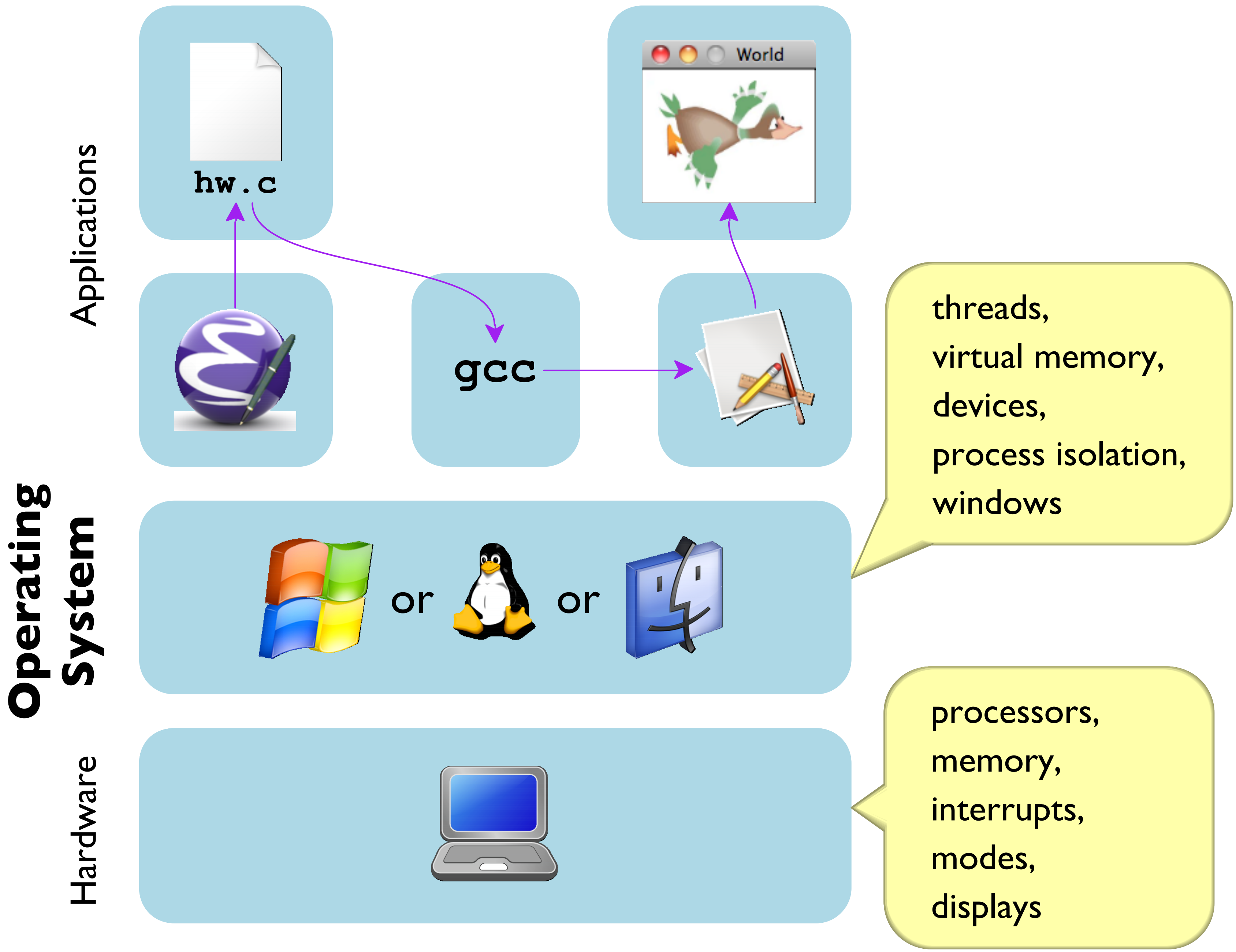
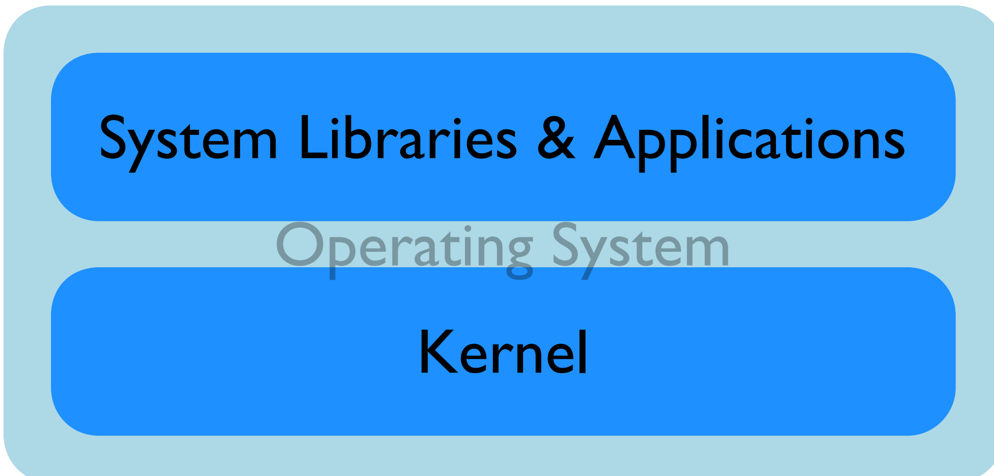

Applications
Operating System
Hardware
hw.c
World
gcc
or
or
threads,
virtual memory,
devices,
process isolation,
windows
processors,
memory,
interrupts,
modes,
displays

OS vs. Kernel

Operating System

OS vs. Kernel



Kernel Features

- ***Processes*** for running multiple programs/instances
- ***Threads*** for managing CPUs
- ***Virtual memory*** for allocating memory
- ***Sockets*** for networking
- ***Filesystems***† for persistent storage
- ***Device drivers*** for plugging in new functionality
- ***Users and groups*** for controlling permissions
- ***Windows**** for managing screen real esate and input

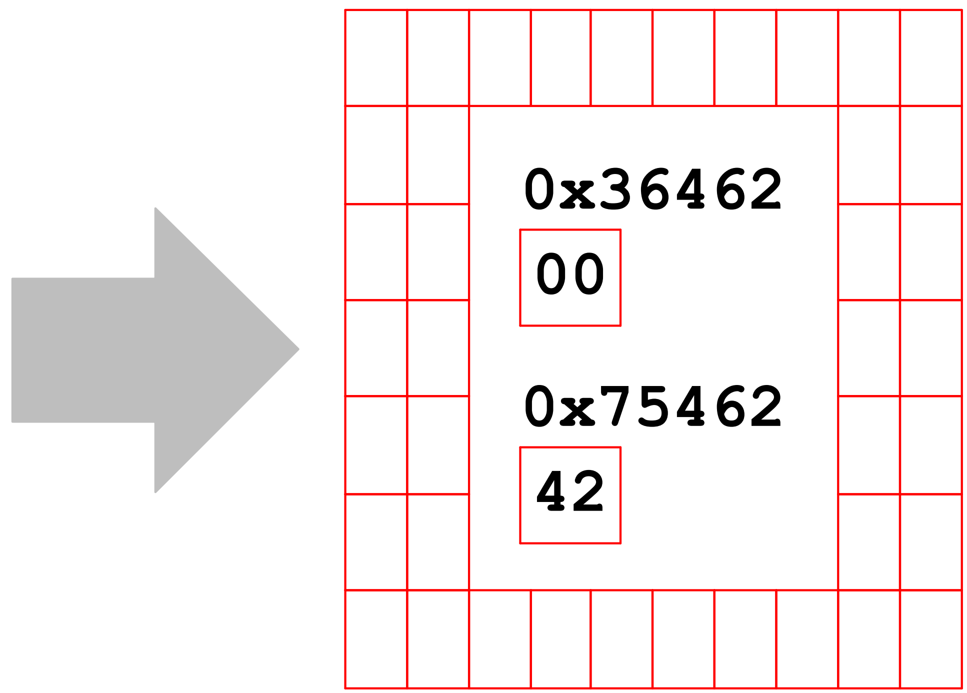
† usually pluggable for different formats and devices

* to varying degrees

Kernel vs. User Code

When you turn on a processor, instructions can do anything: the processor starts in ***prviledged mode***

`mov 42, 0x75462`

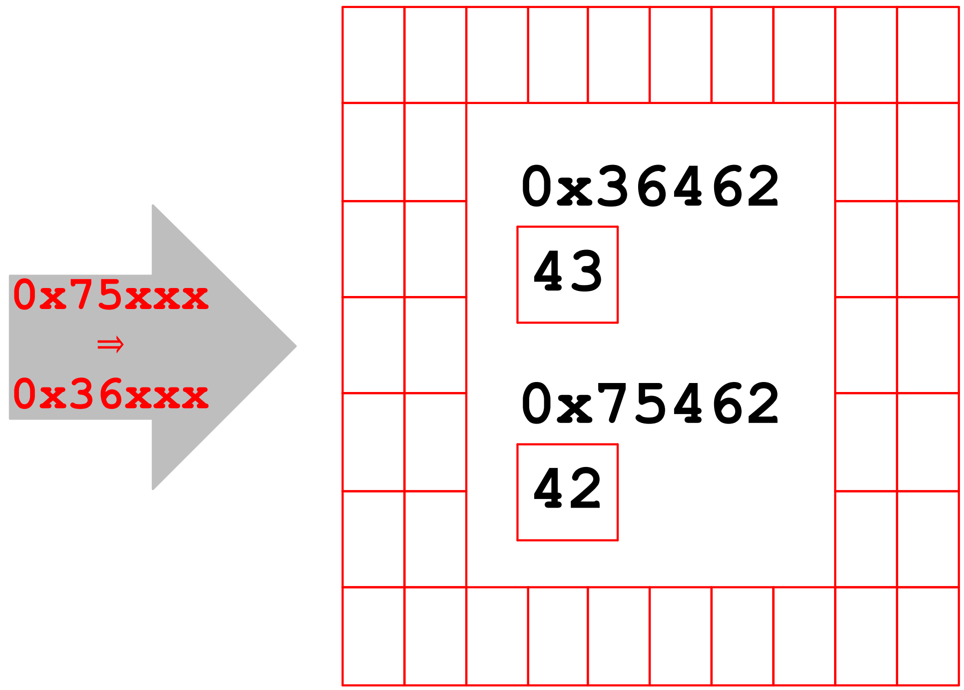


Details here are inspired by x86, but not true-to-life

Kernel vs. User Code

One of the things you can do in prviledged mode is change the way that ***virtual addresses*** are mapped to physical memory

```
mov 43, 0x75462
```

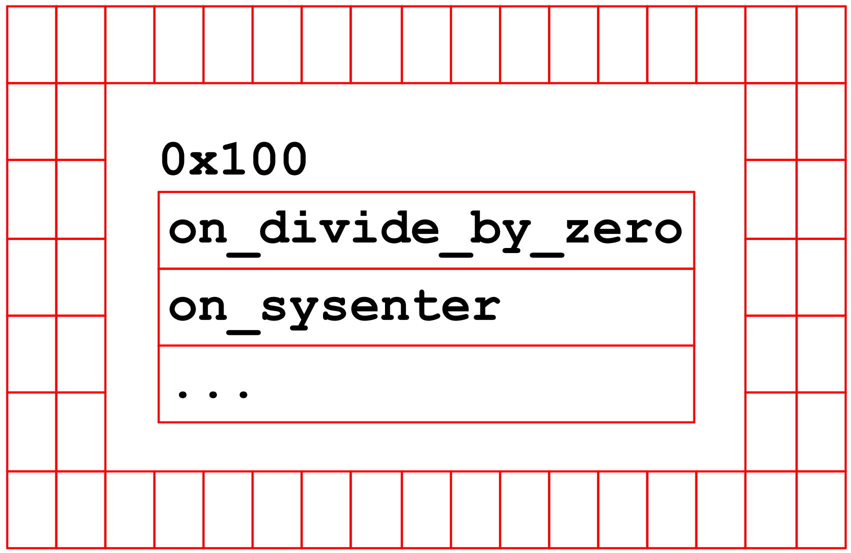


So, you can hide memory from unpriviledged code

but, before you do that...

