PlanetQuest™…The Planet-Wide Observatory

SUMMARY

PlanetQuest will make it possible for millions of people, using their computers and our data, to search the galaxy for undiscovered planets, catalog and classify millions of new stars, have fun learning, and advance the world's scientific knowledge. What makes this "planet quest" not only feasible but also accessible to everyone, from a schoolchild to a PhD, is PlanetQuest's astronomical observing network, distributed computing platform, and Transit Detection Algorithm (TDA)—a special mathematical signal detection technique codeveloped by one of PlanetQuest's founders. This signal detection technique has been used to search for extrasolar planets over the past decade and can be used to identify the transit of a planet in front of its parent star by detecting a very slight drop in the star's brightness that will last only a matter of hours.

The TDA uses mathematical techniques to analyze the brightness of a star over time (the result is called a "light curve") and compare it with computer-generated hypothetical models of planetary transits to see if the brightness dip observed in the light curve of the star matches any of the models. Because the actual (observed) light curve must be compared with millions of such models in order to identify any real planetary transits that may have occurred, the search for planets is ideally suited to distributed computing. The power of millions of people's computers can be harnessed to perform a search for planetary transits around millions of stars—a task once considered monumental involving millions of years of computing time to search millions of stars for planets.

PlanetQuest is a nonprofit organization that was formed in 2004 by Laurance Doyle, PhD, an internationally known and respected astrophysicist, coauthor of the TDA, and a Principal Investigator at the SETI Institute; David Gutelius, PhD, cofounder of Ishtirak (a technology consultancy firm serving Fortune 100 companies), a management consultant for technology start-ups, and a Stanford University visiting scholar; and entrepreneur Jeremy Crandell, cofounder of Brightmail, an antispam software development corporation that was recently purchased by Symantec.

MISSION

The unifying mission of PlanetQuest is to create global participation in the discovery of planets around other stars. It will enlist the active participation of tens of millions of people, at all educational levels. PlanetQuest is designed to provide a new level of participation in scientific

discovery, one in which people—especially children—collaborate on a global scale to discover new worlds. As the Internet has made it possible to share vast amounts of information among people in ways never before witnessed, PlanetQuest will allow free participation by everyone in the actual discovery of worlds never before known. These will be real discoveries; PlanetQuesters will be discovering new worlds, and receiving credit for their discoveries.

The scientific mission of PlanetQuest is the discovery—by PlanetQuesters—of thousands of new planets in our galaxy within the next five years. Some of these planets (around the smallest stars that we'll be observing) could be of the right size and distance from their star to potentially support life, and as the PlanetQuest network grows, it will increase the possibility of finding even more of these smaller "terrestrial-type" planets.

The educational mission of PlanetQuest is to provide the largest Web-based platform for astronomy, computer science, and general math and science education yet designed, reaching virtually all educational levels with the philosophy of learning through real discovery. Online tutorials for PlanetQuest participants will provide instruction at various levels of educational development—for school children up to about age 12 (Level 1), high school students (Level 2), the general public (Level 3), the scientifically literate (Level 4), and graduates in the sciences and astrophysics (Level 5).

Incentives for self-education will include acknowledging participant discoveries about the stars they have worked on, as well as discoveries of planets and their characteristics (length of the planet's year, its size, and so on). Virtually every participant will receive credit for discoveries because every participant is sure to make a unique discovery about the particular stars they are searching for planets around. Initially, about one in 10,000 PlanetQuesters should also find new planets, but this discovery ratio will improve as we build our own telescopes to reach farther and deeper into the galaxy for new and more sunlike stars to observe.

ORIGINS

In the winter of 2000, while SETI@home was in the process of attracting millions of users to process radio signals in the search for extraterrestrial technology, astrophysicist Laurance Doyle first asked the question: What if we could harness the power of millions of people operating millions of computers to also discover planets in our galaxy? And what if, in the process of the search, people learned about astronomy and science and computing and felt that they really were finally participating in the actual discovery of new worlds—really where no one had gone before? And what if, in the process of the search, people from China, the Americas, India, the Middle East, Africa—the whole world—collaborated with each other, sharing knowledge and ideas, while searching for other worlds? Perhaps such a galactic perspective on our place in the

universe could help us see that we all share this one tiny planet, and help us better understand what goes into making our own little world habitable.

