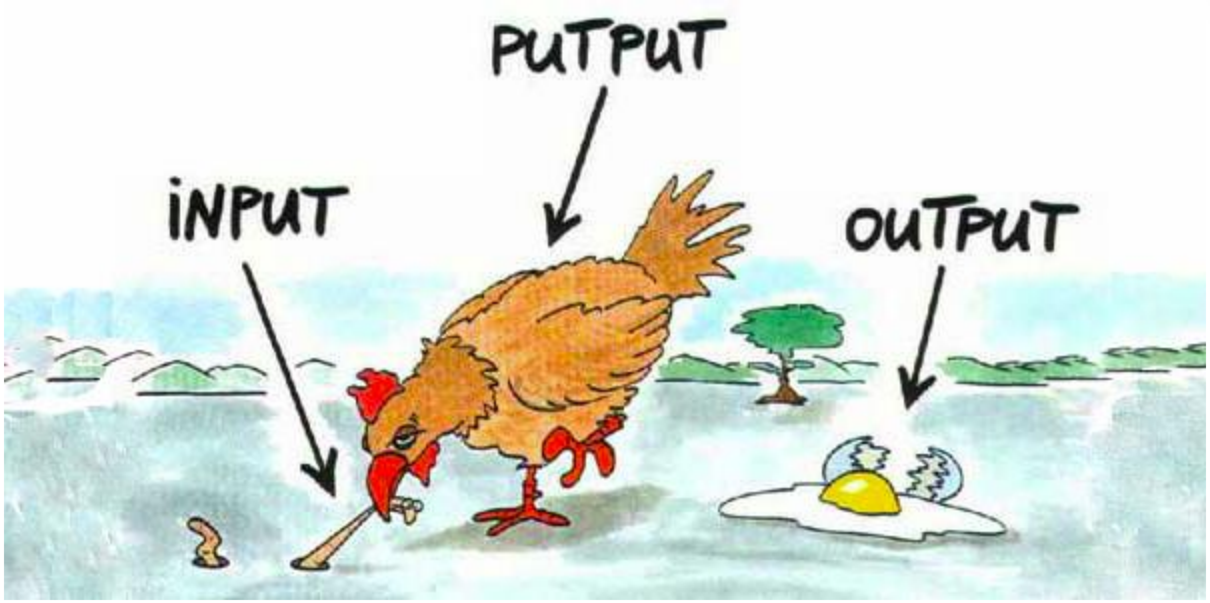
Linux For Embedded Systems

For Arabs

Course 102:

Understanding Linux

Ahmed ElArabawy



Lecture 9: Input/Output Internals

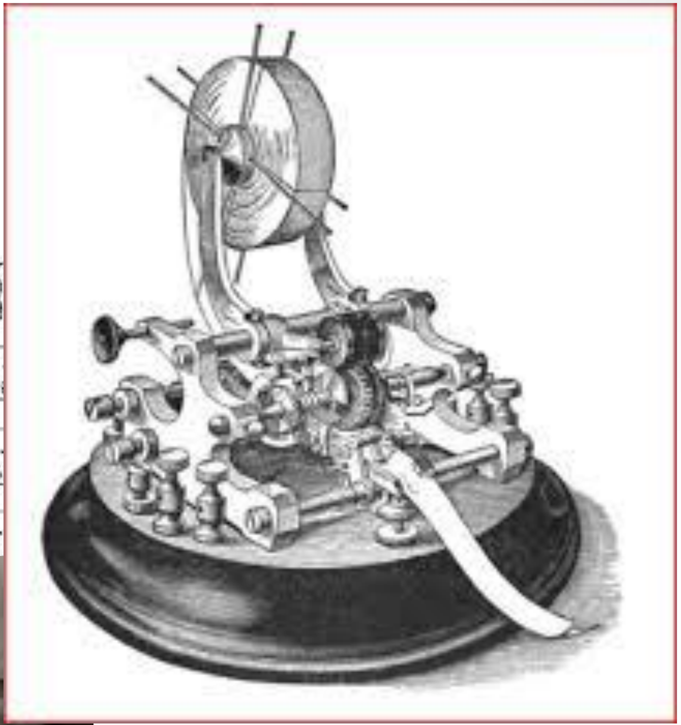
Input/Output Internals

- Each Process in the system comes with
  - Output device : defined by its stdout stream
  - Input device : defined by its stdin stream
  - Error Device : defined by its stderr stream
- We need to understand how does this reflect into messages on the screen, or reading input from the keyboard
- We will then needs to understand how does this work with I/O redirection, and the use of Pipes
- This lecture address all of these issues
- To understand all of that we need to understand the concept of TTY Subsystem in Linux Kernel and how it operates

HISTORICAL BACKGROUND

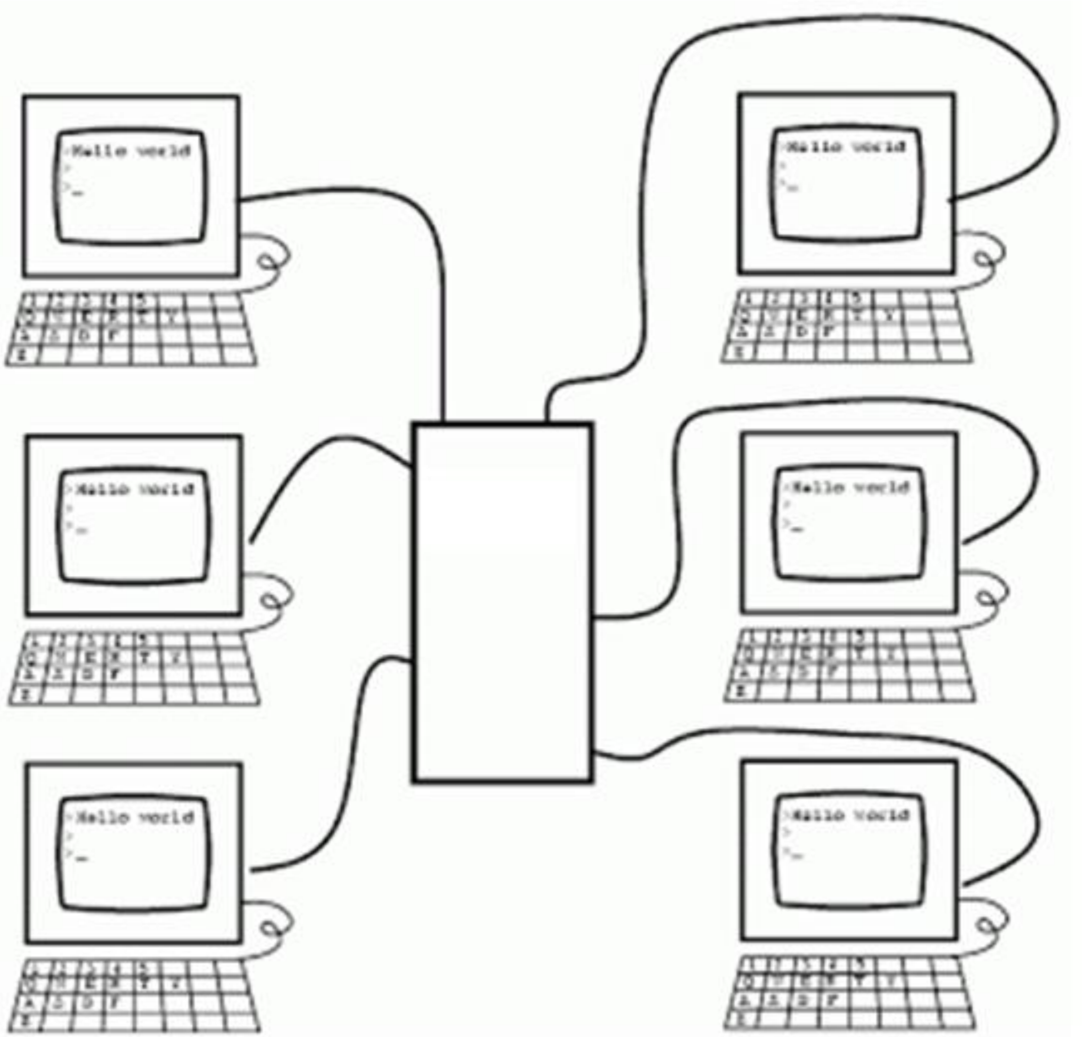
1869
Stock Ticker

.W.PR........SF.....RT.IN....ST......USSPR..........
.......200.76....64½........7¾....161⅝.......200.94½.
.PR.........A.AJ........SS.W.......ST......SF.W.PR..
..... 200.81½......66.92¾.......20.99....161⅝..........
....KN.......APR.....U......SF.....W.PR....B.........
45¾....35½a6....97½...100¾....64¼........76...4S.14.86
.RT.IN.....S.....ST..............MXC.......SF.W.PR.....

