Project 2: Summary of *Power: A First-Class Architectural Design Constraint* by Trevor Mudge

In his article, *Power: A First-Class Architectural Design Constraint*, Trevor Mudge of the University of Michigan argues that power consumption should be taken more seriously in the design of computer systems and looks at some different ways of reducing it. Mudge starts out by explaining what factors determine power consumption and how they relate to each other. He then goes over some different ways of reducing power consumption.

To talk about ways of reducing power consumption, we need to understand what that means and how it is determined. Power consumption in a computer system is the sum of the dynamic power consumption, the power that is consumed doing computational tasks, and leakage, the power that the system consumes simply by being powered on. The part that we have the most control over is the dynamic power consumption, given by the equation $CV^2f$, where $C$ is a constant specific to the construction of the system, $V$ is voltage, and $f$ is the frequency of the system’s operation. Mudge notes that the first observation we can make about this relationship is that because power is proportional to the square of the voltage, this is where the most ground is to be gained. The voltage, and power, can be reduced with only a modest impact on frequency. The caveat, though, is that voltage cannot be reduced indefinitely because the system needs at least a certain amount of voltage to function properly.

Mudge goes on to outline some areas where progress can be made in the reduction of power consumption. At the most basic level, the choice in logic components, the building blocks of a processor, can make a big difference in power consumption. Using components that can be switched off when they are not actively being used, for instance, can reduce power consumption. A large portion of power can also depend on the architecture of a computer system, where components are and how much space they take up. Using memory that is designed not to use as much power while inactive, paying attention to how much power is
consumed by components passing data to each other on busses, and utilizing parallel processing and pipelining techniques where applicable can significantly reduce power consumption.

Power consumption is worth paying attention to for all applications where performance is not the only goal. It is very important for devices powered by batteries, such as phones and laptops, but also for web servers, where electricity and cooling are significant contributors to operating costs. Mudge asserts that power should always be part of the equation when making architectural decisions, and that as manufacturing processes improve and components get smaller with higher power density, systems will have to adapt to maintain the balance.

References: