Guest Editorial

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# Computational Intelligence for Cloud Computing

This special issue of *IEEE Computational Intelligence Magazine (IEEE CIM)* is dedicated to Computational Intelligence for Cloud computing. Cloud computing systems represent an emerging technology which allows its users to have access to large scale, efficient and highly reliable computing systems by paying according to their needs. Cloud computing generally consists of a heterogeneous system that holds a large amount of application programs and data.

The need of effective and efficient cloud computing systems poses a number of difficult, complex issues in optimization and learning as well as other aspects. The objective of this special issue is to promote novel research works using evolutionary algorithms and other metaheuristics to solve such problems. The following topics of interest are:

- ❏ Scheduling in Cloud computing
- ❏ Optimization of public, private and hybrid Cloud computing systems
- ❏ Learning application demands
- ❏ Pricing mechanisms in Cloud computing systems
- ❏ Cloud computing architecture
- ❏ Evolutionary algorithms and metaheuristics on Clouds
- ❏ Virtualization of resources
- ❏ Maintenance and management of Cloud computing
- ❏ Computational Intelligence techniques for energy management in Cloud computing.

In response to the call for papers, we received 12 submissions. All manuscripts underwent a very rigorous peer review process. We finally selected 2 full papers for this special issue. We have to mention that a special issue simply provides a snapshot into the area taken at a particular point in time. Due to the selection rate and page limitations of a volume, it can only include a small number of papers. As a result, its coverage is by no means complete despite our best efforts.

The first paper by I. Arnaldo, K. Veeramachaneni, A. Song, and U.-M. O'Reilly introduces FCUBE, a cloud-based framework that enables machine learning researchers to contribute their learners to its community-shared repository. FCUBE exploits data parallelism in lieu of algorithmic parallelization to allow its users to efficiently tackle large data problems automatically. It passes random subsets of data generated via resampling to multiple learners that it executes simultaneously and then it combines their model predictions with a simple fusion technique. It is an example of what the authors have named a Bring Your Own Learner model. It allows multiple machine learning researchers to contribute algorithms in a plug-and-play style. The authors demonstrate FCUBE executing five different learners contributed by three different machine learning groups on a 100 node deployment on Amazon EC2. They collectively solve a publicly available classification problem trained with 11 million exemplars from the Higgs dataset.

The second paper by S. Nesmachnow, S. Iturriaga, and B. Dorronsoro presents advanced fast heuristics for virtual cloud brokers. This paper introduces a new kind of broker for cloud computing, whose business relies in subletting virtual machines (VMs) to its customers. The essence of the business resides in the large difference in price between on-demand and reserved VMs. The broker owns a number of reserved instances of different VMs from a number of cloud providers and offers them to its customers in an on-demand basis, but at cheaper prices than the ones offered by the cloud providers. The authors define an optimization problem to maximize the profit of the broker and propose a number of efficient and advanced smart heuristics (including seven two-phase list scheduling and a reordering local search technique) to solve it. The goal is to find an allocation of a set of VM requests from customers into the available pre-booked ones that maximize the broker earnings. Encouraging results have been obtained over a set of 400 problem instances that account for realistic workloads and scenarios using real data from public cloud providers.

Many individuals contributed to the success of this special issue. We take this

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distinguish between $x' = 40$ °C and $x'' = 50$ °C, where each will have different secondary membership values.

In [6], we presented a CWW framework employing LGT2 (whose high level architecture is shown in Figure 5c) where the proposed architecture can accomplish a human-like reasoning via words integrating memory for learning and experience folding. Figure 6a shows the system in operation in the University of Essex intelligent apartment (iSpace) where the proposed system was used to provide a meal recipe recommendation system. This system engages in a spoken dialogue with the user to understand how busy they are, how tired they are and what appetite they have. The system then ends up suggesting recipes that suit the user. Once, the user approves a recipe, the ingredients are passed to a humanoid (NAO) robot (as shown in Figure 6b) that engage in a dialogue with the user in case the user is missing some ingredients where the robot can suggest substitutes that can fit the given recipe. The system can be helpful for disabled people and it can also be used to enhance the user comfort. The system has been tested with a large number of users and with various recipes, which validates the use of CWW as a powerful technology to allow more natural human-computer interfaces in AIEs.

## 6. Conclusions and Future Work

This paper presented research results from the Scaleup project demonstrating the role that type-2 FLSs (which are capable of handling and modelling high uncertainty levels) can play in the efforts to realize AIEs. We showed an interval type-2 FLS which can automatically detect, summarize and easily search through visual context information in AmI spaces occupied by multiple users. In addition, we presented interval type-2 fuzzy based systems for blending real and virtual realities allowing the collaboration of people distributed over dispersed geographical locations. Furthermore, we presented how type-2 FLSs can enable developing natural CWW communication with humans which can allow computers to disappear in the users' spaces.

For our current and future work, we are investigating employing type-2 FLSs for wireless communication management in densely populated smart cities where the growth trends in wireless communications suggest that the data requirements in near future will exceed the limits of available wireless spectra [10]. Conventional approaches involve installing more Base Stations (BSs) or offload some of the traffic onto unlicensed WiFi bands which is not scalable and risky [10]. We are working on new type-2 fuzzy logic based systems for tethering over TV white-space (TVWS) with cellular based access mechanisms. The proposed type-2 fuzzy logic based system can operate on the possible hotspot-slave configuration shown in Figure 6c to provide a scalable and cost-effective approach in dense wireless areas. This will be achieved by having users' devices acting as hotspots that tether/relay the data to and from their corresponding slaves over TVWS. The system can iteratively cluster the nodes into hostspots and slaves and allocate resources in order to optimize the network transmission power.

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opportunity to thank all the authors for their submissions. We are also indebted to a small army of referees who have put in the hard work and the long hours to review each paper in a timely and professional way. We would like to thank the Editor in Chief Prof. H. Ishibuchi for providing us valuable and enormous assistance.