CSCI315 – Operating Systems Design

Department of Computer Science
Bucknell University

Virtual Machines Examples

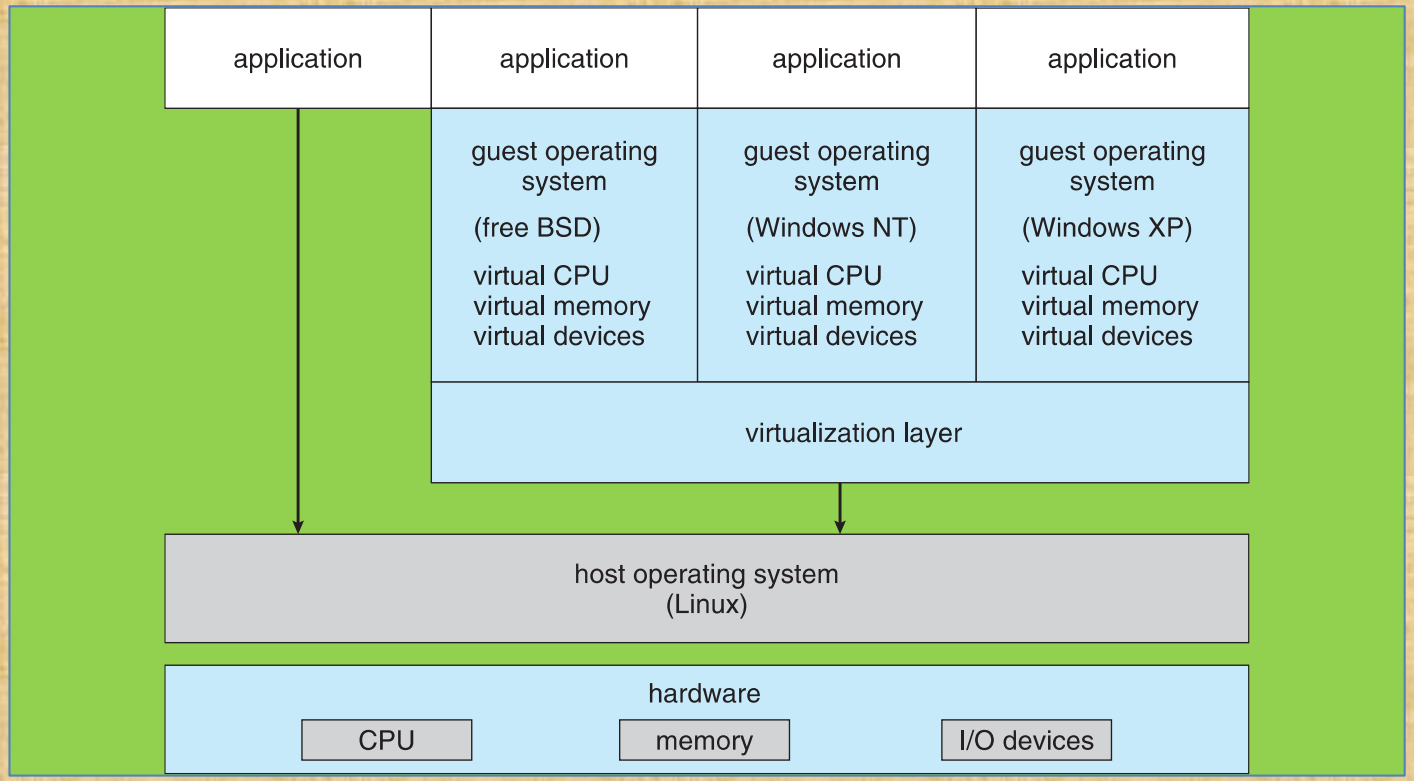
Ch 18.7-18.8

This set of notes is based on notes from the textbook authors, as well as L. Felipe Perrone, Joshua Stough, and other instructors.
Xiannong Meng, Fall 2021.

