



DISTRIBUTING
SCIENCE

Want to calculate the temperature in 2050?

Look for a cure to Alzheimer's disease?

Prove the existence of gravitational waves?

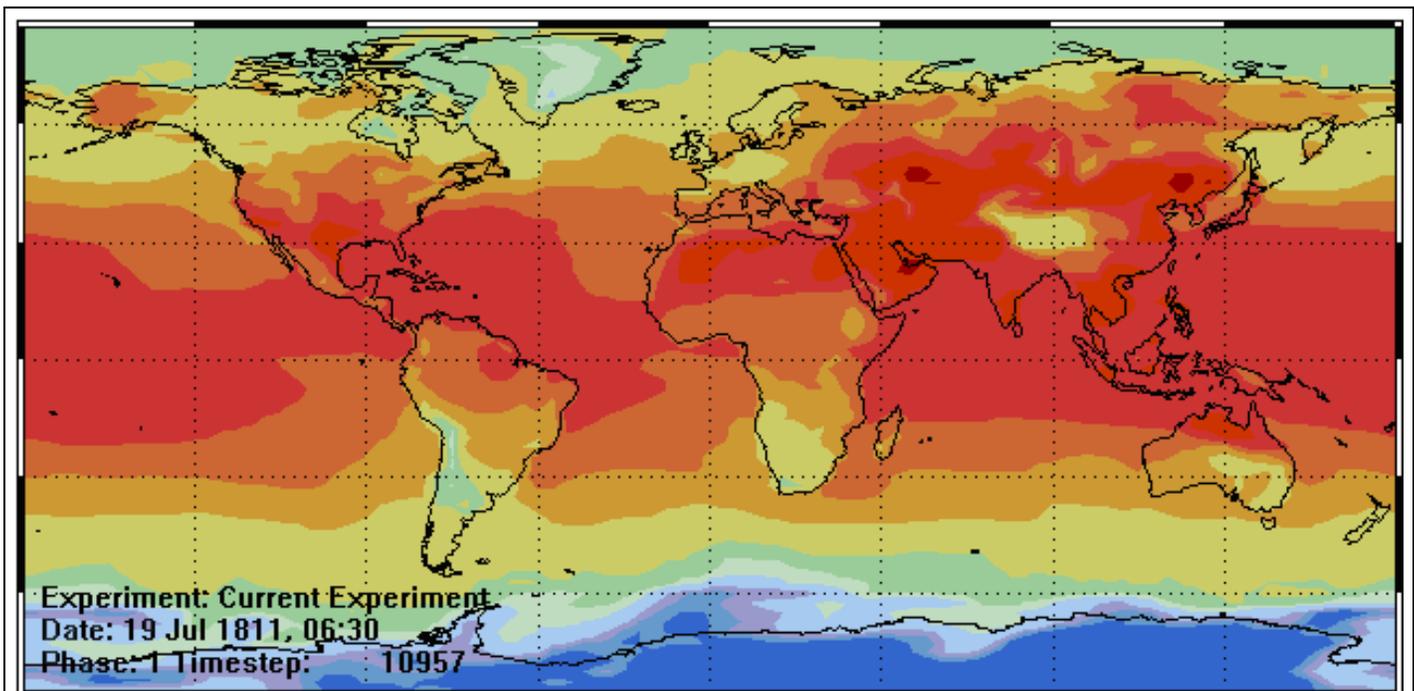
Search for a signal from extraterrestrial life?

Want to do all of the above
while lying in your bed,
sleeping?

Since late 2002, a distributed computing platform called the Berkeley Open Infrastructure for Network Computing (BOINC) has been enabling computer users to do all of those things. BOINC allows a user who runs its software to divide his or her computer's processor time among numerous scientific projects. If you want to predict the temperature in 2050, one popular project – Climateprediction.net – allows its users to do just that. Over 100,000 screensaver scientists have aided professional climatologists in predicting future weather conditions in an effort to realize the impact human beings have had on nature. Interested individuals can download, install, and run the software (see screenshot below) on their computers and instantly begin predicting climate changes 50 years into the future. The project and its ability to involve non-scientists in important research are made possible by the process called distributed computing.

workload among many computers. These individual computers process their portions of the problem, and the results are combined together to form a solution for the original problem. Together, the aggregate power of these computer systems can greatly surpass the computing power of the world's fastest supercomputers.

The largest projects, such as Climateprediction.net, rely almost solely on the Internet as a way of recruiting thousands of interested computer users to run the software. After installing the program, users are sent their first set of data to process, typically called a workunit. The processing happens almost invisibly. The client software has been developed to only crunch data when the processor is not busy doing other things – which means users' computers are always available for them to listen to music, check E-mail, or perform any other task. Once the workunit has been processed, the result is returned to the project's main server, and a



Over 100,000 people have begun modeling temperature graphs like this one, running simulations from 1800-2050 in an effort to try and predict trends in the global climate. The screensaver shows the current progress to the user, including a color-coded map of the Earth (red indicating over 100°F. blue under -40°F). and the exact date and time being predicted at that moment.