Kernel vs. User Code

A certain area in memory, not normally made accessible, contains a table of functions called for special events:



The **`sysenter`** instruction jumps to one of those

The jump ignores address remappings and switches back to priviledged mode

Control the table, and you control the way back to priviledged mode

System Calls

A process asks the OS to do something by making a ***system call:***

```
mov $57, %EAX
sysenter
```

This is a kind of function call, while also switching to priviledged mode

Instead of assembly code, you normally use a wrapper C function

System Calls

Some (C wrappers for) typical system calls on Unix:

- create a process: **`fork()`**
- open a file: **`open()`**
- allocate memory: **`mmap()`**
- create a network connection: **`connect()`**

A system call's **`man`** page will say ``**`(2)`**"

Some System Applications

A command-line ***shell*** is just a program:

- It uses **`fork()`** to create new processes

Windows: **`CreateProcess()`**

- A new processes uses **`execve()`** to load a program into the process

Windows: **`CreateProcess()`** does that, too

- The **`execve()`** system call also handles command-line arguments

Windows: **`CreateProcess()`** does that, too

see **`exec.c`**

Some System Applications

A ***desktop GUI*** is just a program:

- It uses **`open()`** to read directory and file information
- It uses other system calls[†] to open windows, draw on them, and receive mouse events

  † or communicates with a semi-priviledged window-manager program

- If you double-click an application, it uses **`fork()`**, etc.

see **`dir.c`**

Some System Applications

A ***debugger*** like **`gdb`** is just a program:

- Of course, it uses **`fork()`** ...
- It uses a system call to attach to a process

Based the process's user, the request may be declined

- It uses various system calls to inspect a process
- It uses various system calls to receive ***signals***
  - e.g., "the process seg faulted"

each process has a table of signal callbacks

see **`signal.c`**

Some System Applications

A ***web browser*** is just a program:

- It uses system calls like **`connect()`** to contact a server
- It uses other system calls[†] to open windows, draw on them, and receive mouse events

  [†] or communicates with a semi-priviledged window-manager program
- It runs Javascript program in the same way that our interpreter runs MiniRacket programs

see **`connect.c`**

Writing Portable Applications

```
fopen("data.txt", "r");
```

main.c

```
FILE* fopen(char *name,
            char *mode)
{
  ....
  open(name, flag)
  ....
}
```

unix_file.c

```
FILE* fopen(char *name,
            char *mode)
{
  ....
  CreateFile(name, ....)
  ....
}
```

win_file.c

Writing Portable Applications

```
#ifdef _WIN32
  .... VirtualAlloc(....) ....
#endif
#ifdef linux
  .... mmap(....) ....
#endif
#ifdef OS_X
  .... vm_allocate(....) ....
#endif
```

`main.c`

`#ifdef` is a last resort

Applications on Linux

Linux “proper” is just the kernel:

- Processes, users and groups, filesystems, etc.
- New devices and features are exposed through the filesystem

  e.g., **`cat /proc/cpuinfo`**

The kernel does not include graphics

Applications on Linux

A ***distribution*** pairs the kernel with particular applications and libraries

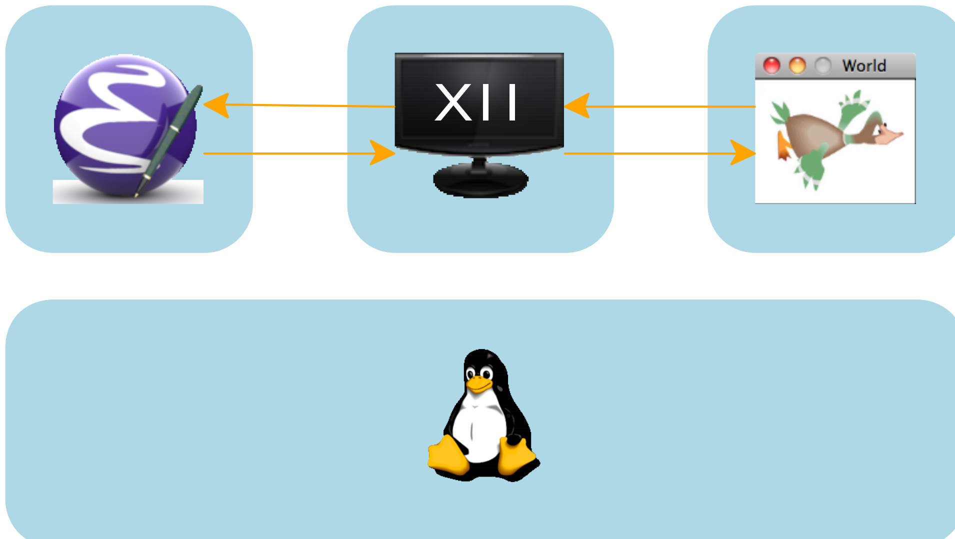
- Ubuntu
- Debian
- Fedora
- Gentoo

These differ in look-and-feel, but they're about the same to an application developer

Applications on Linux

Core graphics functionality is provided by the ***X Windowing System***, a.k.a. ***X11***

X11 is just a program, and others connect to it



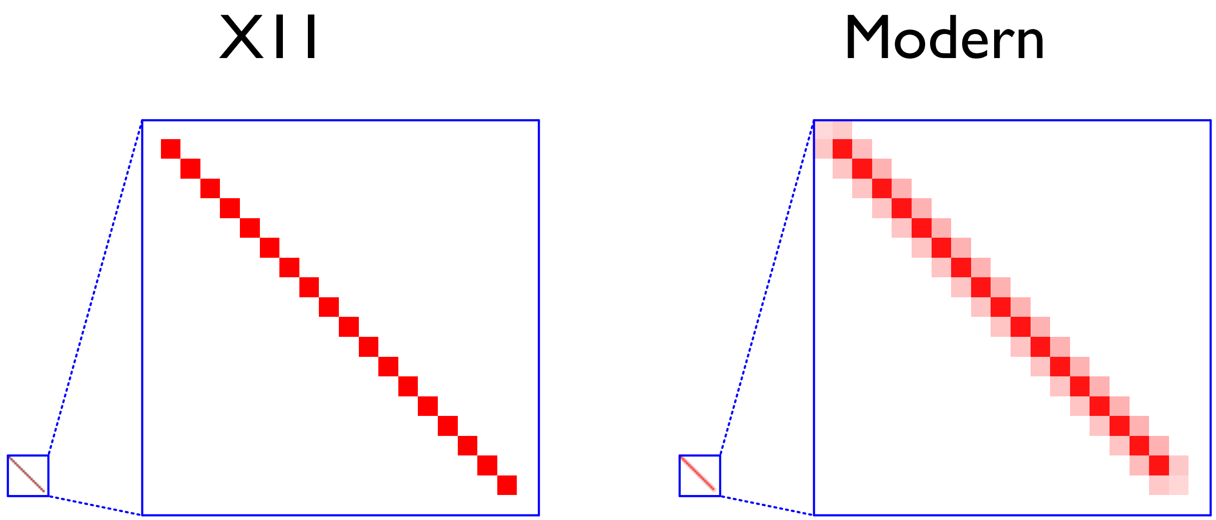
Program connections can even go across a network

see **`x11.c`**

Applications on Linux

The X11 primitive layer:

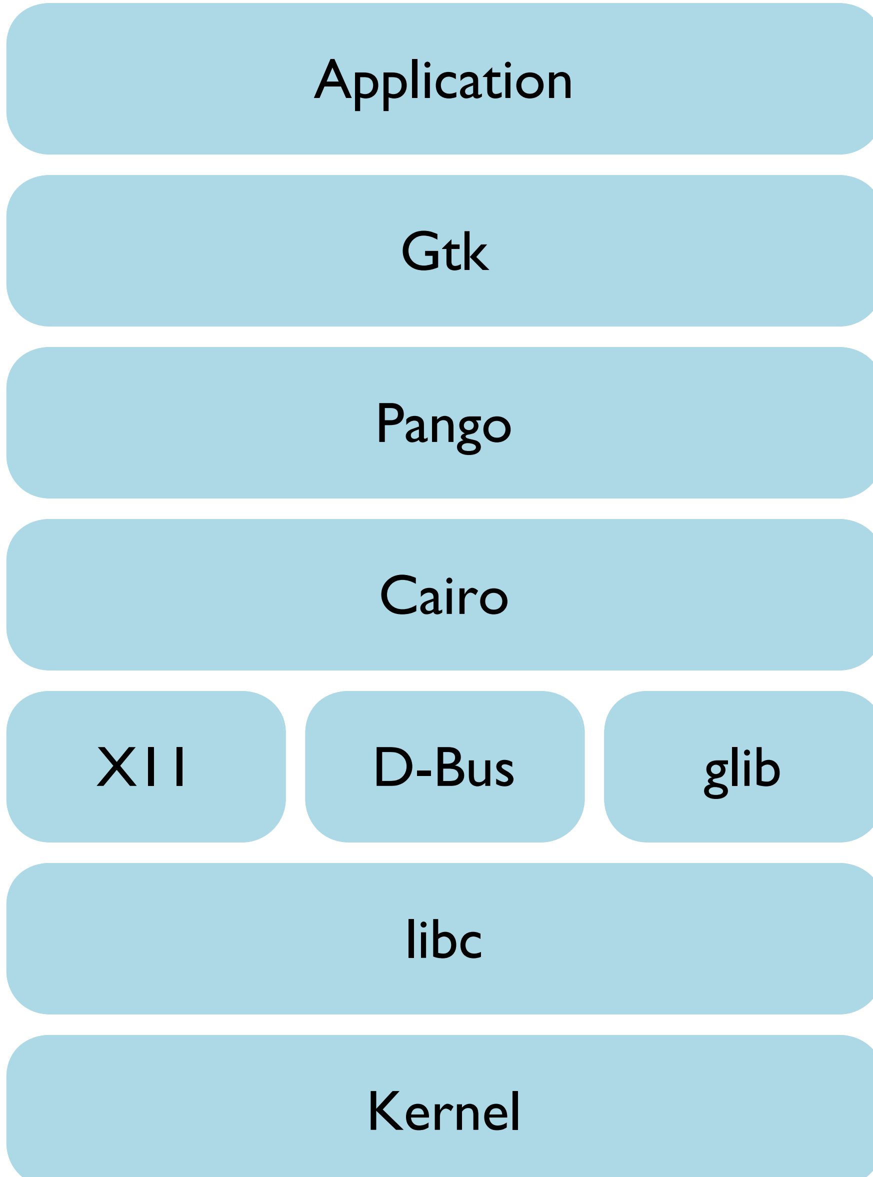
- Drawing:



