

Exploring Self-Optimization and Self-Stabilization Properties in Biologically-Inspired Cloud Computing

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ABSTRACT

Large-scale network systems, such as cloud computing systems, are expected to be autonomous, scalable, adaptive to dynamic network conditions (e.g., workload and resource consumption/availability), survivable against partial system failures and simple to implement and maintain. Based on the observation that various biological systems have overcome these challenges, the proposed architecture, SymbioticSphere, applies biological principles and mechanisms to design cloud computing systems (or simply clouds). In SymbioticSphere, a cloud consists of application services and middle ware platforms.

SymbioticSphere follows key biological principles such as decentralization, evolution, emergence, diversity and symbiosis. Each application service and middleware platform is modeled as a biological entity, analogous to an individual bee in a bee colony, and implements biological behaviors such as energy exchange, migration, replication, reproduction and death. Each agent/platform possesses behavior policies, as genes, each of which determines when to and how to invoke a particular behavior. SymbioticSphere allows services and platforms to autonomously adapt to dynamic network conditions through generations by evolving and optimizing their behavior policies with a multiobjective genetic algorithm. SymbioticSphere also allows services and platforms to autonomously seek stable adaptation decisions as equilibria in extensive-form games and interact with each other on the equilibria.

This presentation will overview the design principles in SymbioticSphere and describe how services and platforms leverage genetic and game theoretic algorithms. Simulation results demonstrate that SymbioticSphere allows services and platforms to autonomously optimize their behavior policies and improve their scalability, adaptability and survivability. They successfully satisfy given performance constraints in, for example, response time, throughput and workload distribution. Simulation results also show that services and platforms autonomously stabilize their adaptation and yield stable performance results that contain a very limited amount of fluctuations.

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