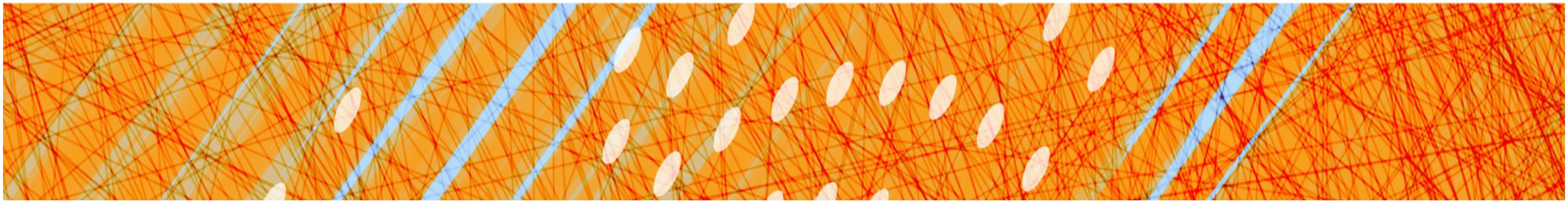


Introduction (Chapter 1)

CS 4410
Operating Systems

Cornell CIS
COMPUTING AND INFORMATION SCIENCE

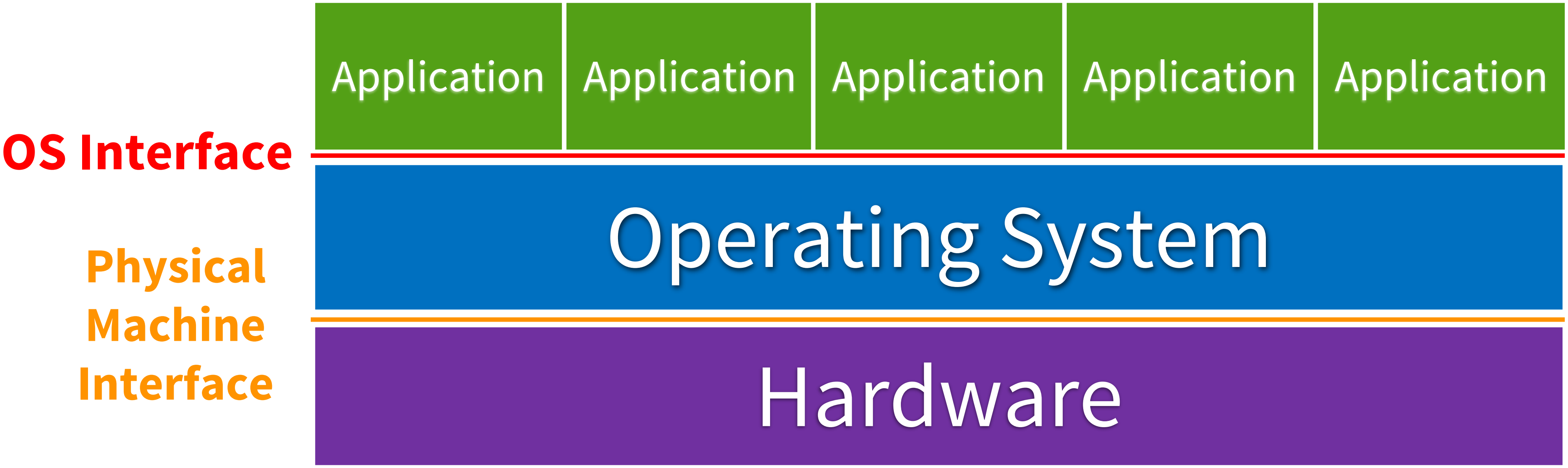
[R. Agarwal, L. Alvisi, A. Bracy, M. George, E. Sirer, R. Van Renesse]

Meet the OS

- Software that manages a computer’s resources
- Makes it easier to write the applications you want to write
- Makes you want to use the applications you wrote by running them efficiently

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...

"All the code you did not write"

OS wears many Hats

Referee

- Manages shared resources: CPU, memory, disks, networks, displays, cameras, *etc.*

Illusionist

- Look! Infinite memory! Your own private processor!

Glue

- Offers 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
- OS must export less than full power of underlying hardware

Communication/Coordination

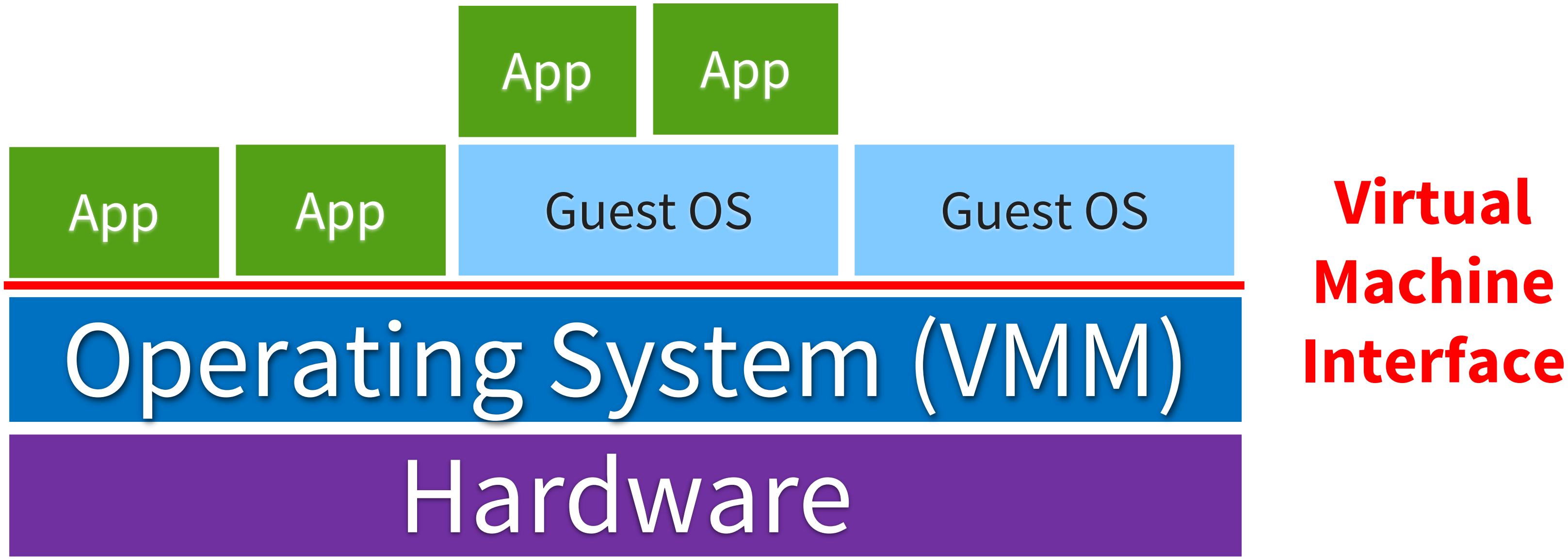
- Apps need to coordinate and share state
- Web site: select ads, cache recent data, fetch/merge data from disk, *etc.*

OS as Illusionist (1)

Illusion of resources not physically present

Virtualization:

- processor, memory, screen space, disk, network
- the entire computer:
  - fooling the illusionist itself!
  - ease of debugging, portability, isolation



OS as Illusionist (2)

Illusion of resources not physically present

- Atomic operations
  - HW guarantees atomicity at word level
    - what happens during concurrent updates to complex data structures?
    - what if computer crashes during a block write?
  - 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 of byte streams
- read/write files
- pass messages
- share memory
- UI

Decouples HW and app development

Why Study Operating Systems?