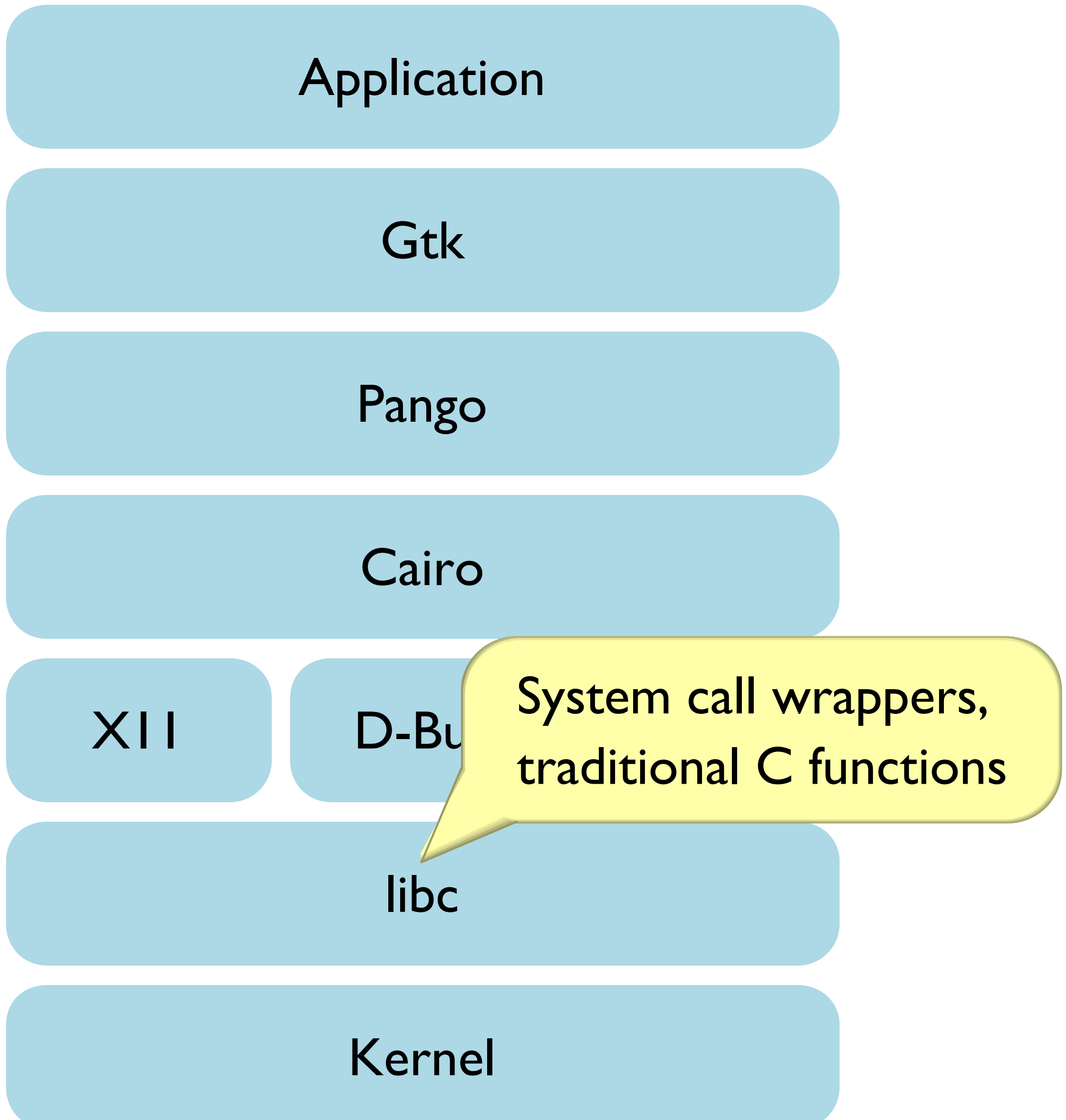
- GUIs: **`XCreateWindow()`**

no buttons, menus, ...

