Preface

Requirements for the design and implementation of information systems that are used for educational and research purposes have become more complex. These information systems include a plethora of services, applications, resources, and interactions. The resulting conglomerate of services and solutions is becoming increasingly difficult to deal with and improve further. In addition, new and extremely important concepts, such as mobility, pervasiveness, services on demand, have further fuelled the need for change and improvement of the existing approaches. With a huge growth in the number of users, services, contents, and resources, these systems have become more and more large-scale. One of the basic problems in developing a model of infrastructure for educational and research institutions is how to provide scalability and reliability of applications and services. As a result, efforts to design a new computing architecture, the so-called cloud computing, have been initiated over the last couple of years and are ongoing across the world. New paradigms such as high performance computing and cloud computing will provide a reliable and cost-effective IT infrastructure that enhances the realization of research and educational processes.

The main subject of the book is a high performance computing and cloud computing application in the areas of scientific research and education. Supercomputers are used for compute-intensive tasks such as problems including quantum physics, weather forecasting, climate research, oil and gas exploration, molecular modeling, and physical simulations. Cloud computing is an emerging area that includes a set of disciplines, technologies, and business models used to deliver IT capabilities as an on-demand, scalable, elastic service. This book presents various concepts and applications of high performance and cloud computing in the fields of scientific research and education.

The primary goal of this book is to provide a variety of research and survey articles in the field of modern computer technologies and their application in science and education. Findings and discussion provided within the book should foster potentials and capabilities of research, of the academic community, and of industry as well. The publication is oriented towards making an impact in practice. The research presented in the book will leverage the dissemination of knowledge and awareness of potential benefits of high performance and cloud computing.

The target audience of this book is composed of professionals and researchers working in the field of information and communication technologies and their application in scientific research and education. Researchers and scholars will gain insight onto how modern technologies can be used as a support for scientific research. The book will also provide resources on how cloud technologies can be used to build an effective infrastructure of educational institutions. Administrators, technicians, teachers, and researchers within education and research institutions are the prime target of the book. This book is also beneficial to computer and system infrastructure designers, developers, business managers, entrepreneurs, and investors within the cloud computing-related industry.
The real value of the proposed book is reflected in a variety of experimental studies and case studies within real systems for e-learning, m-learning, high performance computing laboratories, scientific laboratories as well as implementations and solutions within a scope of a few international projects in the area of cloud computing, high performance computing, physics, etc.


The first section of the book discusses the main concepts and implications of cloud computing. In the chapter “From Mainframe to Cloud,” the authors define cloud computing, the related types, and models. The major trends of cloud computing, such as social computing, context-aware computing, and pattern-based strategy are described. In the conclusion, the authors provide an overview of the future use of cloud computing. In the chapter “Organizational and Management Aspects of Cloud Computing Application in Scientific Research,” the authors discuss the differences between the traditional and the cloud computing approaches to information and communication technologies in the organization. By means of theoretical analysis and practical examples, the authors demonstrate the development of the business model related to scientific research in bioinformatics. The impacts of cloud computing on organizational structure and organizational performance are analyzed. The components of the Seven Bridges Genomics Business model are discussed with respect to cloud computing. The chapter titled “Digital Identity Management in Cloud” investigates various approaches to identity management, particularly in a cloud computing environment. Several complex issues are discussed, such as cross-domain authentication, provisioning, multi-tenancy, delegation, and security. The main goal of the research is to provide a highly effective, scalable identity management for end-users in an educational private cloud. A federated identity concept was introduced as a solution that enables the organization to implement secure identity management and to share information on the identities of users in the cloud environment. As a proof of concept, the identity management system was implemented in an e-learning system. The chapter “From Software Specification to Cloud Model” is related to software design and deployment on cloud computing infrastructure. The method has been described using various steps to be performed and artifacts to be created in order to move the software in the cloud. The move2cloud problem emphasizes the problem of rearranging the software components into groups that might be provisioned into different clouds. The architecture model describes architectural components of the software, and it is the initial model in the MOCCA method. The authors have introduced a model and use case driven transformation that can be used to automatically derive architectural model from software requirements specification.

