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Editorial

Service-Oriented System Engineering

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ABSTRACT

Service-Oriented System Engineering (SOSE) is one of the emerging research areas that involves a number of research challenges in engineering service-oriented systems, the architecture and computing paradigm as well as the development and management of service-oriented systems. Service-Oriented Computing (SOC) exploits services as the fundamental elements for developing computer-based systems. It has been applied to various areas and promotes fundamental changes to system architecture, especially changing the way software systems are being analyzed, architected, designed, implemented, tested, evaluated, delivered, consumed, maintained and evolved. The innovations of SOC also offer many interesting avenues of research for scientific and industrial communities. In this paper, we present the concepts of the SOSE from the related work. The motivation, opportunities and challenges of the SOSE is highlighted thereafter. In addition to this, a brief overview of accepted papers in our Special Issue on SOSE is presented. Finally we highlight and summarize this paper.

1. Introduction

In the past a few years, Service-Oriented Computing (SOC) has rapidly developed alone with the cloud computing, which is a new paradigm that splits the developers into three independent roles: application builders, the service brokers, and the service developers [1]. As result of this, the developer no longer needs to make the executable that meets the requirements translated from the task specification, and the application development is done via discovery and composition rather than traditional design and coding. In other words, the application is completed through a collaborative environment based on the three independent roles: application builders, service developers, and service brokers [2]. Currently, SOC has been applied to many areas, for example, electronic business, cloud computing, Internet of Things (IoT), Mobile-Edge Computing [3–5].

The remainder of the paper is organized as follows. We summarize the motivation, opportunities and challenges of Service-Oriented System Engineering (SOSE) in Section 2. Section 3 presents an overview of the solutions proposed in accepted papers of this Special Issue on SOSE. Finally, we provide the conclusion in Section 4.

2. Motivation, opportunities and challenges of SOSE

The SOC mainly involves developing Service-Oriented Architectures (SOAs) and corresponding middleware that enables to combine a number of interoperable services to virtually support any business process regardless of the psychical constraint or user context [6]. As result of this, SOA could offer an environment that could be used to smoothly run distributed applications simpler with reasonable cost. Particularly, the coarse-grained servicers approach allow the SOA provides the flexibility and capability for the specific business requirements.

Grid services and Web services are the most common service for implementing SOC, where Grid services provide the foundation of the distributed systems to support the processing of very large data sets. In contrast to Grid services, Web services provide relatively small service access over the network. Therefore, Web Services have become the preferred implementation technology for realizing SOAs.

3. A brief review of accepted articles of this special issue

In this special issue, a number of papers have been accepted in the domain of SOSE, which includes:

3.1. Software defined networks

H. Zhong et al. [7] proposed a load balancing scheme based on server response times by using the advantage of SDN flexibility,

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named LBBSRT (Load Balancing by Server Response Time). They process user requests by obtaining an evenly balanced server loads using the real-time response time of each server measured to balance the load. Simulation experiments show that their scheme exhibits a better load balancing effect and process requests with a minimum average server response times. In addition, their scheme is easy to implement, and exhibits good scalability and low cost characteristics. In comparison to the traditional load balancing schemes, the proposed scheme can be applied to existing types of servers for a better load balancing effect. The OpenFlow environment is used in the design, where the controller is used to obtain the real-time response times of each server in order to determine the minimum or most stable response time for the chosen server.

3.2. QoS

L. Barakat et al. [8] proposed a novel adaptive execution approach, which efficiently handles service changes occurring at execution time, for both repair and optimisation purposes. The adaptation is performed as soon as possible and in parallel with the execution process, thus reducing interruption time, increasing the chance of a successful recovery, and producing the most optimal solution according to the current environment state. The effectiveness of the proposed approach is demonstrated both analytically and empirically through a case study evaluation applied in the framework of learning object composition. In particular, the results show that, even with frequent changes (e.g. 20 changes per service execution), or in the cases where interference with execution is non preventable (e.g., when an executed service delivers unanticipated quality values), their approach manages to recover from the situation with minimal interruption.