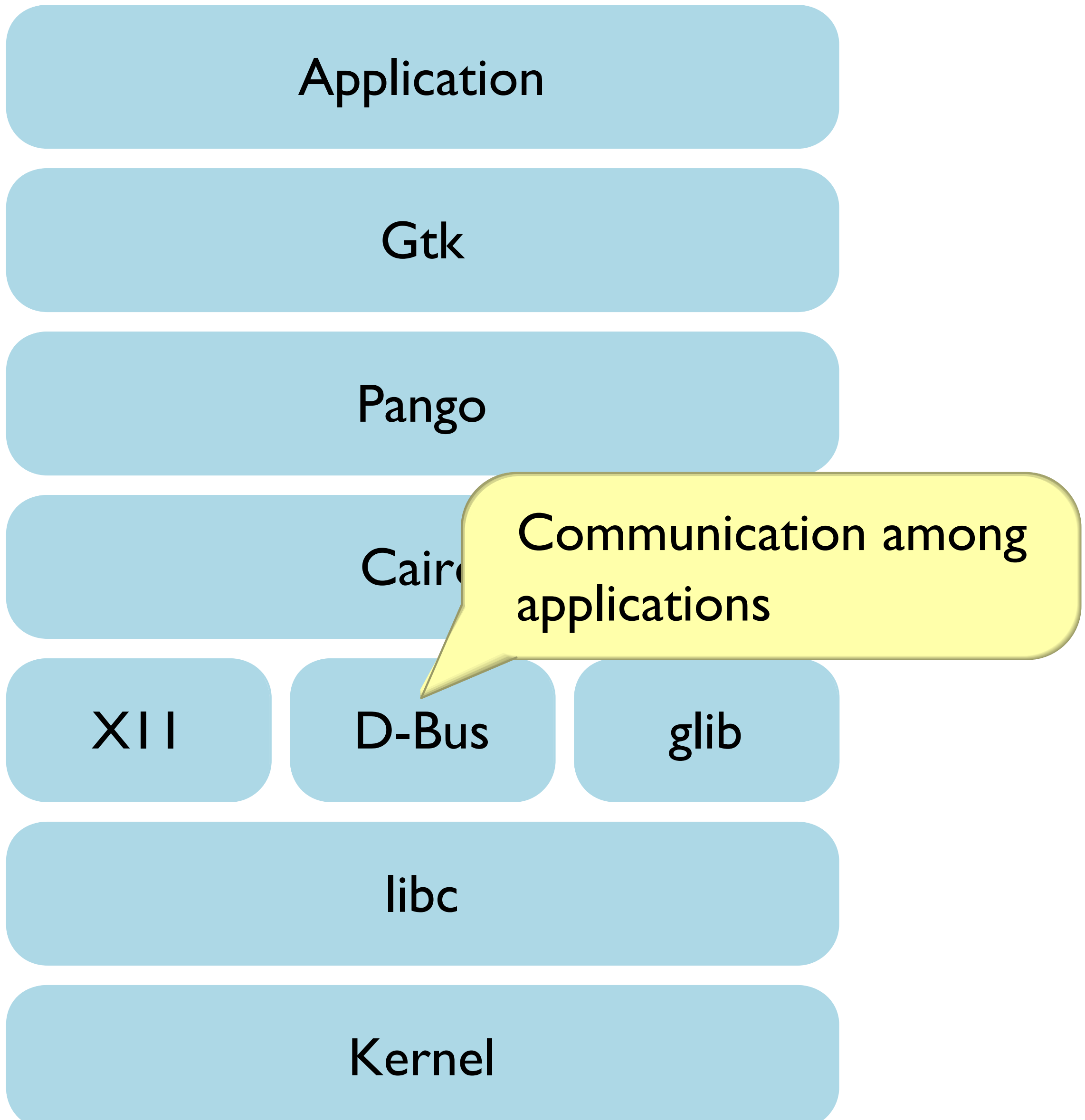
Applications on Linux



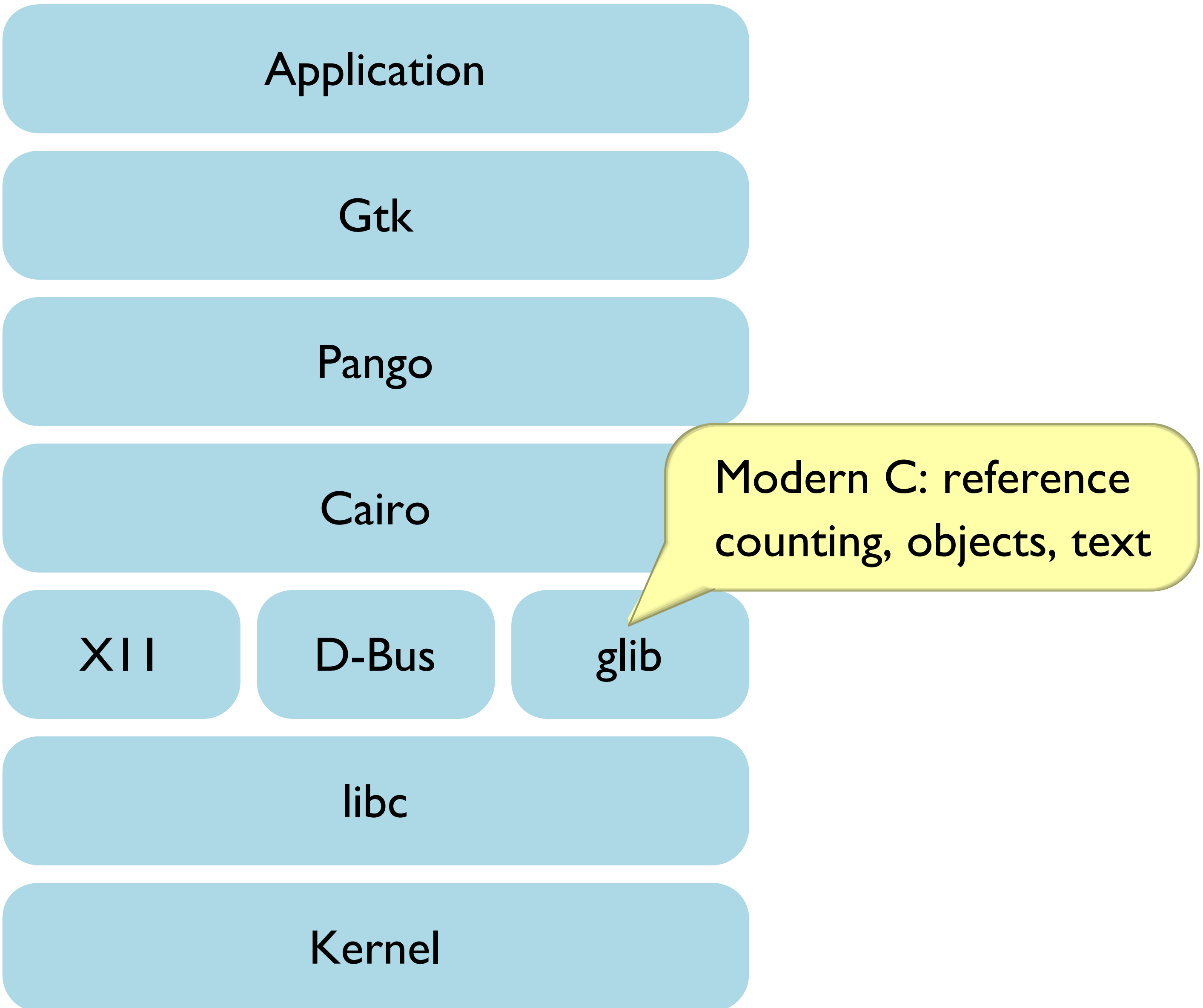
Applications on Linux



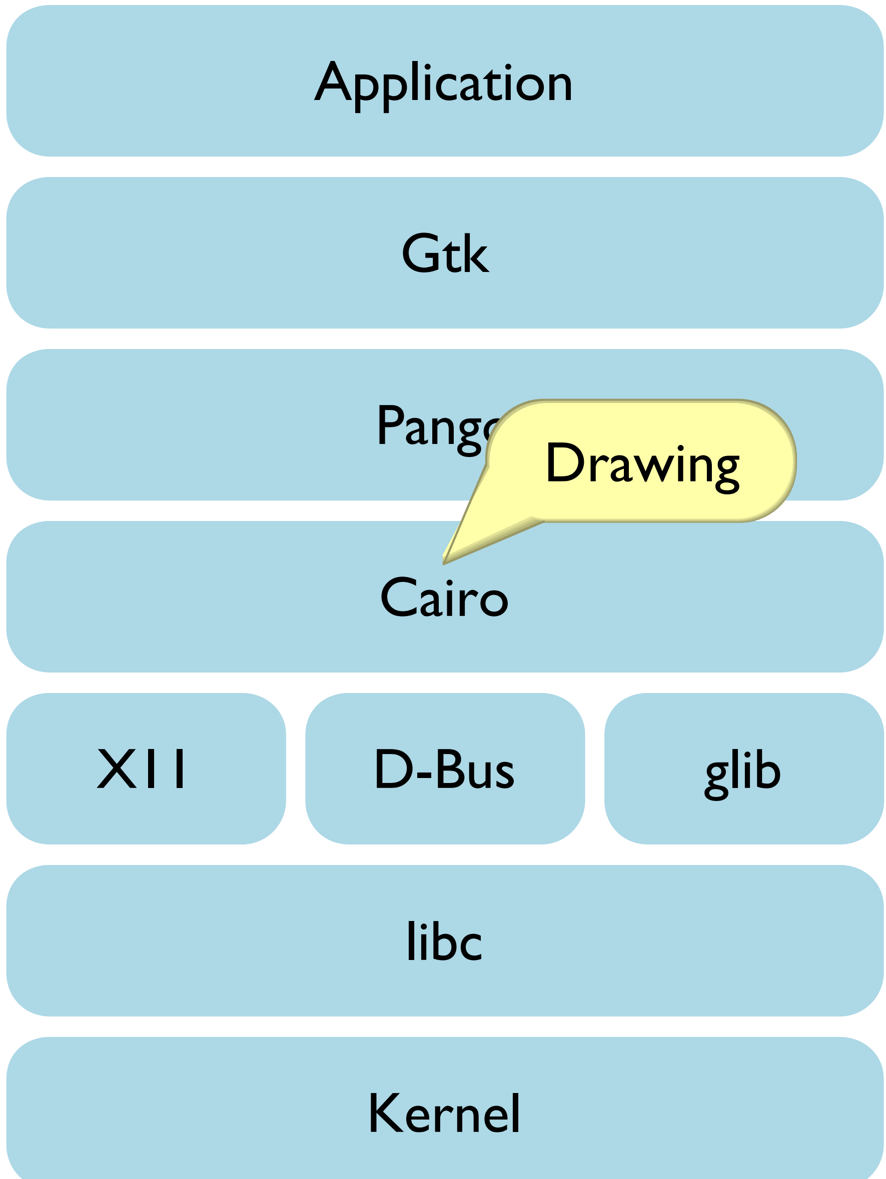
Applications on Linux



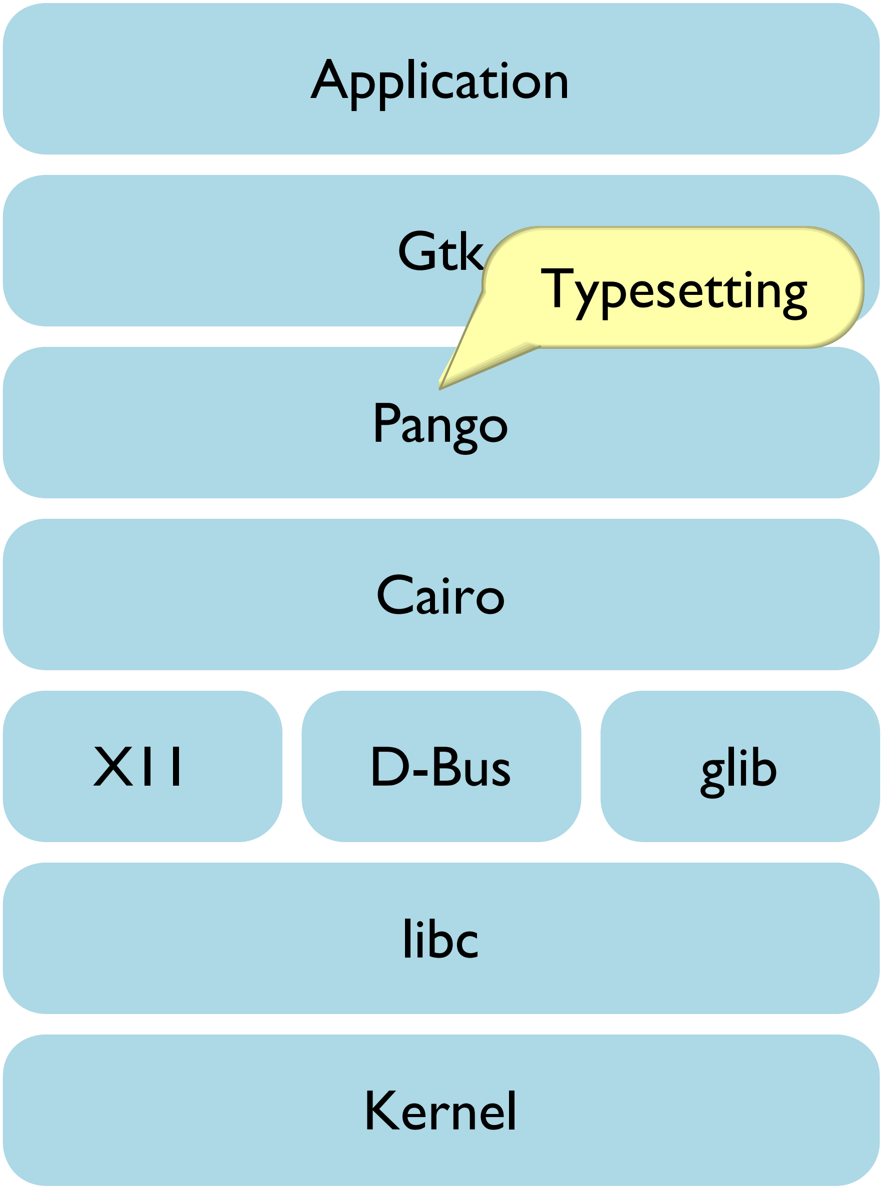
Applications on Linux



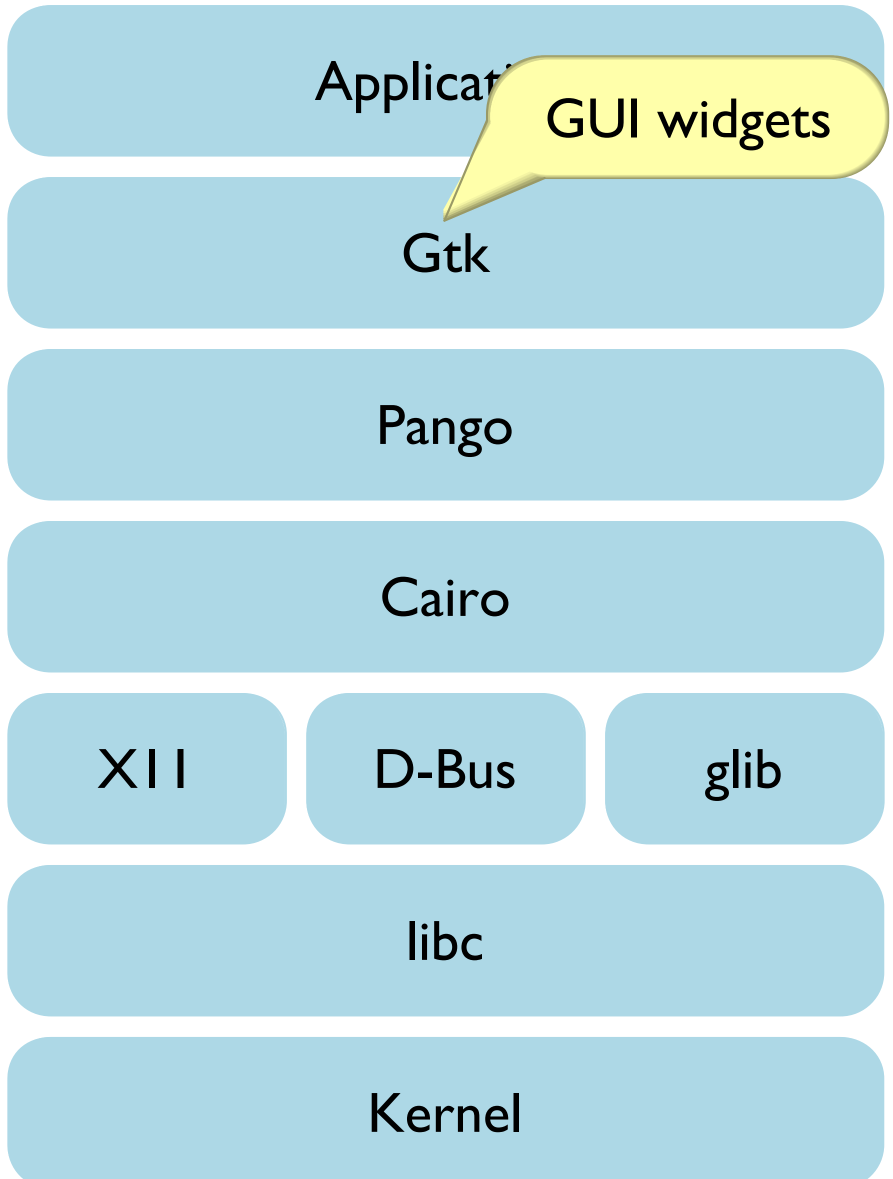
Applications on Linux



Applications on Linux



Applications on Linux



Applications on Linux

In practice:

- First, you pick a set of libraries to build on

  Gtk is just one option for GUIs, though probably the most popular

- Documentation is distributed among producers of different libraries

- Usually, you can look at a library's source code

  With respect to documentation quality, this is both good and bad

Applications on Windows

Everything is built into Windows:

- Processes, users and groups, filesystems, etc.
- Graphical windows also primitive kernel objects
- Unicode wired deeply into the kernel