The second section of the book discusses the possibilities of cloud computing applications in education. The first chapter in this section, titled “Model of E-Education Infrastructure based on Cloud Computing” deals with defining and developing a model of IT infrastructure for e-learning by using the cloud computing concept. The chapter demonstrates a measurable improvement of the e-learning system by developing infrastructure for e-learning through CC. The experimental part of the chapter consists of a study directed towards the validation of the proposed IT infrastructure model for e-learning. The results of the study have shown that the implemented model enabled the e-learning system to be more efficient, more flexible, and more economical. The chapter “Mobile Learning Services on Cloud” discusses mobile learning services in a cloud environment. Mobile cloud computing brings numerous benefits and enables overcoming technical constraints of mobile learning. Cloud computing service models: IaaS, PaaS, and particularly SaaS, provide flexible and efficient ways to augment computing, storage, and communication capabilities of mobile learning services and applications. This chapter investigates the possibilities for delivering mobile learning services through cloud computing. The main
techniques and approaches in mobile cloud computing are analyzed, particularly Weblets and cloudlets. A model for mobile learning services delivery through cloud computing is proposed. Further, several examples of mobile learning services implementations on cloud are presented. The next chapter, “Student Relationship Management Using Social Clouds,” introduces implementation and improvement of the Student Relationship Management (SRM) concept as a cloud service in an e-education system by using social media. The experimental part of the chapter presents the design and implementation of SRM in e-education based on cloud computing. SRM was provided as SaaS on cloud computing infrastructure for e-learning. The chapter “Ontology-Based Multimodal Language Learning” investigates the possibility of applying ontology-based, dynamically generated learning objects implemented on a cloud computing infrastructure in order to satisfy the requirements for ubiquitous and learner-centric language learning. The authors have designed an ontology-based, modular, flexible, and multiplatform system for mobile language learning that preserves the advantages of utilizing learning objects from learning management systems.