DISTRIBUTED COMPUTING

Distributed computing is the method of splitting a large problem into smaller pieces and allocating the

new set comes in to restart the cycle.

Through the volunteering of computer resources, participants are helping to direct the future of distributed computing and pointing scientific researchers towards areas that interest the community

as a whole. Through distributed computing, BOINC is enabling people to get involved. Cutting-edge science no longer has to feel out of reach for a large percentage of the population.

BOINC

BOINC was created at the University of California-Berkeley by the Space Sciences Laboratory, a group involved with the SETI@home project. It is the first computing tool that allows any scientist to use high-powered computing to run computationally expensive projects. Some of these projects such as modeling Earth's future climate are so computationally intense that without this system, they would not even be attempted. Thus, research problems that were once considered impossible can now be investigated wherever there is a computer. From research computer grids to the laptop in your bedroom, every computer connected to BOINC will have an impact on the direction of science.

Currently there are 5 main projects using the BOINC infrastructure. Among these, the ones logging the most computing time are SETI@home and Climateprediction.net. Together, these projects have run millions of hours worth of computing time that would otherwise be unused on idling computers. The results of many distributed computing projects are immensely important. From predicting the climate for the entire 21st century to searching for cures to protein-related diseases such as Alzheimer's, Parkinson's, and Mad-Cow disease, BOINC projects have the potential to make a real difference in the world. Most of these projects have attached screen savers. These screen savers are not only interesting to view when a computer is idling but also show what a computer is doing with the model or project it is running. With fully interactive virtual globes, multiple climate maps, and satellite views in Climateprediction.net and a real-time view of the radio signals being analyzed in SETI@home, users are always able to see exactly what type of work their computer is performing and can better understand how their contribution benefits the project as a whole.

Even when project results leave a single computer and are processed together with the results from other computers, users will be on the cutting edge of learning about their impact. From

participation in global computing teams to personal discussions about the many different science (and other) topics, the BOINC community will keep users in touch with the projects in which they contribute.

COMMUNITY

Prior to the advent of the distributed science allowed by the BOINC architecture, a large project's accessibility would be limited to a select number of researchers, most likely from established universities. External access would be limited and consequently so would outside opinions and ideas. By placing the discussion and projects in the public domain, BOINC promises to overcome this limitation; thus, research communities on a larger, global scale have the impressive power to shape the course of a project.

This community based around the use of BOINC is another incentive for users. The relationships that the members within each project develop are similar to the professional camaraderie that would develop between the "classic researchers" described above, but this community is on a much larger scale.

"There's been really an incredible amount of virtual community formation," says Dr. David Anderson, BOINC's founder and architect. "It's clear that a lot of people are really interested in getting involved in ways other than just running software on their computer."

The community is what provides value and excitement during the running of the distributed science project. In this sense, BOINC is transforming the concept of a research community. Through the development of these larger, global scientist communities, another concept of community develops based solely on the use of BOINC. The open, global communities of BOINC have the sole requirement of interest in a project.

These worldwide communities are each centered on the common interest of the goal or topic of a project. Whether it is an interest in searching for extraterrestrial life or a desire to contribute to the investigation of global warming, each community bonds over its common goal, through message boards, individual profiles, teams, and a credit system.

What does the future hold for the weather on Earth? Climateprediction.net is attempting to study the possibilities that are in store for Earth's climate in the next century. Running a model thousands of times with small variations allows scientists to study the sensitivity of the environment to changes in variables like carbon dioxide or the sulfur cycle.

Participants are given their own climate model to run on their computer. With the screen saver that comes with the software, users can watch their own version of Earth as precipitation forms, temperatures change, pressure rises and falls, and many other characteristics evolve. At the completion of the run, results are returned to Climateprediction.net for analysis.

So far, Climateprediction.net has allowed scientists to see that global warming may be more of a problem than previously believed. Simulations of ocean churning have provided more insight on the effects of thermohaline circulation as well. As more participants join the project and complete model runs, climatologists will learn more and more about what's in store for the weather on Earth. More on Climateprediction.net can be found at <http://climateprediction.net/>.

Proteins are the building blocks of life as we know it. In an attempt to learn more about the structure of proteins, Predictor@home is searching for and testing new ways for linking the sequence of proteins to their structure. Ultimately, they hope to use the knowledge they gain to answer questions regarding protein related diseases.

The work unit for Predictor@home consists of data for a sequence of proteins and an algorithm to attempt to predict the structure of the protein. The user's computer runs the algorithm on the structure data provided. Upon completion of a run, the results are returned to be compared with the other predicted results made by other users.

Predictor's work is providing new insight towards the study of proteins. As methods for predicting the structure of proteins improve, we will be better able to design drugs to treat new and existing diseases. More information on this work can be found at <http://predictor.scripps.edu/>.

It's been almost 90 years since Einstein first predicted that ripples exist in the fabric of time and space. However, concrete proof has never been found. Einstein@home is an attempt to find these gravitational waves.

