Plenary Lecturer I

The Challenge of Emergent Phenomena in Emergent Applications Software

George Eleftherakis

Computer Science Department
CITY College, International Faculty of the University of Sheffield
Thessaloniki, GREECE
E-mail: eleftherakis@city.academic.gr

In the last few decades the application of distributed solutions to computerized systems has expanded to a variety of new domains, facing a growing number of users that demand more advanced services leading to emergent applications software. Present systems are not trustworthy, and this together with the predicted rise of complexity is going to lead us to an enormous increase of the cost aiming to build trustworthy systems. Combined with the vision of the Internet of things, and visions from leading companies like IBM's smarter planet, as well as the introduction of service oriented computing, cloud computing and similar technologies, has imposed a considerable strain on the design and operational performance of distributed systems. Consequently, the architectures upon which distributed systems are built have moved from the initial centralized structured approaches, to more decentralized solutions that avoid the single point failure problem and offer better utilization of network resources. Moreover, unstructured approaches, where the overlay network follows a random graph distribution, have been introduced in order to cope with churn, heterogeneity, as well as to avoid the topology constraints which create significant problems in open dynamic environments that utilize structured architectures. Latest research efforts have concentrated on developing hybrid solutions which combine different paradigms in terms of decentralization and structure.

In this context, many novel approaches have used biological systems as inspiration in the design of artificial distributed systems aiming for solutions to various problems and challenges encountered. The rationale for looking in nature for inspiration is based on the notion that the structure, the behaviours of individuals and the laws that govern their interactions in decentralized biological systems existing in nature seems to solve seamlessly and effortlessly problems common in open distributed ICT systems. Large scale biological collectives like ant colonies and termite hives have shown a remarkable ability to produce a variety of useful behaviours including availability, scalability, self- organization and adaptation in a fully decentralized manner.

Emergence is known to be the enabler for a variety of beneficial properties in natural systems. Adaptability, scalability and robustness, as well as a multitude of self-* properties, have been shown to emerge out of simple interactions at the microscopic level of a system. Distributed systems are particularly well suited to hosting emergent phenomena especially in cases where the individual nodes possess a high degree of autonomy and the overall control tends to be decentralized. Being able to engineer macroscopic behaviours in distributed systems by introducing behaviours and interactions of individual nodes inspired by systems found in nature could greatly assist with managing the complexity inherent into artificial distributed systems.

This talk is discussing the challenge of emergent phenomena, either positive or negative towards the behaviour of the system, in emergent applications software, and identifies some possible research direction towards harnessing emergent phenomena in engineered systems.

Brief Biography of the Speaker: George Eleftherakis is a Senior Lecturer and Research Coordinator of the CS department at CITY College Thessaloniki, which is an International Faculty of the University of Sheffield. He is also leading the Information and Communication Technologies Research Track of the South Eastern European Research Centre (SEERC). He holds a BSc in Physics from the University of Ioannina, Greece and, an MSc with distinction and a PhD in Computer Science from the University of Sheffield, UK. He is the head of the Intelligence, Modelling & Computation research group at CITY. His main research work is in the area of Formal Methods, Biologically Inspired Computing, Complex Systems, Emergence, Multi-Agent Systems, Education, Serious Games, and Information Security. He gave more than 15 invited talks to Universities, conferences and companies around the world and published more than 60 papers in International Conferences and Journals. He edited 8 books, more of them in the area of formal methods. He also organized, chaired and joined scientific committees of several international conferences in the areas of his research, and also a number of International Student Conferences (the Student Spring Symposium series and the South East European Doctoral Student Conference). He founded and is leading Thessaloniki's Java User Group. He is a Senior Member of the Association of Computing Machinery (ACM) chairing ACM's Council of European Chapter Leaders. He is also a member of the Greek Computer Society, serving the last years as a member of the administration board of the Macedonia-Thrace annex.