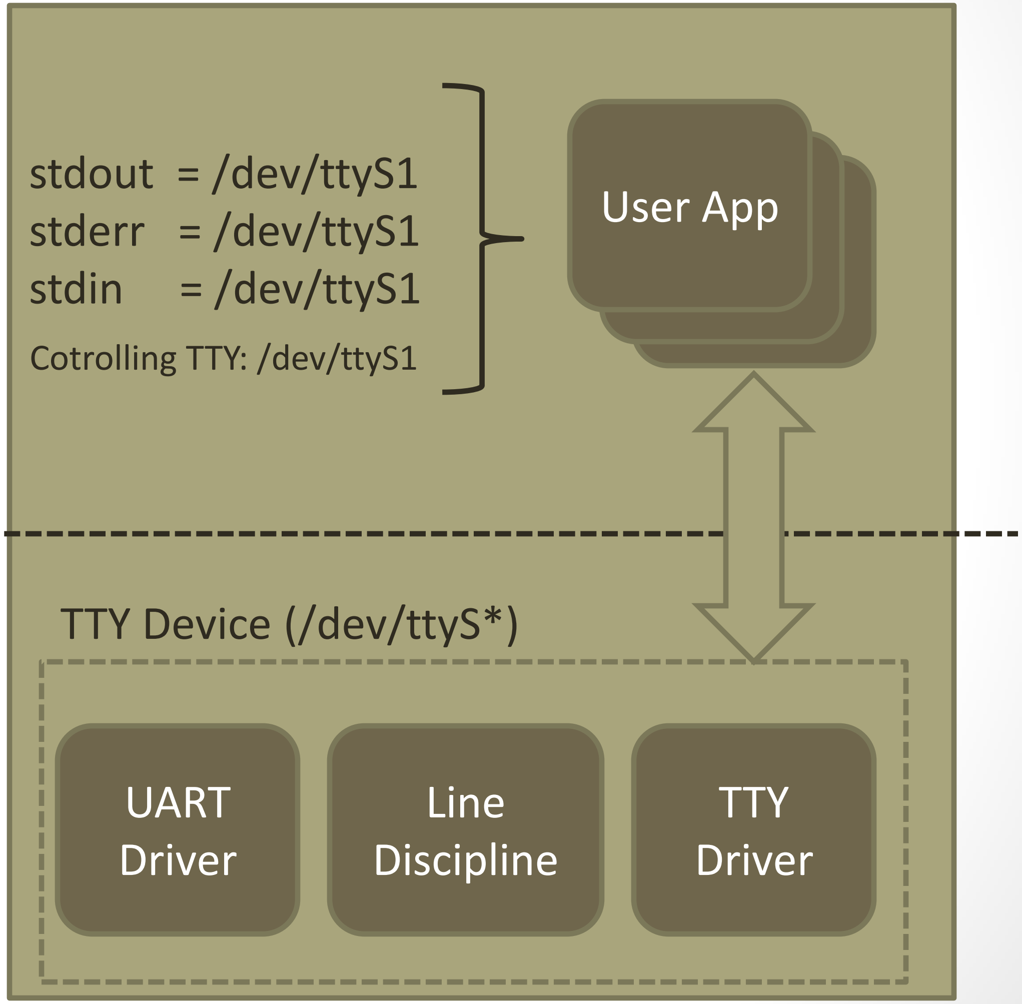


Telex

The Birth of Computers


>Hello world
>Hello world
>Hello world
>Hello world
>Hello world
>Hello world

TTY Device



stdout = /dev/ttyS1
stderr = /dev/ttyS1
stdin = /dev/ttyS1

Cotrolling TTY: /dev/ttyS1

User App

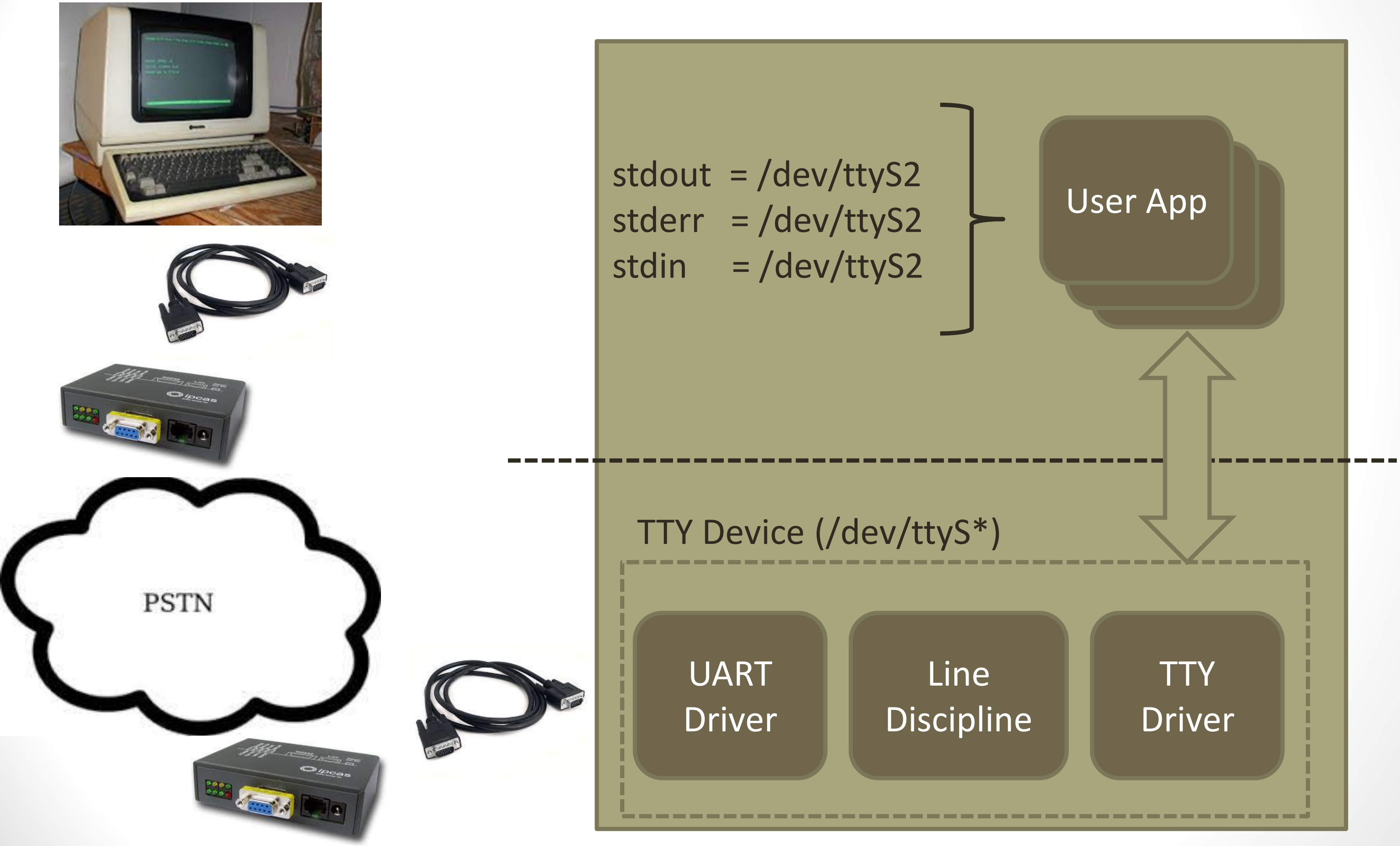
TTY Device (/dev/ttyS*)