The Windows OS API is traditionally called ***Win32***

Applications on Windows

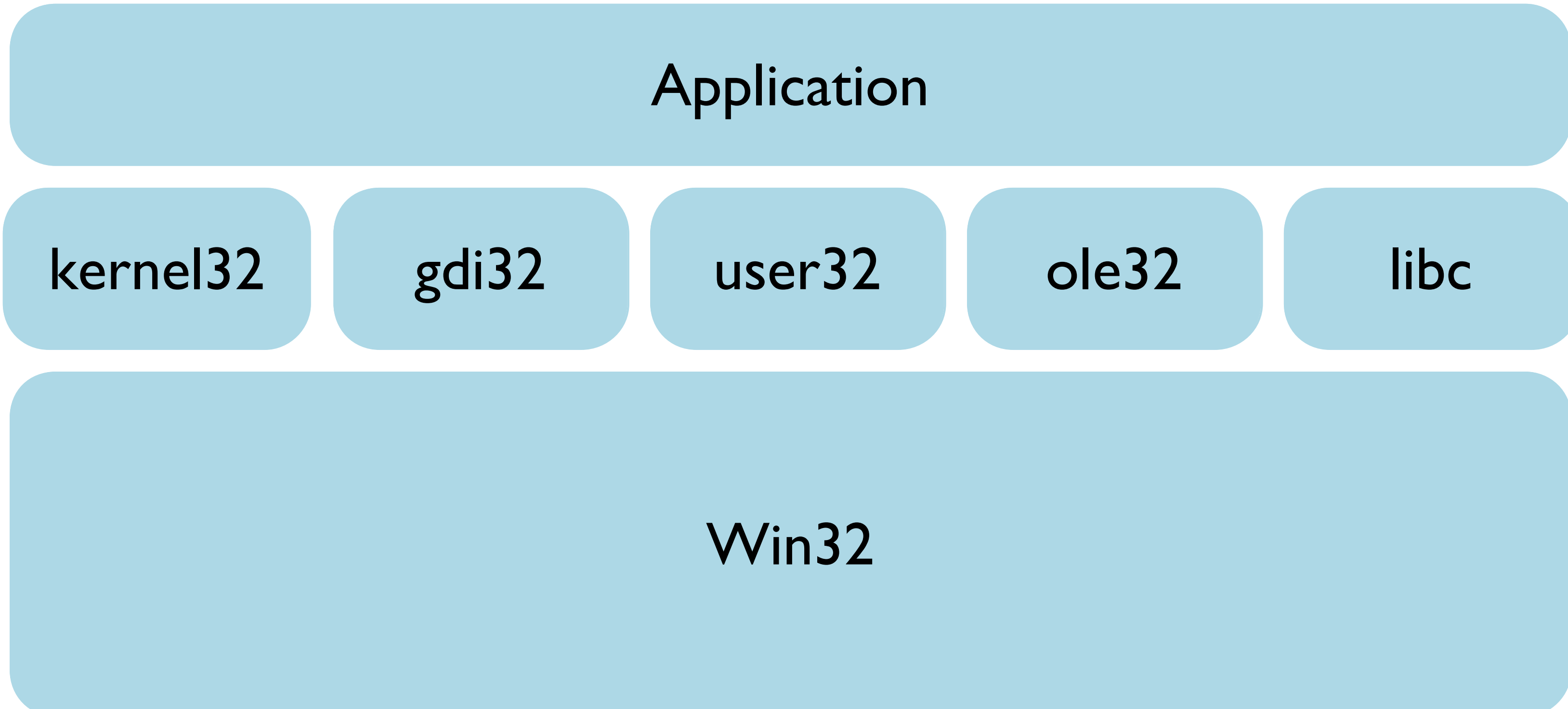
Creating a button in Win32:

```
CreateWindow("BUTTON", "Click Me",
             WS_CHILD | WS_CLIPSIBLINGS,
             0, 0, 100, 50,
             container, NULL, NULL, NULL);
```

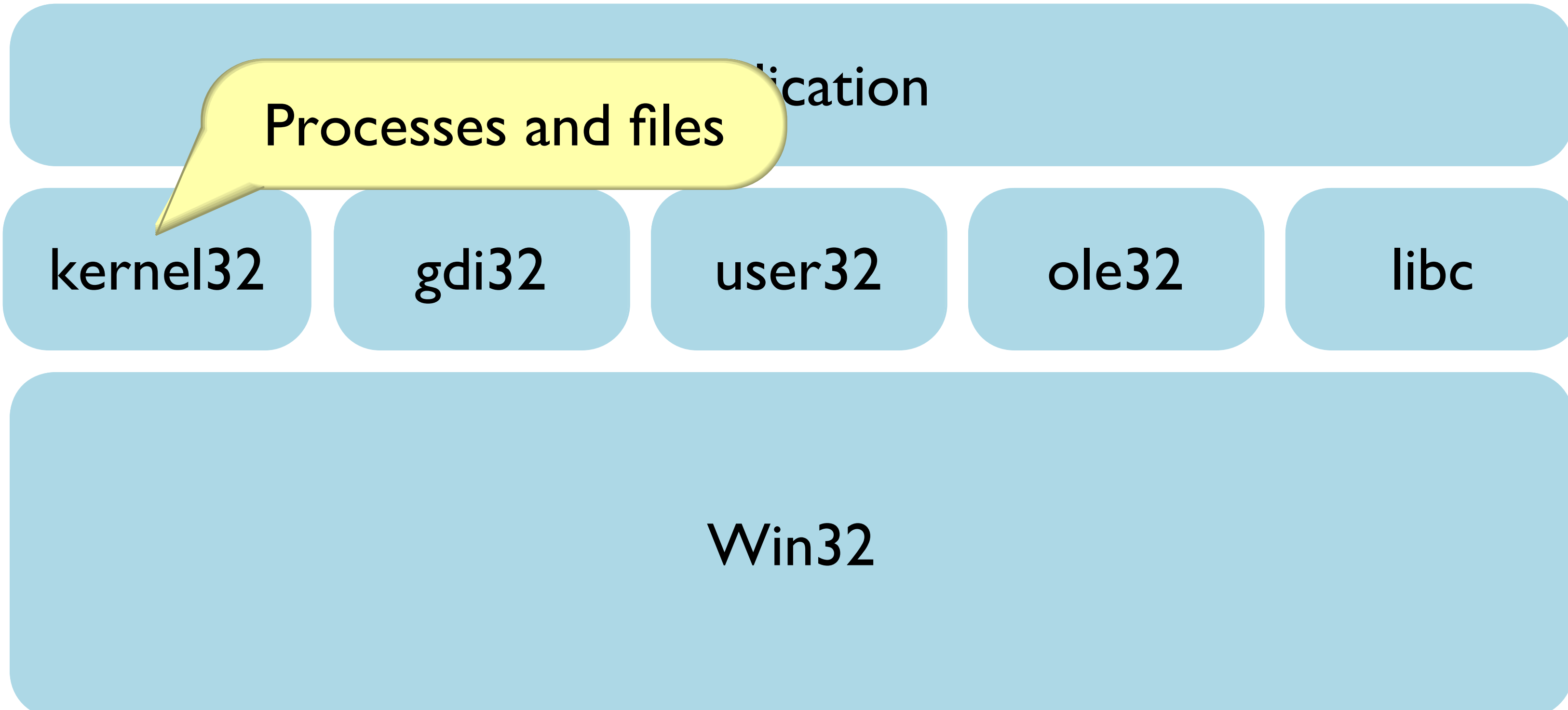
Creating a Chinese button in Win32:

```
CreateWindowW(L"BUTTON", L"打这里",
              WS_CHILD | WS_CLIPSIBLINGS,
              0, 0, 100, 50,
              container, NULL, NULL, NULL);
```