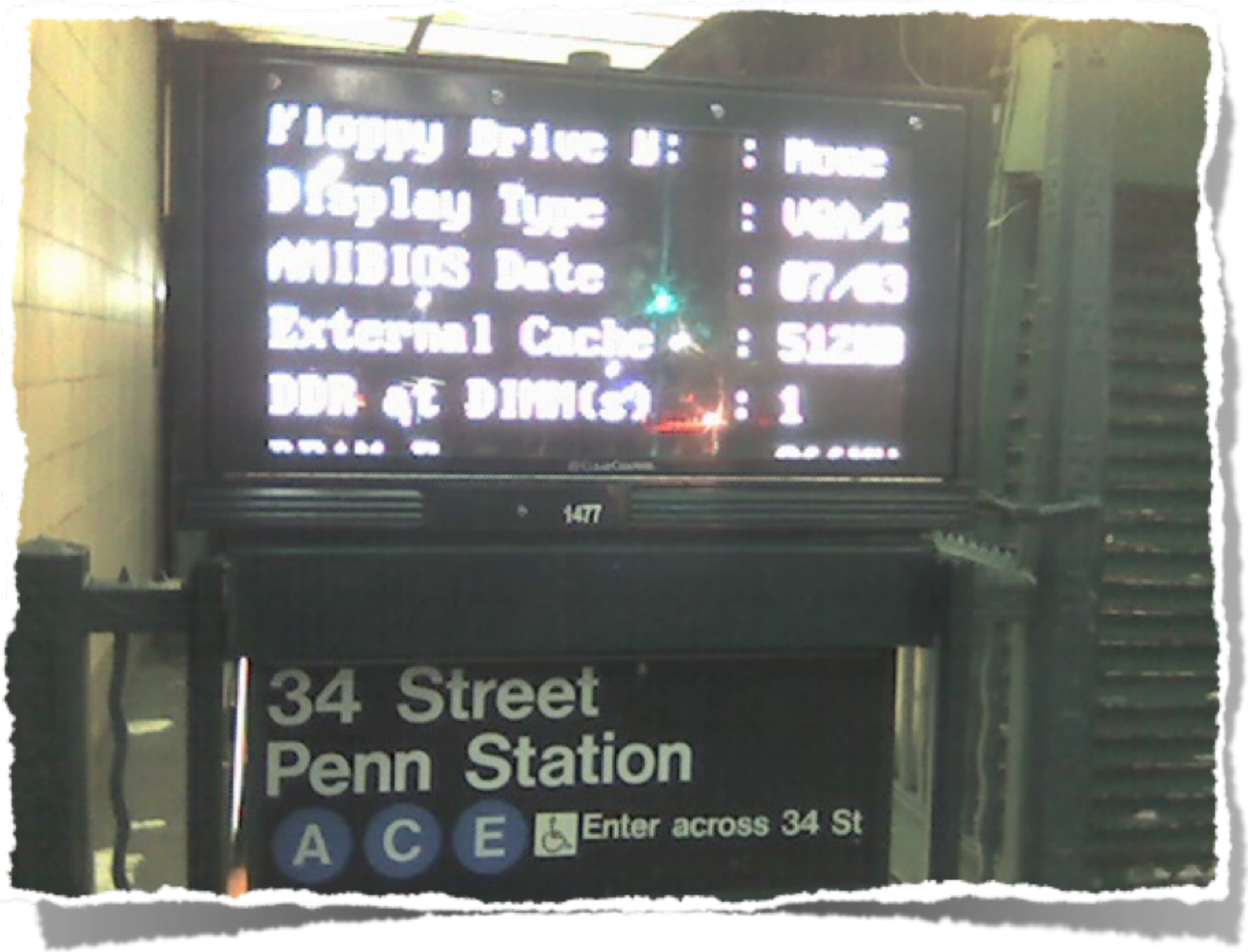
To Learn:

- **How to manage complexity** through appropriate abstractions
  - infinite CPU, infinite memory, files, locks, *etc.*
- **About design**
  - performance vs. robustness, functionality vs. simplicity, HW vs. SW, etc.
- **How computers work**

Because OSs are everywhere!