UART Driver

Line Discipline

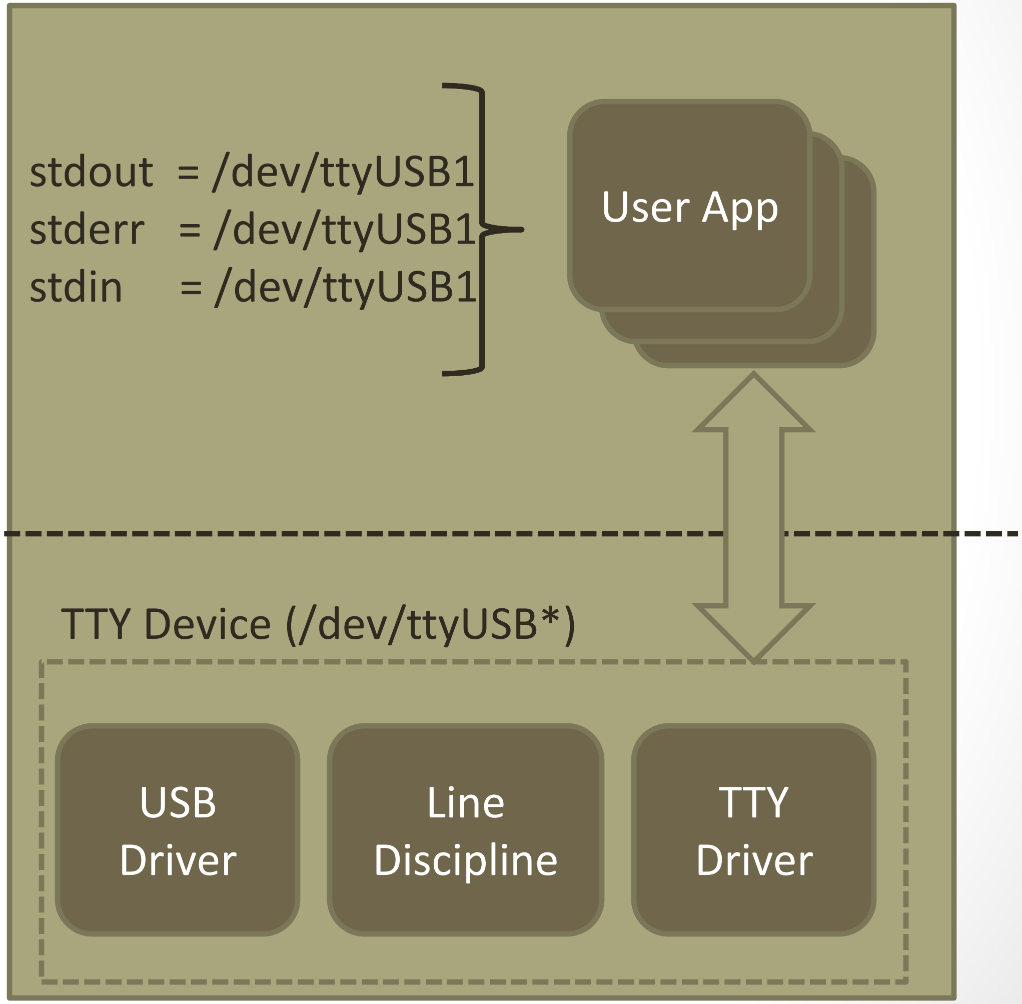
TTY Driver

TTY Device



stdout = /dev/ttyS2
stderr = /dev/ttyS2
stdin = /dev/ttyS2

TTY Device



stdout = /dev/ttyUSB1
stderr = /dev/ttyUSB1
stdin = /dev/ttyUSB1

User App

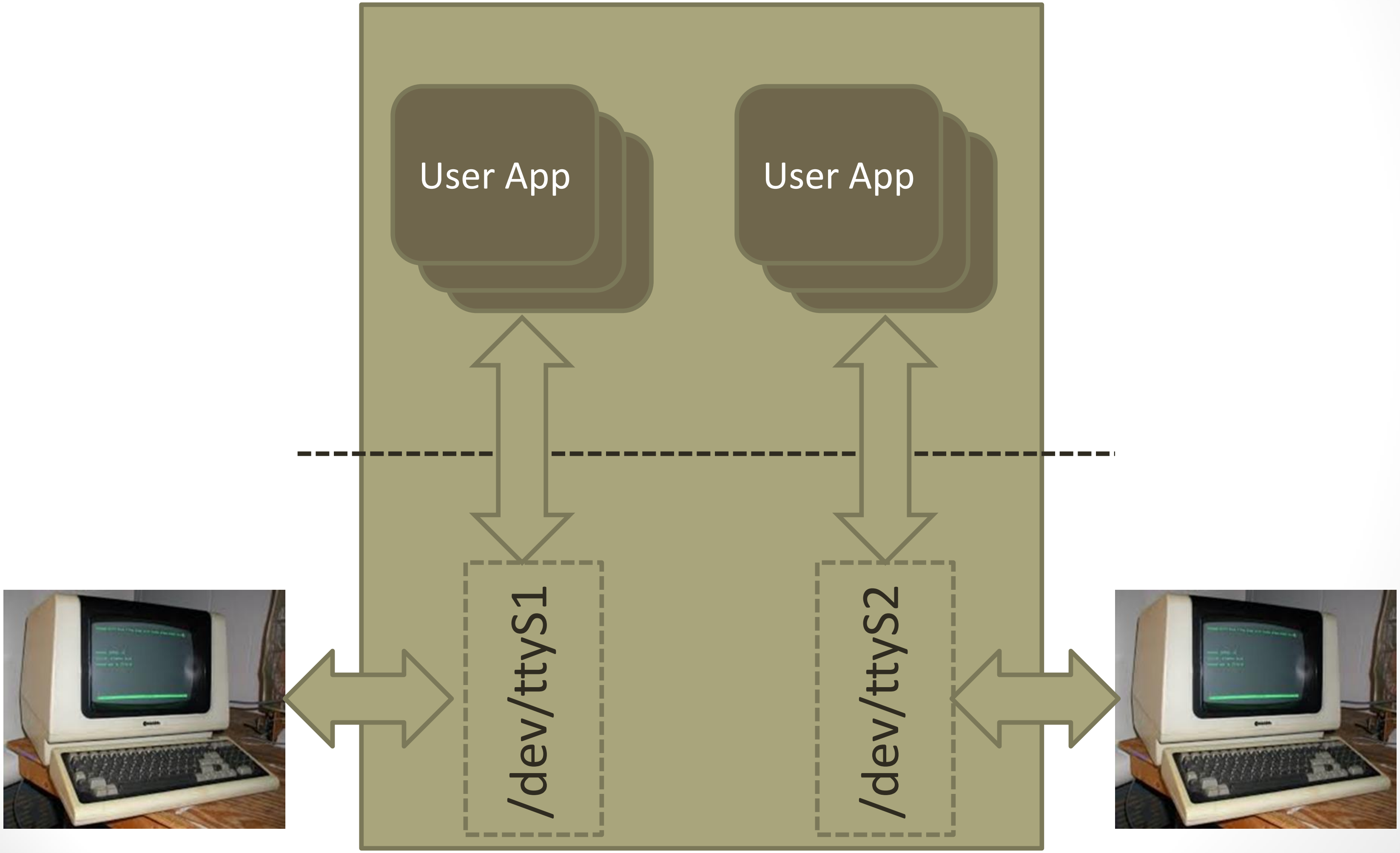
TTY Device (/dev/ttyUSB*)