V. Gabrel et al. [9] provided a unified understanding of the wide variety of existing approaches and the theoretical complexity induced by each QoS criterion were analysed and compared. They stated that optimal solution for execution time or throughput QoS criteria can be determined in polynomial time but optimality is no more guaranteed in polynomial time for QoS criteria like cost or reliability. They also showed that the composition problem became NP-hard when optimizing such QoS criteria. Secondly, they proposed a novel approach for solving more efficiently polynomial cases. This approach is based on a scheduling formulation with AND/OR constraints, using a directed graph structure. Based on the experimental test using the Web Service Challenge-09 benchmark, the proposed algorithm outperforms the related work.

3.3. Modeling and automation

M. Geiger et al. [10] proposed a review of the state of support and implementation for Business Processing Model and Notation (BPMN) 2.0. The BPMN has been hailed as a major step in business process modelling and automation, and the vendors of business process management systems (BPMS) is going to switch to the new standard and support the execution in the process engines. Authors presented a detailed analysis of the current state and evolution of BPMN 2.0 support and implementation. They have found only three out of 47 BPMS considered support the execution format defined in the standard, although all of them claim to comply with the BPMN 2.0 standard. Furthermore, there are three process engines: BPM, jBPM and activiti have been evaluated and their degree of support over a period of more than three years has been assessed in the paper as well. The results of this evaluation have provided the first hand evidences that the areas of the standard considered by the implementers, which may conclude that the features that are not available by now will be implemented in the future.

3.4. Wireless Sensor Networks (WSNs)

Z. Zhou et al. [11] proposed a service-oriented wireless sensor networks (WSNs) framework that is used to work in a collective fashion for achieving complex application with the wide-adoption of the Internet of Things as well as heterogeneous smart things. In this work, the functional integration of neighbouring sensor nodes was achieved in a matter of the cooperation between sensor nodes, in which the sensor nodes were encapsulated and represented as energy-aware WSN services. WSN services are categorized into a number of service classes based on their functionalities. As results of this, the service class chains were generated with respect to the requirement of domain applications, and the composition of WSN services was constructed through discovering and selecting appropriate WSN services as the instantiation of service classes contained in chains. This WSN services composition was reduced to a multi-objective and multi-constrained optimization problem, where the particle swarm optimization (PSO) algorithm and genetic algorithm (GA) were adapted to resolve this problem. Experiment results show that PSO outperforms GA in finding approximately optimal WSN services compositions.

Y. Sahni et al. [12] proposed a middleware for WSN-based structural health monitoring (SHM) application using the SOA. The main reason for this proposal solution is that the SHM domain experts lack the knowledge of low-level network issues and cannot develop an application with high efficiency, and the proposed middleware will provide programming abstractions for an application developer that makes it easier to develop an application. In addition, the proposed middleware use SOA to increase the flexibility for developing different applications. The proposed middleware consists of a three-layered middleware with each of the layers containing various services that address issues such as in-network processing, fault tolerance, dynamicity, quality of service etc. They described operations of various services and use two application examples to illustrate the usability and flexibility of the proposed middleware for SHM, and a comparison with other SOA-based WSN middleware is also presented in this paper.

3.5. Cloud service

J. Li et al. [13] proposed an intelligent algorithm called Eagle+ to update the matching Automaton and Table to avoid re-computing the whole patterns after each update. In Eagle+, they only compute the latest update set of patterns to update the Automaton and Table. Moreover, Eagle+ achieves accurately local updating based on three atomic operations, adding, updating and deleting, each of which modifies values on classical Aho-Corasick (AC) automaton, Set Backward Oracle Matching (SBOM) automaton and Wu-Manber (WM) table with an incremental approach. Compared with existing pattern updating methods, Eagle+ reduces the computation complexity from $O(n^2)$ to $O(n)$. The experimental results show that Eagle+ can save nearly 72%–92% of the time consumption in updating automatons and perform 100 times faster in WM table.

3.6. Wireless rechargeable networks

F. Chen et al. [14] proposed a service based mobile charging network that could be used to reduce the charging completion time for wireless rechargeable networks. In order to reduce the charging completion time, the authors proposed that the charger charges network nodes while moving, which would significantly reduce overlooked while waiting for the charger to move to specific spot and then starts to charge the nodes nearby. However, the major challenge to exploit the charging opportunity is the setting of the moving speed of the charger. In order to balance the charging delay and the moving delay, they first formulated the problem of

delay minimisation as a Traveling Salesman Problem with Speed Variation (TSPSV), and then they solved the problem suing linear programming to generate the moving path, speed and staying time for the charger. Extensive simulation experiments were conducted to study the delay performance under various scenarios. The results demonstrate that our proposed method achieves much less completion time compared to the state-of-the-art work.

