University at Buffalo
State University of New York

Department of Computer Science and Engineering

January 26, 2019

Graduate Admissions Committee
Department of CSE
University at Buffalo
Re: PhD applicant Chen Xu

Dear Colleagues:

I learned of Chen Xu's desire to return to UB for doctoral study under my supervision when he appeared at my door on Dec. 14. I have delayed writing this letter to allow time to interact with him this month. His communications last week and this week have started to impress me and bear out some things I had written for him in early 2016 which I include below. Before then, I had known him first in my Fall 2014 class "CSE596: Intro Theory of Computation" and then in my Spring 2015 advanced graduate course "CSE696: Computational Complexity." He did a Master's thesis with original research under Jinhui. His applications in early 2016 were all to schools and companies in California. The startup he joined did not succeed; currently he is working at another company.

Chen earned a B in CSE596 and followed it with a B+ in CSE696. I was initially a little concerned in 696 given his grade in 596 (and he did not have a high GPA at Fudan University), but he convinced me that his creativity and interest in the subject would show to advantage in CSE696 and that proved out. His score on my CSE696 take-home final was a B+ by itself—behind Mike Wehar and Chaowen Guan with A and James Clay with A-. I don't have their papers to hand, but per my recollection the difference was not understanding the material or industriousness or creativity but just in problem-solving power. What go along with power are technique and expressiveness, and these are what I focused on improving when I met with Chen in 2015—including expressivity in English which may have been more a factor in 596. (In my letter three years ago I noted how it helps that he is effusive rather than quiet and that his writing is crisp and literate despite occasional grammar glitches.)

I do think that the theory courses had a good effect on him—by the start of the Fall 2015 term I saw a big step up in both creativity and command. He first brought to my attention some matrix problems involving Krylov space methods, which I tried to connect to topics that Richard Lipton and I had been discussing with Joel Ouaknine of Oxford in connection with Skolem's Problem. Then I learned about his MS thesis work on sparse-matrix methods, whose complexity objective was to classify new problems into random polynomial time. His strategy was good—looking for sparse solutions to under-specified linear systems and then finding ways to sample approximations to them effectively. He also generated lively conversations among the theory students by inventing a novel way of "blurring" instances of (3)CNF-satisfiability by conjoining a formula with its images under flipping subsets of its variables. A mark of his initiative is that he once suddenly decided to fly out to Berkeley

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to attend a workshop on "Computational Complexity of Low-Polynomial Time Problems" at the Simons Institute. I don't think he was supported at the time. He seemed to get a lot out of it including conversing with some senior people about his sparse linear subspace problem.

In our interactions this month—after reading materials I gave him before Christmas—he has made several creative and perspicacious suggestions on a problem that Chaowen and I have been working on since summer. Some of them were shadowed by things Chaowen and I have tried but two were not. One was to consider so-called "bent functions" and I hadn't realized that the quadratic form given by Albert's normal form of an alternating matrix over GF(2) is a canonical bent function. He took a reasonable stab at a concrete problem I posed about transferring the work in Regan-Chakrabarti-Guan (2018) from qubits to *qutrits*. Just yesterday he gave me and Chaowen a three-page writeup on how Gaussian elimination can be sped up for sparse matrices by treating them as small sets with constant-time updates. The overall time depends on how those sets may grow and his analysis of that is incomplete—but it seems he intends to say it is incomplete since he cites a relevant technical problem as being NP-complete from a 1981 paper by Michalis Yannakakis. And he recognizes that the case for the mod-2 field may afford other savings. The current qubit case involves hybrid mod-2 and mod-4 arithmetic.

So, what do I think? Chen's area of expertise is perfect for my current work. He is research-mature and creative and enthusiastic. He would also help keep Chaowen involved after Chaowen graduates. Speaking with colleagues at yesterday's retreat reinforced the positive impressions. Hence I will be glad to work with him, and am happy to recommend his re-admission to the department as a PhD student with support.

Yours sincerely

Dr. Kenneth W. Regan