Program Level Energy and Power Analysis and Optimization

Power consumption is a particularly important design metric for battery-powered systems because the battery has a very limited lifetime.

Power consumed by the CPU is a major part of the total power consumption of a computer system and thus has been the main target of power consumption analysis.

How long the device needs to run and whether the batteries can be recharged, need to be thought out ahead of time. In some systems, replacing a battery in a device can be a big expense. This means the system must be conscious of the amount of power it uses and take appropriate steps to conserve battery life. There are several methods to conserve power in an embedded system, including clock control, power-sensitive processors, low-voltage ICs and circuit shutdown.

By measuring the current drawn by the processor as it repeatedly executes distinct instructions or distinct instruction sequences, it is possible to obtain most of the information that is required to evaluate the power consumption of a program for the processor under test.

Power is modeled as a base cost for each instruction plus the inter-instruction overheads that depend on neighboring instructions. The base cost of an instruction can be considered as the cost associated with the basic processing needed to execute the instruction.

However, when sequences of instructions are considered, certain inter-instruction effects come into play, which are not reflected in the cost computed solely from base cost.

1. **Circuit state :** Switching activity depends on the current inputs and previous circuit state.
2. **Resource constraints :** Resource constraints in the CPU can lead to stalls e.g. pipeline stalls and write buffer stalls.
3. **Cache misses :** Another inter-instruction effect is the effect of cache misses.

As the instruction cache size increases, the energy cost of the software on the CPU declines, but the instruction cache comes to dominate the energy consumption.

If the cache is too small, the program runs slowly and the system consumes a lot of power due to the high cost of main memory accesses.

If the cache is too large, the power consumption is high without a corresponding payoff in performance. At intermediate values, the execution time and power consumption are both good.

Method for improving energy consumption :

1. Try to use registers efficiently
2. Analyze cache behavior to find major cache conflicts
3. Make use of page mode accesses in the memory system whenever possible

Some additional observations about energy optimization as follows :

1. Moderate loop unrolling eliminates some loop control overhead
2. Software pipelining reduces pipeline stalls, thereby reducing the average energy per instruction.
3. Eliminating recursive procedure calls where possible saves power by getting rid of function call overhead.