USB Driver

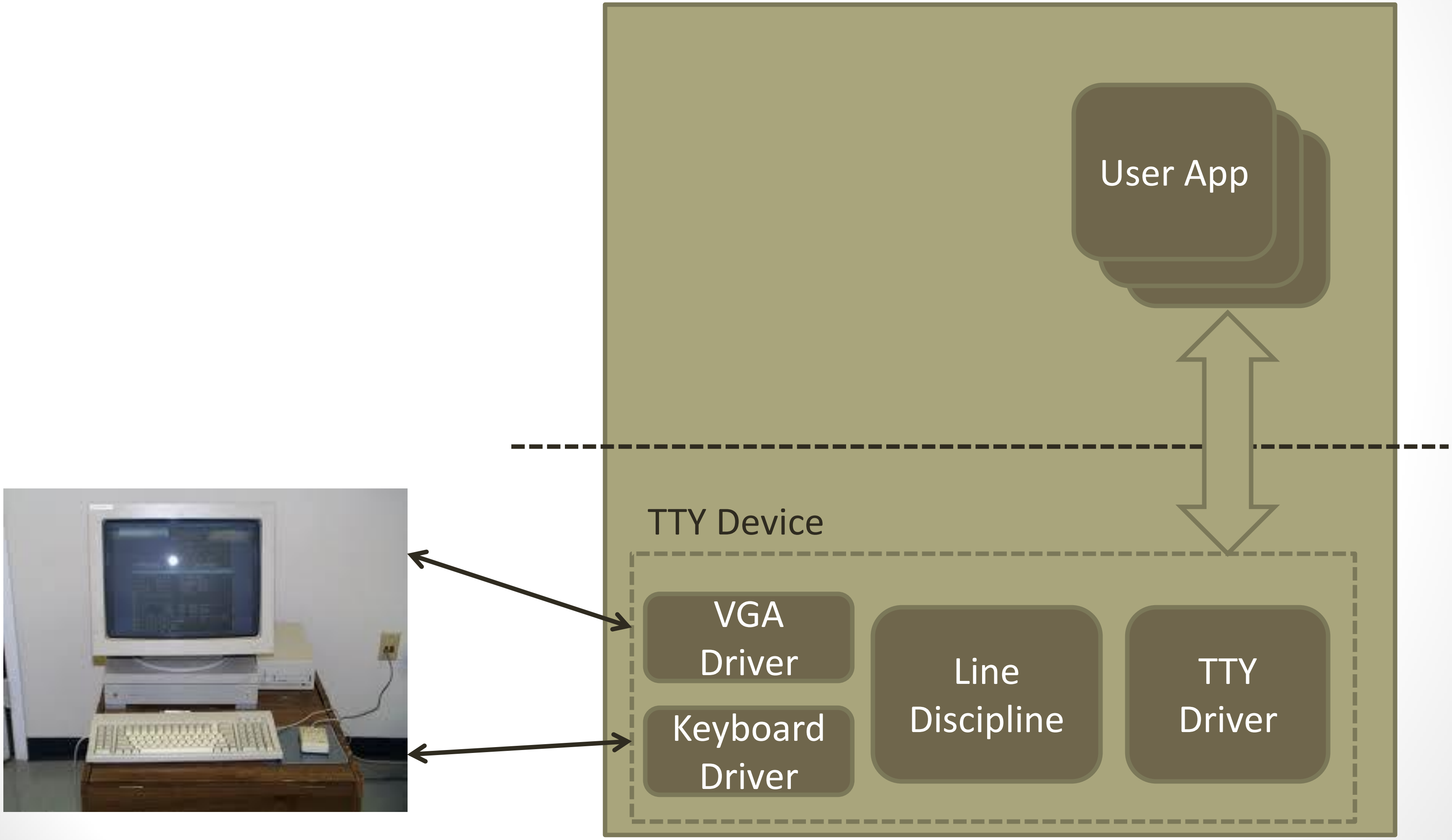
Line Discipline

TTY Driver

Multiple Terminals



Then Comes the Personal Computers



User App

TTY Device

VGA Driver

Keyboard Driver

Line Discipline

TTY Driver

TTY Devices

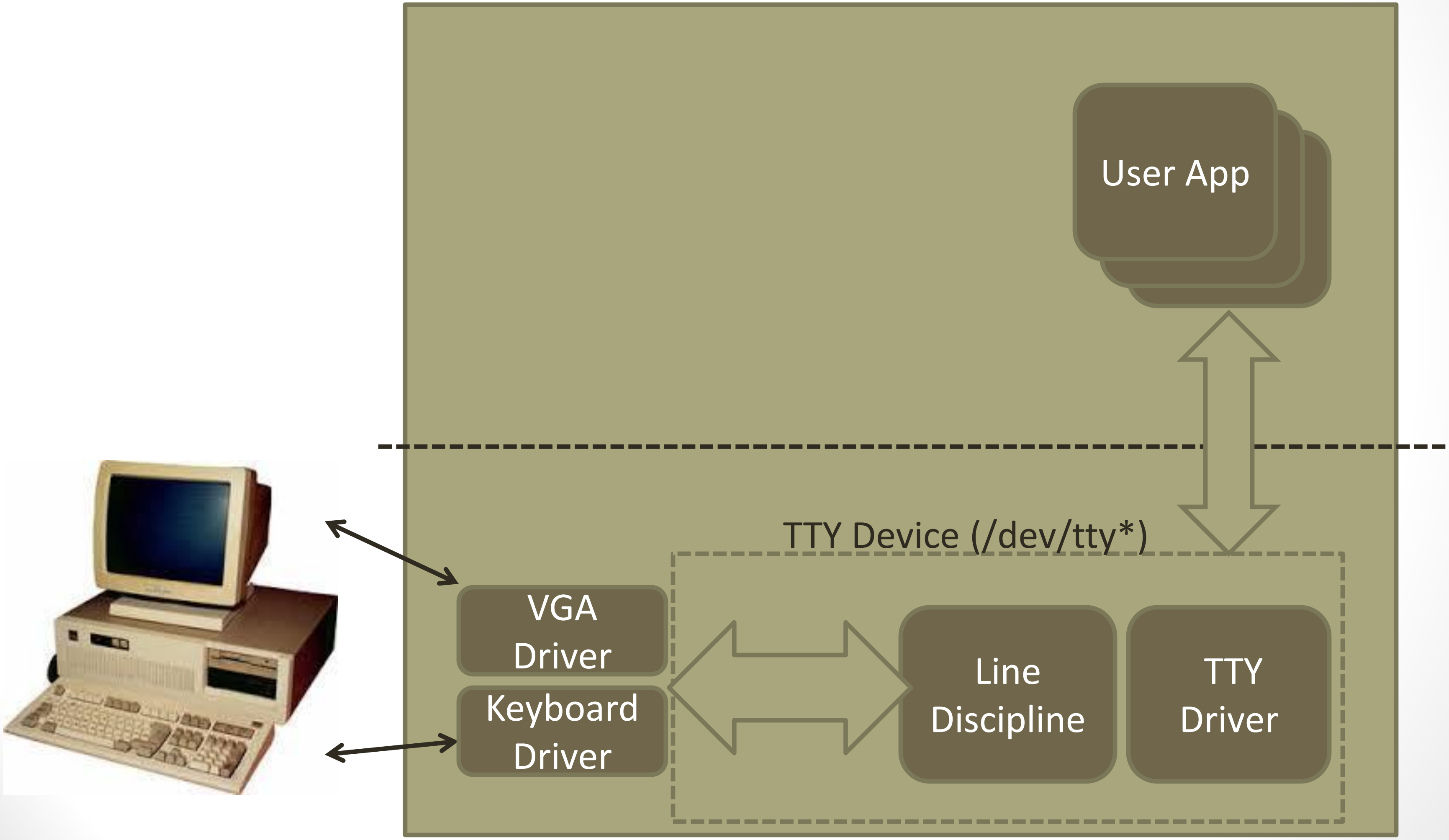
- TTY stands for TeleTYpewriter
- TTY machines were used originally in stock tickers, and Telex Machines
- When Computers were introduced, a computer was a big central unit, TTY machines were used as an I/O terminal, and connect to the computer via UART (Serial Interface)
- In case the terminal is remote, a modem pair were used
- Unix supported all of this via the introduction of TTY subsystem in its kernel
- TTY device is composed of 3 blocks
  - A driver to the hardware interface(UART driver, USB driver, VGA/KB drivers, ..)
  - Line Discipline to handle low level editing commands (backspace, erase word, clear line, ….)
  - TTY driver to interface with the user space applications
- The User space application communicates with the TTY driver via system calls and signals
- The default I/O Streams of the user application is the assigned TTY device (/dev/tty*)
- This TTY Terminal is also the controlling terminal for its user applications

