

EEL 6892 – Virtual Computers

Spring 2016 - Syllabus

Class schedule: MWF, 9th Period, LAR 330

Instructor: Prof. Renato J. Figueiredo (renato@acis.ufl.edu)
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Office Hours: TBD, please refer to my online schedule at <http://byron.acis.ufl.edu>

Text: “Virtual Machines”, James E. Smith and Ravi Nair (Morgan Kaufmann), ISBN 1558609105, April 2005. Readings will also be based on a collection of relevant technical papers.

Web page: UF's Canvas E-learning – you need to log in with your Gatorlink account

Topics Covered: 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.

Prerequisites: Principles of Computer Systems Design (EEL 5737), Computer architecture (EEL5764 or equivalent) and operating systems principles (COP5615 or equivalent) or instructor approval. Knowledge of TCP/IP networking and C/C++ programming.

Computer usage: You will use virtual machines for assignments. Detailed instructions will be given in class.

Assignments: Homeworks and a project will be assigned in this class. The project entails an exploration of a topic related to virtual computers. Solid knowledge of high-level/scripting languages (e.g. C, C++, C#, Java, Python) and proficiency in programming are expected from students.

Exams: There will be 1-2 midterms and one final exam in this class, to be scheduled.

Grade: The grade will be based on assignments, and exams. A tentative breakdown of the final grade is: 40% assignments, 30% midterm, 30% final. Refer to this site for University grading policies: <http://www.registrar.ufl.edu/catalog/policies/regulationgrades.html>

Course topics:

Virtual machines (approximately 70% of the material)

- Taxonomy and basic principles

- Classic virtual machines; VMware, KVM

- Application-level and para-virtualized virtual machines; Xen

- Processor extensions in support of virtualization; Intel VT

- Hardware-based virtual machines and binary translation

Virtual networking (approximately 20% of the material)

- Tunneling

- Overlay routing

- Applications in distributed systems: grid and cloud computing

Virtual storage (approximately 10% of the material)

- Basic principles

- Centralized and distributed file systems

- Virtual file systems

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Tentative Reading List

This list contains relevant, contemporary technical papers on virtualization. Some will be covered in detail in class, some will be presented by students, and may be used as reference for the class project.

Virtual Machine introduction/theory:

IEEE Computer special issue on virtualization technologies, Renato J. Figueiredo, Jose A. B. Fortes, Peter A. Dinda, Editors (May 2005). (Articles available online to UF students from IEEE Express).

“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.

“On the Relationship Between Virtual Machines and Emulators”, Efreem G. Mallach, Proc. Workshop on Virtual Computer Systems, Cambridge, MA, 1973, pp 117-126

Virtual machine techniques and case studies:

“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

“Scale and Performance in the Denali Isolation Kernel”, A. Whitaker, M. Shaw, S. Gribble, Proceedings of the 5th USENIX Operating Systems Design and Implementation (OSDI), 2001.

“A Comparison of Software and Hardware Techniques for x86 Virtualization”, K. Adams and O. Agesen, Proceedings of ASPLOS, 2006.

B. Lin, and P. Dinda, “VSched: Mixing Batch and Interactive Virtual Machines Using Periodic Real-time Scheduling”, Proceedings of ACM/IEEE SC 2005 (Supercomputing), November, 2005

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

Virtual Machine security/isolation:

“Application and Analysis of the Virtual Machine Approach to Information System Security and Isolation”, Stuart E. Madnick and John J. Donovan, Proc. Workshop on Virtual Computer Systems, Cambridge, MA, 1973, pp 210-224.

“Terra: a virtual machine-based platform for trusted computing”, T. Garfinkel, B. Pfaff, J. Chow, M. Rosenblum, D. Boneh, Proceedings of the nineteenth ACM symposium on Operating systems principles, 2003

“Analysis of the Intel’s Pentium Ability to Support a Secure Virtual Machine Monitor”, John S. Robin, Cynthia E. Irvine, Proc. 9th USENIX Security Symposium, Denver, CO, August 2000.

G. Dunlap, S. King, S. Cinar, M. Basrai, and P. Chen. ReVirt: Enabling Intrusion Analysis through Virtual-Machine Logging and Replay. Proceedings of OSDI 2002

Virtual networks and applications in distributed systems:

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

Tsugawa, Maurício; and Fortes, José A.B. "A Virtual Network (ViNe) Architecture for Grid Computing". In Proceedings of 20th International Parallel and Distributed Processing Symposium (IPDPS-2006), Rhodes Island, Greece, April, 2006

Ganguly, Arijit , Abhishek Agrawal, P. Oscar Boykin, Renato Figueiredo 'WOW: Self-Organizing Wide Area Overlay Networks of Virtual Workstations'. In Proc. High Performance Distributed Computing (HPDC)

Virtual file systems:

"The PUNCH Virtual File System: Seamless Access to Decentralized Storage Services in a Computational Grid", R. J. Figueiredo, N. H. Kapadia, and J. A. B. Fortes. Proceedings of the Tenth IEEE International Symposium on High Performance Distributed Computing. IEEE Computer Society Press, August 2001.

"Distributed File System Support for Virtual Machines in Grid Computing", Proceedings of the IEEE International Symposium on High Performance Distributed Computing. IEEE Computer Society Press, August 2004.

Miscellaneous:

"Virtual Appliances for Deploying and Maintaining Software", C. Sapuntzakis, D. Brumley, R. Chandra, N. Zeldovich, J. Chow, M. S. Lam, and M. Rosenblum, In Proceedings of the 17th Large Installation Systems Administration Conference (LISA 2003), pages 181-194, October 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)

"Are Virtual-Machine Monitors Microkernels Done Right?", Gernot Heiser, Volkmar Uhlig, and Joshua LeVasseur, ACM Sigops Operating System Review (OSR), January 2006

"Are Virtual Machine Monitors Microkernels Done Right?", Steven Hand, Andrew Warfield, Keir Fraser, Evangelos Kotsovinos, Dan Magenheimer, HotOS 2005.