Green Computing

can computation advance sustainability? an exploration

Launched 2009
Status Completed
Participant
Michael Halle, Brigham and Women’s Hospital and IIC

Selected accomplishments

- Identified a number of faculty interested in translational research on the interface between computation and sustainability
- Initiated discussions of how research computing might be organized to be more sustainable and efficient, and identified disincentives and structural problems
- Identified potential funding sources and educational benefits of future green computing projects using the Harvard campus as a testbed
The Green Computing Project was launched in January 2009 as a development and networking effort intended to bring the IIC’s multidisciplinary approach to computational science and engineering to bear on the challenges of environmental sustainability. Over the longer term, the project aimed to catalyze faculty efforts around two main goals: solving computational problems in the fields of environmental sustainability and climate change, while at the same time working to mitigate the impact of computation itself on the environment.

The project was designed to forge useful links between leading researchers in different fields at Harvard—including computer science, environmental science and engineering, other domain sciences, business, design, public policy, public health and information technologies—to translate research ideas into practical developments to help both the university and the world address a broad range of complex and pressing environmental issues.

Background and motivation
The Harvard community currently lacks any other such translational research effort at the intersection of computation and the environment. Two main Harvard entities have environmental sustainability as their primary focus: the Harvard Office of Sustainability (HOS) and the Harvard University Center for the Environment (HUCE). HOS is an inward-looking organization: It deals with on-campus issues related to power conservation, recycling, and other issues related to Harvard’s impact on the environment. HUCE, on the other hand, is a longstanding, outward-looking research confederation with a goal to “encourage research and education about the environment and its many interactions with human society.”

As of early 2009, neither HOS nor HUCE had any significant focus on computation: HOS currently has no staff with IT expertise, and HUCE has no strong faculty collaborations with computer science or the computational sciences. Given the rapid increase in the local and global impact of computation on our planet and society, as well as the central role that computation plays in all aspects of environmental research, this gap seems especially troubling. With immediate, pressing demands on campus for greener data centers and efficient research buildings, individual schools and informal groups such as Harvard Green IT have developed their own expertise in this area out of necessity.

Compounding this problem is the fact that HOS and HUCE efforts generally do not overlap. This split means of operational and research interests means that on-campus sustainability efforts at Harvard, including an ambitious and public goal to reduce its campus carbon footprint by 30% by 2012, are not fully informed by the university’s own world-leading research.

Conversely, and perhaps more importantly, a huge opportunity is lost to use the Harvard campus itself as a translational test bed for new innovations emerging from research labs. Sensor networks that, for example, provide environmental monitoring over the diverse range of Harvard properties today could monitor remote and environmentally sensitive habitats tomorrow. Computer visualization of the power consumption of today’s Harvard buildings could inform the future of green building design at the Graduate School of Design. A prototype social networking system that allows Harvard undergrads to measure and compare their individual carbon footprints could be the basis of a world-wide energy conservation movement next year. The use of the Harvard community as a miniature prototype city has the further advantage of directly involving its “citizens”—students, faculty and staff—in developing an environmentally friendlier future.

History
The IIC Green Computing Project was envisioned in late 2008 with the goal of pursuing these missed opportunities. Michael Halle, the project manager, had just completed winding down the major research work of IIC’s Astronomical Medicine project. Inspired by the “environmental to call to arms” by Harvard President Drew Faust and former U.S. Vice President Al Gore at a university-wide convocation, Dr. Halle pulled together the broad outlines of the project, including a draft white paper and possible collaborations. The IIC Executive Committee reviewed the proposal in December 2008 and expressed interest in moving the project forward. Dr. Halle began the process of refining the white paper, understanding the current state of sustainability-related efforts at Harvard, and discussing the project with various potential participants from across campus.
The uncertain status of the IIC limited this project to discussion and planning. These preliminary discussions, however, confirmed the widespread need and general support for such an entity at Harvard. This report includes a summary of those discussions as well as current project activities and possible ways to move the project goals forward.

**Computer science**

The most in-depth conversations about green computing involved the Harvard SEAS computer science faculty. Professors Greg Morrisett and Margo Seltzer, both members of the IIC Executive Committee, provided initial enthusiasm and ideas that helped shape the project in its early stages. In his role as Area Dean for Electrical Engineering and Computer Science (EECS), Prof. Morrisett has envisioned the possibility of a coordinated effort supported by external funds. Cornell University received a $10 million grant in 2008 through NSF’s Expeditions program to establish a consortium-based Institute for Computational Sustainability. One of the Cornell ICS’s primary aims is to “inject computational thinking into sustainability.” Prof. Morrisett expressed confidence that research collaborations centered within Harvard’s academic community could form a strong and compelling proposal for a similar type of center here.

Prof. Seltzer found resonance with the Green Computing Project through her involvement with a proposed undergraduate course in “take-apart computing.” This course teaches computer science concepts by disassembling computer hardware and revealing how individual components work together inside today’s computers. This idea can be extended by wrapping this content with information about how computers are manufactured and, after the machine’s lifespan it reached, how the components are disposed of or recycled. By changing the relative emphasis of the different aspects of the course material, the course itself could be adapted to serve as elements of either or both EECS and environmental engineering curricula.

Further discussions of potential project interaction with computer science included Prof. Matt Welsh, whose research includes the development of sensor networks for environmental monitoring. Prof. Welsh has described the difficulty of establishing and maintaining strong collaborations with members of the Harvard Public Health and Design schools, in part because of limited resources and in part because of the lack of support or interest in translational science activities. The Green Computing Project was based on the belief that successful and sustained translational science can be fostered with the right kind of support environment and faculty. Prof. Welsh agrees with Prof. Morrisett’s view that a federally funded Center formed by a core group of faculty would perhaps be the best way to establish a green computing effort at Harvard.

