Course Title	Distributed and Cloud Computing				
Course Code	WSS504				
Course Type	Compulsory (Both Specializations)				
Level	MSc (Level 2)				
Year / Semester	1 / 2				
Teacher's Name	Dr. Achilleas Achilleos, Prof. Costas Kyriakou				
ECTS	10	Lectures / week	3	Laboratories/week	0
Course Purpose	The aim of this course is to provide students with critical understanding on the evolution path towards distributed systems and cloud computing. The course addresses the concepts, methods, technologies and tools for cloud setup, management and deployment of applications. Initial topics covered in the course include parallel and distributed computing, their differences, as well as the concepts of utility and cloud computing. Then, the cloud computing levels, models and the cloud architecture are introduced. Following the cloud service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) & Software as a Service (SaaS) are defined and presented in detail. The course proceeds to introduce the concepts of abstraction and virtualization, the notion of virtual machines, machine images and containers. These concepts are presented in practice via an overview of the OpenStack and Azure cloud environments. The course has a theoretical underpinning, but practical examples are also performed that reveal how to setup and manage an OpenStack private cloud or an Azure public cloud using the introduced implementation methods, techniques and tools. The course concludes with the introduction of Serverless Computing that aims to be the realisation of the cloud computing vision of utility computing.				
Learning Outcomes	Upon successful completion of the course students will be able to: • Describe and explain the concepts, as well as the differences between parallel, distributed, utility, cloud and serverless computing. • Outline the layers of the cloud computing stack and define the main cloud computing levels; infrastructure, platform and software. • Understand and present the different cloud computing types: cloud deployment models and cloud service models. • Critically discuss service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) & Software as a Service (SaaS). • Learn and understand the concepts of abstraction and virtualization, virtual machines, machine images and containers. • Learn the basic concepts of the OpenStack cloud environment and install, configure and use it to setup a private cloud. • Understand the differences and benefits of multi-cloud development in comparison to utilizing a single cloud provider.				

*One hour out of the three is normally devoted to cloud management and scripting exercises.

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<tr><td></td><td colspan="3">• Learn the basic concepts of the Azure public cloud environment and utilise DevOps tools and APIs to create images, deploy applications and manage them through shell scripting.</td></tr>
<tr><td>Prerequisites</td><td>None.</td><td>Corequisites</td><td>None.</td></tr>
<tr><td>Course Content</td><td colspan="3">
1. Introduction to Cloud Computing (1 Week)
- Personal Computing. Parallel and Distributed Computing. Distributed Systems. Defining cloud computing. Overview of cloud types – cloud deployment and cloud service models. Understanding the paradigm shift of cloud computing. The benefits and disadvantages of cloud systems.
2. The Cloud Computing Stack – Cloud Architecture (1 Week)
- Using the cloud computing stack to describe different cloud models. Understanding how platforms and virtual appliances are used. The cloud computing communication protocols. The new class of cloud-connected clients such as Google Chrome OS.
3. Services and Applications by Type (1 Week)
- Learning about different service types. Creating clouds with Infrastructure as a Service. Working with Software as a Service. Developing applications on a Platform as a Service. Securing cloud transactions with Identity as a Service.
4. Abstraction and Virtualization (1 Week)
- Abstraction and cloud computing. Virtualization and shared resource pools. Load balancing to enable large cloud computing applications. Hypervisors and virtual machines. System imaging and application portability for the cloud.
5. Capacity Planning (1 Week)
- Learning about capacity planning for the cloud. Capturing baselines and metrics. Determining resources and their ceilings. Scaling your systems appropriately.
6. Introduction to Multi-Cloud (1 Week)
- Defining Multi-Cloud. Cloud Portability Definition and Issues. The Importance of Multi-Cloud. A Simple Architecture. Multi- Cloud Deployment Toolkits. Apache jClouds.
7. The OpenStack Cloud Environment (2 Weeks)
- Learning the basics of OpenStack. OpenStack Architecture. OpenStack Services. OpenStack Private Cloud Setup. OpenStack Cloud Inventories and Management. OpenStack Documentation. OpenStack Clients.
8. The Azure Public Cloud – Management with Scripting (3 Week)
- Learning the basics of Azure. Azure Cloud Management Methods. The Azure PowerShell Az module in Windows and Linux environments. Connecting to Azure, Creating and Managing Resources using shell scripting.
9. The Rise of Serverless Computing (1 Week)
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	- Defining Serverless Computing. History and Related Work. Architecture. Programming Model. Tools and Frameworks. Technical and Research Challenges.
Teaching Methodology	The methodology followed in this course is structured around lectures and laboratory exercises, so that students gain theoretical knowledge as well as practical skills. The taught part of course is delivered to the students with the help of computer presentations. Presentations are available through the e-learning system for students to use in combination with the textbooks. Furthermore, theoretical principles are explained by means of specific examples and solution of specific problems using practical examples. The code for these cloud scripting examples is also made available in the e-learning system. Lectures are supplemented with supervised computer laboratories, which include demonstrations of taught concepts and experimentation with related technologies to solve specific problems via exercises. Hence, during laboratory sessions, students apply their gained knowledge and identify the principles taught in the lecture sessions by means of working on different tasks and solving problems. The course includes a course project or two assignments that test both the theoretical understanding and the practical application of the taught concepts. Finally, the course assessment is completed by means of a three-hours final exam at the end of the semester.
Bibliography	**Textbooks:** 1. Barrie Sosinsky, “Cloud Computing Bible”, Book: Copyright © 2011 by Wiley Publishing, Inc., Indianapolis, Indiana, ISBN: 978-0-470-90356-8. **References:** 1. Dana Petcu, “Multi Cloud: expectations and current approaches”, In Proceedings of the 2013 international workshop on Multi cloud applications and federated clouds (MultiCloud '13). ACM, New York, NY, USA, 1 6. DOI: 10.1145/2462326.2462328. 2. M. A. AlZain, E. Pardede, B. Soh and J. A. Thom, “Cloud Computing Security: From Single to Multi clouds”, 45th Hawaii International Conference on System Sciences, Maui, HI, 2012, pp. 5490 5499. DOI: 10.1109/HICSS.2012.153. 3. K. Hui, D. Radez, “Getting Started With OpenStack”, RackSpace, Available Online: https://www.openstack.org/assets/presentation-media/Getting-Started-With-OpenStack-Icehouse-v2.pptx. 4. OpenStack.org, “OpenStack Documentation”, Available Online: https://docs.openstack.org/train/. 5. Microsoft, “Azure Documentation”, Available Online: https://docs.microsoft.com/en-us/azure/. 6. Paul Castro, Vatche Ishakian, Vinod Muthusamy, Aleksander Slominski, “The Rise of Serverless Computing”, Communications of the ACM, December 2019, Vol. 62 No. 12, Pages 44-54. DOI: 10.1145/3368454.

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Assessment	• Course Project or Two Assignments: 40% • Final Exam: 60%
Language	English.

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