Tutorial 2

1 Error correction

1. The paper: "Bianca Schroeder, Eduardo Pinheiro, Wolf-Dietrich Weber: DRAM errors in the wild: a large-scale field study. Commun. ACM 54(2): 100-107 (2011)" analyzes the frequency of DRAM errors in a large server population from Google. They report the number of errors detected by the memory system error correcting code (ECC) system.

   a) The study found that on average 8% of the memory DIMMs in Google's computers are affected by at least one memory error. Assume, the same error rate occurs in a cluster of 100 computers with 8 ECC DIMM slots in each, how many errors per year ECC detects in the cluster at least? (Note: the Google observed correctable error rate is quite high, and this speaks for the use of ECC memory.)

   b) The same study observed uncorrectable error rates per machine to be in the order of 0.05% to 0.4%. If we assume the higher uncorrectable error rate per machine to be in the order of 0.4%, how many machines are affected by an uncorrectable memory error per year on average in a cluster of 1000 machines? (Note: Google reports uncorrectable error rate to be quite high in most servers with Standard Single Error Correct, Double Error Detect (SECDEC) ECC memory employed, and speaks for the use of more agressive ECC, e.g., "chip-kill" ECCs correct upto 4 bit errors: `http://en.wikipedia.org/wiki/Chipkill`. Moreover, ECC performance is influenced greatly by age.)

2 Energy efficiency

2. The following article from Google: "Luiz André Barroso, Urs Hölzle: The Case for Energy-Proportional Computing. IEEE Computer 40(12): 33-37 (2007)" makes a case that computers should be energy proportional for optimal energy efficiency under varying loads. That is, the power consumption of a computer should follow the compute load in a linear fashion: If a computer at 100% load uses x Watts of power, it should use $y\% \times x$ Watts of power at $y\%$ load. For example a computer using 250W of power at 100% load should use $20\% \times 250W = 50W$

of power at 20% load. Unfortunately, the current computers are far from energy proportional. A recent benchmark shows the power consumption with different server configurations: i) Standard commercial server: 294W at 100% load, 160W at 0% load (idle). ii) Highly power optimized server: 265W at 100% load, 118W at 0% load (idle). Assume that power consumption increases linearly in proportion to loads given in i) and ii).

a) If the standard commercial server is run at 25% load to complete a task in 4 hours, how much energy does it consume compared to running the standard commercial server at 100% load for 1 hour?

b) If the highly power optimized server is run at 25% load to complete a task in 4 hours, how much energy does it consumes compared to running the highly power optimized server at 100% load for 1 hour?

c) If the computers are of identical speed and are forced to complete the same 4 hour workload at 25% load, what is the energy saving percentage of running a highly power optimized server compared to a standard commercial server?

(Note: The Google paper from 2011 shows most of their servers at 10%-50% server loads, so the energy efficiency of servers in that load scale is quite important. Also getting the server load up is quite important, as doing so not only improves the speed of computing but also improves the server energy proportionality (by avoiding idling).)