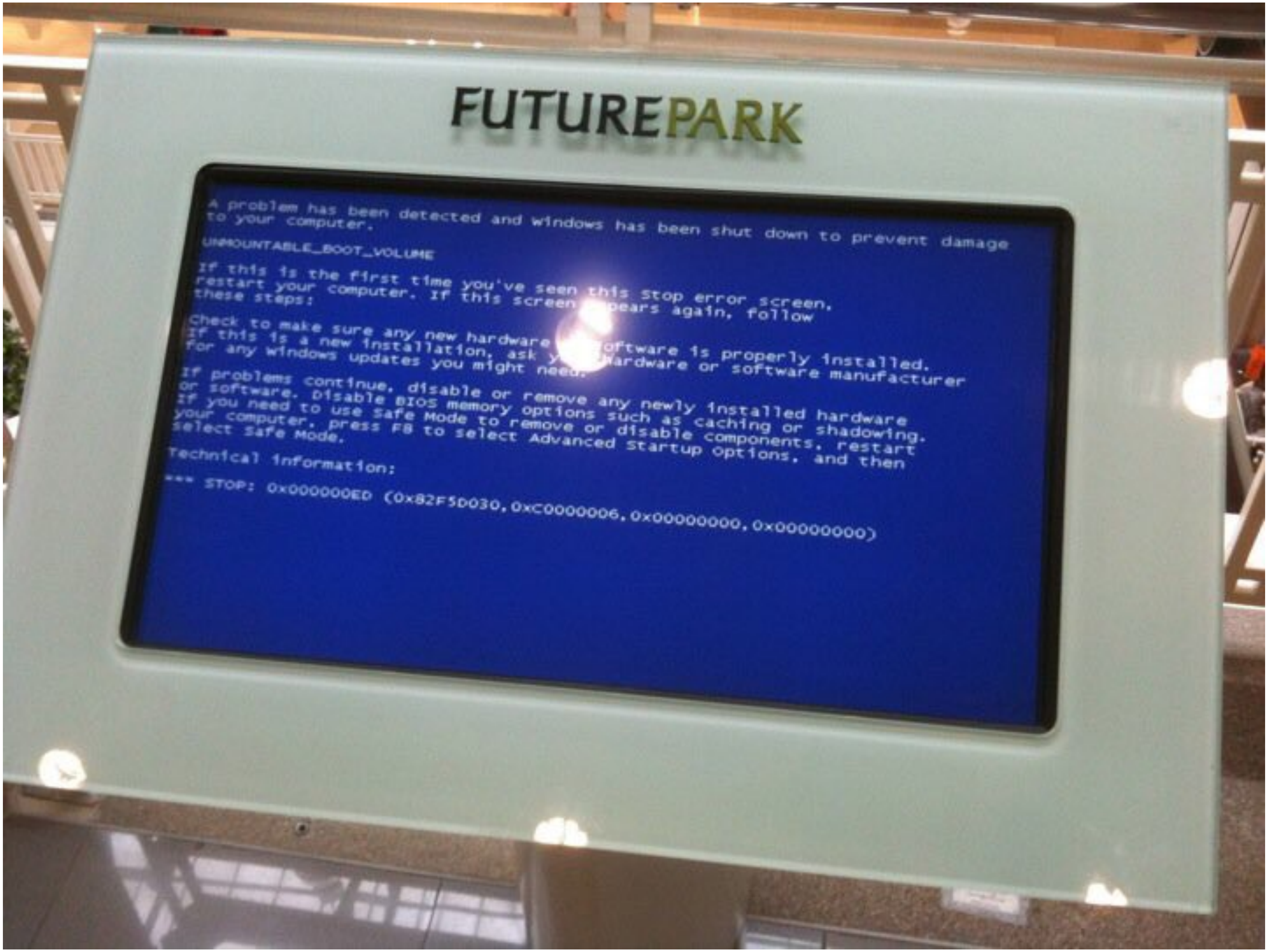
```
*** STOP: 0x00000077 (0xC0000185,0xC0000185,0x
KERNEL_STACK_INPAGE_ERROR

If this is the first time you've seen this Stop error scree
restart your computer. If this screen appears again, follo
these steps:

Check to make sure any new hardware or software is properl
If this is a new installation, ask your hardware or softwa
for any Windows 2000 updates you might need.

If problems continue, disable or remove any newly installe
or software. Disable BIOS memory options such as caching o
If you need to use Safe Mode to remove or disable componen
your computer, press F8 to select Advanced Startup Options
select Safe Mode.

Refer to your Getting Started manual for more information o
troubleshooting Stop errors.
```

