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EDITORIAL

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Special issue: Elastic computing from edge to the cloud environments

1 | INTRODUCTION

We are pleased to present a special issue that focuses on state-of-the-art research on *Elastic Computing from Edge to the Cloud Environments*. Today, a huge amount of data is being generated by the Internet of Things (IoT) devices such as smartphones, sensors, cameras, cars, and robots.[1] In order to process the generated data, there exist Big Data platforms (such as Hadoop and Spark). Conventionally, they are deployed in centralized Data Centers, which, however, fall short of addressing time-critical requirements of the applications due to high latency between the Edge, where the data are generated and the Data Centers where they are processed.[2] The emerging Edge and Fog computing paradigms promise to solve this problem by seamlessly integrating hardware and software resources across multiple computing tiers, from the Edge to the Data Center/Cloud. Since computing resources at the Edge may be power and capacity constrained, it is necessary to invent new lightweight platforms and techniques that seamlessly interact, sense, execute and produce results with very low latency, while at the same time address other high-level requirements of applications, such as security and privacy. Regarding these problems, there are many challenges that must be addressed with the invention of new architectures, methods, algorithms, and solutions.

This special issue addresses various problems, challenges, new approaches and technologies to shape future directions for research, foster the exchange of ideas. In this special issue, six research articles are carefully selected after multiple rounds of peer-review to address some new and upcoming avenues of next-generation clouds. They include:

- Integrate and process data from underlying IoT platforms and services
- Improve the energy-efficient management of resources and tasks processing
- Address the Quality of Service (QoS) and time-critical aspects of smart applications
- Facilitate intelligent integration of information arising from various sources
- Address the requirements of very dynamic Big Data pipelines (e.g., moving smartphones, sensors, cars, robots with dynamically changing requirements for processing)
- Provide orchestration methods and scheduling policies that address dependability, reliability, availability and other high-level application requirements
- Adequately address the inherent variability of resources from the Edge to the Data Centers
- Provide new architectures which use the powerful computing resources of Data Centers, while at the same time providing optimal QoS to applications
- Implement distributed Artificial Intelligence methods from the Edge to the Data Centre/Cloud

2 | A SUMMARY OF THE CONTRIBUTIONS

This special issue features six papers covering a range of topics including IoT application deployment frameworks in edge-cloud environments, cost optimization models, and lightweight virtualization model.

The first paper in this special issue titled "Edge-adaptable serverless acceleration for machine learning Internet of Things applications"[3] presents STOIC (serverless teleoperable hybrid cloud), an IoT application deployment and offloading system that extends the serverless model. The authors have developed a dynamic feedback control mechanism to precisely predict latency and dispatch workloads uniformly across edge and cloud systems using a distributed serverless

framework. STOIC leverages hardware acceleration (e.g., GPU resources) for serverless function execution when available from the underlying cloud system. Finally, it configures the system to overcome deployment variability associated with public clouds. The system is evaluated using real-world machine learning applications and multitier IoT deployments (edge and cloud) and shown that it reduces overall execution time and achieves placement accuracy in the range of 92%–97%.

The second paper in this special issue titled "Server Configuration Optimisation in Mobile Edge Computing: A Cost-Performance Tradeoff Perspective"[4] studies the problem of server configuration optimization in Mobile edge computing environments. The authors use M/M/m queuing models and establish the performance and cost models for the system. The article considers cost-constrained performance optimization, and performance constrained cost optimization based on multiple numerical algorithms. The numerical simulation-based experiments have shown this approach is able to balance the trade-off between investment cost and service quality.

The third paper in this special issue titled "EFFORT: Energy-efficient framework for offload.

Communication in mobile cloud computing"[5] proposes a task offloading mechanism from mobile to the remote cloud. The author's solution aims to solve the energy consumption of communication-intensive applications from mobile devices such as smartphones. The experimental evaluation is done by implementing a demonstration application in Android mobile OS. The results have shown that the proposed solution reduces the energy consumption of smartphones while executing applications and simultaneously reducing the communication cost.

The fourth paper in this special issue titled "Human Microservices: A framework for turning humans into service providers"[6] presents a framework facilitating the deployment of Application Programming Interface on companion devices (smartphones and IoT devices). The author's framework proposes a new approach aiming to integrate humans in the IoT loop and facilitate computation units' deployment in the devices that are closer to users, instead of remote clouds. The solution leverages existing standards for the rapid development of applications and improves software quality. Through a detailed case study on monitoring people's activity, the authors developed a software application following framework specification and demonstrated the feasibility of their proposed solution.

The fifth paper in this special issue titled "Function delivery network: Extending serverless computing for heterogeneous platforms"[7] introduces the extension to Function-as-a-Service model. The authors consider heterogeneous clusters and support heterogeneous functions through a network of distributed heterogeneous target platforms called Function Delivery Network (FDN). The article proposes Function-Delivery-as-a-Service, a service model to deliver the function to the required to be targeted platform. It also ensures that Service Level Objective (SLO) energy efficiency requirements are met when scheduling functions. The new benchmarking system FDNInspecto is implemented which benchmarks the different distributed target platforms. The results have found that functions scheduling on edge reduce energy consumption by 17× without violating the SLO requirements when compared to a high-end target platform.

Finally, the last paper of this special issue titled "A Lightweight Virtualisation Model to Enable Edge Computing in Deeply Embedded Systems"[8] builds a virtualization model for resource-constrained embedded devices. The existing containers cannot be used in many deeply embedded systems (DES) due to an underlying operating system's resource requirements including storage, memory, and processing power. To mitigate this issue, the authors present the Hellfire hypervisor, a lightweight virtualization model that enables separation and improves the security of IoT applications on DES. The Hellfire simplifies essential components of virtualization including compute, storage, and I/O among others. The experimental results conducted with the coremark benchmark show Hellfire has a small footprint of 23 KB while keeping a low average virtualization overhead of 0.62% for multiple virtual machines execution.

To summarize, the articles in this special issue provide new definitions, architectural principles, systems, and approaches to solve the challenges posed by emerging distributed systems such as edge and cloud computing, mainly driven by IoT workloads. They address important problems including lightweight platforms, energy efficiency, reliability and easy to integrate frameworks.

We hope that you will find this special issue truly useful and enjoyable.

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