

B. Project Summary

The Mission: The high-level goal of this project is to foster the rapid transformation of large amounts of existing (and future) physical computational resources (such as processor power, memory, network bandwidth, specialized hardware, *etc.*) into a type of commodity that is vastly more *liquid*, in the economic sense, than computational resources typically are at present. *Liquidity* refers generally to the ease with which a commodity can be effectively exchanged between parties.

Currently, computational resources are not very liquid. If someone wishes to harness a large amount of computational power for some custom application, at present a large amount of human intervention is usually required to purchase, borrow, or lease the required resources, and then arrange either for the resources to be physically delivered or to be made available for remote access. The large amount of human labor that is currently necessary for this process incurs a high overhead, and as a result, large amounts of unused computational resources are often wasted, because the high expected overhead of enabling the resources to be reused today often exceeds the value of such reuse.

However, given the increasing ubiquity of the Internet, there is no reason in principle why the remote usage of computational resources could not be fully automated - to the extent that a user of an appropriately instrumented scientific or commercial application could, for example, merely give that application a valid credit card number and a spending limit, and the application would automatically lease whatever resources it needs from a public network of automated servers, and put those resources to work towards the user's computational needs.

The OCEAN (Open Computation Exchange & Auctioning Network) project [Ocea,Tob00] aims to implement the total automation of remote, distributed computation in a way that promotes an extremely high level of liquidity (or equivalently, very low overhead and very high versatility), and furthermore, to do so in a way that will encourage the technology to become as widespread as possible as quickly as possible, in order to maximize its total economic benefit.

To elaborate, the OCEAN effort has adopted the following adjectives describing its high-level design goals: open, portable, compatible, secure, efficient, scalable, easily deployable, configurable, unobtrusive, easily programmable, customizable, monitorable, automatic, dynamic, and robust. What we mean exactly by each of these qualities, and their implications for the detailed functionality of our system, is described in more detail in the proposal body. But what these adjectives have in common is that they are all geared to support the goals of high computational liquidity and rapid, widespread adoption, to make the technology as useful as possible.

The Technology: The core of OCEAN, as a technology, is a set of *open* standards that we are developing - based on and compatible with a variety of relevant, inter-related industry standards that are currently emerging - to support the highly liquid exchange of computational resources, as described above. Some of the relevant existing, emerging, and proposed standards include: Java [Java], XML [XML], MPI [MPI], CORBA [CORB], SOAP [SOAP], UDDI [UDDI], ATP [ATP], WSDL [WSDL], *etc.* These and others are described in more detail in the proposal body. The common theme of the recent wave of standardization is to provide universal digital languages for conducting automated business, of a variety of sorts, across the Internet. The exchange of computational resources is but one of many potential applications of this movement, but it is one that opens the door to an unlimited variety of other computationally-intensive applications being piggybacked on top of it, which in our opinion makes it more broadly useful and interesting than most e-commerce efforts.

In addition to developing the standards for computation exchange, the OCEAN project is concurrently developing a reference implementation of these standards, in Java, which will be made available to the public, in source and binary form, for users to install and/or customize. The licensing for this software will permit commercial implementations to be derived from it, fostering competitive improvement of the technology implementation. The associated standards, however, will be copyrighted in a way that forces them to be kept as *open* as possible, so that no one company or trust can transform or extend the standard in such a way so as to become proprietary. This arrangement ensures that no single organization can monopolize the standard, so that competition remains alive for every aspect of the system implementation.

OCEAN is truly a *strategic* technology for promoting the future development of internet-based computing in general, especially distributed and mobile-agent forms of computing, which would both benefit greatly from an infrastructure that makes widely distributed resources much more easily available.