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Exercise 1:

Paper 1:

The paper “Microprocessor Design Issues: Thoughts on the Road Ahead” by Michael J. Flynn and Patrick Hung, published in 2005, collects and visualizes the trends in microprocessor design and architecture. It establishes predictions about the future architectures and usage of microprocessors and showcases the problems that microprocessor designers are facing in trying to increase the computational power of microprocessors.

It gives insight into the reasons why the design of microprocessors needs to shift in order to increase performance further. The paper explains the two options (area and power) for further increasing the computing performance of general-purpose microprocessors and weighs their trade-offs. It comes to the conclusion that to further increase the performance of microprocessors, the area of the microprocessor dies will need to increase (because of the power constraints of a microprocessor) or that the industry will move to more application-specific integrated circuits where the hardware can be optimized for specific tasks to gain more performance.

In my opinion, the paper describes the problems that the industry faced during this time, some of which it still faces today, like the problem of latency when accessing memory. Considering that the paper was published in 2005, a lot of its predictions hold true, such as the shift to multi-core microprocessors, the rise of SoCs and ASICs, and extremely low-power computing (IoT).

Paper 2:

The paper “Benchmarking Amazon EC2 for high-performance scientific computing” by Edward Walker published in 2008 compares performance of two computing clusters, namely the commercially available Amazon EC2 and the cluster of the National Center of Supercomputing Applications of the University of Illinois. To compare the performance of both a single compute node and a computing cluster configuration, a benchmark suite NPB for HPC systems is used. The benchmarks are aimed at simulating the workload which such a cluster would experience when solving scientific calculations.

The paper shows that the performance of the HPC cloud system is not on-par with the one at the NCSA, although they use the same CPUs and Chipsets. When using the OpenMP version of the NPB benchmark, the author measures that degradation of performance to be between 7-21% (varies for the different tests within NPB) when using an Amazon EC2 compute node compared to a compute node of the NCSA and can be up to 1000% when the MPI benchmark version is used. Finally, the author confirms his hypothesis that the interconnection of the compute nodes is the factor slowing down the Amazon EC2 cluster by measuring the message-passing performance (latency and bandwidth) using the mpptest benchmark.

In my opinion, this paper shows well where the drawbacks of HPC cloud cluster computing lay in 2008. It would be interesting to see if other cloud computing offerings of that time would have produced similar results. Also, a revision of this test on the current Amazon instances would be interesting, to see if the situation has improved.

Exercise 1.2:

1)

The currently fastest Supercomputer from http://top500.org in June 2023 is a Cray System from Frontier with an Rmax Speed of 1,194.00 PFlop/s. The system is already beyond the EFlop/s barrier (1000 PFlop/s). But if you use Moores Law from 1965, his first version assumes that the amount of integrated components per chip doubles every 2 years. This value could be used for an guess of the growth of the potential performance of an Supercomputer. There is a “derived” law from Moore that guesses an performance doubling every 18 months. But to use Moores Law to guess the performance increase you can use the formula for exponential growth.

$$N(t) = N_0 * 2^{(t/T)}$$

where

- $N(t)$ is the quantity at time t,
- N_0 is the initial quantity
- t is the time that has passed
- T is the doubling time

2)

Moore’s Law is often described in terms of doubling the number of transistors on a microchip approximately every two years. But there are some “derived” Laws. One of them describes the doubling of CPU performance every 18 months. Mathematically this can be expressed using the formula for exponentional growth.

$$N(t) = N_0 * 2^{(t/T)}$$

where

- $N(t)$ is the quantity at time t,
- N_0 is the initial quantity
- t is the time that has passed
- T is the doubling time

	Fastest System in 2007 https://top500.org/lists/top500/2007/11/	Fastest System 2011 https://top500.org/lists/top500/2011/11/
Rmax (TFlop/s)	478.20	10,510.00
Rpeak (TFlop/s)	596.38	11,280,38
Cores	212,992	705,024

To calculate the growth rate the Rmax Value from 2011 has to be compared with the Rmax Value from 2017. According to the lecture slides we assume that Moores Law defines 18 Months for performance doubling.

When will the system according to this list breach the EFlop Barrier?

$$10,510.00 = 478.20 * 2^{(t/1.5)}$$

$$2^{\frac{t}{1.5}} = \frac{10,510.00}{478.20}$$

$$\frac{2t}{3} = log_2(\frac{10,510.00}{478.20})$$

$$t = \frac{3}{2} x\, log_2(\frac{10,510.00}{478.20})$$

$$t \approx 16,484$$

The solution tells us that the EFlop barrier breach will be in the 16,6 years in the future.

$$2007 + 16,484 \approx 2023$$

Moores Law tells us that the EFlop barrier will be breached 2023

Excercise 1.3

1)

Amdahls law says that the maximum achievable speedup is mainly determined by the serial proportion of the programm.

Assume that

$$s + p = 1$$

s = linear portion
p = parallel portion

Also:

$$p = 1 - 0.4 = 0.6$$

Maximum Speedup:

$$a = \frac{1}{s + \frac{p}{N}} = \frac{1}{0.4 + \frac{0.6}{10}} = 2.17$$

2)

Amdahls Law (speedup)

$$S = \frac{1}{(1-p) + \frac{p}{N}}$$

Case 1: parallel portion $p = 20\%$
speedup $n = 10x$

Case 2: parallel portion $p = 50\%$
speedup $n = 1{,}6x$

Case 1:

$$S = \frac{1}{(1-0{,}2) + \frac{0{,}2}{10}} \approx 1{,}22$$

Case 2:

$$S = \frac{1}{(1-0{,}5) + \frac{0{,}5}{1{,}6}} \approx 1{,}231$$

The second case has an increased speed gain compared to the first case

3)

$$p = \frac{(a-1)N}{a(N-1)} = \frac{(100-1)128}{100(128-1)} \approx 0.9978$$

$$s = 1 - 0.9978 = 0.0022$$

Willingness to present:

Exercise 1:
Paper 1: Yes
Paper 2: Yes

Exercise 2:
Exercise 1.2.1: No
Exercise 1.2.2: No

Exercise 3:
Exercise 1.3.1: No
Exercise 1.3.2: Yes
Exercise 1.3.3: No