Earlier, from 1994, Doyle and collaborators had authored a series of papers appearing in scientific journals, including *Scientific American*, describing this method for detecting planets around other stars. The method uses images of hundreds of thousands of stars from telescopes at observatories around the world to detect the shadow of a planet as it crosses in front of a star.

Teaming up with partners Gutelius and Crandell in early 2004, Doyle began developing a model for PlanetQuest that would offer a robust innovative distributed computing platform for the creation of the world's largest planet detection network—that would be free to all who wished to participate. Using the power of distributed computing, this project would involve people in a way and on a scale that could set an example for future scientific and educational ventures. PlanetQuest will be the world's largest astronomy educational facility, the largest "collaboratory" for planet discoveries, and the largest computational network, dedicated to bringing the actual discovery of other worlds to everyone who has a computer.

HOW IT WORKS

Since the creation of the modern telescope in 1608, only three new planets—all in our own solar system—had been discovered. But since 1995, over 150 planets around other stars have been discovered. With PlanetQuest in operation, thousands of additional new planets could be discovered within the next five years, and by people who are not even trained in astrophysics, mathematics, or signal detection techniques.

The science behind PlanetQuest is fairly straightforward. Using the TDA and observational data downloaded from the PlanetQuest website, one can find planets around other stars by measuring a drop in the brightness of a star as a planet crosses, or transits, in front of it. But in order for us to witness this event, the orbit of the planet has to move across our line-of-sight to the star, and this happens for only a few percent of the stars in our night sky. Thus, the more stars being observed, the greater the chance for a planetary orbit to be aligned correctly, and the greater the probability of discovery.

PlanetQuest will focus telescopes on extremely dense star regions, such as the star clouds in the constellation Cygnus in the Northern Hemisphere, and the center of the galaxy in Sagittarius in the Southern Hemisphere. Each image from a given telescope will include many tens of thousands of stars, and PlanetQuest's software will allow participants to obtain facts about the stars they are working on based on their brightness, color, and other characteristics.

The data from these images (the brightness variations of the stars) will be distributed to millions of computers, and software incorporating the Transit Detection Algorithm (TDA) will compare

each star's brightness variations with all possible planetary transit models to see if a planet is present in a PlanetQuester's data. Our approach has been adopted for the NASA Kepler spacecraft mission to be launched in 2007.

PlanetQuest users will be able to compare and share information about the stars they are working on, ask questions of PlanetQuest's professional astronomers, and work through some of the PlanetQuest educational materials with the goal of being able to "graduate" to a higher level in the PlanetQuest educational setting (for example, from grammar school Level 1 to high school Level 2). Of course, the discovery of a planet is determined not by a participant's educational level but by whether a particular star actually has a planet whose orbit moves across (transits) the star. This is certainly not determined by PlanetQuest, and such unknowns illustrate the fact that PlanetQuesters will be doing real science and making real discoveries at the frontiers of knowledge.

When a participant has discovered a new fact about a star or possibly has a new planet candidate, PlanetQuest will acknowledge and record that finding and the discoverer's name in the PlanetQuest Discoveries Catalog. Planet candidates will then need to be verified by checking the light curve with additional confirming data. Virtually all PlanetQuesters will receive credit for discoveries of astronomical importance. Some will be credited with the discovery of new planets, as well. Their names will become part of astronomical history, and their new worlds may be studied for centuries to come.

DATA ACQUISITION

At first, PlanetQuest plans to use two telescopes—the Crossley 0.9-meter telescope at the University of California's Lick Observatory in the Northern Hemisphere and the Siding Spring 1.0-meter telescope in Coonabarabran, Australia in the Southern Hemisphere—during the two or three years it will take to build dedicated PlanetQuest 2.5-meter telescopes.