VIRTUAL TERMINALS

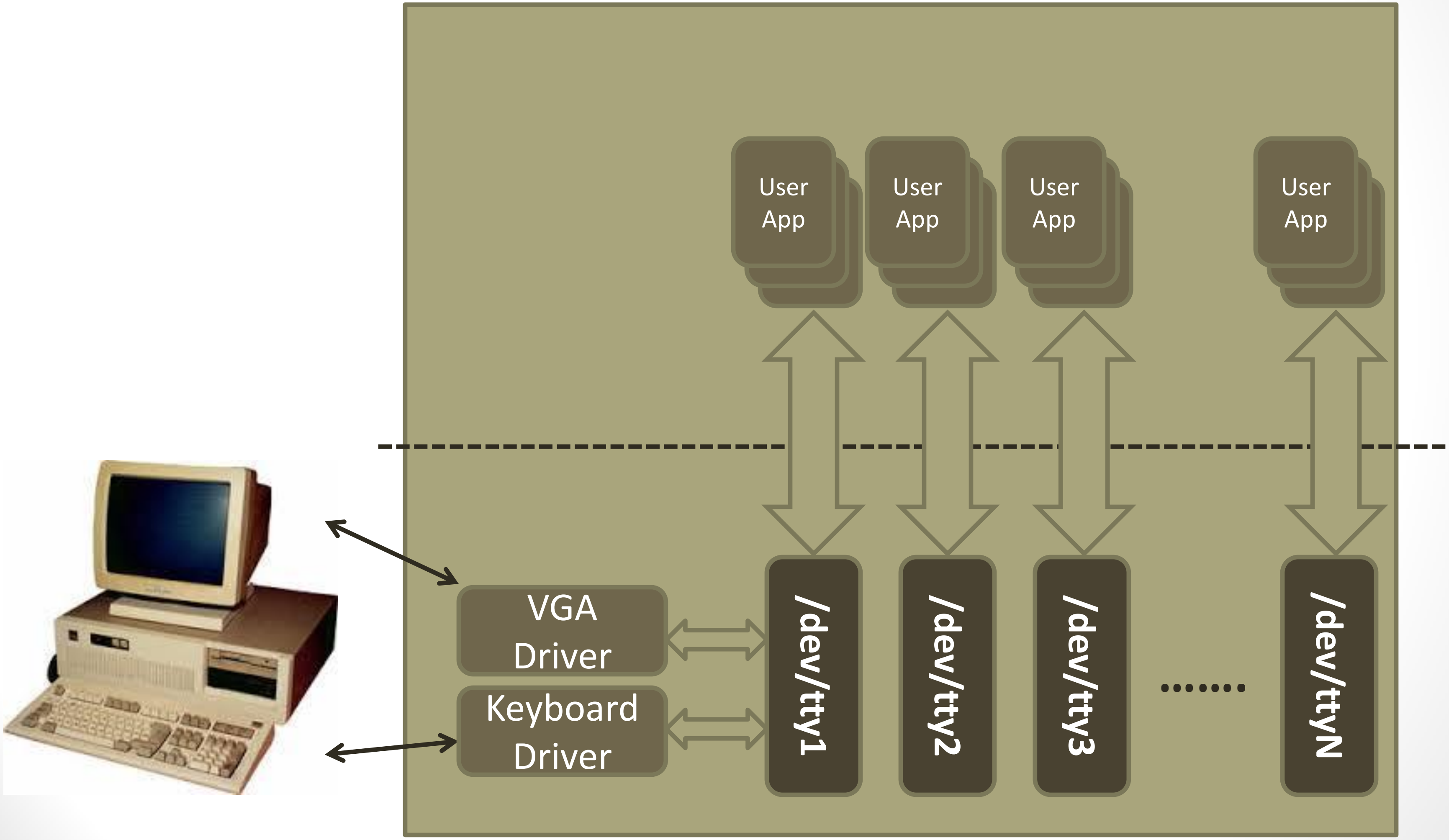
Introducing Virtual Terminals

- When we were connecting terminals via the serial interface, we were able to have multiple terminals to the computer
- However, when we connect the monitor and keyboard directly to the PC, and use the same architecture, we can not have multiple terminals (only one monitor/keyboard pair)
- We need a new architecture that will enable us to run multiple terminals from the same Physical Terminal(Keyboard/Monitor)
- This led to the introduction of the concept of Virtual Terminals in Linux

