CMP SCI 635: Modern Computer Architecture

Facelift: Hiding and Slowing Down Aging in Multicores

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Date: 19th Sept, 2019

Paper: 5 – Wearout [Torrellas08]

Strengths:

1. The detailed view of the epoch times, the equations to calculate it, what to do in case of new vs used cores , how to take care of sensitivity , when to apply what voltage, how to model critical path delays, modelling process variations, the non-linear optimization; these all makes this paper an ideal piece of literature which an architecture designer can refer to build a multicore environment, where the goal is longevity. This paper has gone into enough depth that a hobbyist can create their own framework too.

2. Shows significant improvements in aging of multicore multifrequency environments. It takes into account the two most contributing factors: NBTI and HCI, convincing the reader on how they can take a multicore designed for a 7-year service life and, by hiding and slowing down aging, enable it to run, on average, at a 14–15% higher frequency. Alternatively, we can design a multicore for a 5 to 7-month service life and use it for 7 years.

Weaknesses:

1. In some cases, running a test to rank processors according to their speeds might not be feasible, even when it is in an interval of a month or so. Some systems which are ubiquitous and always heavily used might cannot afford to have this maintenance period. And running a test suite for each core will cause a lot of downtime. This will also increase leakage, as stated in the paper.

2. To make chip-wide changes (to tweak the voltage levels), one must have knowledge of the underlying architecture. So, will this framework be different for each architecture? If so, then this must be limited to few processors as all the hardware configurations aren't always available. For the commercial processors, this will never be a viable option as manufacturers might not divulge into raw circuit level details, let alone publish their processors' service life times.

Questions/Assertions:

1. The wire delays which are affected by electromigration may be the result of the atoms of a conductor piling up and drifting toward other nearby conductors, creating an unintended electrical connection known as a hillock failure or whisker failure (short circuit). Both of these situations can lead to a malfunction of the circuit. Which might be prevalent in any kind of public models, how is that not observed yet (according to the paper)? How is this the phenomena explored after the publication of this paper?

2. {Addition to #Q1} The CPU fan not working might not cool down the circuits, resulting into wire damages due to temperature.

3. In aging-driven scheduling, it is said that high activity applications should be in fast core and slow applications on slow core. But how would a new application will be initially assigned, without us knowing its behaviour? Suppose it's an arbitrary choice, wouldn't changing cores to suit it, after some considerable time has elapsed, result in same problem of slow core also being highly active due to application changing its environment?

4. Suppose there are two processors, and two tasks, unfortunately for Facelift, both are equally computationally heavy; how will Facelift assign these two tasks to the cores. Obviously, one will have to run on slow core, degrading its performance even farther. Is there any way around this?

5. What might be the reason behind manufacturers not revealing the service life and aging rates of the processors? Is it because some other competitor might claim higher numbers and hence, sell more units? If the info was available to the public, they might have better idea on how to manage their processors, as in, when to do away with one core and insert a new one in its place. But I guess general consumers don't always do that. But at least this will still help third-parties making improvements for service life.

6. Do processors just tend to die off after their service life is over? I had a Pentium 4 processor for around 15 years and although, it was very slow in the end, I never heard about it shutting down for once and for all. Is this aging something we see more for heavy-loaded servers, rather than for home computers?

7. With the advent of quantum computing, there soon might be a replacement for silicon transistors with 'qubits'. How would that change the microprocessor aging issue? Will using a different material, like, nanomagnet, simply do away with voltage and heat issue we face currently?