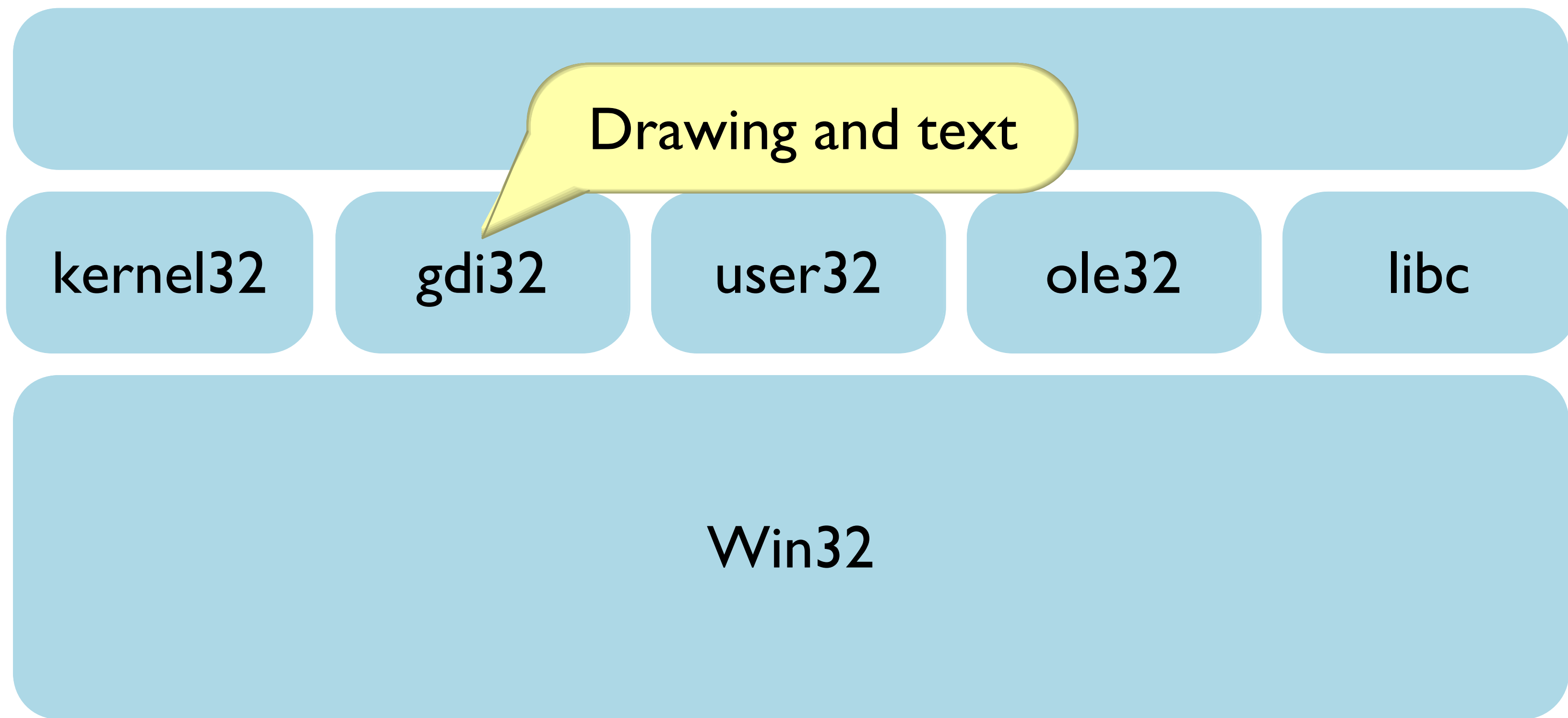
Applications on Windows



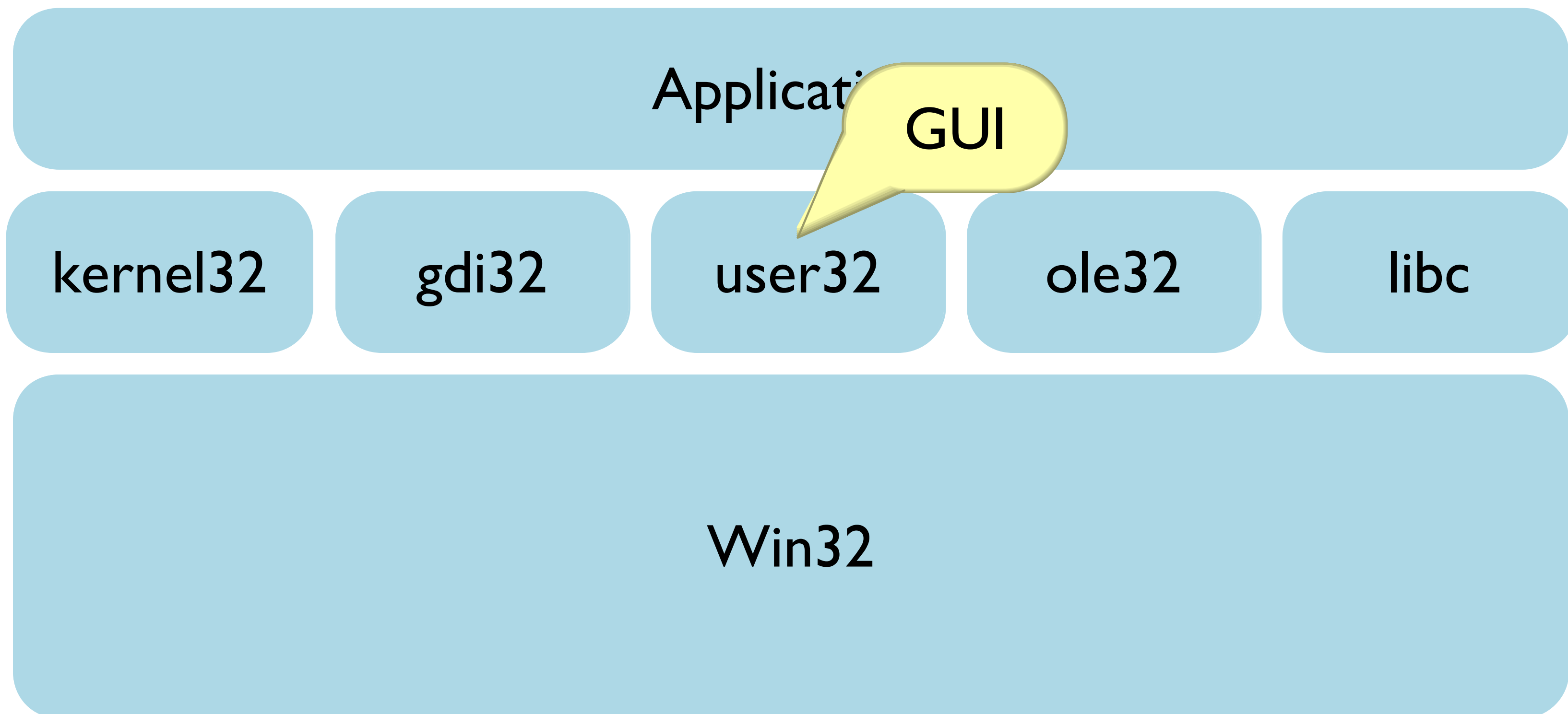
Applications on Windows



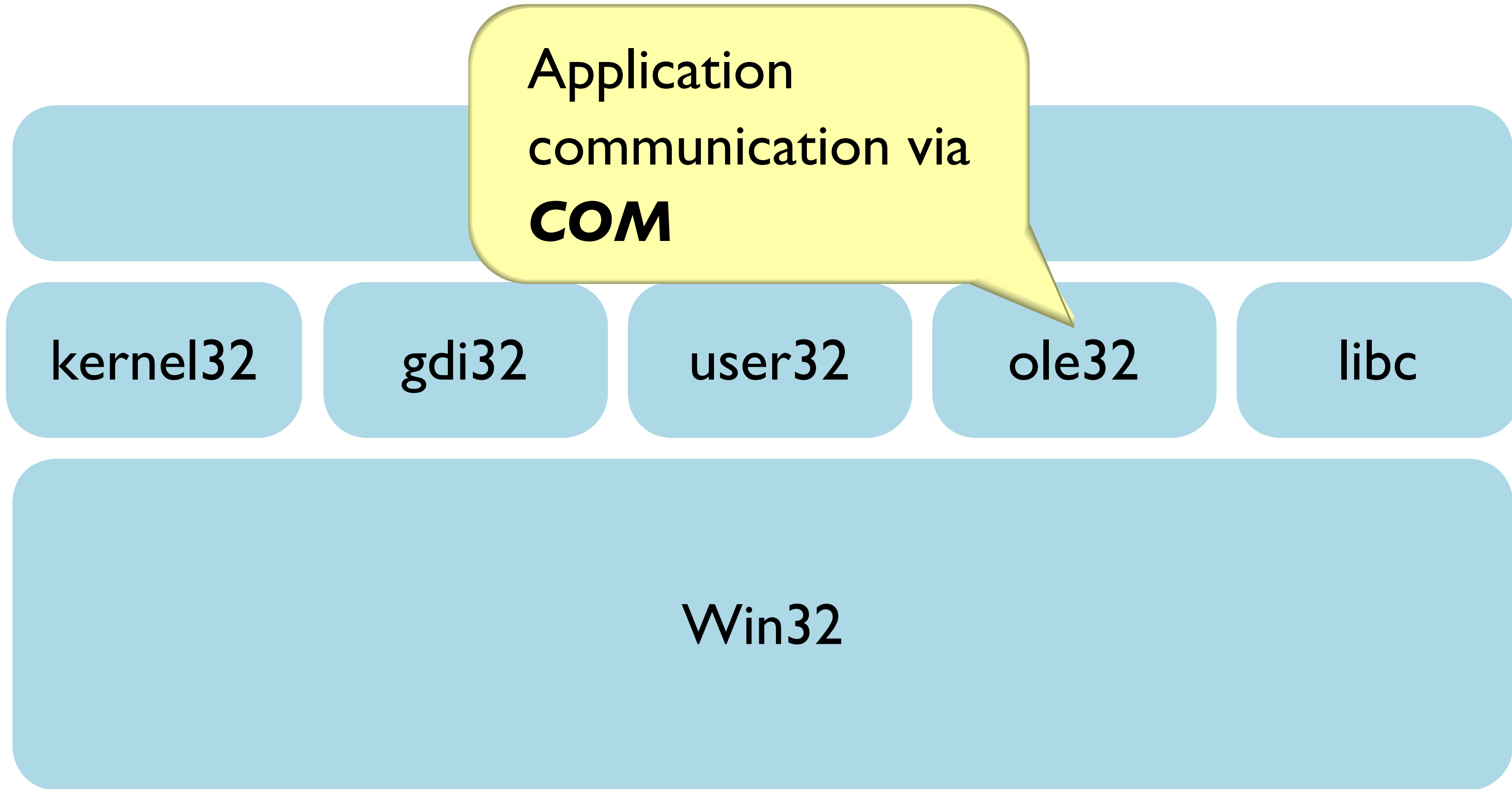
Applications on Windows



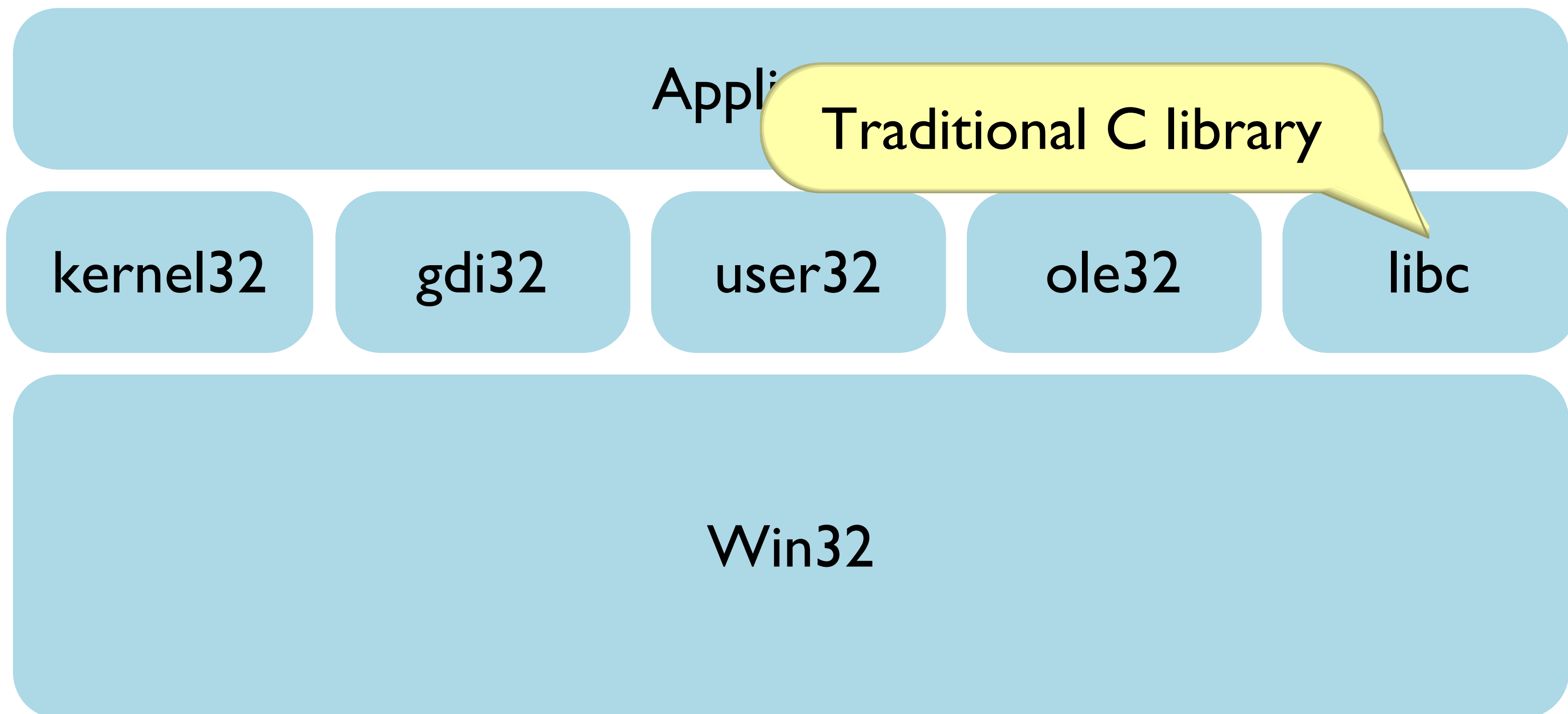
Applications on Windows



Applications on Windows



Applications on Windows



Applications on Windows

In practice:

- "Everything" is built in, but there are some choices
  - Win32: C API
  - MFC: C++ wrapper on Win32

Non-C languages are more common on Windows

- Documentation is centralized at MSDN
- COM is sometimes used to glue together applications

In contrast, `stdio`-based subprocesses are more common in Unix

Applications on Mac OS X

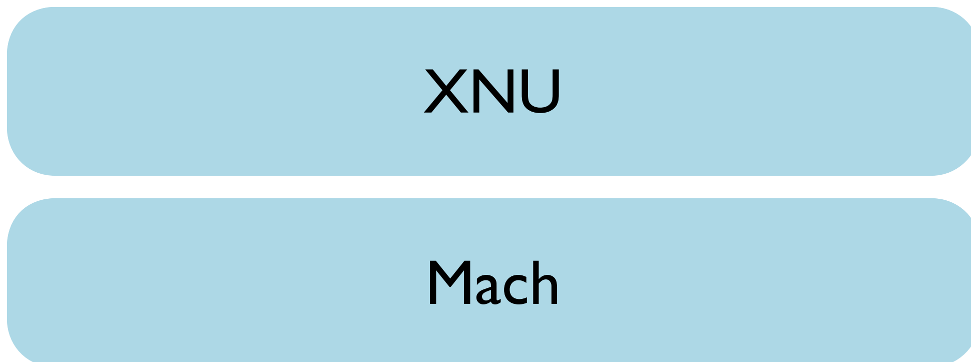
The Mac OS X kernel is called ***Mach***

- Processes, memory management, message passing
- New devices/features accessed via message passing

