

# Intro: What is a System?



COS 316: Principles of Computer System Design

<https://cos316.princeton.edu/>

<https://princeton.zoom.us/j/99476809145>

Lecture 1

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- Today: Systems!



- Next time:



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## Example Systems

- Operating system (OS) kernel
- The Internet
- Database
- Distributed file system
- Web framework
- Game engine

You make it fun,  
we make it run!



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## What is a System?

- Provides an interface to underlying resources
- Mediates access to shared resources
- Isolates applications
- Abstracts complexity
- Abstracts differences in implementation

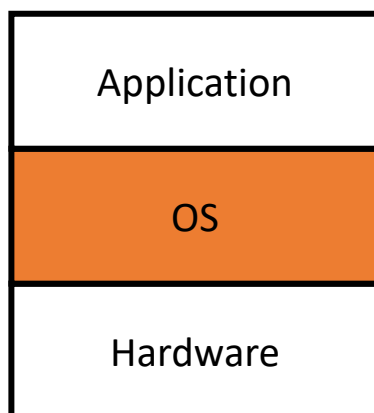
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## Example System: OS Kernel

- Interface: system calls
- Underlying resources: hardware (CPU, memory, network, disk)
- Isolation: Firefox, terminal, zoom, ... don't worry about each other
- Abstraction: Collection of system calls
  - Instead of specific protocols for using specific devices
  - Don't need to rewrite Firefox to display on new monitors, or save to new disks, or ...

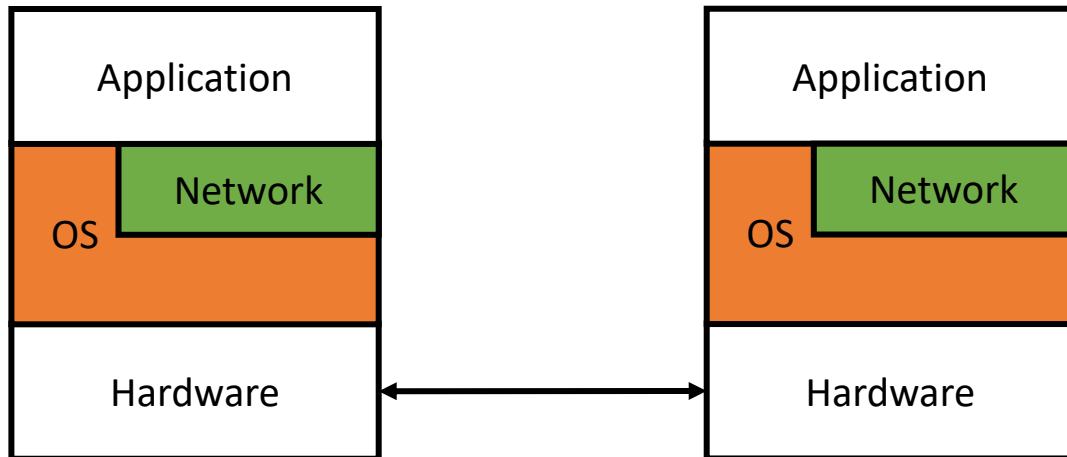
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## Systems Stack (terminal)



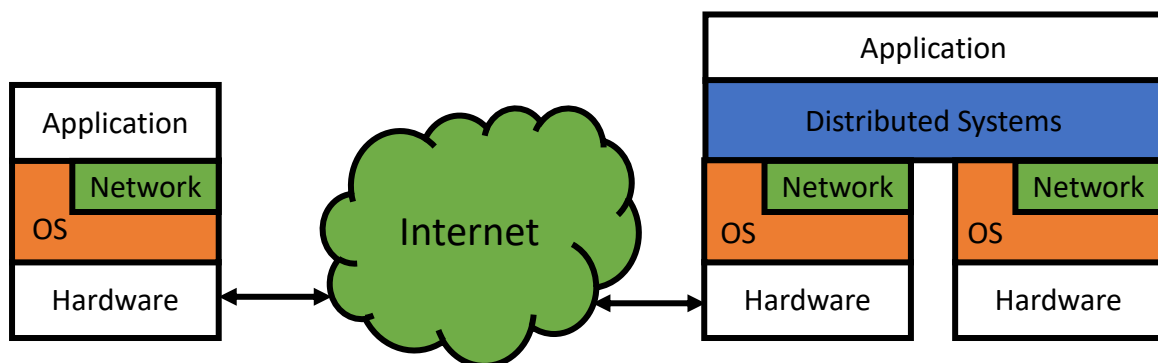
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## Systems Stack (Firefox)



