Graduation Diary

by Jing Chen

After five years and eight months of hard work, I finally graduated and received my Ph.D. degree. In general case, the Ph.D. candidates in McGill's School of Computer Science graduate in four to five years. Naturally, there were students who graduated in less than four years, while there were also students who took six to seven years to finish the program. When I look back today over my time as a Ph.D. candidate, I feel that it included both achievements and regrets.

To summarize briefly, there were three main things that I consider achievements. The first was a major breakthrough in the algorithm design into elementary function hardware accelerators, a continuation of my master's research—and these results could be immediately applied in a wide range of high-performance computing fields. The second achievement was that my work on elementary function hardware accelerators was published at international conferences on computer architecture and FPGAs. Finally, the third achievement was that the experience of presenting my work at conferences improved my ability to express my ideas and engage in discussions, as well as greatly widening my scope.

As for regrets, I have three of those, too. My first regret is that the fruits of my Ph.D. research were not published at top-level international conferences/journals on computer architecture. This is not really a problem, since there are many important research findings that are not published at such top-level conferences or journals.

My second regret is that I received almost no research funding from my supervisor. There were several reasons for this. First of all, my bachelor degree was from Capital Normal University, which is a fairly average university in China. My supervisor, Prof. Xue (Steve) Liu, holds a bachelor degree from

Tsinghua University, and most my fellow students in the lab came from prestigious Chinese universities in the C9 League. As everyone knows, McGill is one of Canada's top universities, and it has produced countless world-renowned scientists. When I came here to study, my supervisor had some worries about whether I would be able to keep up with the heavy workload. Indeed, some Ph.D. students were withdrawn from the program after one-year study, due to they fail to meet the minimum academic requirement. Another reason for my lack of funding was that my research was mainly focused on hardware R&D, such as elementary function hardware accelerators, FPGA development, CPU design and so on. Such research has a relatively long timeframe for design and development, with high risks attached. However, when there is a breakthrough in a fundamental hardware-computing component, it can result in major improvements in overall computer performance. Finally, my research interests were greatly different with those of my supervisor, so he believed that his research funding should be invested in other students and projects, whose were less risky and more promising. Fortunately for me, although I almost receive no financial assistance from my supervisor, I have more freedom when it came to my research. This freedom relieved me of outside interference and made it possible for me to devote myself to the research projects in which I was interested.

My third regret is that I, too, had a chance to shorten my Ph.D. career by one year. As of September 2018, I had already published two full papers and one poster. Had I started to prepare for graduation then, I could have my thesis defense in late 2018 or early 2019, and would have graduated one year earlier. This was not possible because my supervisor thought that the contribution of the reciprocal and square root hardware accelerators is slightly not sufficient for graduation. So, I spent another half a year on the development of a 32-bit RISC-V processor. After that, my supervisor was still not entirely satisfied with the workload of my work, but fortunately, after we talked it over, he agreed at last to my writing a doctoral thesis. Otherwise, I would have had to spend yet another year in my Ph.D. program. In early 2019, I finished an initial draft of

my doctoral thesis in roughly two months, then waited for about three months to receive my supervisor's approval, finally submitting my thesis to the review committee.

There were three main reasons why my thesis did not pass the first review. Firstly, there were overlaps between the elementary function accelerators project during my doctoral and master's thesis, so I had to explain what parts of it I expanded and innovated upon during my time as Ph.D. candidate. Secondly, I needed to clarify the respective technical contributions made by my supervisor, my collaborator from University of Toronto and me personally in my doctoral projects (for more information, please read section 1.1 of my thesis, "Clarification of Research Contributions"). Thirdly, the depth and extent of literature review in my thesis require further improvement; I should have read and compared a broader range of equivalent works from the past decade worldwide. After my thesis failed to pass the first review, I revised it again and added new content. Unfortunately, this process was affected by the Christmas holiday and then by the coronavirus pandemic, but I was finally able to pass the oral defence on April 24 and graduate officially on June 9.

