

# Virtualization and Abstractions

The background of the slide features a photograph of the Alma Mater statue at the University of Illinois, which is a central figure in a long, flowing gown with her arms outstretched. The statue is set against a backdrop of trees with bare branches. The entire image is overlaid with a semi-transparent red filter.

**CS 240 - The University of Illinois**

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# Operating Systems: A Great Illusionist

★ So far, the Operating System has done an amazing job:

- As a process, it appears that we have \_\_\_\_\_.
- ...and has \_\_\_\_\_!

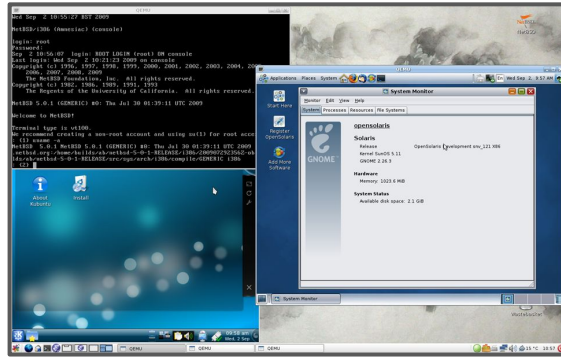
★ Do we really need more abstraction??

# Big Idea: The OS is an illusionist



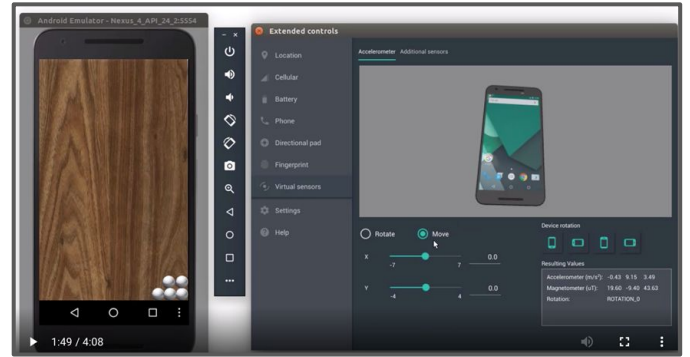
## Hardware Platform Virtualization

Running hardware platform-specific binaries on different hardware.



## Operating System Virtualization

Running guest operating systems within a host operating system environment (VirtualBox)



## Hardware Virtualization

Mobile development is full of hardware virtualization to test mobile apps in various environments.

# Virtualization

- ★ The goal of all virtualization is to map a \_\_\_\_\_ onto a \_\_\_\_\_:

# Virtualization

- ★ The goal of all virtualization is to map a **virtual machine** onto a **host machine**:
  - All virtual states  $\mathbf{S}_x$  can be represented on the host system as  $\mathbf{H}(\mathbf{S}_x)$ .
  - For all sequence of translations between  $\mathbf{S}_1 \Rightarrow \mathbf{S}_2$ , there's a sequence of operations that map  $\mathbf{H}(\mathbf{S}_1) \Rightarrow \mathbf{H}(\mathbf{S}_2)$ .

# A Virtual “Machine”

★ A “machine” is:

# A Virtual “Machine”

- ★ A “machine” is: **any entity that provides an interface:**
  - **Language Virtualization**
  - **Process Virtualization**
  - **System Virtualization**

# A Virtual “Machine”

- ★ A “machine” is: **any entity that provides an interface:**
  - **Language Virtualization**
    - Machine := Entity that provides the API
  - **Process Virtualization**
    - Machine := Entity that provides the ABI
  - **System Virtualization**
    - Machine := Entity that provides the ISA



# Language Virtualization

The image features a large crowd of people, mostly seen from the back, gathered around a central statue. The statue depicts a woman in a long, flowing dress, standing on a pedestal. The background is filled with the bare branches of trees, suggesting an outdoor setting. The entire scene is overlaid with a semi-transparent red filter. The text 'Language Virtualization' is prominently displayed in the center in a bold, white, sans-serif font.

# Language Virtualization Example

Initial State ( $S_1$ ):

Transition ( $S_1 \Rightarrow S_2$ ):

**System #1**

COPY r1 1  
SHIFTL x 2  
ADD x r1

**System #2**

COPY r1 x  
SHIFTL x  
SHIFTL x  
ADD x r1

**System #3**

COPY r1 x  
ADD r1 x  
ADD r1 x  
ADD r1 x  
ADD r1 x

Final State ( $S_2$ ):

# Process Virtualization

A photograph of a crowd of people gathered around a statue of a woman in a long dress, set against a background of bare trees. The entire image is overlaid with a semi-transparent orange filter. The text "Process Virtualization" is centered in white.

