ECE471: Embedded Systems – Practice Homework 10
Power/Performance

Not due, Practice for the Exam

1. Power and Energy

Table 1: ATLAS 300x300 DGEMM (Matrix Multiply)

Machine	Processor	Cores	Frequency	Idle Power	Load Power	Time	Total Energy
Raspberry Pi	ARM 1176	1	700MHz	3.0W	3.3W	23.5s	77.6J
Gumstix Overo	ARM Cortex-A8	1	600Mhz	2.6W	2.9W	27.0s	78.3J
Beagleboard	ARM Cortex-A8	1	800MHz	3.6W	4.5W	19.9s	89.5J
Pandaboard	ARM Cortex-A9	2	900MHz	3.2W	4.2W	1.52s	6.38J
Chromebook	ARM Cortex-A15	2	1.7GHz	5.4W	8.1W	1.39s	11.3J

(a) Table 1 shows the energy use of various ARM machines doing a 300x300 Matrix Multiply. Which machine consumes the least amount of energy? Which machine computes the result fastest?

Least amount of energy is the Pandaboard.
Fastest is the Chromebook.

(b) The chromebook is a laptop with a display and wi-fi running. Why might the energy comparison be unfair for it, compared to the pandaboard which has no display and uses wired ethernet?

The display and wi-fi consume relatively substantial amounts of energy so the comparison is not as fair as it could be.

(c) Consider a use case with an embedded board taking a picture once every 20 seconds and then performing a 300x300 matrix multiply transform on it. Could all of the boards listed meet this deadline?

No, the Raspberry Pi and Gumstix Overo both take longer than 20s and the Beagleboard is dangerously close.

(d) Assume a workload where a device takes a picture once a minute then does a 300x300 matrix multiply (as seen in Table 1). The device is idle when not multiplying, but under full load when it is. Over an hour, what is the energy usage of the Chromebook? What is the energy usage of the Gumstix?

Chromebook per minute: $(1.39s \times 8.1W) + (58.61s \times 5.4W) = 327.75J$
Chromebook per hour: 327.75J * 60 = 19.7kJ

Gumstix per minute: $(27s \times 2.9W) + (33s \times 2.6W) = 164.1J$

Gumstix per hour: 164.1J * 60 = 9.8kJ

(e) Given your answer in part d, which device would you choose if you were running this project off of a battery?

The gumstix board uses a lower amount of energy due to the lower idle power, even though it is much slower overall than the Chromebook.

2. Performance

The `time` command is run on a benchmark and gives the following results:

```
real 0m9.987s
user 0m9.844s
sys 0m0.140s
```

(a) Why is the real time larger than the user time?

The real time is the wallclock time, while user time is the time the actual program was running. The system can be busy doing things that aren't the program being measured (time spent in the kernel, and time context switched to other processes).

(b) What is measured by the system time?

The time spent in the operating system.