Examples - VMware

- VMware Workstation runs on x86, provides VMM for guests
- Runs as application on other native, installed host operating system -> Type 2
- Lots of guests possible, including Windows, Linux, etc. all runnable concurrently (as resources allow)
- Virtualization layer abstracts underlying HW, providing guest with is own virtual CPUs, memory, disk drives, network interfaces, etc.
- Physical disks can be provided to guests, or virtual physical disks (just files within host file system)

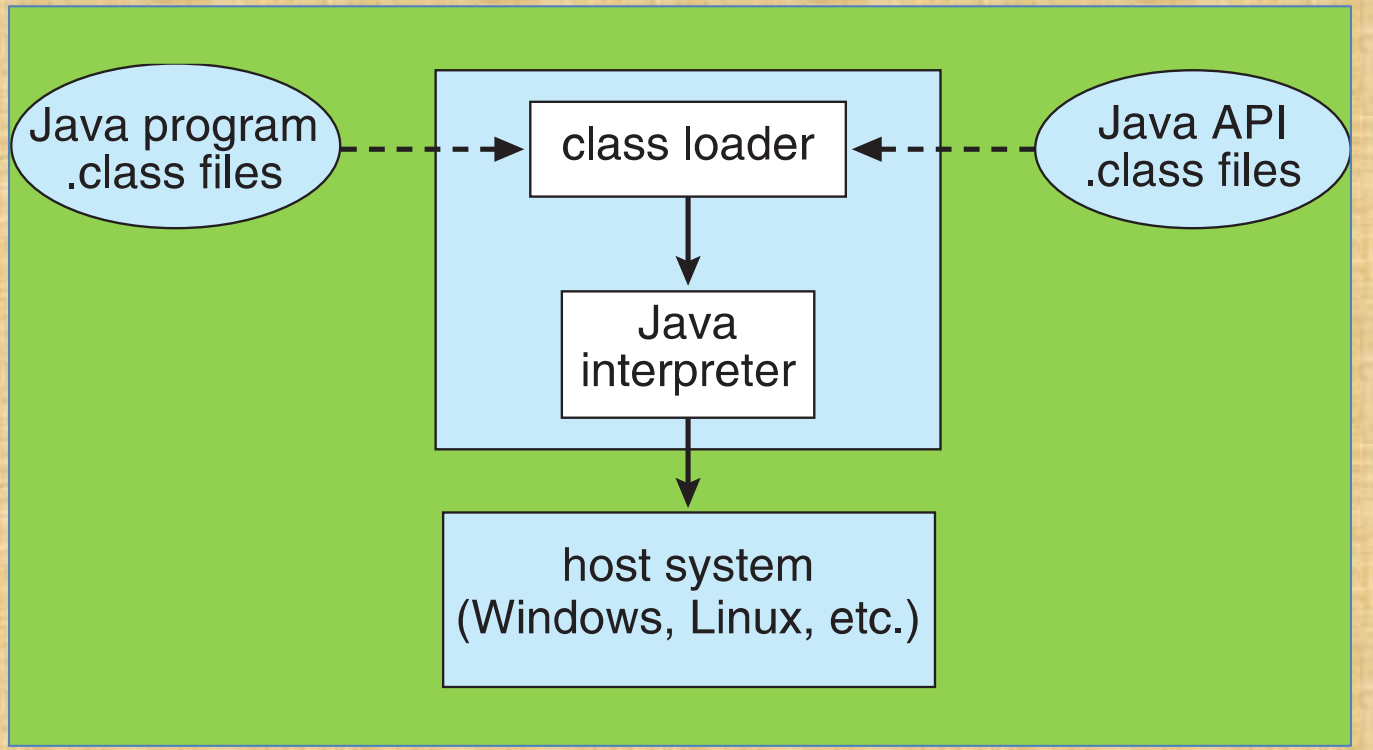
VMware Workstation Architecture



Examples – Java Virtual Machine

- Example of programming-environment virtualization
- Very popular language / application environment invented by Sun Microsystems in 1995
- Write once, run anywhere
- Includes language specification (Java), API library, Java virtual machine (JVM)
- Java objects specified by class construct, Java program is one or more objects
- Each Java object compiled into architecture-neutral **bytecode** output (`.class`) which JVM **class loader** loads
- JVM compiled per architecture, reads bytecode and executes
- Includes **garbage collection** to reclaim memory no longer in use
- Made faster by **just-in-time** (**JIT**) compiler that turns bytecodes into native code and caches them

