WHY WE’RE BUILDING PARALLEL SYSTEMS

The vast increases in computational power that have been at the heart of many of fields asdiverse as science, the Internet, and entertainment. For example, decoding the humangenome, ever more accurate medical imaging, astonishingly fast and accurate Websearches. As our computational power increases, the number of problemsthat we can seriously consider solving also increases. The following are a few
examples:

- **Climate modeling**. In order to understand climate change, we need far moreaccurate computer models, models that include interactions between the atmosphere,the oceans, solid land, and the ice caps at the poles.

- **Protein folding**. It’s believed that misfolded proteins may be involved in diseasessuch as Huntington’s, Parkinson’s, and Alzheimer’s, but our ability to studyconfigurations of complex molecules such as proteins is severely limited by ourcurrent computational power.

- . **Drug discovery**. There are many ways in which increased computational powercan be used in research into new medical treatments. For example, there are manydrugs that are effective in treating a relatively small fraction of those sufferingfrom some disease. It’s possible that we can devise alternative treatments by carefulanalysis of the genomes of the individuals for whom the known treatmentis ineffective.

- **Energy research**. Increased computational power will make it possible to programmuch more detailed models of technologies such as wind turbines, solar cells, andbatteries. These programs may provide the information needed to construct farmore efficient clean energy sources.

- **Data analysis**. We generate tremendous amounts of data. By some estimates, thequantity of data stored worldwide doubles every two years but the vastmajority of it is largely useless unless it’s analyzed. As an example, knowing thesequence of nucleotides in human DNA is, by itself, of little use. Understandinghow this sequence affects development and how it can cause disease requiresextensive analysis.

- Much of the tremendous increase in single processor performance has been driven by the ever-increasing density of transistors—the electronic switches—on integrated circuits.
- As the size of transistors decreases, their speed can be increased, and the overall speed of the integrated circuit can be increased. However, as the speed of transistors increases, their power consumption also increases. Most of this power is dissipated as heat, and when an integrated circuit gets too hot, it becomes unreliable.
- In the first decade of the twenty-first century, air-cooled integrated circuits are reaching the limits of their ability to dissipate heat Therefore, it is becoming impossible to continue to increase the speed of integrated circuits.
- However, the increase in transistor density can continue—at least for a while. Also, given the potential of computing to improve our existence, there is an almost moral imperative to continue to increase computational power. Finally, if the integrated circuit industry doesn't continue to bring out new and better products, itwill effectively cease to exist.
- Rather than building ever-faster, more complex, monolithic processors, the industry has decided to put multiple, relatively simple, complete processors on a single chip. Such integrated circuits are called multicore processors, and core has become synonymous with central processing unit, or CPU. In this setting a conventional processor with one CPU is often called a single-coresystem.