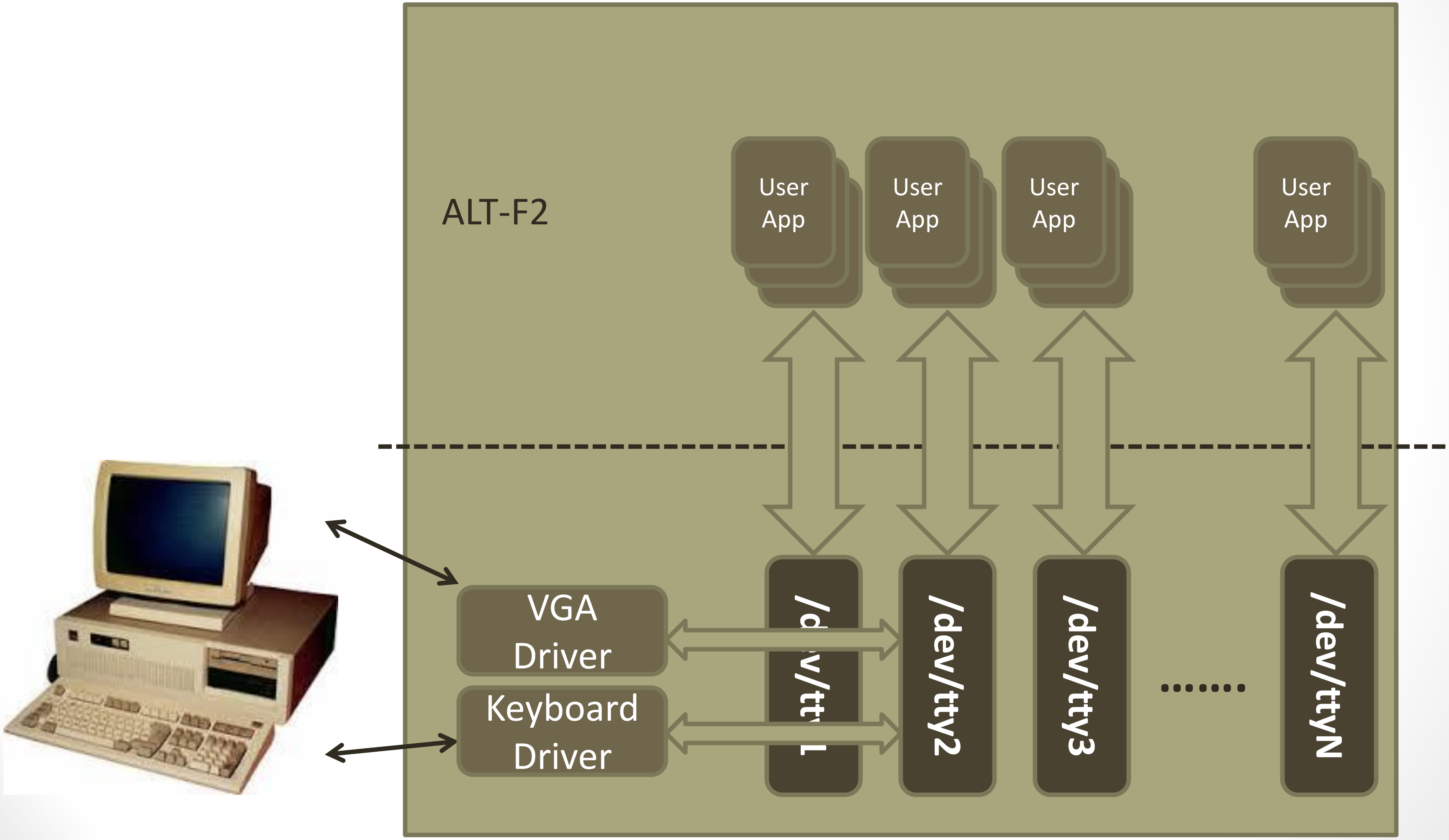
Virtual Terminal



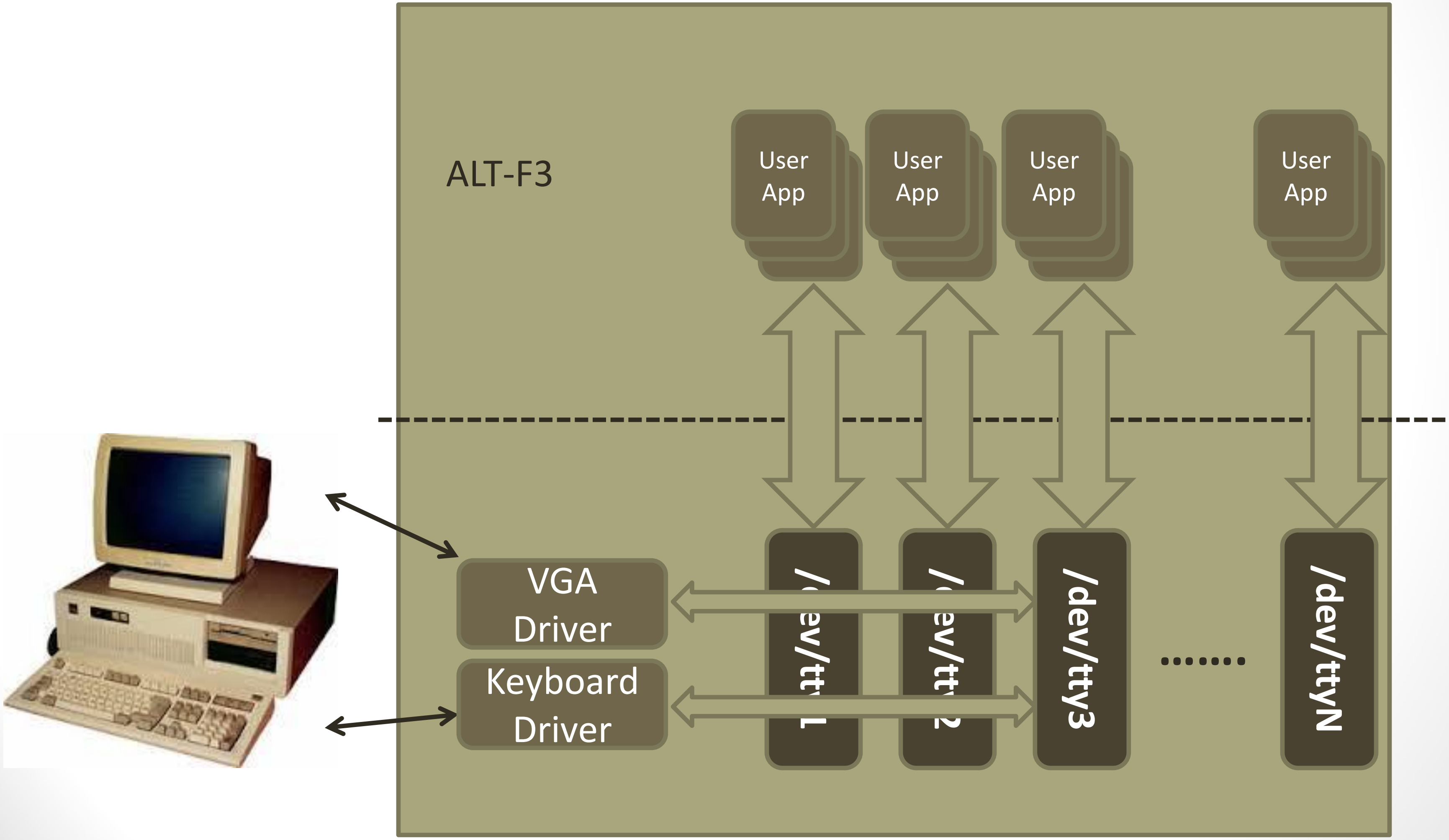
Multiple Virtual Terminals



Multiple Virtual Terminals



Multiple Virtual Terminals



ALT-F3

User App

User App

User App

User App

VGA Driver

Keyboard Driver

/dev/tty1

/dev/tty2

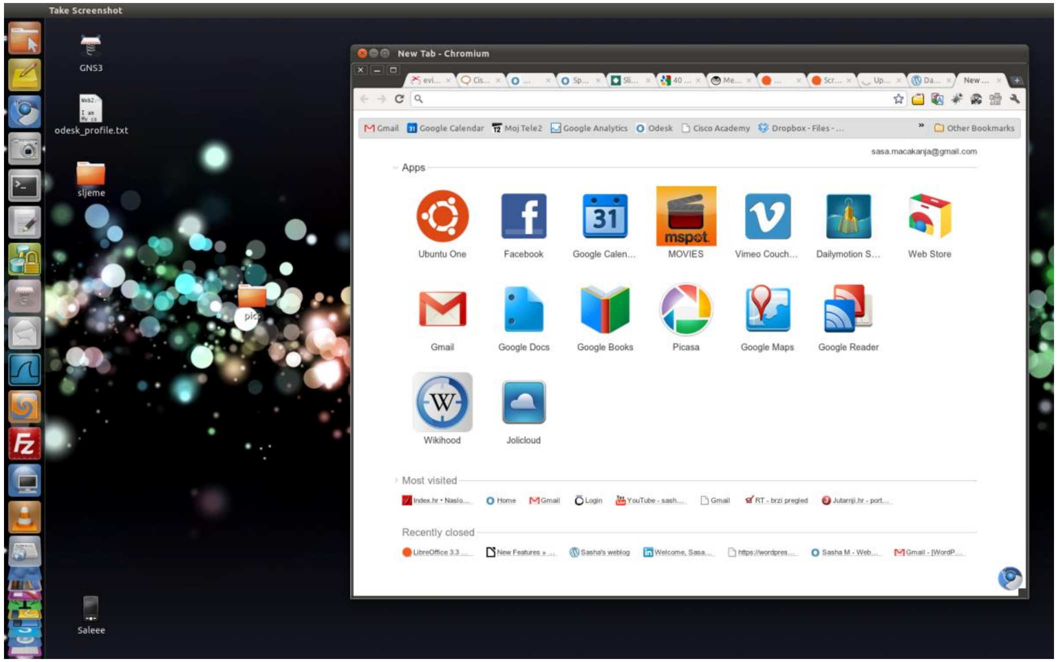
/dev/tty3

....

/dev/ttyN

Virtual Terminals

- A new architecture is used to be able to have multiple terminals on the same machines (with the same physical terminal)
- The Monitor/Keyboard drivers are no longer part of a TTY device, they are now separate devices
- Linux kernel provides up to 63 virtual terminals (VT) (/dev/tty1 up to /dev/tty63)
- Most distributions initialize only 7 VTs (/dev/tty1 - /dev/tty7)
- On each of these VTs, the user app ***getty*** is started. This program is responsible for user login
- All VTs are active, but only one have access to the Physical terminal (Monitor/Keyboard)
- To switch between different VTs, use ***ALT-Fn*** to go to the VT#n



