

personal  
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Modern technology is amazing. With the advent and development of the Internet, it is largely agreed that the world is more connected than ever before. A well-understood weakness of this modern connectivity is known as the ‘last-mile problem’. As these final terminals are integrated, people are declared ‘connected’ and so it is good. The problem is that I disagree with this definition of ‘connected’. As an Internet citizen, I am connected to any other *person* in the world, but I am not connected to *the world itself*. I am impassioned not by the last-mile but rather the last-inch. This distinction is embodied by the term ‘Internet of Things’, and it is my passion.

I believe in a connected and integrated world. I am a big proponent of open access and firmly believe the best way to enable other researchers is dissemination of work, including software, hardware, and data.<sup>1</sup> This availability enables researchers to leverage my work instead of duplicating it and ensures it is available to any interested parties, especially those in developing countries looking to leverage quality platforms to jump-start a research program. These beliefs are endemic to my personality, extending back to my high school career, when my school district briefly flirted with a ‘banned books’ list. While the ban was only for elementary and middle school students, it was egregiously overreaching, and we formed the Student Union, a group that lobbied (successfully) for school board candidates opposed to the ban and was successful enough to be formally invited to the consultations for the new district superintendent.

I am very grateful that as an undergraduate I was able to amass a large amount of teaching experience. Teaching was one of the most fun and rewarding experiences of my life, and I am proud to have won the 2011-2012 Best EECS Undergraduate Instructor Award. I find as I begin my Ph.D. research, however, that I am even more grateful to have been awarded the Computer Science Department First-Year Fellowship. The time and effort required to be the kind of teacher I wish to be, coupled with a research load and outreach activities would mean that something would have to give. As an NSF Fellow, I can continue to be a highly effective researcher, a highly available mentor, and a highly invested person in my community. Looking to the future, I cannot see a better career path than research faculty. The opportunity to be on the forefront of new technology, helping to shape the world, while at the same time helping to shape the minds of the next generation is a dream job. The correlation between successful NSF Fellows and successful faculty is no coincidence, and I believe an NSF Fellowship will put me on a path towards lifelong success.

**Intellectual Merit.** NSF Fellows are “expected to become knowledge experts and leaders”. My favorite book as a child was *The Way Things Work*, a fantastic encyclopedia of everyday things taken apart to see how they work. I took from that book a lifelong quest to understand how things work *completely* and my education reflects that. From the physics that defines electrical components, to the circuits they build, to the architecture that defines their arrangement and execution, through the compiler that translates human ideas,

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<sup>1</sup>Available: <http://umich.edu/~ppannuto/research.html>

to the operating systems that run them, and the networks that connect them, I am deeply educated on the full stack of modern computing. On the surface this may seem contrary to the modularity that has enabled the modern computing revolution. In practice, however, it means I am uniquely poised for work in embedded systems, where the leaky abstractions provided by all these layers break down.

Leadership is a natural aspect of my personality. From high school achievements, an Eagle Scout captaining both athletic (swimming) and project (*FIRST* Robotics) teams, to a recent unsolicited invitation to give an invited talk and serve as judge for a weekend hack-a-thon, I believe my peers have recognized me as a natural leader in my field. Reflecting further, I believe this is an extension of my endless quest to understand how things work extending to understanding people. I have been tutoring my peers since the second grade, when a very insightful teacher saw an opportunity for a bright young student to help a struggling one, and I have come to discover that if you can understand how another person thinks about a problem, you can translate underlying ideas in a way that allows them to learn. Applied to a group of people, this understanding evolves to leadership.

**Broader Impact.** My other essays document the impacts of my existing (M-ulator), current (M3), and future (VLC/PLC) work on the research community. My record as an educator – exemplary student reviews, best undergraduate instructor award, and the dissemination of my course materials to the University of Utah<sup>2</sup> – speaks for itself. Here then, I would like to address innovations in science and engineering.

Dean Kamen’s wildly successful *FIRST* Robotics program presents one key idea – make it *fun*. Drawing inspiration from my complex adaptive systems course and programming competitions, I built an implementation of the game *Blokus*. The key insight is to distill a player into a series of simple rules – ‘Use big pieces first’, ‘Play towards the center’, ‘Block other players’. Players can build a bot by stringing together and weighting rules. Put a display in the atrium with a leaderboard and you have built a competition. But this is quickly too simple to build a winning strategy, so expose a very simple Python interface to write new rules, with all the existing rules as templates. A very low barrier to opening up an imaginative world of strategies. When this limited interface of stitching together rules is no longer enough, expose the underlying board, piece, and move libraries and suddenly you have created a programmer. The final element is preserving the low barrier to entry for new participants by silo-ing sub-competitions: best stock-rule bot, best custom-rule bot. New entrants playing with stock rules can still innovate to the top and then chase down their peers in the upper levels. I am in contact with my former high school, who eliminated their only programming class over ten years ago, about piloting this game in the spring. I am seeking sponsors to incentivize winners of each category. More than anything else, I am excited to see what people can build.

I believe my transcripts, CV, and previous work more than attest that I am capable of delivering on my vision. I am confident that both my professional and personal work stand to have large impact on the world. I believe that as an NSF Fellow I can be a better researcher and that this fellowship will aide my endeavors to become a professor, to shape the impending ‘connected’ world and the next generation of minds that will build it.

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<sup>2</sup>Detailed in Previous Work