If I had the chance to do my Ph.D. over again, there are lessons that I would consider, and there are attitudes that I would insist on. The lessons that I have learned are as follows. When choosing a supervisor, one must carefully research the academic background of the supervisor and his laboratory, and find answers for two questions: (1) Are you interested in the supervisor's research fields? and (2) Does the supervisor have enough funding to support his students' research? When I applied for Ph.D. positions, I was too concentrated on universities' reputations, however, overlooked this point and ended up on a winding path. The research areas that my supervisor valued were tasks scheduling in real-time systems, optimization of algorithms for smart grid systems and data centers, computer network and security, and big data applications. The research in which he was engaged focused on software applications, adjusting and adapting known models according to different

application scenarios, and his research results are majorly published as papers and journals.

When I first joined the lab, my supervisor had me take part in a project, which he appreciated. This project discovered a flaw in the “like” button functionality on Facebook. Malicious users could take advantage of this flaw to generate fake “like” information and trick regular users for their own gain. I felt that Ph.D. students should be engaged in more innovative work and that my supervisor did not know about my area of expertise. Regrettably, this divergence in research priorities between myself and my supervisor was a constant companion during my doctoral study.

When it comes to the attitudes that a student must carry on, I feel that it is important to stick by one’s research interests and not be swayed by doubting voices from the outside. My research on computer architecture and fundamental hardware components design is relatively long-term and risky, and my supervisor did not know it well, so I sometimes heard doubting remarks about my work. For example, “Smart people don’t engage in computer architecture research because it’s not cutting-edge field and doesn’t use mathematics,” “The performance of the hardware accelerator functions is good, but it is of no use in machine learning,” “Hardware is an unimportant, niche field with no future,” and so on. I remember one occasion when a labmate asked to give me a lecture about his research because my supervisor had said that “if Jing Chen can understand it, anyone can.”

Fortunately, I was not affected by these doubts and pressure, completed my research projects and then graduated by overcame various difficulties. As a graduate of an average university in China, stick to my research ideas when studying under a supervisor of Tsinghua University, who believed his research level is among the top ten worldwide, was something that took considerable courage. I will carry this working attitude forward in my future career.

While preparing for my graduation, I also paid some attention to developments of computer technology both in China and the world; for example, the embargo on exporting mask aligners, the ban on the use of some EDA and MATLAB tools and so on. China's IT industry seems to be flourishing, so why are these "strangleholds" occurring over and over again? I feel that China's IT industry is currently more focused on application rather than fundamental research; this can be seen from the fact that names of Chinese researchers are rarely attached to computer science innovations of fundamental researches. An article [1] showed that the total value of the integrated circuit chips imported by China in 2018 was more than US$300 billion, higher than the total value of petroleum imports, making China the country with the highest import share for chips worldwide. As long as some countries control the export of fundamental hardware components and software, they will have a huge impact on China's entire IT industry. As we know, China is currently the second largest economic player in the world, and for China to realize its dream of being a major power in IT, it cannot depend on purchasing or imitating technology from others, and it should place more emphasis on technological innovation to the world. Viewed from this perspective, if someone wants to make a major impact in an IT-related field, then they should tackle the tough problems and conduct pioneering research, rather than being satisfied to follow others or merely make improvements on frameworks made by others. To achieve this, working on innovative fundamental research is essential.

It is not my intention to belittle those engaged on the application side of computer science. These people are also necessary, but I think that the Ph.D. students at the world's top universities should be more oriented towards innovative fundamental research. At the same time, it is also not my intention to belittle scholars who explore the research fields that are popular at the moment. Emerging researches have not been plowed thoroughly, so it is relatively easy to produce results or publish articles. That said, some constantly switch research topics, and the real reason why they are pursuing what is popular is to cover up their embarrassment about their lack of success in their

previous field. For example, if they cannot make achievements in designing processors, then they will have a hard time designing FPGAs. This is because technology is hierarchical, and if the old problems have not been solved, it is all the more difficult to overcome new ones. Many people believe that artificial intelligence and neural networks are emerging fields, but this is not the case; the basic theory behind them was already highly developed in the early 1990s, but they were not widely applied at the time due in part to inadequate computing power. At the low tide of the artificial intelligence field, those working in it sometimes were taken for fraudsters, and it was hard to find work in the industry. The main reasons that this field started to regain momentum around 2012 were firstly that those researchers pushed through this humiliation and persisted in their research efforts, and secondly that innovations in hardware had brought about huge advances in computing power.

[1]. 突破 2.1 万亿！2018 年中国集成电路进口再创新高，摩尔芯闻，
http://news.moore.ren/industry/87867.htm