3.7. Cloud-based applications

M. U. Yaseen et al. [15] developed a cloud-based automated video analysis system to process large numbers of video streams, where the underlying infrastructure is able to scale based on the number and size of the stream(s) being considered. The system automates the video analysis process and reduces manual intervention. An operator using this system only specifies which object of interest is to be located from the video streams. Video streams are then automatically fetched from the cloud storage and analysed in an unsupervised way. The proposed system was able to locate and classify an object of interest from one month of recorded video streams comprising 175 GB in size on a 15 node cloud in 6.52 h. However, a GPU powered infrastructure took 3 hours to accomplish the same task. Occupancy of GPU resources in cloud is optimized and data transfer between CPU and GPU is minimized to achieve high performance. The scalability of the system was demonstrated along with a classification accuracy of 95%.

3.8. InOt-RePCoN: Forecasting user behavioural trend in large-scale cloud environments

J. Panneerselvam et al. [16] propose a solution for forecasting workloads that would help the service providers to achieve an optimum energy-efficient scaling of the datacentre resources in accordance with the incoming workloads. But the extreme dynamicity of both the users and their workloads impose several challenges in accurately predicting their future behavioural trend. This paper proposes a novel prediction model named InOt-RePCoN (Influential Outlier Restrained Prediction with Confidence Optimisation), aimed at a tri-fold forecast for predicting the expected number of job submissions, session duration for users, and also the job submission interval for the incoming workloads. Our proposed framework exploits autoregressive integrated moving average (ARIMA) technique integrated with a confidence optimiser for prediction and achieves reliable level of accuracy in predicting the user behaviours by the way of exploiting the inherent periodicity and predictability of every individual jobs of every single users. Performance evaluations conducted on a real-world Cloud trace logs reveal that the proposed prediction model outperforms the existing prediction models based on simple auto-regression, simple ARIMA and co-clustering time-series techniques in terms of the achieved prediction accuracy.

3.9. Social collaborative service recommendation approach based on trust and domain-specific expertise

A. Kalaï et al. [17] present a Web service decentralized discovery approach which is based on two complementary mechanisms. The trust detection is the first mechanism to detect the social trust level among users. This level is defined in terms of the users' interactions for a period of time and their interest similarity which are inferred from their social profiles. The service recommendation is the second mechanism which combines the social and collaborative approaches to recommend to the active user the appropriate services according to the expertise level of his most trustworthy friends. This level is extracted from the friends' past invocation histories according to the domain- specific which is known in advance in the target user's query. Performance evaluation shows that each proposed mechanism achieves good results. The proposed Level of social Trust (LoT) metric gives better precision more than 50% by comparing with the same metric without taking into account the time factor. The proposed service recommendation mechanism which based on the trust and the domain-specific expertise gives, firstly, a RMSE value lower than other trust-aware recommender systems like TidalTrust, MoleTrust and TrustWalker. Secondly, it provides a better response rate than the recommendation mechanism which based only on trust with a difference equal to 4%.

3.10. A service-oriented framework for collating retail intelligence

M. Anderson and J. Bolton [18] present a case study that explores the impact of a software development project on a Small to Medium Enterprise in the United Kingdom as a means of delivering improved understanding of data in the retail sector. In this paper, the link between the actions undertaken by management in retail and the relationship with the environment provided by IT systems is considered. Many retailers in the United Kingdom make use of sensor devices to understand the behaviour of their customers. As retail outlets grow over a period of time, the diversity of sensor devices may change as new devices are installed. Equally, outlets that are operated within retail groups will collect and store data locally. As a consequence, management within the retail sector face a number of challenges to understand the operation of individual outlets and the holistic performance of retail chains. As a result, both the IT systems and also the working practices employed to complete the day to day tasks essential to meet the needs of a retailer's customers rapidly become unfit for purpose. The case study considered in this paper reviews the requisite practices adopted by a service provider in the business intelligence sector, and the positive impact that the company realized through the re-engineering of both IT systems and business workflows. This paper demonstrates the efficacy of applying current software engineering methods to the redesign of IT-based business practices as opposed to more traditional approaches.