The Java Virtual Machine



Virtualization Research

- Very popular technology with active research
- Driven by uses such as server consolidation
- **Unikernels**, built on **library operating systems**
  - Aim to improve efficiency and security
  - Specialized machine images using one address space, shrinking attack surface and resource footprint of deployed applications
  - In essence, compile application, libraries called, and used kernel services into single binary that runs in a virtual environment

https://en.wikipedia.org/wiki/Unikernel

http://unikernel.org/

Virtualization Research

- Better control of processes available via projects like **Quest-V**
  - Real time execution and fault tolerance via virtualization instructions
  - Partitioning hypervisors partition physical resources amongst guests, fully-committing all resources (rather than overcommitting)
  - For example a Linux system that lacks real-time capabilities for safety- and security-critical tasks can be extended with a lightweight real-time OS running in its own VM

http://www.cs.bu.edu/fac/richwest/quest.php

Virtualization Research (Cont.)

- Separation hypervisors like Quest-V, each task runs in a virtual machine
  - Hypervisor initializes system and starts tasks but not involved in continuing operation
  - Each VM has its own resources the task manages
  - Tasks can be real time and more secure
  - Other examples are Xtratum, Siemens Jailhouse
  - Can build chip-level distributed system
  - Secure shared memory channels implemented via extended page tables for inter-task communication
  - Project targets include robotics, self-driving cars, Internet of Things

Current Popular List of VM Software (1)

- Based on a list by TechRadar (dated 09/24/2020)
  - 1. VMware Workstation Player
  - 2. VirtualBox
  - 3. Parallels Desktop
  - 4. QEMU
  - 5. Citrix Hypervisor
  - 6. Xen Project
  - 7. Microsoft Hyper-V

https://www.techradar.com/best/best-virtual-machine-software

Current Popular List of VM Software (2)

- Based on a list by Software Testing Help (dated 10/1/2020)
  - SolarWinds Virtualization Manager
  - V2 Cloud
  - VM Ware Fusion
  - Parallels Desktop
  - Oracle Virtualization **(a.k.a. Virtual Box)**
  - VM Ware Workstation
  - QEMU
  - Virtual PC
  - Microsoft Hyper-V
  - Redhat Virtualization
  - Veertu-for MAC
  - Apple-Boot Camp

https://www.softwaretestinghelp.com/virtualization-software/

Virtual Machine: QEMU

- Here is a running example of VM: QEMU.
  - hardware emulator of x86 processor
- I used it to study the bootstrap programs, which was demonstrated early in the course.
- One can specify the disk capacity and memory configuration for each run.
- https://www.qemu.org/
- https://en.wikipedia.org/wiki/QEMU