The goal was to make the kernel as small as possible

Applications on Mac OS X

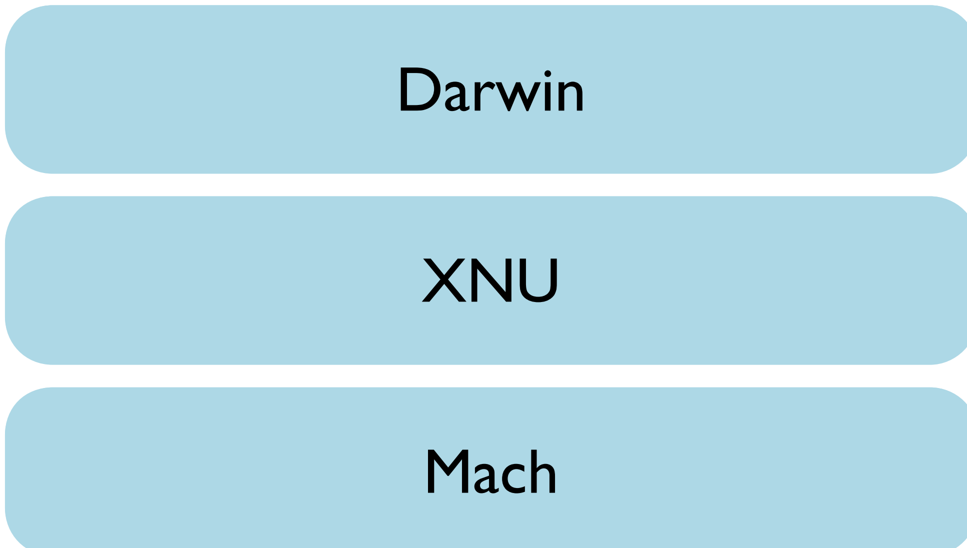
XNU is a Unix-like kernel layer on Mach



- Adds filesystems, users and groups, etc.
- Based on BSD

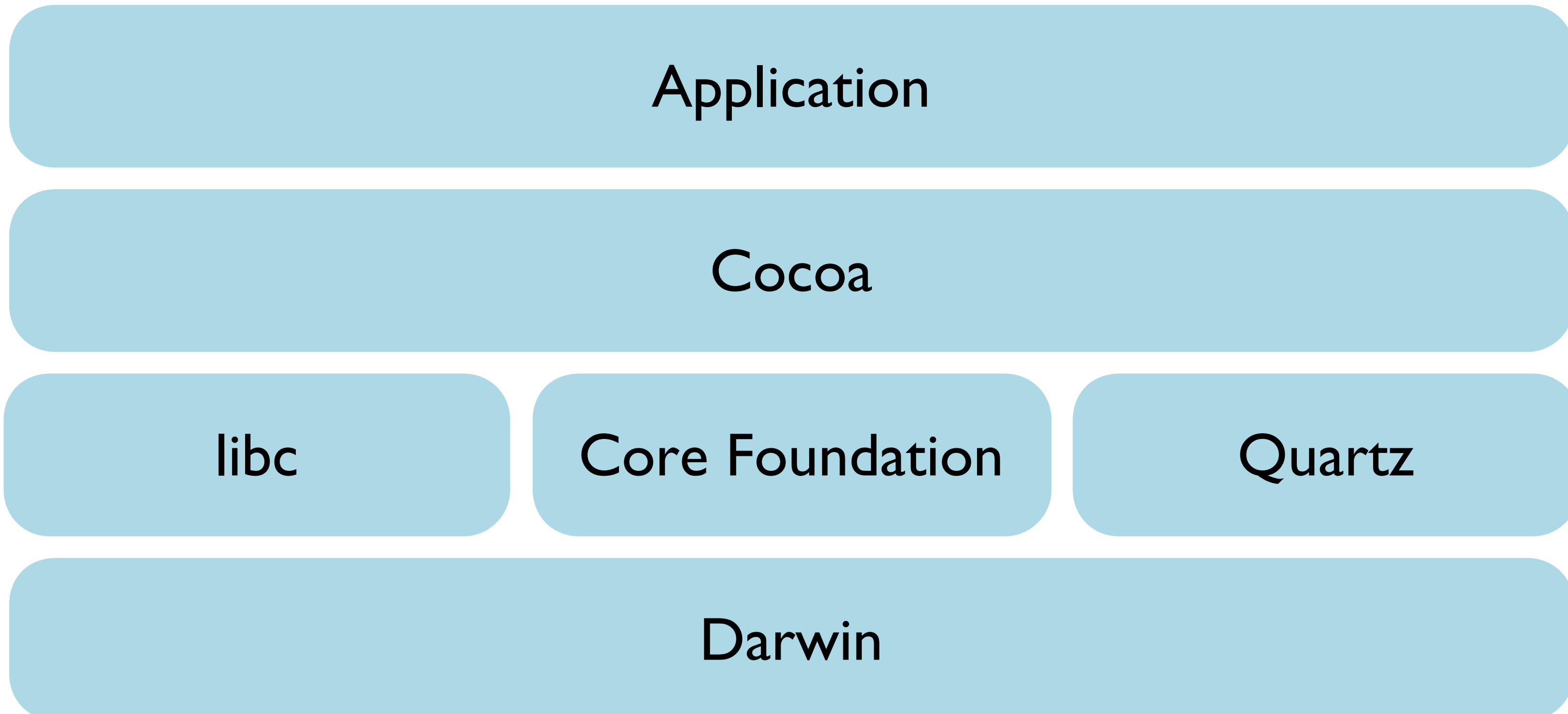
Applications on Mac OS X

Add system libraries and applications to XNU, and you get ***Darwin***

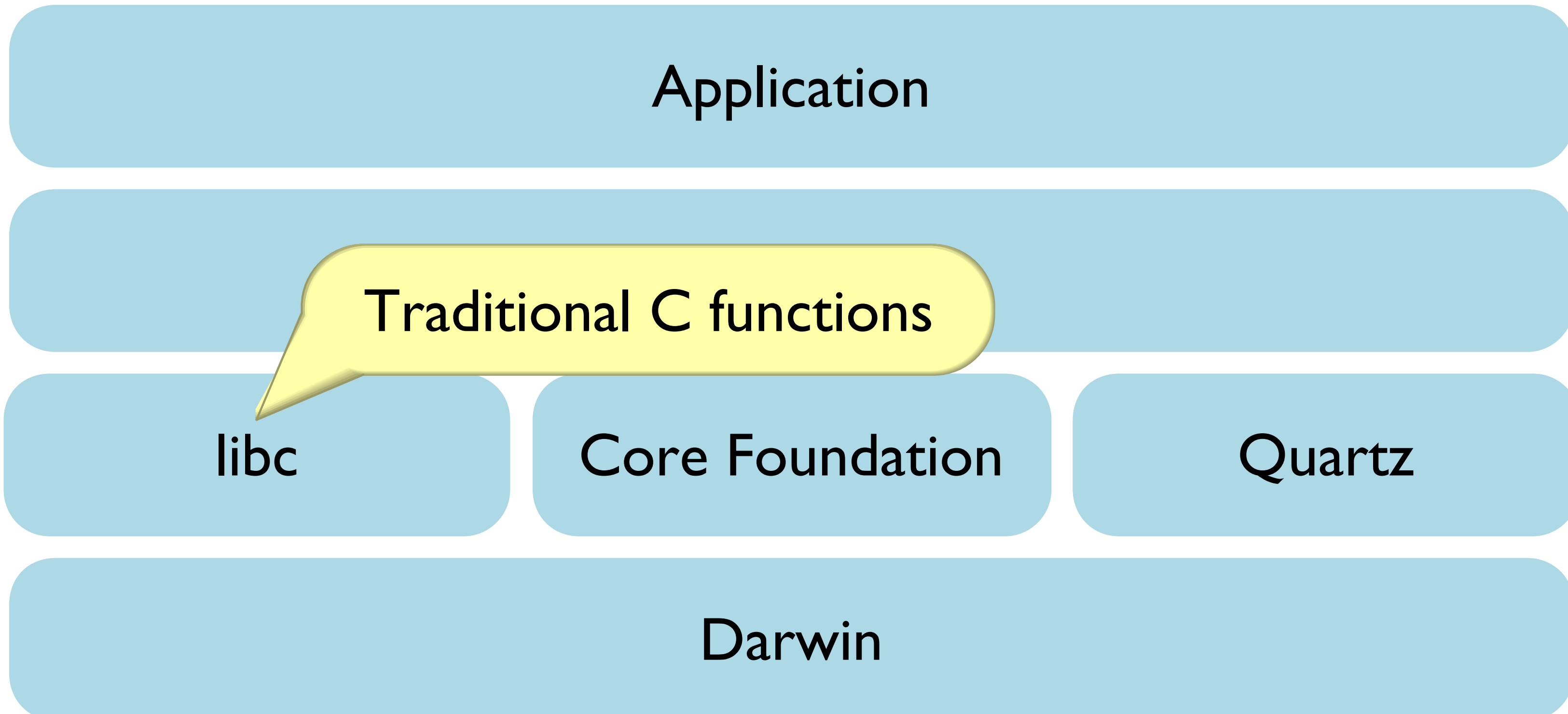


This layer makes application development on Mac OS X feel like Unix

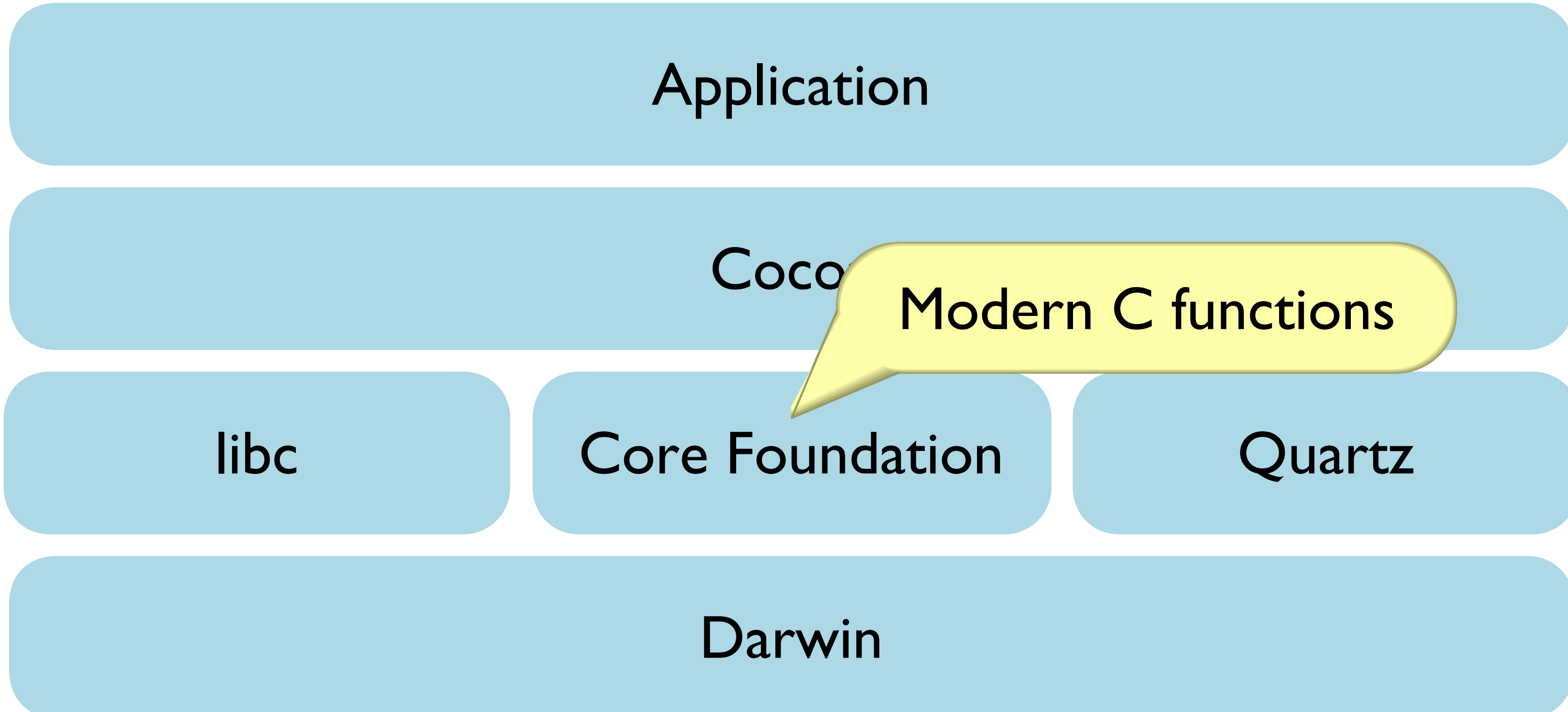
Applications on Mac OS X



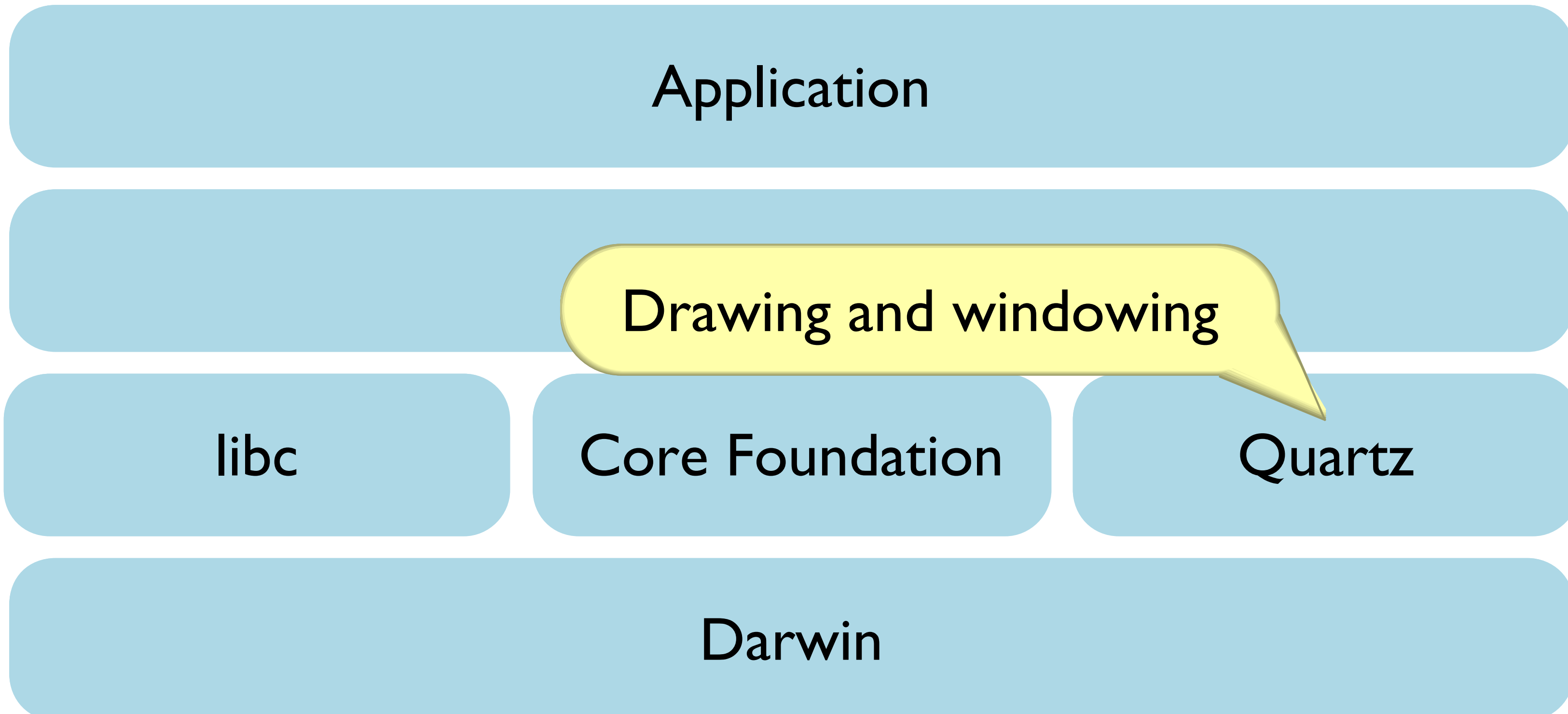
Applications on Mac OS X



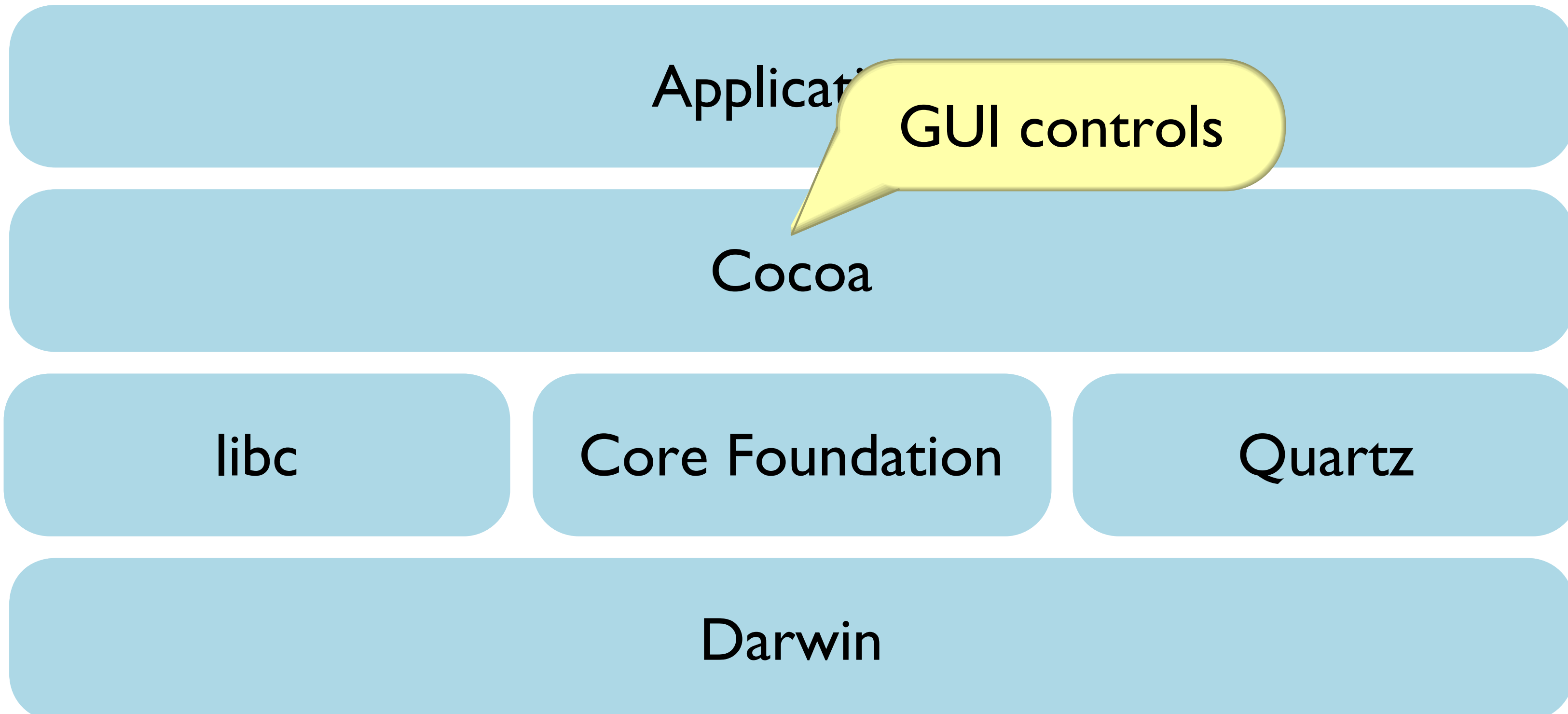
