

Virtual Computers

EEL 6892

Class Periods: MWF Period 5

Location: CSE-E107

Academic Term: Spring 2020

Instructor:

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Teaching Assistants:

Please contact through the Canvas website

Course Description

Virtualization technologies allow the decoupling of the user-perceived behavior of hardware/software systems from their physical implementation. Techniques to virtualize the basic functionality of today's typical computing systems – processing, networking, and data storage – are becoming pervasive in industry and form a foundation for the Infrastructure-as-a-Service (IaaS) cloud computing model. The combination of virtualization technologies and ubiquitous network connectivity allows for the creation of virtual computers where processing, data and communication are distributed and decoupled from physical resources. This class will cover the basic mechanisms and techniques involved in resource virtualization, from individual machines to virtualized networked infrastructures.

Course Pre-Requisites / Co-Requisites

Principles of Computer Systems Design (EEL 5737), or instructor approval

Course Objectives

Students will learn techniques that are used in modern computer systems to enable virtualization of major sub-systems (CPU, networking, and storage), which are becoming pervasive in industry and form a foundation for the Infrastructure-as-a-Service (IaaS) cloud computing model.

Materials and Supply Fees

N/A

Required Textbooks and Software

- Title: "Virtual Machines"
- Author: James E. Smith and Ravi Nair
- Publication date, edition, and publisher: first edition, Morgan Kaufmann, April 2005.
- ISBN number: 1558609105
- Software: Desktop virtualization software (VMware or VirtualBox)

The course will also cover several technical papers in the literature – a tentative reading list is provided at the end of the syllabus.

Recommended Materials

- Title:
- Author:
- Publication date, edition, and publisher:
- ISBN number:

Course Schedule

- Week 1: Introduction to virtualization and review of computer system fundamentals
- Week 2: Introduction to virtual machine monitors (VMMs) (Goldberg paper)
- Week 3: Formal requirements for CPU virtualization (Popek and Goldberg paper)
- Week 4: Memory virtualization
- Week 5: I/O virtualization and the hosted I/O model (Sugerman et. al paper)
- Week 6: Para-virtualization and Xen (Barham et. al paper)
- Week 7: x86 virtualization challenges and binary-translation in VMMs (Robin and Irvine paper) and hardware extensions for virtualization (Neiger et. al paper)
- Week 8: Memory virtualization in consolidated servers (Waldsurger paper)
- Week 9: Virtual machine migration (Sapuntzakis et. al paper, and Clark et. al paper)
- Week 10: High-availability in VMMs (Cully et. al paper) and O/S containers (Banga et. al)
- Week 11: System call-based virtualization (Dike paper) and VM introspection (Garfinkel and Rosenblum paper)
- Week 12: Multiprocessor virtualization
- Week 13-14: Virtual networks, VNET (Sundararaj and Dinda paper) and IPOP (St. Juste et. al paper)
- Week 15-16: Storage virtualization, VMFS (Vaghani paper) and UFO

Attendance Policy, Class Expectations, and Make-Up Policy

Excused absences are consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

Evaluation of Grades

Assignment	Percentage of Final Grade
Homework Sets (3)	10%
Quizzes (around 16)	0%
Midterm Exams (2)	40%
Final Exam	30%
Final project	20%
TOTAL	100%

Grading Policy

Final letter grades will be assigned based on the distribution of the final grades above by students in class.

In order to graduate, graduate students must have an overall GPA and a major GPA of 3.0 or better (B or better). Note: A “B-” average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement.

More information on UF grading policy may be found at:
<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020>

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Campus Resources:

Health and Wellness

U Matter, We Care:

If you or a friend is in distress, please contact umatter@ufl.edu or 352-392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.

<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.

<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.

Tentative reading list

“Survey of Virtual Machine Research”, Robert P. Goldberg, IEEE Computer, June 1974, pp 34-45.

“Architecture of Virtual Machines”, Robert P. Goldberg, Proc. Workshop on Virtual Computer Systems, Cambridge, MA, 1973, pp 74-112.

“Formal Requirements for Virtualizable Third Generation Architectures”, Gerald J. Popek, Robert P. Goldberg, Communications of the ACM, 17(7), July 1974, pp 413-421.

“Virtualizing I/O Devices on VMware Workstation’s Hosted Virtual Machine Monitor”, Jeremy Sugerman, Ganesh Venkitachalam and Beng-Hong Lim, Proc. 2001 USENIX Annual Technical Conference, Boston, MA June 2001.

“A user-mode port of the linux kernel”, Jeff Dike, Proceedings of the USENIX Annual Linux Showcase and Conference, Atlanta, GA, Oct 2000

“Xen and the Art of Virtualization”, Paul Barham, Boris Dragovic, Keir Fraser, Steven Hand, Tim Harris, Alex Ho, Rolf Neugebauer, Ian Pratt and Andrew Warfield, Proceedings of the ACM Symposium on Operating Systems Principles (SOSP), October 2003

Christopher Clark et al, “Live Migration of Virtual Machines”, Proceedings of the 2nd ACM/USENIX Symposium on Networked Systems Design and Implementation (NSDI), 2005.

A. Sundararaj, P. Dinda, “Towards Virtual Networks for Virtual Machine Grid Computing”, Proceedings of the third USENIX Virtual Machine Research and Technology Symposium (VM 04), May, 2004.

Xuxian Jiang, Dongyan Xu, “VIOLIN: Virtual Internetworking on OverLay INfrastructure”, Department of Computer Sciences Technical Report CSD TR 03-027, Purdue University, July 2003

“The Collective: A Cache-Based System Management Architecture”, R. Chandra, N. Zeldovich, C. Sapuntzakis, and M. S. Lam In Proceedings of the Second Symposium on Networked Systems Design and Implementation (NSDI 2005)

“Resource Containers: A New Facility for Resource Management in Server Systems”, Gaurav Banga, Peter Druschel, Jeffrey Mogul, Proceedings of the 3rd Symposium on Operating Systems Design and Implementation, February, 1999

“Intel Virtualization Technology: Hardware Support for Efficient Processor Virtualization”, Gil Neiger, Amy Santoni, Felix Leung, Dion Rodgers, Rich Uhlig, Intel Technology Journal 10(3), 2006

“A Virtual Machine Introspection Based Architecture for Intrusion Detection”, Tal Garfinkel and Mendel Rosenblum, Proceedings of NDSS, 2003

“Remus: High Availability via Asynchronous Virtual Machine Replication”, Brendan Cully, Geoffrey Lefebvre, Dutch Meyer, Mike Feeley, Norm Hutchinson, and Andrew Warfield, Proceedings of NSDI 2008

“Memory Resource Management in VMware ESX Server”, Carl Waldspurger, Proceedings of the 5th Symposium on Operating Systems Design and Implementation, 2002

“Virtual Machine File System”, Satyam Vaghani, ACM SIGOPS Operating Systems Review, 2010

“TinCan: User-Defined P2P Virtual Network Overlays for Ad-hoc Collaboration”, P. St Juste, K. Jeong, H. Eom, C. Baker, and R. J. Figueiredo, ICST Transactions on Collaborative Computing, vol. 14, no. 2, 2014.