Where’s the OS?
Las Vegas

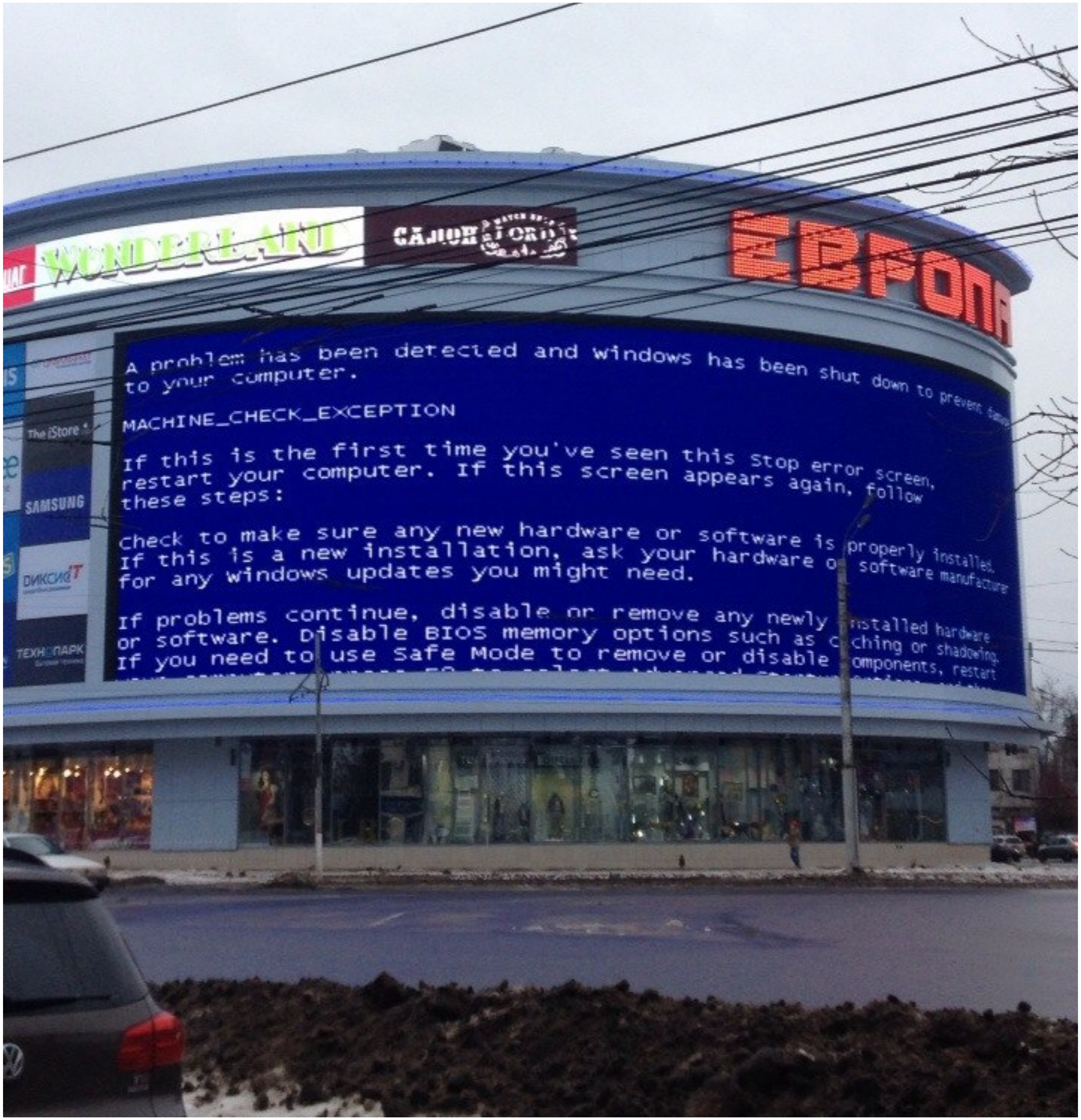


```
Floppy Drive B:    : None
Display Type       : VGA/E
AMIBIOS Date       : 07/03
External Cache     : 512KB
DDR at DIMM(s)     : 1
```