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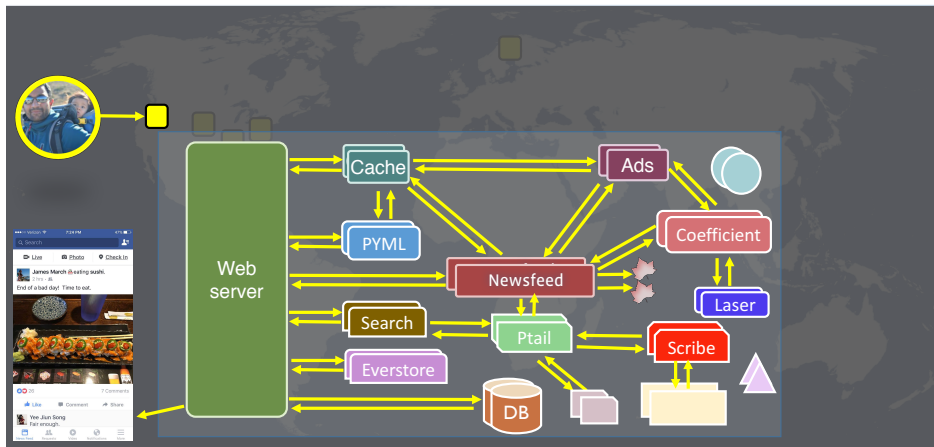
## Systems Stack (Firefox to Google)



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## So Many Systems...

Each user request touches hundreds of systems

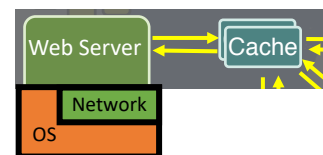


[Slide from Kaushik Veeraraghavan Talk's on Kraken at OSDI 2016]

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## Systems Are Everywhere!

- People use applications
  - Applications are built on systems
  - On systems on systems on systems...
- If you're building applications
  - Useful to understanding underlying systems
    - What could be causing X?
    - Why can't they do Y?
    - What can I trust Z to do or not?
- If you're building systems 😊
  - That's what this is all about!
  - Useful to understanding your underlying systems



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## Why Are Systems Challenging? Part-1a

- **Correctness**
  - Incorrect system => incorrect applications
  - Correctly implement interface's guarantees
- **Performance**
  - Slow system => slow applications
  - Make system fast enough
- **Security**
  - Insecure system => insecure applications
  - Build security into the system



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## Why Are Systems Challenging? Part-1b

- Distributed storage system that keeps data forever (e.g., videos)
- **Correctness**
  - Accurately retain data forever. Really delete data on deletes.
- **Performance**
  - Fast and highly concurrent.
- **Security**
  - Only allow authorized users to retrieve data

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## Why Are Systems Challenging? Part-2a

- How general should an interface be?
  - More general => supports more application-level functionality
  - Less general => easier to implement, easier correctness, better performance, easier security
- How portable should an interface be?
  - More portable => supports more underlying resources
  - Less portable => ...
- Design tradeoffs!