The third section of the book is related to cloud computing applications in scientific research within different areas. The chapter “High Performance and Grid Computing Developments and Applications in Condensed Matter Physics” introduces applications of High Performance Computing (HPC), Grid computing, and development of electronic infrastructures in Serbia, in the South Eastern Europe region, and in Europe as a whole. Grid computing is designed and optimized for large-scale distributed computing, ideally supporting the execution of an enormous number of independent tasks (Monte Carlo simulations, search of large, multidimensional parameter spaces). On the other hand, HPC is ideally suited for capability computing, when solving of challenging problems requires highly parallel and scalable systems, able to support simultaneous execution of tens of thousands parallel processes. The main HPC and Grid infrastructures, initiatives, projects and programs in Europe, Partnership for Advanced Computing in Europe (PRACE) and European Grid Initiative (EGI) associations, as well as Academic and Educational Grid Initiative of Serbia (AEGIS) are presented. Further, the chapter describes some of the applications related to the condensed matter physics, developed at the Scientific Computing Laboratory of the Institute of Physics in Belgrade. The chapter “Exploiting Spatial and Temporal Patterns in a High-Performance CPU” introduces an approach to improve traditional cache systems. The main idea behind Dual Data Cache (DDC) is that two different types of locality (spatial and temporal) in data access patterns can be observed, and that data exhibiting predominantly one of these types of localities should be treated differently from the data that exhibit the other. The modified DDC described in the chapter introduces different internal organizations of the temporal and spatial parts, for better utilization of data characteristics. Conducted simulations showed substantial improvements over traditional cache systems, with little increase in the surface area and power consumption. The chapter “Designing Parallel Meta-Heuristic Methods” discusses meta-heuristics as powerful tools for addressing hard combinatorial optimization problems. A major issue in the meta-heuristic design and calibration is to provide high performance solutions for a variety of problems. Parallel meta-heuristics aim to address both issues. The objective of this chapter is to present a state-of-the-art survey of the main parallelization ideas and strategies, and to discuss general design principles applicable to all meta-heuristic classes. To achieve this goal, the authors explain various paradigms related to parallel meta-heuristic development, where communications, synchronization, and control aspects are the most relevant. They also discuss implementation issues pointing out the characteristics of shared and distributed memory multiprocessors as target architectures. All these topics are illustrated by the examples from the literature related to the parallelization of various meta-heuristic methods. The authors focus on the Variable Neighborhood
Search and Bee Colony Optimization. The chapter titled “Application of Cloud-Based Simulation in Scientific Research” is a review of the literature related to the use of cloud-based computer simulations in scientific research. The authors examine the types and good examples of cloud-based computer simulations, offering models for the architecture, frameworks, and runtime infrastructures, which support running simulations in a cloud environment. Using the possibilities offered by cloud computing platforms, researchers can efficiently use the already existing IT resources in solving computationally intensive scientific problems. Further on, the authors emphasize the possibilities of using the existing and already known simulation models and tools in a cloud computing environment. The chapter “Grids, Clouds, and Massive Simulations” discusses issues surrounding high performance computing-driven science on the example of the Petascale science Monte Carlo experiments conducted at the Brookhaven National Laboratory. The nature of the HPC hungry experiments is described. The development of parallel processors, multiprocessor systems, custom clusters, supercomputers, networked super systems, and hierarchical parallelisms are presented in an evolutionary manner. A coarse-grained, rigid Grid system parallelism is contrasted by cloud computing which is classified as flexible and fine-grained soft system parallelism. Advantages and disadvantages of using Grid, Cloud, or Grid/Cloud hybrid for Petascale science experiments are comparatively analyzed. In the process of evaluating various high performance computing options, a clear distinction between a high availability-bound enterprise and high scalability-bound scientific computing is made. This distinction is used to further differentiate the cloud from the pre-cloud computing technologies and fit cloud computing better into the scientific HPC. The chapter “Model of Interoperable E-Business in Traffic Sector based on Cloud Computing Concepts” analyzes the possibilities of applying the cloud concepts in the realization of the interoperable electronic business of traffic and transport subjects. Special attention is paid to defining the Business-to-Business (B2B) model of integrating the traffic business subjects in cloud computing technological environment. It describes the design, implementation, and application of the Cloud concepts on the examples of B2B integration in the field of traffic. The examples demonstrate the usage of PaaS and SaaS by traffic business subjects in the Republic of Serbia. The defined model of B2B integration allows for interoperability of the traffic business subjects on the syntactic, conceptual, and semantic levels. The chapter “DotNet Platform for Distributed Evolutionary Algorithms with Application in Hydroinformatics” describes .NET platform for distributed evaluation using WCF (Windows Communication Foundation) Web services in order to reduce computational time. This concept provides a parallelization of evolutionary algorithms independently of the geographic location and platform where evaluation is performed. Hydroinformatics is a typical representative of fields where complex systems with many uncertainties are studied. Application of the developed platform in hydroinformatics is also presented. Two real-world benchmarks were performed with different single individual evaluation complexity and different hardware/software platform to run on. The first one used relatively complex individual evaluation in the environment of ordinary LAN of office PCs. The second used a bit less complex individual evaluation on the real HPC resource – a computational cluster running Mono on top of Linux kernel and libraries. Both benchmarks have shown a significant speedup and good scalability potential. In order to properly quantify how the expense of a single evaluation affects speedup and scalability, the additional benchmarks have been performed, this time with quasi-evaluators simulating various durations. The results of this additional analysis are of practical use – one can take them as a guideline to estimate the duration of a very long EA run in a heuristic fashion.
The concluding section of the book discusses issues related to the security of cloud computing. The chapter “Security Issues of Cloud Computing and an Encryption Approach” considers scientific and educational employment of a cloud as a particular instance of a public cloud and its security, and also as a potentially specific issue; a request for a heavy minimization of the costs implied by security is pointed out. Consequently, the problem of minimization of the overheads implied by security/privacy mechanisms is addressed. The main security requirements are given as well as the main recommendations, providing a framework for the security management. As a particular issue, data protection is considered and the significance of data access control and encryption are discussed. Accordingly, an illustrative approach to achieving lightweight and provable secure encryption is shown. The considered encryption is based on joint employment of cryptographic and coding methods.

This book provides numerous examples, practical solutions, and applications of high performance computing and Cloud computing that can improve capacity, capability, and quality of research, teaching, and learning processes. Setting up new IT infrastructures and services, as well as enabling efficient and cost-effective usage of software and hardware resources, are of significant importance, particularly in developing countries. In addition, the presented works are expected to contribute to introducing cloud computing and high performance application and services in business and industry as well.

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