Where's the OS?
New York



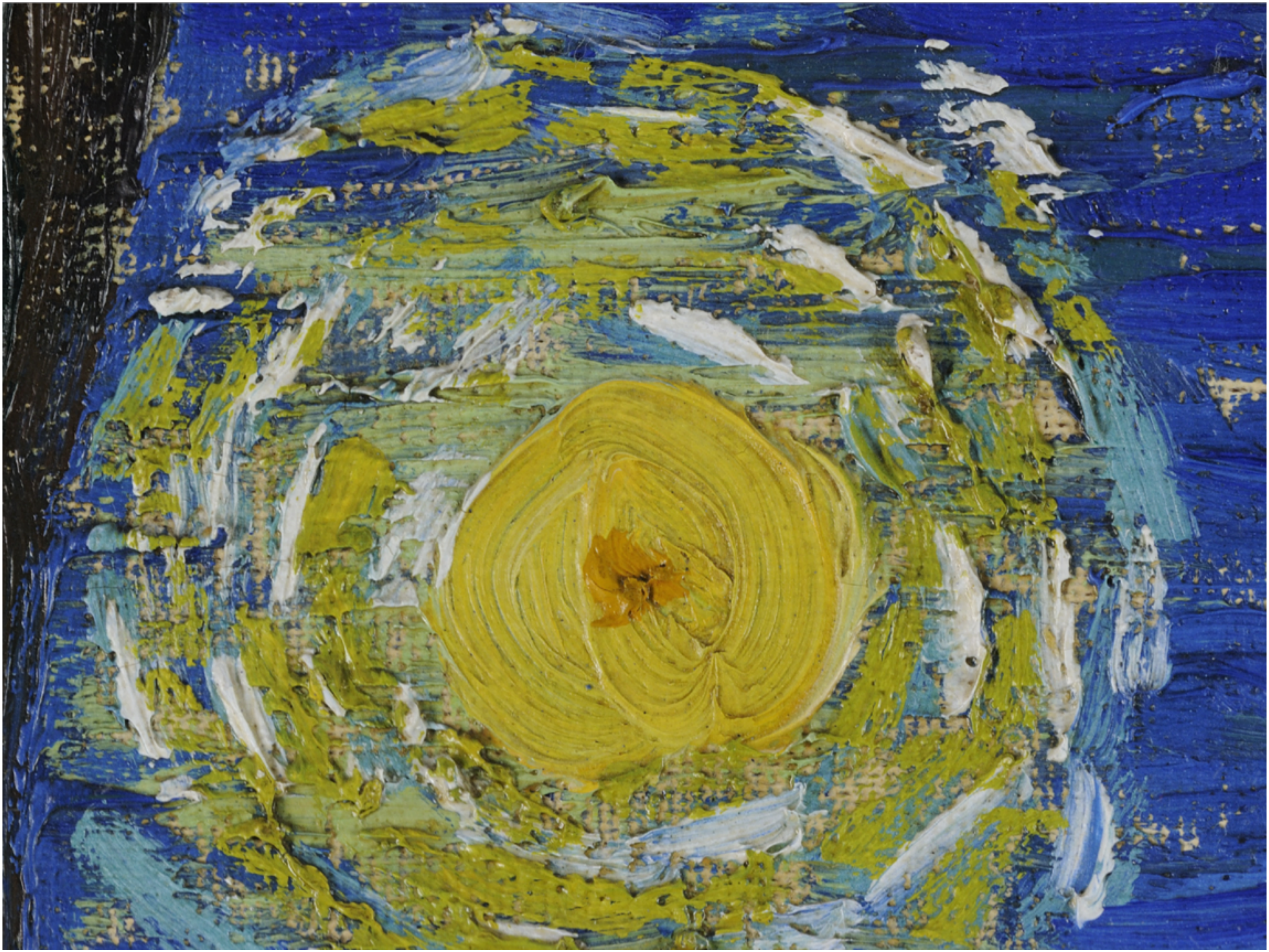
```
A problem has been detected and windows has been shut down to prevent damage
to your computer.

UNMOUNTABLE_BOOT_VOLUME

If this is the first time you've seen this Stop error screen,
restart your computer. If this screen appears again, follow
these steps:

Check to make sure any new hardware or software is properly installed.
If this is a new installation, ask your hardware or software manufacturer
for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware
or software. Disable BIOS memory options such as caching or shadowing.
If you need to use Safe Mode to remove or disable components, restart
your computer, press F8 to select Advanced Startup Options, and then
select Safe Mode.

Technical information:

*** STOP: 0x000000ED (0x82F5D030,0xC0000006,0x00000000,0x00000000)
```



```
A problem has been detected and windows has been shut down to prevent damage
to your computer.

MACHINE_CHECK_EXCEPTION

If this is the first time you've seen this Stop error screen,
restart your computer. If this screen appears again, follow
these steps:

Check to make sure any new hardware or software is properly installed.
If this is a new installation, ask your hardware or software manufacturer
for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware
or software. Disable BIOS memory options such as caching or shadowing.
If you need to use Safe Mode to remove or disable components, restart
```

