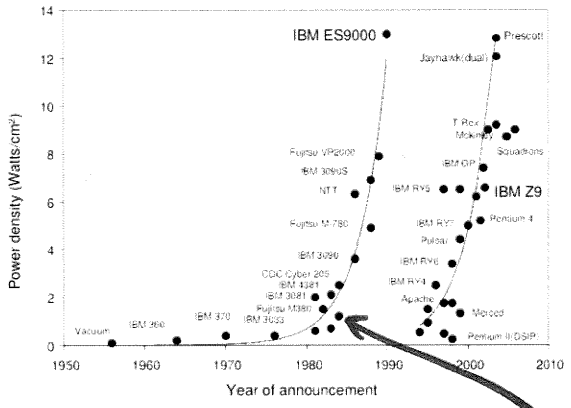
○ 1 ○ 2×10^{-5} ○ 100 ○ 0.01 ● 50,0[illegible] ← Broken question due to typo.

Note that is mostly unrelated to determining the correct answer: the ratio would be somewhat lower in many modern wireless sensor network nodes because processor speed has increased more slowly than radio speed.

5 11. Indicate the reliability and integrated circuit relevant parameter temperature least influences.

- ◯ Noise due to capacitive coupling.
- ◯ The rate of wear, ultimately leading to permanent faults.
- ◯ Leakage power consumption.
- ◯ Maximum safe integrated circuit operating frequency.
- ◯ Threshold voltage.

5 12. Indicate the labels associated with the left and right curved lines in the following figure. These labels indicate types of implementation technology.



Not single-/multi-core. Look at the years.

(a) Left line: BJT

(b) Right line: CMOS

5 13. Indicate the property or properties relevant to representing time that are not satisfied by floating point numbers. Lee discussed this in his paper on cyberphysical systems.

- ◯ The precision with which time is represented should be finite and should be the same for all observers in a model
- ● The precision with which time is represented should be independent of the absolute magnitude of the time. In other words, the time origin (the item for the meaning of time zero) should not affect the precision.
- ● The addition of time should be associative.
- ◯ Monotonicity: any observer of time in a model that is a sequential process (a sequence of state changes) should observe non-decreasing values of time.

5 14. In the energy-efficient communication protocol paper of Heinzelman et al., which nodes had their batteries depleted fastest when using minimum transmission energy routing?

- ● Those closest to the network sink node.
- ◯ Those farthest from the network sink node.
- ◯ Batteries were depleted throughout the network at roughly the same time.

Everything was routed through them.

[5] 15. In the work relating energy management and reliability by Zhu et al., what was the primary mechanism (not policy) used to decrease fault rate (one sentence, maximum)?

I took many answers for this but frequency and voltage scaling influenced fault rates.

[5] 16. Using at most two sentences, state one method of using software to prevent the type of attack described in the MEMS accelerometer security work of Trippel et al.

Aperiodic or out-of-phase sampling.

[5] 17. In the wireless sensor network deployment described by Polastre et al., what was the typical range of mean packet loss rate?

● 0%–30% ○ 30%-50% ○ 50%-70% ○ 70%-100%