Work units received by users for Einstein@home consist of 12-megabyte data chunks from the US Laser Interferometer Gravitational wave Observatory (LIGO) and the British-German GEO-600 gravitational wave observatory. This data portrays only a very small fraction of the celestial sphere, thus allowing a user's computer to rigorously and thoroughly scour the data over several days in search of a gravitational wave.

The discovery of gravitational waves would be monumental for both theoretical and experimental physics if found. Their existence would confirm much of Einstein's theory and provide us with a better understanding of our universe. Visit Einstein@home at <http://einstein.phys.uwm.edu/> for more details on the search for gravitational waves.

Is ET really out there? SETI (Search for Extraterrestrial Intelligence) is attempting to find him. Experts have reasoned that the most probable way alien life would attempt to contact us is through radio waves. The SETI project harnesses the collective computing power of its 128 thousand current users to sift through massive amounts of data collected at the Arecibo Observatory in Puerto Rico.

A user's computer will receive a 100 second block of radio data recorded at Arecibo. The computer's task is to analyze the data, looking specifically for pulses, triples or other patterns in the signals that would not occur in space naturally. Any signals that seem out of the ordinary are sent back to Berkeley for further analysis.

Most of the data - 99.9999% - are dismissed as either noise, interference from terrestrial objects, or equipment malfunction. However, the other very small percentage of signals does not currently have explanations, but none have provided conclusive evidence of other civilizations. For more information, visit the SETI@Home web site at <http://setiweb.ssl.berkeley.edu/>.

Each BOINC project is given a Web site template to create the communities; so one will find a home page, a message board, and a credit system that is the basis for user and team leader boards for any BOINC project. On the message board, individuals are able to discuss whatever interests them, such as questions about the projects, the science behind the particular topic, or interesting results they have encountered. The message boards encourage the formation of sub-communities, each of which in turn develops respective teams. Teams encourage the formation of individual relationships and make real-life gatherings a possibility.

For example, the ClimatePrediction.net forums commonly discuss the results of a world simulation. Perhaps the polar ice caps melted because the average world temperature jumped 12 degrees by the year 2065, or perhaps a scenario with double the CO₂ content resulted in nearly no effect on the earth's temperature. Users learn about climate science together, and put their new knowledge to use by discussing and interpreting the results of their models.

Because the projects have large numbers of participants (for example, SETI@home has about 135,000 active users), the community relies on the messages boards to break the group down by sub-interests; examples of sub-interests include common nationality or a common reason for joining the project. The sub-communities' significantly smaller size in turn makes individual relationships more of a reality. For example, language-specific communities as well as national communities have developed their own sites and message boards similar to that of the worldwide project page.

"[BOINC] is now available in twenty to thirty different languages," says Anderson, "which is important because the participation is really global – about half the participants are outside the United States."

Leader boards organized by individual, computer, and team are displayed prominently on the front page of each project, illustrating the importance in the sub-community. A user's relative position on the boards is based upon the number of credits that a user obtains. Credits are awarded for each work unit processed on the user's computer; so, the greater the contribution to the project, the more credits one can receive. Credits serve as the fuel for the communities

by sparking the natural spirit of competition. With that competition, a sort of social hierarchy develops, where the amount of respect a member of the community receives is proportional to the amount of credits he or she has earned. A large number of credits elicits a correspondingly large number of responses to message board posts.

The sub-communities beget real-life events in the same way that a school honor society or fraternity holds meetings and reunions, and release publications and newsletters. For example, the German SETI@home community has held conventions for several years. In fact, at least three couples that met directly through the SETI@home community have married.

CONCLUSION

Perhaps what is most exciting about BOINC, however, is how the software is growing and evolving. As the number of projects using BOINC increases, so does the power that participants are granted by participating. With more choices, BOINC users make their own decisions about which areas of science are the most important. Home to the most popular distributed computing projects, BOINC has already shown its ability to attract researchers in a variety of different fields.

One particularly exciting project on the horizon is called the PlanetQuest Collaboratory, which will analyze telescope imagery, searching for variations in brightness of stars. These variations might suggest the existence of an orbiting planet.

"You can do these multiple, incredibly exciting things, looking for pulsars, looking for extraterrestrial life," explains Anderson. "It's real science and it's happening on your computer."

Through distributed computing, BOINC is truly enabling everyone to get involved in cutting-edge scientific research. Now, only one question remains: Who wouldn't want to do this?

How to sign up?

1. Enter <http://boinc.berkeley.edu> into browser.
2. Download client from site.
3. Go to homepage of project for which you wish to join.
4. Fill out sign-up form and get account key.
5. Enter account key into BOINC.
6. Enjoy!

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Authors:

Daniel Carroll	dancarroll@gmail.com
Tim Psiaki	tim_psiaki@yahoo.com
Christopher Rahmlow	sfugi108@gmail.com
Greg Wojtaszczyk	grw24@cornell.edu