NOW LET US ADD SOME GUI

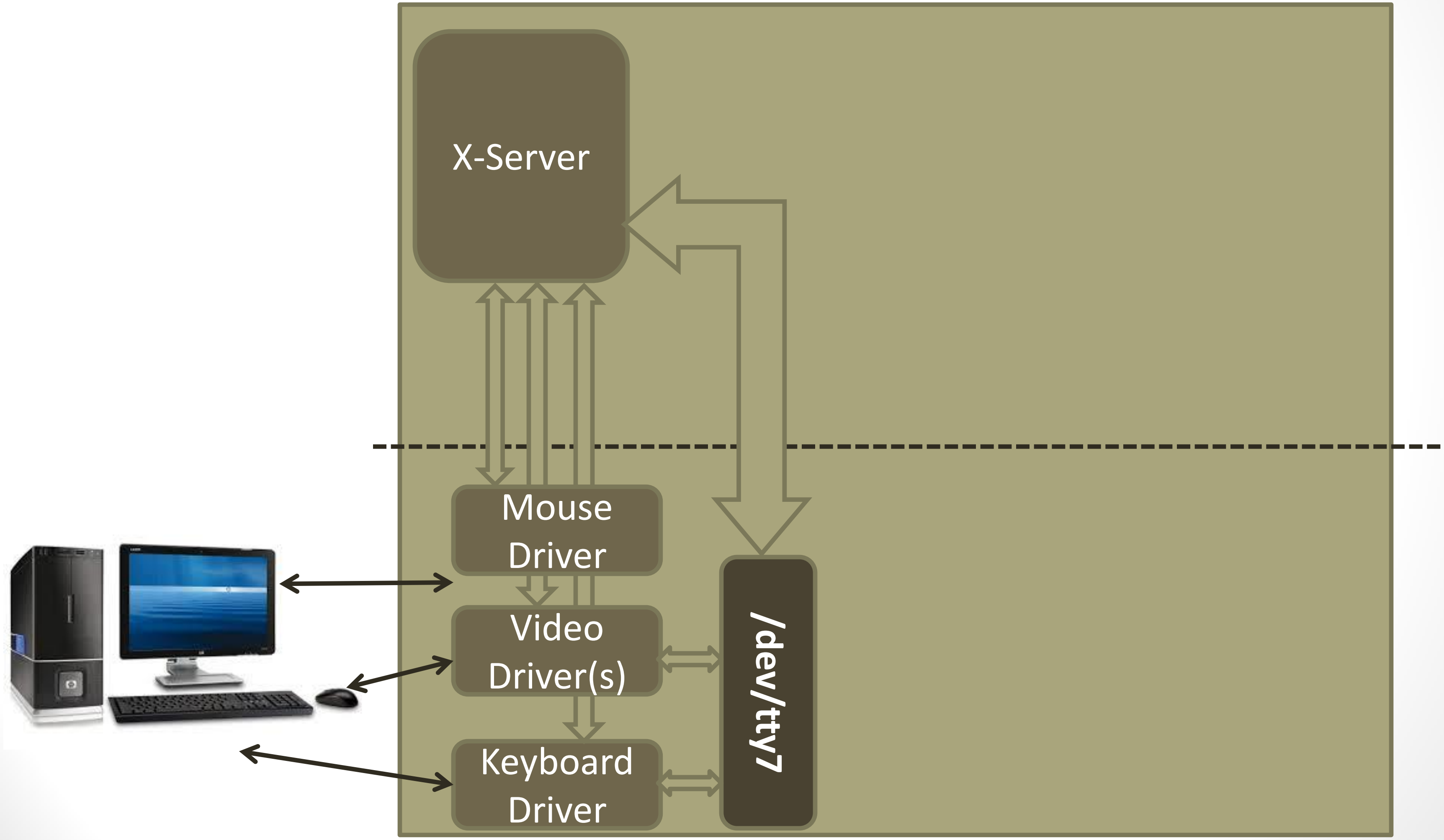
Linux GUI

- So far we have talked about Text I/O
- We need to have,
  - Windowing (Multiple windows, maximize, minimize, ...)
  - Fonts, colors, icons
  - Handling of mouse actions
  - Displaying of Graphics
- For performing all of these tasks, Linux uses X-Window System
- The X-Window System (also Called X system, or X11 System) is a Windowing system for bitmap displays
- It is composed of:
  - Server (X-Server):
    - A user application that is responsible for handling the Graphical User Interface and connecting to the drivers
    - Most Linux distributions use the ***Xorg*** application for this
  - Client (X-Client)
    - The client part lives in every user application that needs to use the GUI
    - The user app connects to the Xserver using the ***X Protocol***

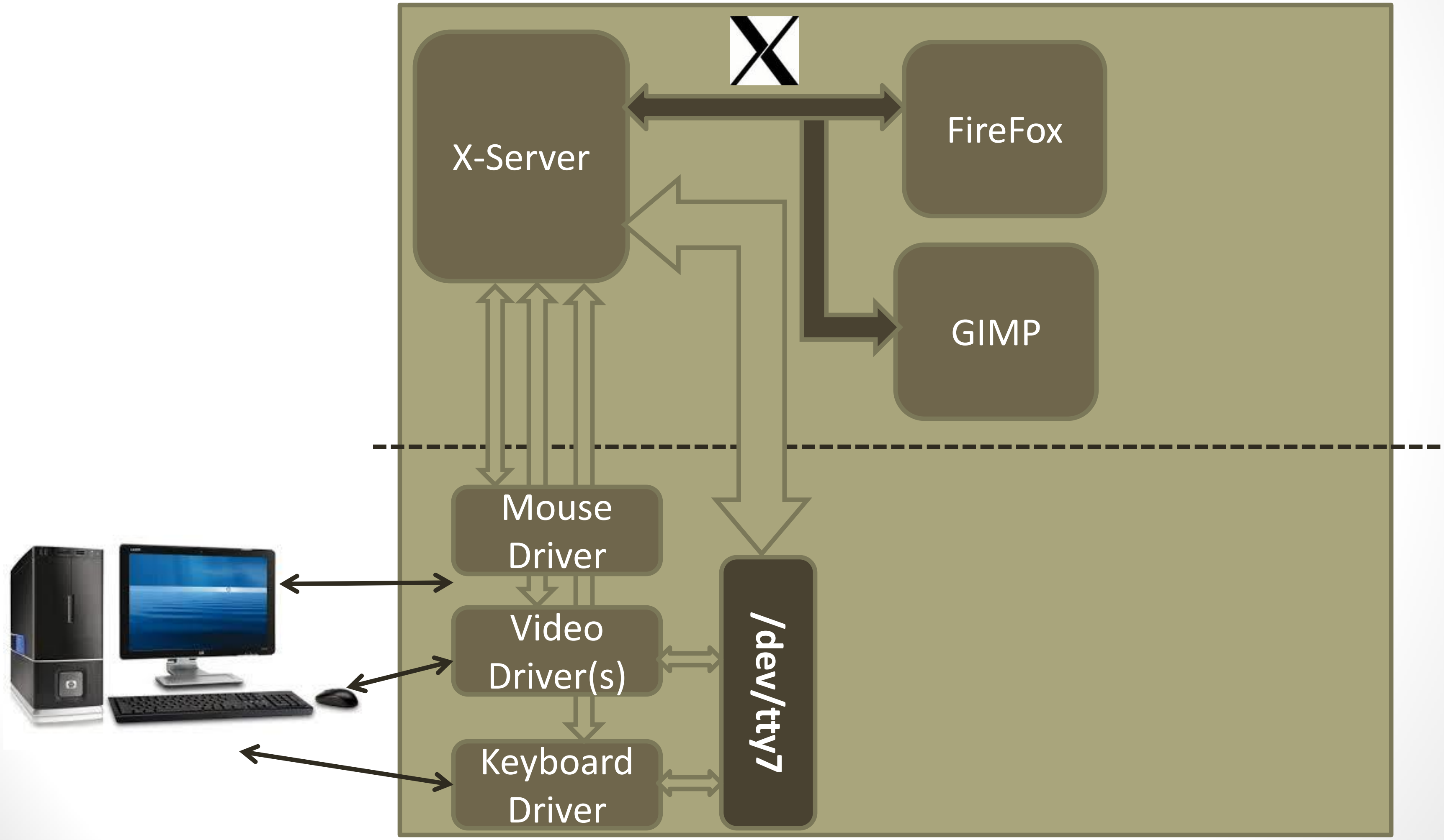
X-Server and VTs

- As mentioned before, Linux distributions, initialize some VTs to run getty for user login (most Distributions use /dev/tty1 to /dev/tty6 for that)
- The X-Server is started on at least one VT (normally /dev/tty7). This is X-Session # 0
- Some Distributions start the X-server on multiple VTs (so we get multiple X-Sessions)
- A User can add more X-Sessions or stop X-Sessions if needed. Remember, the X-Server, is just a User application that is started on one of the VTs
- Since Alt-Fn has some meaning for the GUI, to move from the GUI to another VT, use Ctrl-Alt-Fn instead
- So assuming we have X-server running on /dev/tty7
  - To move to VT#1 ➔ Ctrl-Alt-F1
  - To move back to the GUI ➔ Alt-F7

