Contents

Contents xi

1 Introduction 1

1.1 Motivation . . . 3
1.2 Summary of the state of art . . . 5
1.3 Objectives of the thesis . . . 8
1.4 Structure of the document . . . 11

2 Towards Migratable Virtual Elastic Clusters on Hybrid Clouds 15

2.1 Introduction . . . 16
2.2 Enhanced Virtual Clusters . . . 17
2.2.1 Elasticity . . . 18
2.2.2 Hybrid Scenarios . . . 20
2.2.3 Migration . . . 20
2.3 Discussion and Application Scenarios . . . 22
2.4 Conclusion . . . 22

3 Virtual Hybrid Elastic Clusters in the Cloud 25

3.1 Introduction . . . 26
3.2 Background and Related Work . . . 27
3.3 Virtual Hybrid Elastic Clusters . . . 28
3.3.1 Elasticity Rules . . . 30

3.4 Case Study . . . 31
3.4.1 Cloud bursting . . . 32
3.4.2 Maintenance period in a datacenter . . . 34
3.5 Conclusions and Future Work . . . 35

4 Self-managed Cost-efficient Virtual Elastic Clusters on Hybrid Cloud Infrastructures 37

4.1 Introduction . . . 38
4.2 Related work . . . 39
4.3 Elastic Cloud Computing Cluster (EC3) . . . 41
4.3.1 Previously developed EC3 components . . . 42
4.3.2 Overall architecture . . . 43
4.3.3 Checkpointing Manager (ckptman) . . . 46
4.3.4 Checkpointing algorithms . . . 47
4.3.5 Hybrid features . . . 49
4.4 Case studies . . . 51
4.4.1 Structural Dynamic Analysis of Buildings using EC3 . . . 51
4.4.2 Results and Discussion . . . 53
4.4.3 Analysis of the checkpointing algorithms . . . 57
4.4.4 Results and Discussion . . . 59
4.5 Conclusions and future work . . . 61

5 eScience with a Galaxy web-service connected to an Elastic Cluster in the Cloud for Computational Biodiversity 63

5.1 Introduction . . . 64
5.2 Related work . . . 65
5.3 Galaxy Virtual Elastic Cluster . . . 68
5.3.1 Architecture . . . 68
5.4 Use case . . . 71
5.4.1 Application domain . . . 72
5.4.2 Tools which are deployed . . . 72
5.4.3 Dataset . . . 73
5.4.4 Launch elastic Galaxy web-service with EC3 . . . 74
5.4.5 Experimentation . . . 75
5.5 Conclusion . . . 77

6 Towards Migration of Virtual Clusters across Clouds 79
6.1 Introduction . . . 79
6.2 Background and Related Work . . . 81
6.2.1 Application migration . . . 82
6.2.2 Virtual Machine migration . . . 83
6.2.3 Virtual cluster migration . . . 85
6.3 Proposed solution for virtual cluster migration . . . 86
6.3.1 The migration process . . . 88
6.4 Case study . . . 89
6.5 Conclusions and Future Work . . . 91

7 Container-based Virtual Elastic Clusters 93
7.1 Introduction . . . 94
7.2 Background and Related Work . . . 96
7.2.1 Related work . . . 98
7.3 Elastic Cluster for Docker (EC4Docker) . . . 101
7.3.1 Features of the Container-based Virtual Elastic Cluster . . . 102
7.3.2 Behaviour of a container-based virtual elastic cluster . . . 103
7.3.3 Elasticity Rules . . . 105
7.4 Case study . . . 107
7.4.1 Results and discussion . . . 109
7.5 Conclusions and Future Work . . . 112

8 EC3aaS: EC3 as a Service 113
8.1 Configuration and Deployment of a Cluster . . . 113
8.2 Termination of a cluster . . . 117
8.3 Other available materials . . . 118
8.4 Use Cases . . . 119

9 Discussion and Results 121
9.1 Software and tools developed . . . 122
9.2 Publications and contributions . . . 124
9.3 Projects where EC3 is integrated . . . 126
9.4 EC3 in the academia . . . 128

9.5 Contributions to other projects and tools 128

10 Conclusions 131

10.1 Conclusions 131
10.2 Future work 133
10.3 Fundings of this project 134

A Sequence diagrams of EC3 137

B Flowcharts of ckptman behaviour 141

Bibliography 145

Index 169