Cornell University

Introduction

CS 4410

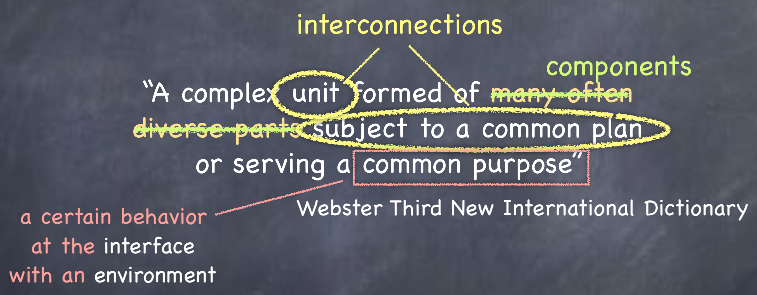
We study a system

What is a system?

"A complex unit formed of many often
diverse parts subject to a common plan
or serving a common purpose"

Webster Third New International Dictionary

What is a system?



interconnections

components

"A complex unit formed of ~~many often~~
~~diverse parts~~ subject to a common plan
or serving a common purpose"

Webster Third New International Dictionary

a certain behavior
at the interface
with an environment

"A set of interconnected components
with an expected behavior observed at
the interface with its environment"

Common systems challenges

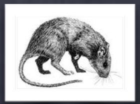
- Emergent properties
- Propagation of effects
- Incommensurate scaling
- Trade-offs

Propagation of effects

To improve ride experience, change wheels from 14” to 16”

- □ Redesign wheel well
- □ Redesign trunk for bigger spare wheel
- □ Move back seat slightly forward
- □ Thin back seat
- □ Stiffen rear springs
- □ Change speedometer gearing
- □ …

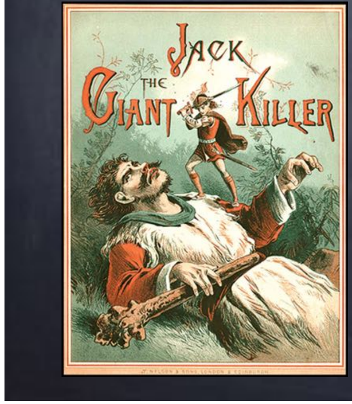
Propagation of effects: fighting malaria



- WHO sprayed villages in N. Borneo with DDT
- Wiped out mosquitos, but…
- Roaches collected DDT in tissue
- Lizard ate roaches, and became slower
- Easy target for cats
- DDT cause cats to die
- Forest rats moved into villages
- Rats carried the bacillus of the plague!

Incommensurate scaling

As the system increases in size or speed, not all components can manage the scale, and things break down



10x higher than Jack!

but also 10x wider and thicker!

About 1000x Jack’s weight — but their cross section of their bones was only 100x Jack’s

A human thigh bone breaks at about 10x human weight

The giant would have broken his thighs every time he was taking a step!

On being the right size
J.B.S. Haldane

Inevitable Trade-offs

Speed vs power in processors

Bandwidth vs computation in compression

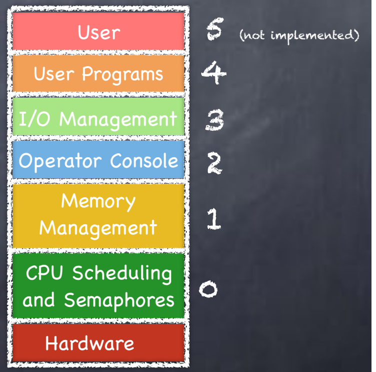
Space vs time almost everywhere

A pawn vs better position in chess

...

How to Manage Complexity

- Modularity
  - □ Good modularity minimizes connections between components
- Abstraction
  - □ Separate interface from internals; separate specification from implementation
- Hierarchy/Layering
  - □ Constrain interactions so they are easier to understand

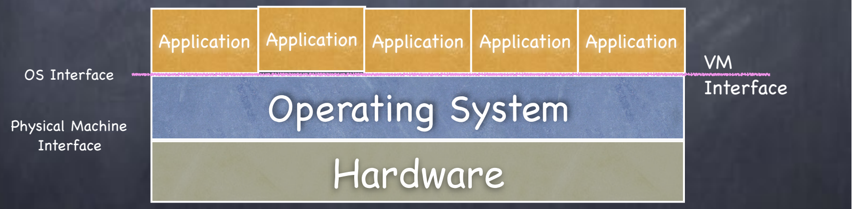


THE Operating system

EWD 196, 1965

What is an OS?

- An Operating System implements a virtual machine whose interface is more convenient* that the raw hardware interface



* easier to use, simpler to code, more reliable, more secure...

OS wears many hats

- Referee
  - □ Manages shared resources: CPU, memory, disks, networks, displays, cameras...
- Illusionist
  - □ Look! Infinite memory! Your own private processor!
- Glue
  - □ Offers a set of common services (e.g., UI routines)
  - □ Separates apps from I/O devices

OS as Referee

Resource allocation

- □ Multiple concurrent tasks, how does OS decide who gets how much?