# Process Virtualization Example

Initial State ( $\mathbf{S}_1$ ):

Transition ( $\mathbf{S}_1 \Rightarrow \mathbf{S}_2$ ):

Final State ( $\mathbf{S}_2$ ):

# System Virtualization

A photograph of a crowd of people gathered around a statue of a woman in a long dress, set against a background of trees. The entire image is overlaid with a semi-transparent orange filter. The text "System Virtualization" is centered in white.

# System VMs

★ Type 1 Hypervisor

# System VMs

## ★ Type 1 Hypervisor

- Implement **on bare hardware**
- Most efficient,
- Must support hardware emulation (drivers), and
- Replaces any OS hosted on the bare hardware.

# System VMs

★ Type 2 Hypervisor



# System VMs

## ★ Type 2 Hypervisor

- Implement a VMM **on top of a host OS:**
- Less efficient,
- Leverages the OS drivers and hardware abstractions, and
- Easy to install on top of the host OS.

# System VMs

★ How has this changed our industry?

# Midterm Exam

A photograph of a crowd of people gathered around a statue of a woman in academic regalia, with the text "Midterm Exam" overlaid in white. The scene is set outdoors, likely on a university campus, with trees and a building visible in the background. The image has a strong orange-red color cast. The statue is the central focus, with the crowd of people surrounding it. The text "Midterm Exam" is prominently displayed in the center of the image.



