Design and Implementation of the Bio-Networking Architecture

February 6, 2003

UCI Artificial Intelligence/Machine Learning Seminar

Dr. Jun Suzuki (jsuzuki@ics.uci.edu)
Dr. Tadashi Nakano (tnakano@ics.uci.edu)
Prof. Tatsuya Suda (suda@ics.uci.edu)
Department of Information and Computer Science
University of California, Irvine
http://netresearch.ics.uci.edu/bionet/

We believe that the future networks, which will be orders of magnitude more complex and larger than current networks, should exhibit self-organization with inherent support for scalability, adaptability to environmental changes in networks, and survivability/availability from massive failures and attacks. To make this research vision a reality, we have been investigating a new framework for developing scalable, adaptive and survivable network applications, called the Bio-Networking Architecture, by applying biological concepts and mechanisms. The architecture is motivated by the observation that the above desirable properties (such as scalability, adaptability and survivability) have already been realized in various biological systems, and it applies key biological principles and mechanisms for designing network applications.

In the Bio-Networking Architecture, a network application is implemented as a decentralized collection of autonomous objects called *cyber-entities*. This is analogous to a bee colony (a network application) consisting of multiple bees (cyber-entities). Each cyber-entity implements a functional component related to its service or application, and follows simple behavior rules (e.g., replication, reproduction and migration) similar to biological entities. Cyber-entities store and expend *energy* for living. They gain energy in exchange for providing their services, and expend energy for performing their biological behaviors, invoking other cyber-entities' services and utilizing resources (e.g., CPU cycles and memory space).

This talk overviews our research efforts to investigate several key aspects in the Bio-Networking Architecture through simulation and empirical implementation work. We will address the adaptability of network applications through biological evolutionary process, present the design of our adaptation mechanism, and demonstrate how the evolutionary process allows network

applications to optimize their performance in large-scale network environments using some of simulation results. We will also present our empirical research effort to implement platform software (middleware system) to deploy the Bio-Networking Architecture on actual network environments. The platform software provides reusable components for deploying and executing cyber-entities. These components abstract low-level operating and networking details (e.g., I/O, concurrency, messaging and network connection management) and provide a series of runtime services that cyber-entities frequently use for performing their services and invoking their biological behaviors.