continue, disable or rem
Disable BIOS memory opt
Mode to remo
to select Ad
formation:
0x00000004, 0x0
h dump ...
ash dump ...
ata for crash dump...
disk for crash dump...
STADIUM

What will this course be like?



What kind of a course is this?

Constructive, top-down

Start from first principles and re-derive the design of every component of a complex system

Deconstructive, bottom-up

Dissect existing systems, learn what tradeoffs they make, what patterns they use

Painting*

- Order
- Design
- Tension
- Balance
- Harmony

System Building

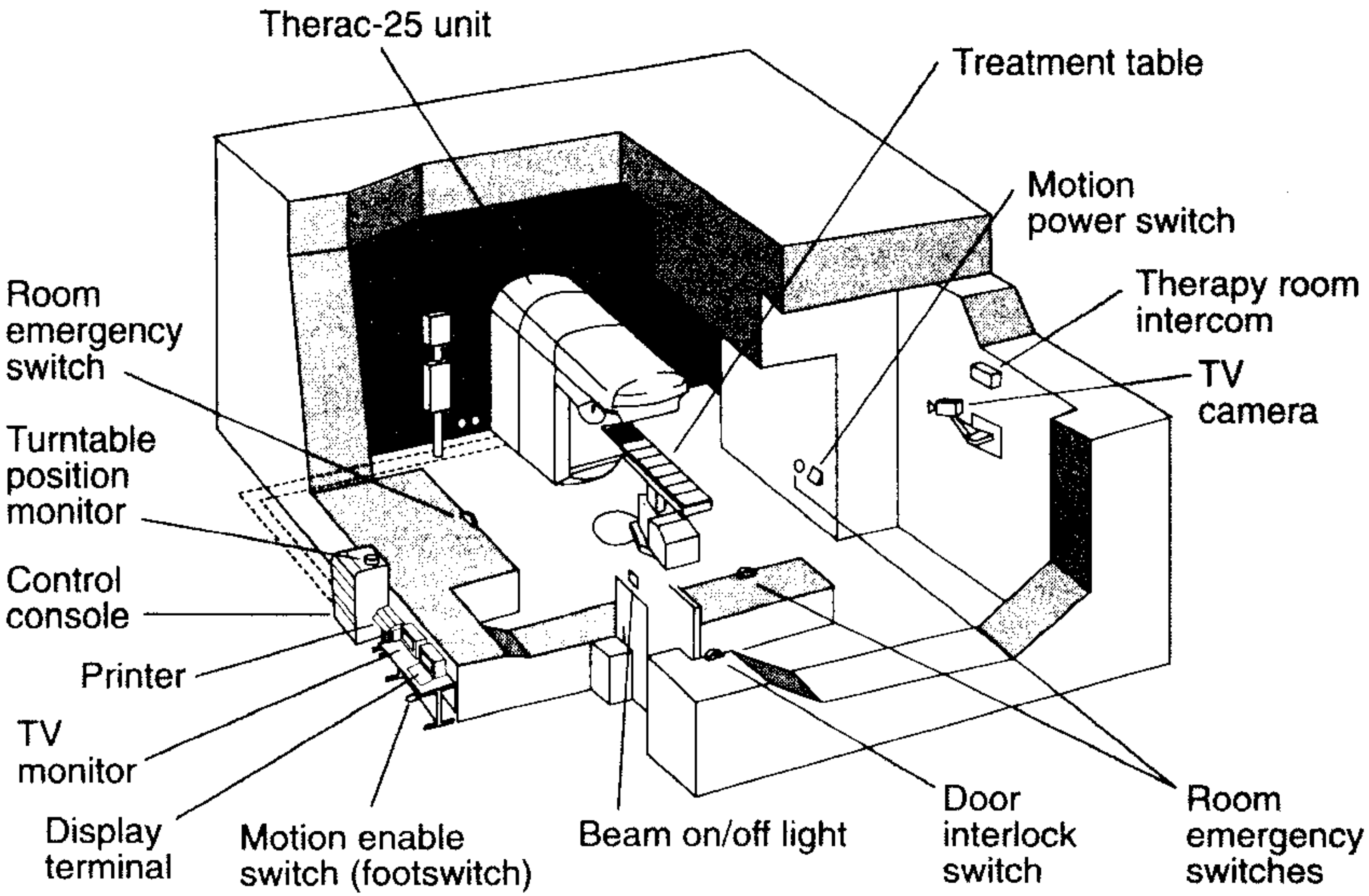
- Reliability
- Availability
- Portability
- Efficiency
- Security

System Building is Hard!

* Sondheim: Sunday in the Park with George

Therac-25 [1982]

- Safety-critical system with software interlocks
- Beam controlled entirely through a custom OS



Therac-25

- Old system used a hardware interlock
  - Lever either in the “zap” or “x-ray” position
- New system was computer controlled
- A synchronization failure was triggered when competent nurses used the back arrow to change the data on the screen “too quickly”

Therac-25 Outcome

- Beam killed one person directly, burned others, and may have given inadequate treatment to cancer patients

- Problem was very difficult to diagnose; initial fix involved removal of the back arrow key from the keyboard

- People died because a programmer could not write correct code for a concurrent system

- 36 Year Later…. Now what?

System Building is Hard

- We do not have the necessary technologies and know-how to build robust computer systems

- The world is increasingly dependent on computer systems
  - Connected, networked, interlinked

- There is huge demand for people who deeply understand and can build robust systems (most people don’t and can’t)

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?

What’s this course about?

Ostensibly, operating systems

- architecting complex software
- identifying needs and priorities
- separating concerns
- implementing artifacts with desired properties

In Reality, software design principles

- OSes happen to illustrate organizational principles and design patterns

This is a Capstone Course. Get Ready!