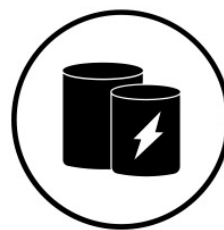


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## Why Are Systems Challenging? Part-2b

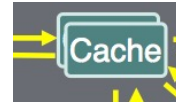


- Distributed cache that provides fast access to popular data
- How **general** should an interface be?
  - Read(key)
  - Write(key, value)
  - Read\_transaction(<keys>)
  - Write\_transaction(<keys>)
  - Read\_and\_write\_transaction(<read\_keys>, <write\_keys>)
  - ...
- Design tradeoffs!

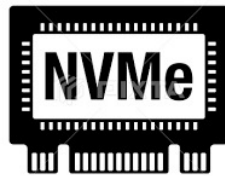
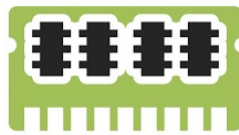


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## Why Are Systems Challenging? Part-2c



- Distributed cache that provides fast access to popular data
- How **portable** should an interface be?



- Design tradeoffs!

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## General vs Portable Interfaces

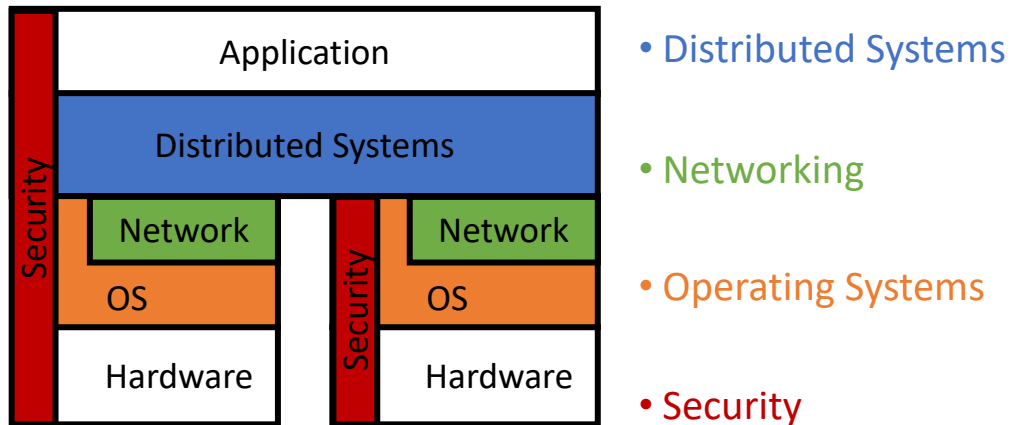


- Cache A:
  - Read, Write on DRAM, SSD, NVM, HDD
- Cache B:
  - Read, Write, Read Transaction, Write Transaction on SSD
- Which cache is more general? More portable?
- PL Example: Javascript vs Assembly?

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## Systems We Will Cover In This Class



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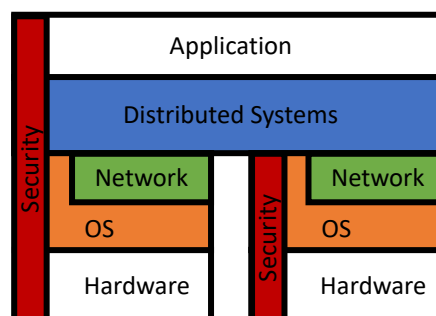
## Why Do I Love Systems?!

- Work on the “hard” problems, so applications don’t have to
- Correctness as a puzzle: reason through all corner cases
- Performance is a different type of puzzle:
  - Where are bottlenecks, how to speed them up?
- Art of reasoning about tradeoffs: e.g., Interface vs. Performance
- Multiplicative impact: improving systems improves all apps built on them

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## Summary

- Systems abstract underlying resources
- Systems are **everywhere**
- Systems are challenging and interesting and cool
- This class is about systems: details next lecture



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## Mini-Logistics: More in the Next Lecture

- Lectures
  - In person, live on zoom, and recorded
  - ... especially during the first few weeks of the term
  - Slides available online
- Precepts on Thursday
  - Create your GitHub account (using your Princeton email address)
  - Install the virtual machine
  - Bring your laptop to precept!
- Ed discussions



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