Isolation

- □ A faulty app should not disrupt other apps or OS

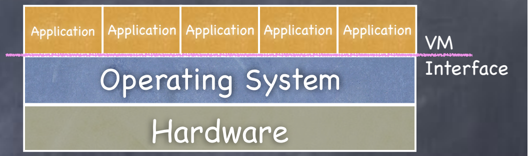
Communication/Coordination

- □ Apps need to coordinate and share state

OS as Illusionist

Appearance of resources not physically present

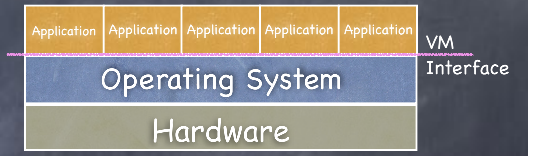
- Virtualization
  - □ Processor, memory, screen space, disk, network

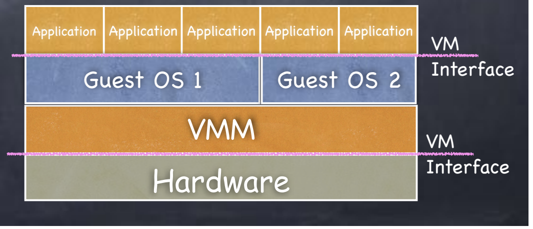


OS as Illusionist

Appearance of resources not physically present

- Virtualization
  - □ Processor, memory, screen space, disk, network
  - □ The entire computer
    - Fooling the OS itself!
    - Eases debugging, portability, isolation





OS as Illusionist

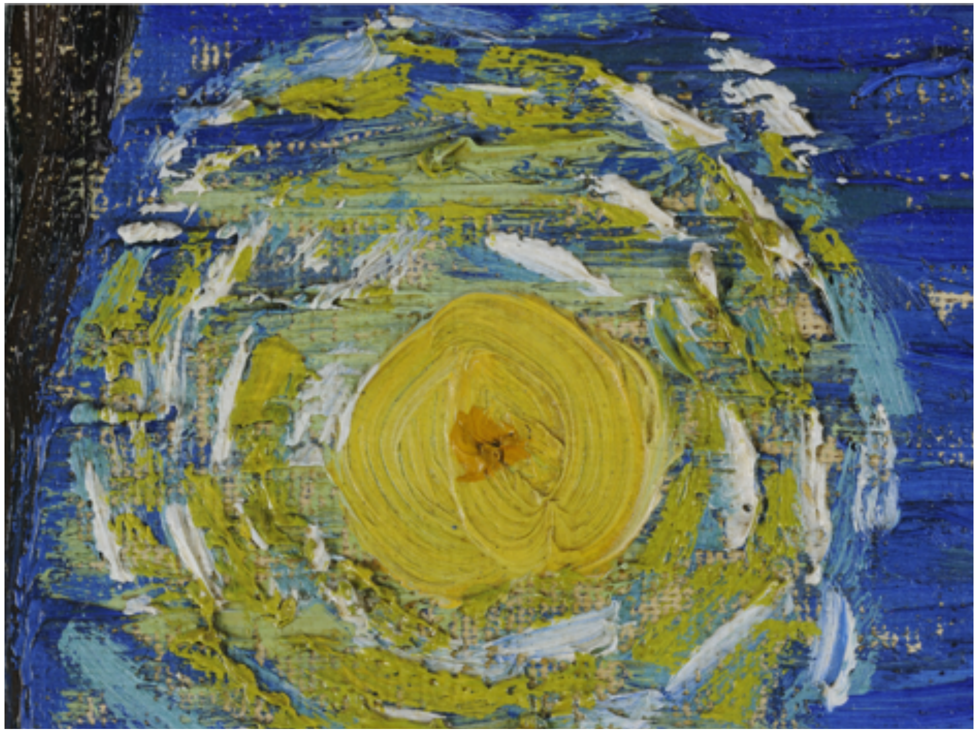
Appearance of resources not physically present

- Atomic operations
  - □ HW guarantees atomicity at the word level…
    - What happens during concurrent updates to complex data structures?
    - What is a computer crashes while writing a file block?
  - □ At the hardware level, packets are lost
    - Reliable communication channels

OS as Glue

- Offers standard services to simplify app design and facilitate sharing
  - □ Send/Receive byte streams
  - □ Read/Write files
  - □ Pass messages
  - □ Share memory
  - □ UI
- Decouples HW and app development

What will the course be like?



Painting[*]	Building OS
□ Order	□ Reliability
□ Design	□ Availability
□ Tension	□ Portability
□ Balance	□ Efficiency
□ Harmony	□ Security

[*] Sondheim: Sunday in the Park with George

Issues in OS Design

- Structure: how is the OS organized?
- Concurrency: how are parallel activities created and controlled?
- Sharing: how are resources shared?
- Naming: how are resources named by users?
- Protection: how are distrusting parties protected from each other?
- Security: how to authenticate, authorize, and ensure privacy?
- Performance: how to make it fast?

More Issues in OS Design

- Reliability: how do we deal with failures??
- Portability: how to write once, run anywhere?
- Extensibility: how do we add new features?
- Communication: how do we exchange information?
- Scale: what happens as demands increase?
- Persistence: how do we make information outlast the processes that created it?
- Accounting: who pays the bill and how do we control resource usage?