Applications on Mac OS X



Applications on Mac OS X



Applications on Mac OS X



Applications on Windows

In practice:

- Major libraries packaged by Apple, usually one per goal

  but legacy libraries are commonly in use: Carbon, QuickDraw, ATSUI

- Documentation is centralized at Apple's developer site

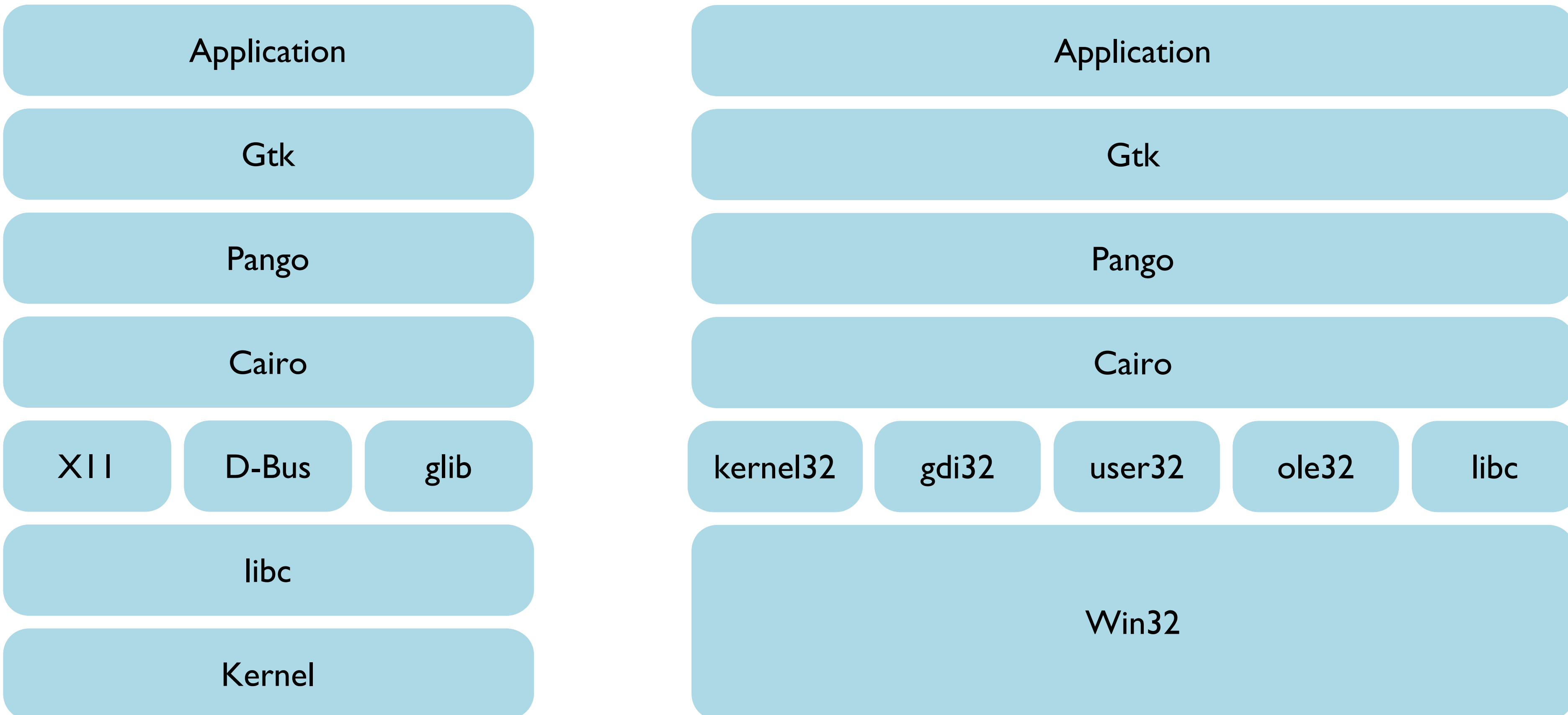
- Library layers (e.g., Core Foundation) are commonly referenced

  feels more like Linux, less like Win32

- GUIs usually written in Objective-C

  ... which is a hybrid of C and Smalltalk

Portable GUI Applications



Other options in place of Gtk/Pango/Cairo include Qt and wxWidgets