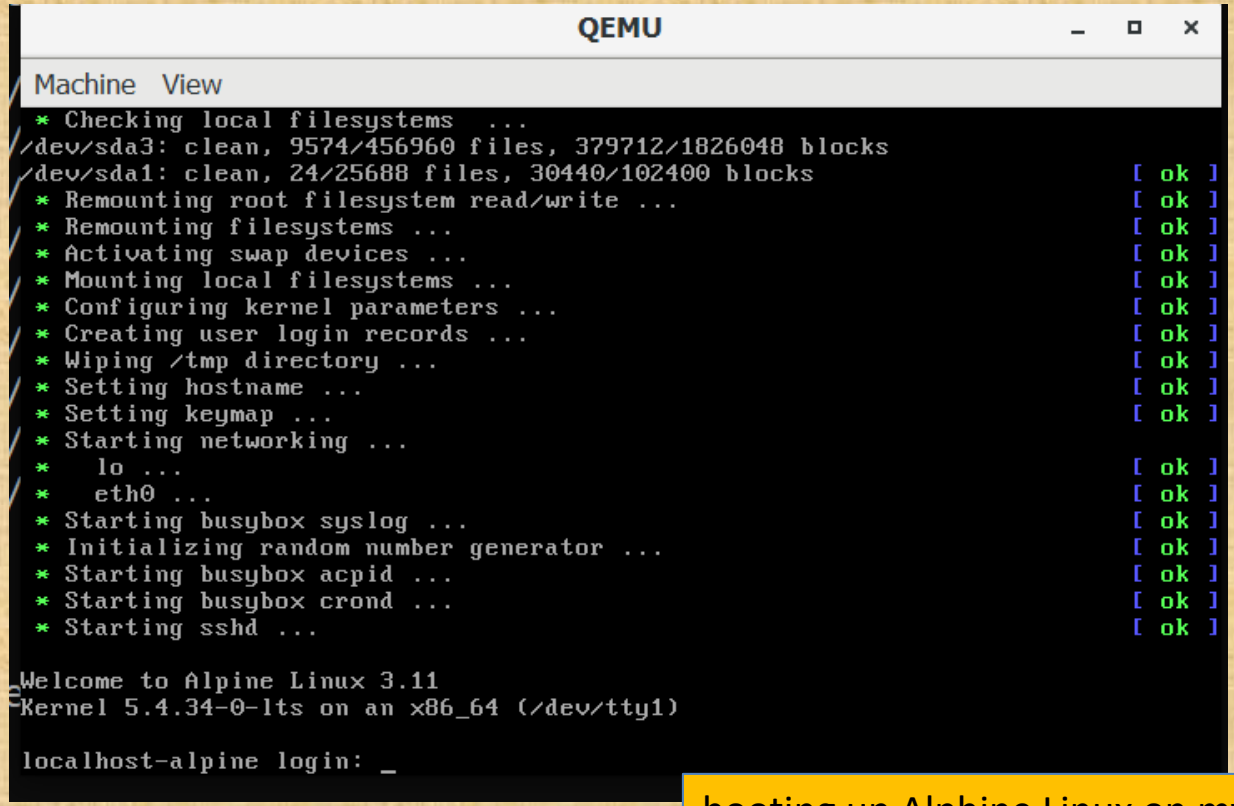
Some Screenshots Running QEMU

```
c:\Users\xmeng\qemu-data>dir
 Volume in drive C is Windows
 Volume Serial Number is 3A36-7B83

 Directory of c:\Users\xmeng\qemu-data

08/02/2020  06:19 PM    <DIR>          .
08/02/2020  06:19 PM    <DIR>          ..
11/15/2020  11:16 AM     1,576,534,016 alpine.qcow2
06/11/2020  10:10 AM               512 boot_go_pm.bin
06/16/2020  09:16 AM               512 boot_sect.bin
06/20/2020  10:01 AM             8,192 os-image
05/31/2020  07:19 AM                71 qemu-alpine.bat
06/01/2020  08:37 AM                21 qemu-simple.bat
08/02/2020  06:19 PM                11 users.txt
               7 File(s)  1,576,543,335 bytes
               2 Dir(s)  145,420,840,960 bytes free

c:\Users\xmeng\qemu-data>type qemu-alpine.bat
@echo off
echo.
qemu-system-x86_64 -m 512 -nic user -hda alpine.qcow2
c:\Users\xmeng\qemu-data>
```

QEMU files on my Windows computer. “alphine.qcow2” is a virtual Linux brand OS.

