

1. Please read the ISSCC 2014 Keynote Publication by Professor Mark Horowitz “Computing’s Energy Problem (and what we can do about it)” [1]

1.1 How does Technology Scaling decrease the cost of Computing? How do reductions in the cost of manufacturing a transistor enable widespread use of computing devices?

Technology scaling shares an opportunity to develop applications that corresponds well to the risks and each other. Since the total cost per function dropped, technology scaling has done remarkable work on scaling down energy cost per function. Therefore, as the performance increased, the overall power needs of the system were continuous.

Moreover, with CMOS, it is capable of creating some chips with several transistors at almost no cost, which has all the transistors operate and run with GHz frequencies. Thus, the cost of computing is reduced significantly.

Additionally, the reduced cost of computing is a consequence of technology scaling. In this case, the reduced cost of computing turns the cheap computers and other technological devices like mobile phones into reality. Since the devices are becoming much cheaper than ever, they are more accessible, which lets increasing people buy and use them. Thus, reductions in the cost of manufacturing a transistor enable widespread use of computing devices.

1.2 Why did scaling processor clock frequency become more difficult in the last 15 years? How did Power dissipation become the primary constraint on server CPU performance?

While the end of voltage scaling, the primary aspect limiting additional improvement in computing has become much more difficult in the last 15 years. Since specialists did not scale the distribution of power voltage, a continuous field rate and scaling clock frequencies are at a higher rate than dictated.

1.3 Why is Moore’s Law slowing down? Why did Dennard Scaling end?

Moore’s law is slowing down since it is more expensive and its technical difficulty to double the number of transistors. For Dennard Scaling, it is ended because of the supply voltage limits and rapid increase on the chip. Unless there are a remarkable amount of on-chip resources available, it need these to stay dark to avoid thermal emergencies.

1.4 Why is the energy consumption by Memory substantial ?

Since memory energy provides the power breakdown of an 8-core superscalar processor that is made of 8MB last level cache and the recent 4nm, it is critical. However, the cache would consume a remarkable energy amount. The reduction in the general system energy by removing energy-intensive memory accesses is significant. Thus, the operation is critical.

Therefore, it is necessary to revisit the cache design that gets closer to minimize the normal memory access energy.

1.5 What solutions to Computing's Energy Problem does Professor Mark Horowitz's envision?

Prof. Mark Horowitz envision that if we could develop tools that incorporate the customers in the design procedure, specialists will have a lot of innovation with more efficient computing devices.

For me, I would agree with the statement that it would be more efficient because of the use and creation of innovative. If the customers could take part in and share their own thoughts, specialists would have a better understanding of the needs and demands of customers during the design process, which could help the specialists to make an improvement in the scaling process.

2. This assignment requires you to review several references on RISC V beginning with a summary transcript [2] of the Debate on Proprietary Vs Open Source Instruction Sets at the 4th Workshop on Computer Architecture Research Directions, June 2015 sponsored by the ACM. This Debate between Professor David Patterson (author of the textbook you are using) and Dave Christie of AMD highlights all of the key technical and business arguments for and against an Open-Source ISA such as RISC V as of 2015 (the same year the RISC V Foundation was established). A Technical Report from EECS UC Berkeley highlights the technical reasons for Open ISAs [3] providing a more detailed discussion on the advantages offered by open source ISAs

(1) Articulate your views on the topics debated in [2]. Justify your views.

To conclude, the subject of the debate is to determine whether the invention of computer hardware could be faster and quicker with the use of ISAs, which is also set to establish the relevance of the lessons of open software.

In debate which is between Prof. David Patterson and Prof. Dave Christie, David Patterson argued in favor of open ISA and Dave Christie argued in favor of proprietary ISA.

Prof. Dave Christie suggests that Since the operation of ISAs is based on the algorithm and software above the software or hardware below it, it do not count that

much.

On the other side, Prof. David Patterson does believe that ISAs counts. He states that ISAs are a very critical interface in a computer system, which is to support his perspective. Prof. David Patterson also lists the benefits of open ISA that we discussed in question 2 shown below. Prof. David Patterson also explains the difference between proprietary ISAs and minimal modular ISAs like RISC-V.

(2) Review and summarize technical reasons for Open-Source ISAs in [3].

Open-Source ISAs have features shown below:

- *It's not an error of omission.*
- *Nor is it because the companies do most of the software development.*
- *Neither do companies exclusively have the experience needed to design a competent ISA.*
- *Nor are the most popular ISAs wonderful ISAs.*
- *Neither can only companies verify ISA compatibility.*
- *Finally, compared with Open-Source ISAs, proprietary ISAs are not guaranteed to last.*

The influences of Open-Source ISAs to the market shown below:

- *Greater innovation via free-market competition*
- *Shared open core designs*
- *Processors becoming affordable for more devices*

The reasons why Open-Source ISAs in are shown below:

1. Open-Source ISAs are free and open since most of the software for the companies that have Open-Source ISAs are built by outsiders.
2. In designing competent ISA, there is lots of work included. And many people could build them today.
3. Open-Source ISAs are developed to ensure that they are compatible with the latest hardware standards.
4. Compared with the proprietary ones, Open-Source ISAs will not have an issue that when a company die, it will take its ISA with it, which is not guaranteed to last.