With a response similar to that received by SETI@home—millions of users—PlanetQuest will require two 2.5-meter telescopes, each equipped with 4,000 × 4,000 array CCD imaging cameras, with a minimum observing schedule of about 200 nights per year on each telescope. This will yield thousands of hours of data on several million stars that PlanetQuest users can classify and search for planets.

To expand the project to 20 million participants, PlanetQuest will need to build ten dedicated 2.5-meter telescopes (seven in the Southern Hemisphere and three in the Northern Hemisphere) in several sites—for example, Chile (we have been invited to do so at the Cerro Tololo Inter-American Observatory). With 2.5-meter telescopes in the Southern Hemisphere we would have access to virtually all the 170 million stars in the center of the Milky Way galaxy catalogued to

date, with the discovery of many more extending this number to over a billion stars over the following five years.

To accommodate an even greater number of PlanetQuest participants in the future—up to perhaps 50 million users—even larger telescopes could be established in both hemispheres, and it is not inconceivable that a mission built after the design of the NASA Kepler spacecraft could be launched that could constantly access the many tens of millions of stars required for so many PlanetQuest users. In other words, there will be no lack of stars for PlanetQuest, and facilities are available or could become available for any number of expected users into the foreseeable future.

DATA PROCESSING

PlanetQuest has developed and tested all the basic TDA software specific to the detection of planets and is currently adapting this software to the distributed computing environment using the BOINC platform, initially developed at the University of California, Berkeley, for SETI@home and other projects.

The PlanetQuest Collaboratory will work on any operating system. A participant needs only to download the Collaboratory from the PlanetQuest website. As its name suggests, the Collaboratory is designed to encourage frequent interaction, self-education, and deep commitment to what can become a lifelong engagement in astronomy and science.

PlanetQuest will build a central online archive, catalog of discoveries, and databases of other information for users. The Discoveries Catalog—available to all participants—will list the name of each PlanetQuester who worked on a particular star and what they discovered. The catalog will also list the names of people who discovered new planets. With millions of stars and thousands of planets to be discovered and catalogued, the archive must be highly robust, secure, and easily accessible. For this, PlanetQuest draws on expertise developed in the database management of the NASA Cassini Saturn images that are currently being transmitted to Earth from that orbital mission.

TIMELINE

PlanetQuest operations will launch in the fall of 2005 with a limited public release of the Collaboratory software platform to 50,000 PlanetQuest Charter Members.

In 2006, PlanetQuest will launch the worldwide Collaboratory with the goal of engaging up to about 4 million participants within the year. We also hope to add an optical SETI component to the PlanetQuest Collaboratory so that users can simultaneously look for planets and participate in

the newest search techniques for possible extraterrestrial technology (these techniques detect nanosecond *optical* pulses from stars rather than narrow-band *radio* signals).

By 2007, we plan to introduce scientific, refereed publications and subsidiary products, such as educational games (Sim Galaxy), educational videos, radio programs, and other educational products. We also expect to see the expansion of the program to 10 million participants, resulting in the discovery of thousands of new planets. Finally, we envision the launch of an international event to discuss major findings and discoveries, with publication of the proceedings online. By 2009, PlanetQuest should be self-sufficient.

FUNDING

Revenues to support the launch, growth, and operation of PlanetQuest will be raised from several sources:

Corporate sponsorships
PlanetQuest members—individual donors
Online advertising—sponsor logos
Licensing of PlanetQuest products, such as games and educational materials
Fundraisers and annual conferences
Foundation and government grants
Publications

A key to the successful perpetuation of PlanetQuest is that, through advertising, PlanetQuest Academy memberships, and other products, we expect PlanetQuest to be self-sufficient within the first five years. Although the actual planet searching process will be free to all who want to participate, there will be many avenues through which those who wish to advertise, receive additional educational materials, go on PlanetQuest expeditions and/or contribute financially, can participate at a higher level.

For additional information, visit us at www.planetquest.org