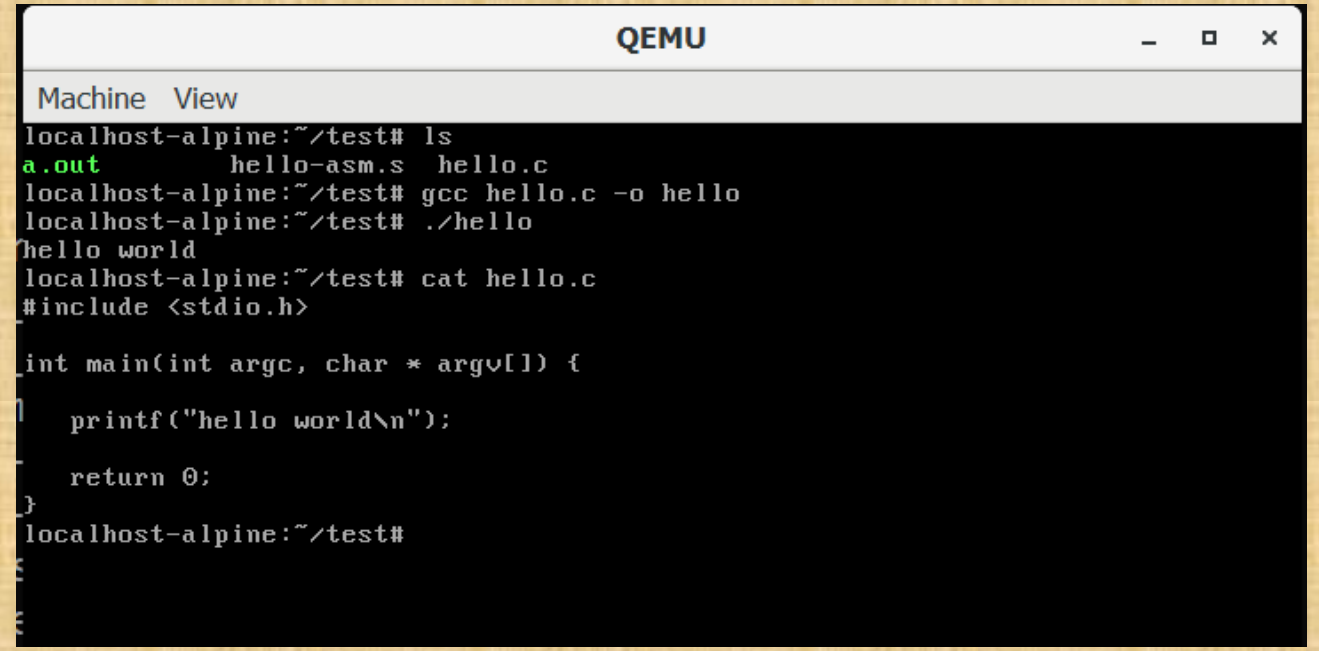
https://alpinelinux.org/

Some Screenshots Running QEMU



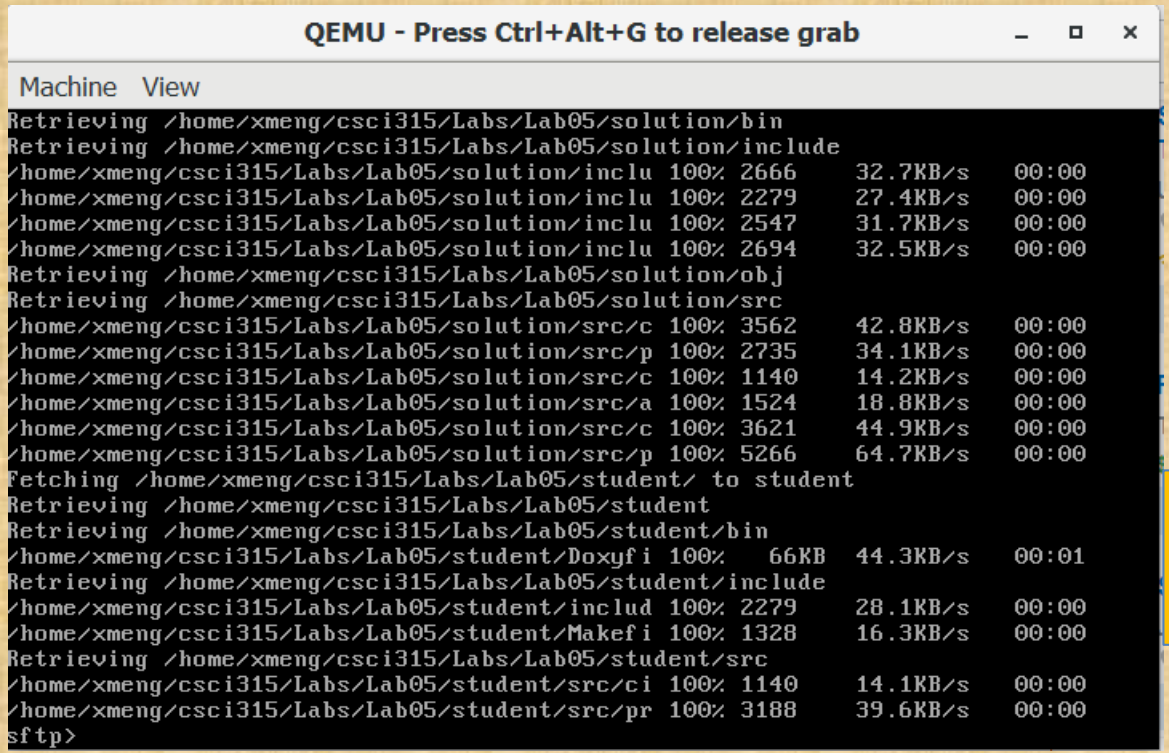
booting up Alphine Linux on my Windows computer under QEMU

Some Screenshots Running QEMU



compiling and running hello.c