Further discussions with individual CS faculty members with research interests overlapping the Green Computing Project is ongoing at the time of this writing. Prof. Hanspeter Pfister is an obvious additional member of this group: His field of scientific visualization is a key component of computer-based methods to present large amounts of environmental sensor or simulation data meaningfully to end users.

**Information technology**

Members of Harvard’s information technology staff have been enthusiastic participants in discussions about the Green Computing Project. Eric D’Souza, Harvard CIO senior project manager and founder of the Harvard Green IT group, has been especially helpful in establishing a connection between the Green Computing Project and ongoing data efficiency projects at Harvard. David Gipstein, Director of Information Technology at SEAS, also encouraged the project to move forward. He sees a need for tools to evaluate and present information about data center efficiency to planners and decision-makers, a task tailor-made for data visualization.

FAS Research Computing has expressed support for the Green Computing Project’s effort...
to use commercial “cloud computing” resources as a method for increasing the energy efficiency of research computing. Traditional university research computing has been done on campus using computers purchased by universities or by individual researchers through grants or contracts. University funding models and federal reimbursement rules have long encouraged energy-inefficient practices where end users are insulated from the cost of the resources they consume, often leaving the institution to bear the cost. Cloud computing, on the other hand, fully exposes the cost of computation, moves computers out of energy-limited urban areas, and encourages high efficiency hardware and effective recycling practices. Cloud computing, however, is taxed by overhead and is generally not reimbursable by federal grants.

FAS Chief Information Officer Larry Levine and Executive Director of Research Computing James Cuff met with the Green Computing Project’s management in early May 2009 to discuss the use of cloud computing in research. They agreed with the need for progress in this area that would allow commercial cloud computing to be a viable option for applicable university research. They agreed in principle to support internal and external efforts to encourage cloud computing for research and negotiate lower institutional rates with service providers. These discussions would include Harvard’s finance deans, technical peers at other research universities, and representatives of various cloud computing service providers. In separate discussions, employees of Sun, Google, and IBM have also expressed interest in this kind of discussion; CS faculty ties to Amazon would also assist in bringing that service provider into the discussion.

Computational and domain sciences
The Green Computing Project received early support from Prof. and IIC Director Efthimios Kaxiras. Prof. Kaxiras has expressed interest in Green Computing’s role in facilitating alternative energy research such as that conducted by Prof. Aspuru-Guzik in the Department of Chemistry and Chemical Biology. Prof. Aspuru-Guzik’s research includes theoretical studies of energy and charge transfer in renewable energy materials. He has worked with IBM to deploy photovoltaic optimization algorithms on the World Community Grid, a distributed software environment that uses spare computational resources provided by individual members of the public. Called the Harvard Clean Energy Project, this research collaboration demonstrates the potential usefulness of collaborations between sustainability researchers and experts in computer science, computational science, and software engineering.

While computational tools and techniques for sustainability research may be similar to those used in other fields, pulling them together as part of a single Green Computing entity would make joint development, grant collaboration, and thematic fundraising more effective.

Members of Harvard’s sustainability community
The Green Computing Project’s management met with Jim Clem, the Managing Director of the Harvard University Center for the Environment, to discuss possible collaborations between the IIC and HUCE. The Managing Director expressed interest in a campus-wide brainstorming meeting to match research and computation partners. In particular, he identified the need for data visualization and sensor networks as potential topics for collaboration.

Alex Wissner-Gross, environmental fellow at HUCE and SEAS and founder of CO2stats.com, has been an enthusiastic supporter of a Harvard-based Green Computing Project. He has expressed interest in prototyping new sustainability ideas on campus before deployment in larger communities. He also suggested the idea of an “energy in computation” computer science course that would teach both basic science and practical engineering principles of energy consumption in electronic and computer systems.

The Green Computing Project met briefly with Nathan Gauthier, Assistant Director of the Office of Sustainability, who expressed interest in better resource sharing and coordination with Green IT efforts on campus.

Industrial contacts
Several computer industry representatives have expressed personal support for the IIC Green Computing Project and belief that industrial collaboration with a Green Computing entity would be strong. Jim Waldo, Harvard adjunct professor and Distinguished Engineer at Sun Labs, has offered
to make connections inside of Sun’s green IT team and outside to other industrial contacts. Muthu Muthukrishnan, Research Scientist at Google Research, expressed similar enthusiasm for projects involving sustainability and distributed computing, and has offered to make personal connections inside of Google management to foster the project. Google’s “Green IT” point person, William Weihl, suggested several ways that Harvard could participate in larger efforts to promote sustainable computation, although his personal emphasis does not currently include research-related computational sustainability issues.

**Next steps**

Should there be interest in re-opening faculty discussions of Green Computing, the following steps seem indicated by Dr. Halle’s research:

- Focused discussions with SEAS faculty to write a Center proposal based on faculty research interests. Prof. Morrisett has expressed the willingness to present a strong such proposal to the NSF in solicited or unsolicited form.
- More extensive discussions with FAS Research Computing, leading to facilitation of high-level contact with cloud computing service providers, other research computing universities, and finance deans.
- Construction of an infrastructure to support closer collaboration between sustainability researchers, computational and computer science, and IT staff.
- Cooperation with the University Development Office and other Harvard fundraising entities to estimate the potential for funding a full-blown Green Computing Effort.
- More in-depth investigation of the education, dissemination, and public relations aspects of a mature Green Computing Project.
- Facilitate several small research-based collaborations in line with the project’s larger goals to validate the utility of the project’s research approach.