# Cloud-Scale Abstractions

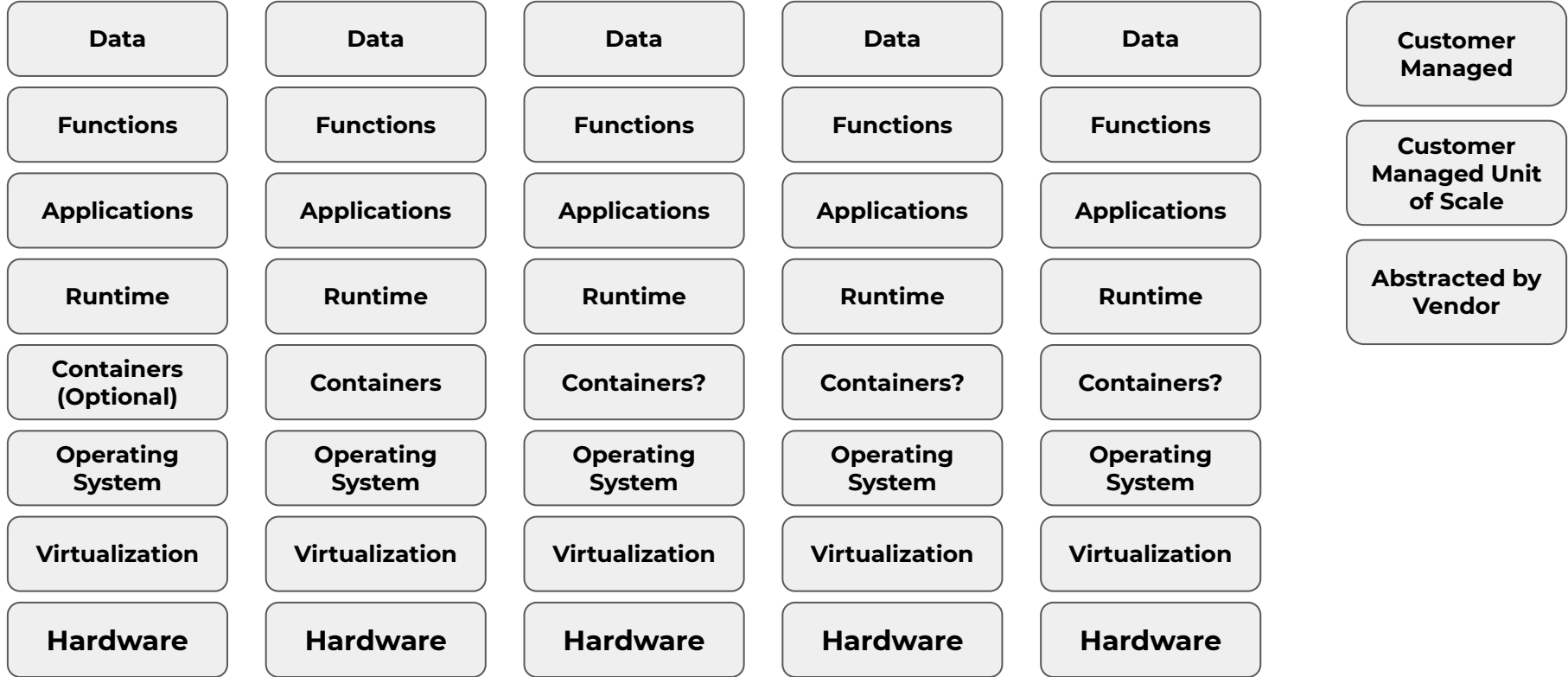
# IaaS

# CaaS

# PaaS

# FaaS

# SaaS



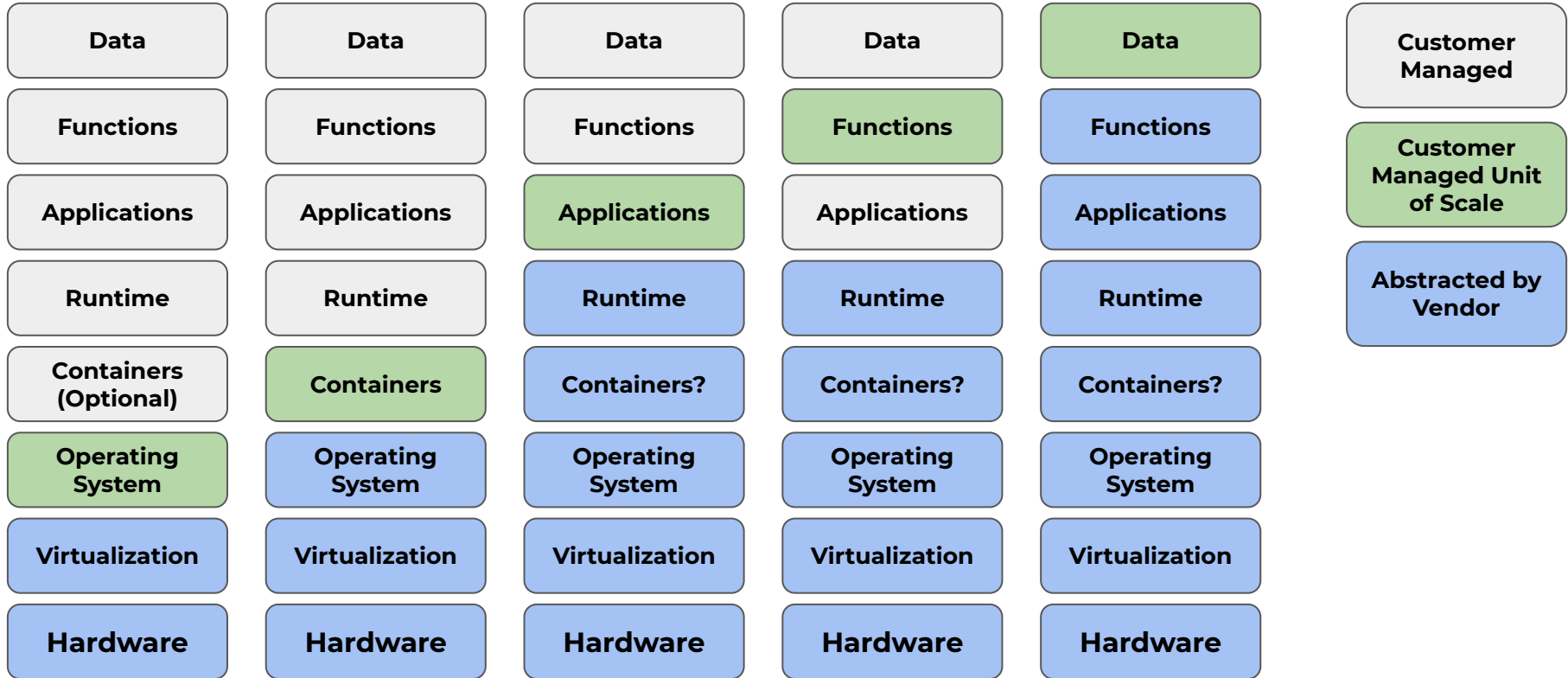
# IaaS

# CaaS

# PaaS

# FaaS

# SaaS



# Infrastructure as a Service (IaaS)

# Containers as a Service (CaaS)

Containers provide an \_\_\_\_\_ of a system that can be deployed in an isolated environment on heterogeneous systems.

Key Technology:



# Docker Containers

Container Developer:

Container User:

```
1 FROM gcc:latest
2 COPY ./docker/entrypoint.sh /
3 RUN chmod +x entrypoint.sh
4 ENTRYPOINT ["/entrypoint.sh"]
```

```
docker build --tag mp3-docker .
```

```
1 docker run -it --rm -v "pwd" :/mp3  
mp3-docker "make"
```

```
1 docker run --rm -it -p 27017:27017 mongo
```