

COMPUTERS

We will be using computers to do our DARPA research project. We know computers are fast. It is worthwhile thinking about the precise capabilities.

Q: How many arithmetic operations (addition, subtraction, multiplication, division) can a typical laptop/desktop computer do each second?

A: About 10^9 .

Q: Every six months a list of the world's fastest supercomputers is published. How fast are these computers?

A: The speediest are about 10 petaflops. (1 petaflop= 10^{15} floating point operations per second).

Q: How are computers timed?

A: Solving systems of linear equations!

Q: Which countries have the most machines on this list?

A: 251 in United States. 64 in China. 31 in Germany. 28 in United Kingdom. 26 in Japan. 25 in France.

Q: How much do these machines cost?

A: Most expensive is \$200,000,000.

Q: How much does the power cost to run the fastest machine for one year?

A: About \$10,000,000. (Good number to know: \$1,000,000/year for a MegaWatt.)

Q: If you could send a present day computer back to 1995, what sort of machine would it need to be in order to make the top-500 list?

A: An iPhone!

Q: Computers are immensely useful for science/engineering. Can easily do problems which are not just hard but even impossible with pencil and paper. Example: Effect of Jupiter on earth's orbit. Does this mean they should be able to solve pretty much any problem? Rajiv, Dave, and I study the properties of solids. Can you think of a reason a computer might not be able to simulate solids simply?

A: There are around 10^{23} atoms in a small solid (say $V = 1 \text{ cm}^3$? To move each atom once, assuming it takes just one addition, would take $10^{23}/10^{13} = 10^{10}$ seconds on the IBM Sequoia of LLNL, the world's fastest computer. This over 10^5 days, or about 300 years. Of course to simulate a solid's motion you need to move each atom many, many times. It takes 300 years just to do one step!

Conclusion: Computers are very fast and powerful, but it is still easy to think of problems they cannot come close to doing.

Exercise: We have considered only the question of processor speed. What sorts of restrictions might processor memory set on simulating a collection of atoms?