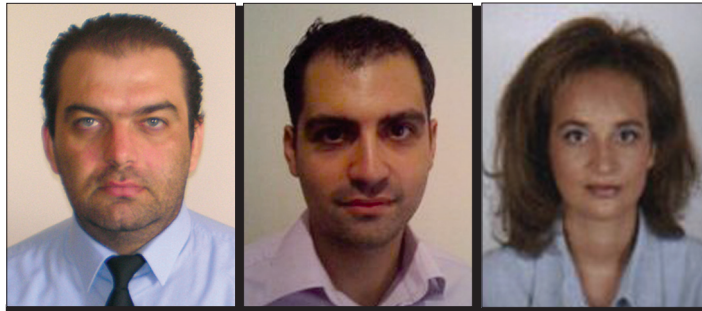# Cloud Computing

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Cloud computing is a recent trend in information technology and networking that has the potential to change radically the way computer services are constructed, managed, and delivered. The key driving forces behind the emergence of cloud computing include the overcapacity of today's large corporate data centers, the ubiquity of broadband and wireless networking, the falling cost of storage, and progressive improvements in networking technologies. Cloud computing opens new perspectives with profound implications in the area of communication networks, raising new issues in their architecture, design, and implementation.

Given the continued intense activity in the cloud arena, we invited researchers to submit articles to this special issue of *IEEE Network* describing research efforts and experiences concerning the networking aspects of cloud computing. From the 20 submissions, after rigorous review, we selected six articles as representative of ongoing research and development activities. The first article presents insights and perspectives for routing data center techniques. The next two articles focus on virtual networking aspects in the cloud. The next article covers security issues in cloud. The fifth article deals with energy-efficient cloud networking. Finally, the last article discusses the challenges of resource allocation in distributed clouds. These six articles are intended to establish a respected information source on foundational research and trends in cloud computing.

The first article in this special issue is "Survey on Routing in Data Centers: Insights and Future Directions" by Kai Chen, Chengchen Hu, Xin Zhang, Kai Zheng, Yan Chen, and Athanasios Vasilakos. This article conducts a survey of the current data center routing techniques, discussing the open issues and challenges for basic routing schemes, traffic engineering, multicasting, and routing security in data center environments.

"In-Network Live Snapshot Service for Recovering Virtual Infrastructures" by Ulas C. Kozat, Pradeep Padala, Bob Lantz, Ken Igarashi, Ardalan Kangarlou, and Dongyan Xu presents a new cloud capability, called GENI-VIOLIN, that can checkpoint a stateful distributed service while incurring very low overhead. GENI-VIOLIN differs from previous distributed snapshot solutions as it relies on the capabilities of modern networking hardware, requiring minimal modifications to virtual machine servers irrespective of the platform virtualization technology used by cloud providers.

In "SNPdisk: An Efficient Para-Virtualization Snapshot, Mechanism for Virtual Disks in Private Clouds," by Lei Yu, Chuliang Weng, Minglu Li, and Yuan Luo, the authors deal with snapshot technologies, which are important for virtual cloud storage and computing resource management. A novel para-virtualization snapshot mechanism, based on an open-source virtual machine monitor, for virtual disks in private clouds is presented. A special sparse tree is introduced to implement an efficient copy-on-write snapshot in limited space. Experiments demonstrate its high performance for private clouds.

The focus of "Mitigating DDoS Attacks with Transparent and Intelligent Fast-Flux Swarm Network" by Ruiping Lua and Kin Choong Yow is on distributed denial of service (DDoS) attacks, which are a significant threat to service availability in cloud providers. In this article, the authors make use of a swarm network to coordinate and relay messages between clients and servers. The swarm system presented has the ability to self-organize and conduct large-scale parallel search for optimal relay solutions. Also, it is explored how swarm intelligence can be incorporated into the existing Internet infrastructure.

"Self-Organizing Sensing Infrastructure for Autonomic Management of Green Datacenters" by Hariharasudhan Viswanathan, Eun Kyung Lee, and Dario Pompili focuses on introducing innovative solutions for autonomic adaptive sampling and thermal image compression, which enable efficient continuous real-time monitoring of datacenters. Then it discusses how the proposed solutions can be utilized effectively in two important autonomic datacenter management applications and how they exploit the information extracted from the sensing infrastructure.

The final article, "Resource Allocation for Distributed Cloud" by Patricia Takako Endo, André Vitor de Almeida Palhares, Nadilma Nunes Pereira, Glauco Estácio Gonçalves, Djamel Sadok, Judith Kelner, Bob Melander, and Jan-Erik Mångs, introduces the concept of distributed clouds. The authors focus on presenting the challenges in resource allocation in distributed clouds, focusing on resource modeling, resource offering and treatment, resource discovery and monitoring, and resource selection.

We hope that through this special issue we are delivering the state-of-the-art research on current cloud computing networking topics, bringing to the attention of the community novel problems that must be investigated. We would like to express our gratitude to the authors of all submitted articles and the reviewers for their contributions to this special issue. We thank Tom Chen, *IEEE Network*'s editor-in-chief for his support of the special issue, and also the production staff at the IEEE Communications Society who made this issue possible.

Biographies

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