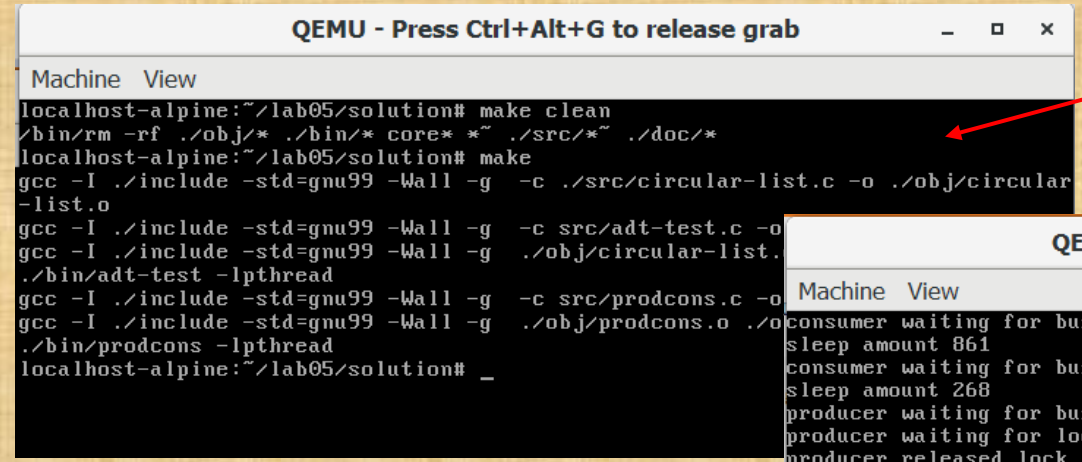
Some Screenshots Running QEMU



retrieving files from linuxremote

```
sftp user@linuxremote.bucknell.edu
cd csci315/lab05
mget  -r  *
```

Some Screenshots Running QEMU



compiling lab05 on QEMU

running lab05 on QEMU