3.11. Testing of transactional services in NoSQL key-value databases

González-Aparicio et al. [19] develop a framework for testing transactional services in NoSQL databases. The novelty and contributions are that we develop a context- aware transactional model that takes into account contextual requirements of NoSQL clients and the system level setting in relation to the data consistency. This can assist NoSQL application developers in choosing between transactional and non-transactional services based on their requirements of the level of data consistency. The framework also provides ways to analyse the impact of the big data requirements and characteristics (e.g., velocity, efficiency) on the data consistency of NoSQL databases. The evaluation and testing are carried out using a widely used NoSQL key/value database, Riak, and a real (open) and big data from the Council of London for public transportation of the London bus services.

3.12. S-InTime: a social cloud analytical service oriented system

F. Piccialli et al. [20] purpose of research work is to demonstrate how a specific core technology and cloud platform with microservices can be designed and used for performing data-intensive computations and implementing services in a real case of social analytics. In detail, we face the challenges of real-time data- intensive processing with the systematic application of in-memory view-based information modeling & computation, which is based on different types of non-materialized views without pre-aggregation of data. Finally, our study presents and compares design alternatives

for these mappings, and demonstrates their effective application for implementing a large set of social analytics service types, with particular reference to the case of streaming sources of twitter data. A prototype of this system was experimented in the contest of a specific kind of social event, a permanent exhibition of Artworks, where the system collected and analyzed in real-time the tweets issued in an entire region, including exhibition sites, and continuously updated analytical dashboards placed in one of the exhibition rooms.

3.13. Energy-aware composition for wireless sensor networks as a service

Z. Zhou et al. [21] propose a service-oriented wireless sensor networks (WSNs) framework, and the cooperation between sensor nodes is achieved through the functional integration of neighboring sensor nodes. Generally, sensor nodes are encapsulated and represented as WSN services, which are energy- aware, and typically have constraints on their spatial and temporal aspects. WSN services are categorized into service classes according to the limited number of types of their functionalities. Consequently, service classes chains are generated with respect to the requirement of domain applications, and the composition of WSN services is constructed through discovering and selecting appropriate WSN services as the instantiation of service classes contained in chains. This WSN services composition is reduced to a multi-objective and multi-constrained optimization problem, which can be solved through adopting particle swarm optimization (PSO) algorithm and genetic algorithm (GA). Experimental evaluation shows that PSO outperforms GA in finding approximately optimal WSN services compositions.

3.14. A computational model to support in-network data analysis in federated ecosystems

A. Reza Zamani et al. [22] propose to leverage software-defined networking (SDN) to gain control over the data transport service with the purpose of dynamically establishing data routes such that we can opportunistically exploit the latent computational capabilities located along the network path. This strategy allows us to minimize waiting times at the destination data center and to cope with spikes in demand for computational capability. We validate our approach using a smart building application in a multi-cloud infrastructure. We show how the in-transit processing strategy increases the computational capabilities of the infrastructure and influences the percentage of job completion without significantly impacting costs and overheads.

3.15. Expert system for nutrition care process of older adults

T. Cioara et al. [23] present an expert system for a nutrition care process tailored for the specific needs of elders. Dietary knowledge is defined by nutritionists and encoded as Nutrition Care Process Ontology, and then used as underlining base and standardized model for the nutrition care planning. An inference engine is developed on top of the ontology, providing semantic reasoning infrastructure and mechanisms for evaluating the rules defined for assessing short and long term elders' self-feeding behaviors, to identify unhealthy dietary patterns and detect the early instauration of malnutrition. Our expert system provides personalized intervention plans covering nutrition education, diet prescription and food ordering adapted to the older adult's specific nutritional needs, health conditions and food preferences. In-lab evaluation results are presented proving the usefulness and quality of the expert system as well as the computational efficiency, coupling and cohesion of the defined ontology.

4. Conclusion

Recent advances in service oriented computing and cloud computing, including computational power, storage, and networking, and infrastructure innovations, are providing exciting opportunities to make significant progress in understanding and solving complex real-world challenges. Such challenges typically require a system-level approach that models a complex system at different levels of abstraction, helps to develop sound architectures for addressing separate system requirements and concerns, and integrates diverse sources of knowledge on the system's components and their interactions.

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