Cloud and Serverless Computing for Scientists

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A Primer

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Foreword

As a researcher in a number of different domains over my career, all of which have benefited from the development in the areas of distributed computing, it is clear that we will continue on this journey of discovery and development of new tools and services for some time to come. We moved away from historic paradigms, such as the mainframe, with the rise of the personal computer and from then onto the increasingly powerful workstation, generic high-performance computing, grid computing, and now "the cloud." One disadvantage of these changes though is that proponents of these new architectures often sell the newest paradigm as being better in nearly all ways than those that have proceeded it and therefore it should replace the systems following the older paradigms, moving users onto newer, bigger, better shinier systems. This is plainly not the case once hype has been ignored and as such the content of this book should be considered as aiming to educate the reader in terms of making sure that the right tool is always used for the right job.

I was struck when reading the book by the diversity of target audience within the research field, making sure that communities of practice, where the use of cloud will become ever more valuable are covered, with relevant examples is a great feature. I would though also make sure that one further cohort reads this book, the project PI or senior professor for whom this book should be required reading. Alongside more traditional responsibilities they are also now the ones who are under legal obligations to comply with requirements on open data and reproducibility, something that the migration of services and data storage to the cloud is extremely suitable for. They should also ensure that they understand the benefits and almost more importantly the challenges that a cloud-first strategy can bring.

When working with Juan and Diego prior to the development of this book, we spent a significant amount of time working through different models of the utilization of Infrastructure as a Service cloud computing for the environmental sciences, in particular climate science. Therefore, a large number of points made by this book have been developed through practical experience of the authors, not through desk-based research. Along with this with my background in the development of pan European Federated Cloud services for research, I can clearly see how lessons learnt, sometimes in very hard ways, in how researchers should be

thinking about using the cloud could have been found quicker and more easily if such a text as this existed, or that we could have shared with members of the user community. As such I also see this book being of great use for those that will in time become users not only of large-scale public clouds to support their research but also in the usage of the European Open Science Cloud as it becomes a more and more useful tool to European Research.

I would finally highlight how the authors already say that in the fast-moving and dynamic world of cloud computing that things get out of date very quickly. Examples of this of course abound, though a key highlight is where the different deployment models of cloud computing mean that it is not always the same cloud that two different researchers talk about when they describe their method of use of "cloud." Therefore, making sure that everyone understands the underlying model of cloud computing as is done early within the book is essential. So to conclude I would say that readers should, once they think they understand how they can use cloud computing within their research, stop, read, and then think about how they want to move forward with the cloud, making sure that they follow sound scientific and IT principles in how they deploy services within the cloud, testing all the time and recognize that cloud is not a magic bullet, but in the longer term it can make things much, much easier if their deployments are well designed.

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Preface

We have written this book for scientists, engineers, or anyone who wants to approach cloud computing, simply to know more about it or if they are considering or evaluating it as an alternative or complementary solution for their computing needs. Additionally, this book can be useful for IT professionals, such as Solutions Architects, who want to learn about the current and future needs of the scientific community and how they can be satisfied using cloud technologies, enabling them to offer more suitable proposals to their customers. Therefore, this text can provide a bridge between user and provider perspectives.

Moreover, this book attempts to provide a broad view of the current status of cloud computing and to serve as an introductory text for graduate, postgraduate, and Ph.D. students across every discipline, providing insight into potential uses and how it can help to develop projects and future work.

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Contents

Acronyms

AI	Artificial Intelligence
API	Application programming interface
AWS	Amazon Web Services
BOINC	Berkeley Open Infrastructure for Network Computing
CDC	USA Centers for Disease Control and Prevention
CERN	European Organization for Nuclear Research—*Conseil Européen pour la Recherche Nucléaire*
CLI	Command Line Interface
CNCF	Cloud Native Computing Foundation
DoD	US Department of Defense
EC2	(AWS) Elastic Cloud Compute
ERP	Enterprise Resource Planning
ESA	European Space Agency
EU	European Union
FaaS	Function as a Service
FDA	U.S. Food and Drug Administration
FMI	Finnish Meteorological Institute
GCP	Google Cloud Platform
GCS	Google Cloud Storage
GPL	GNU Public License
HIPAA	Health Insurance Portability and Accountability Act
HIV	Human Immunodeficiency Virus
HPC	High performance computing
HPCaaS	High performance computing as a Service
IaaS	Infrastructure as a Service
IOPS	Input/output operations per second
IoT	Internet of Things
IRC	Internet relay chat
IT	Information Technologies
JPL	Jet Propulsion Laboratory
JSON	JavaScript object notation

Met Office	United Kingdom's National Weather Service
MPI	Message Passing Interface
NAS	Network Attached Storage
NASA	National Aeronautics and Space Administration
NOAA	USA National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
OS	Operating system
PaaS	Platform as a Service
POSIX	Portable Operating System Interface
PUE	Power Usage Effectiveness
RAM	Random-Access Memory
S3	AWS Simple Storage Service
SaaS	Software as a Service
SDK	Software Development Kit
SEO	Search Engine Optimization
SSD	Solid-State Drive
SSL	Secure Sockets Layer
TLS	Transport layer security
UI	User Interface
VPC	Virtual private cloud
VPN	Virtual private network
VPS	Virtual private server