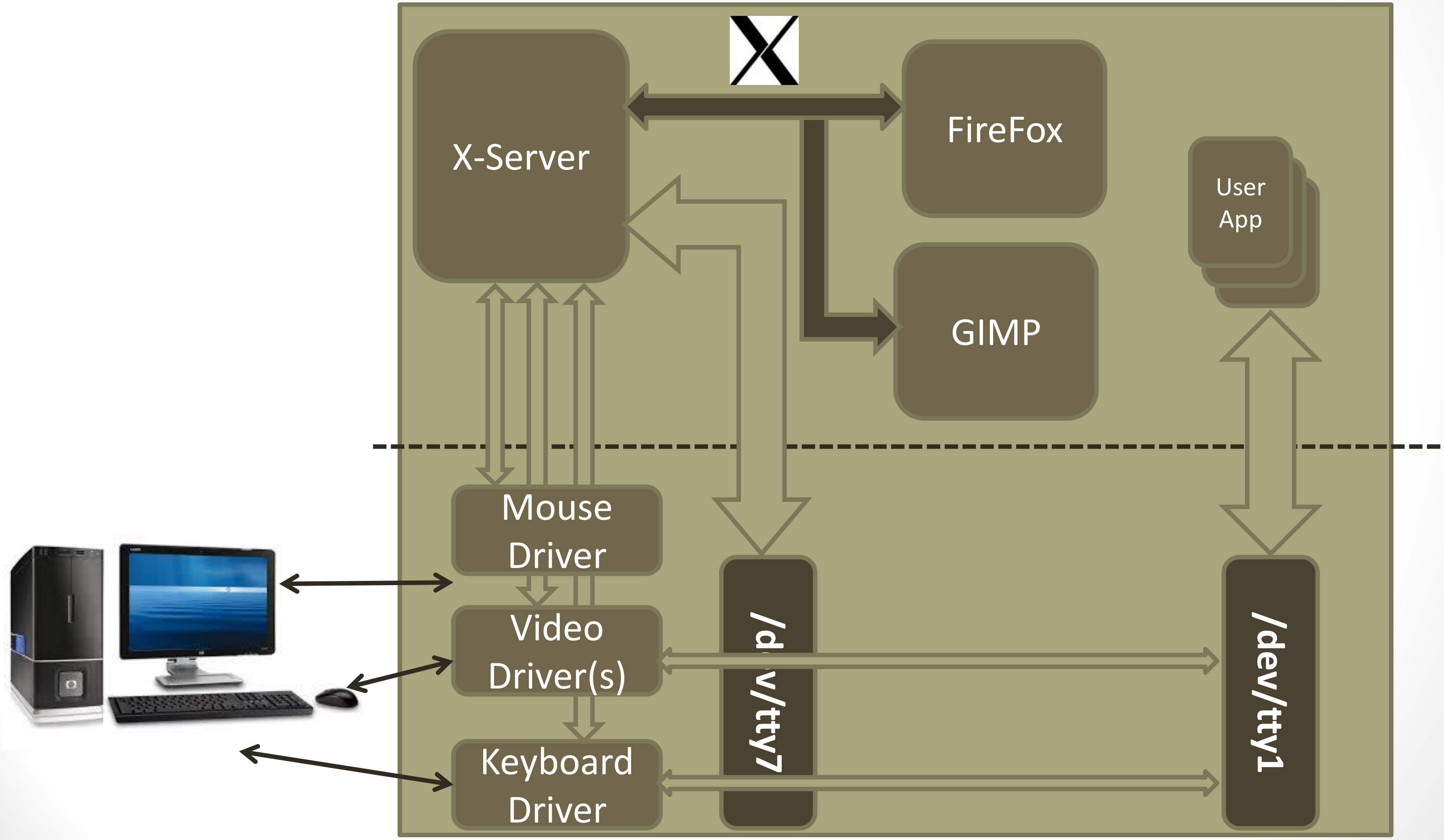
Using X-Server



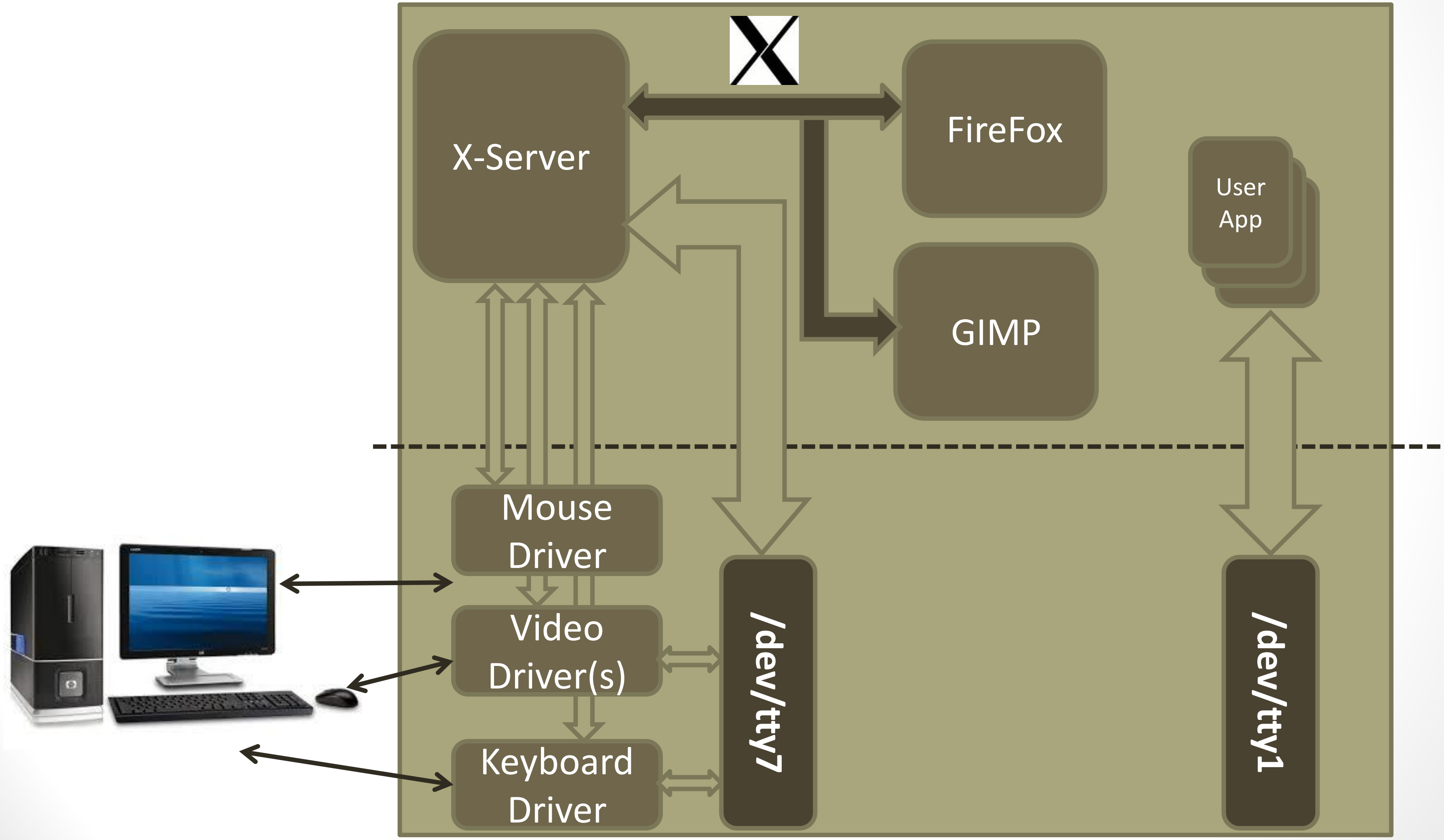
Using X-Server

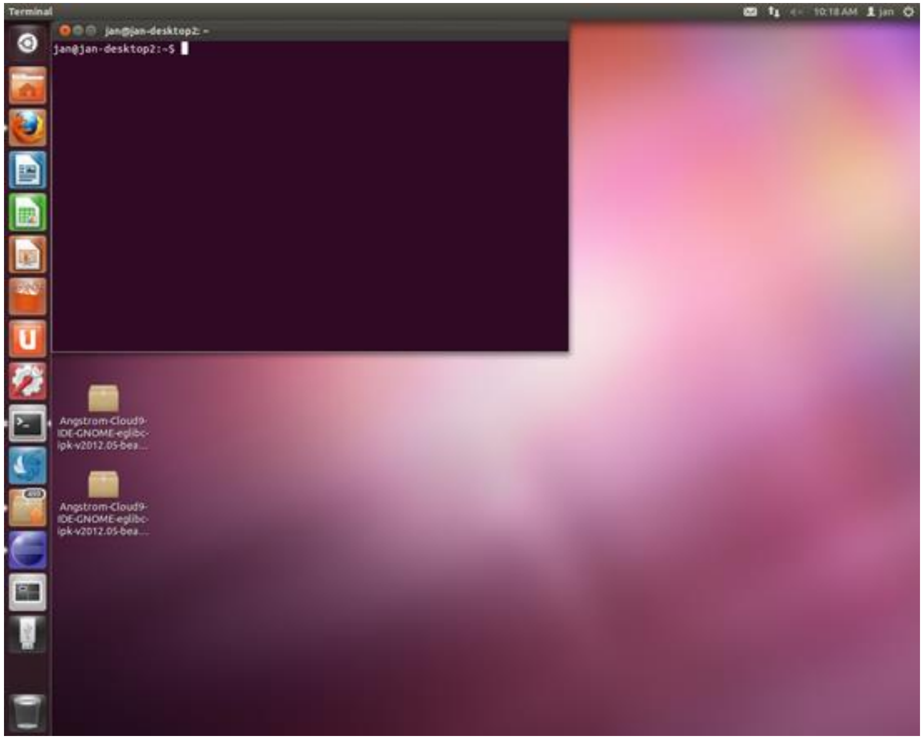


Using X-Server



Using X-Server





Terminal
10:18 AM
jan
jan@jan-desktop2: ~
Angstrom-Cloud9-IDE-GNOME-eglibc-ipk-v2012.05-bea...
Angstrom-Cloud9-IDE-GNOME-eglibc-ipk-v2012.05-bea...

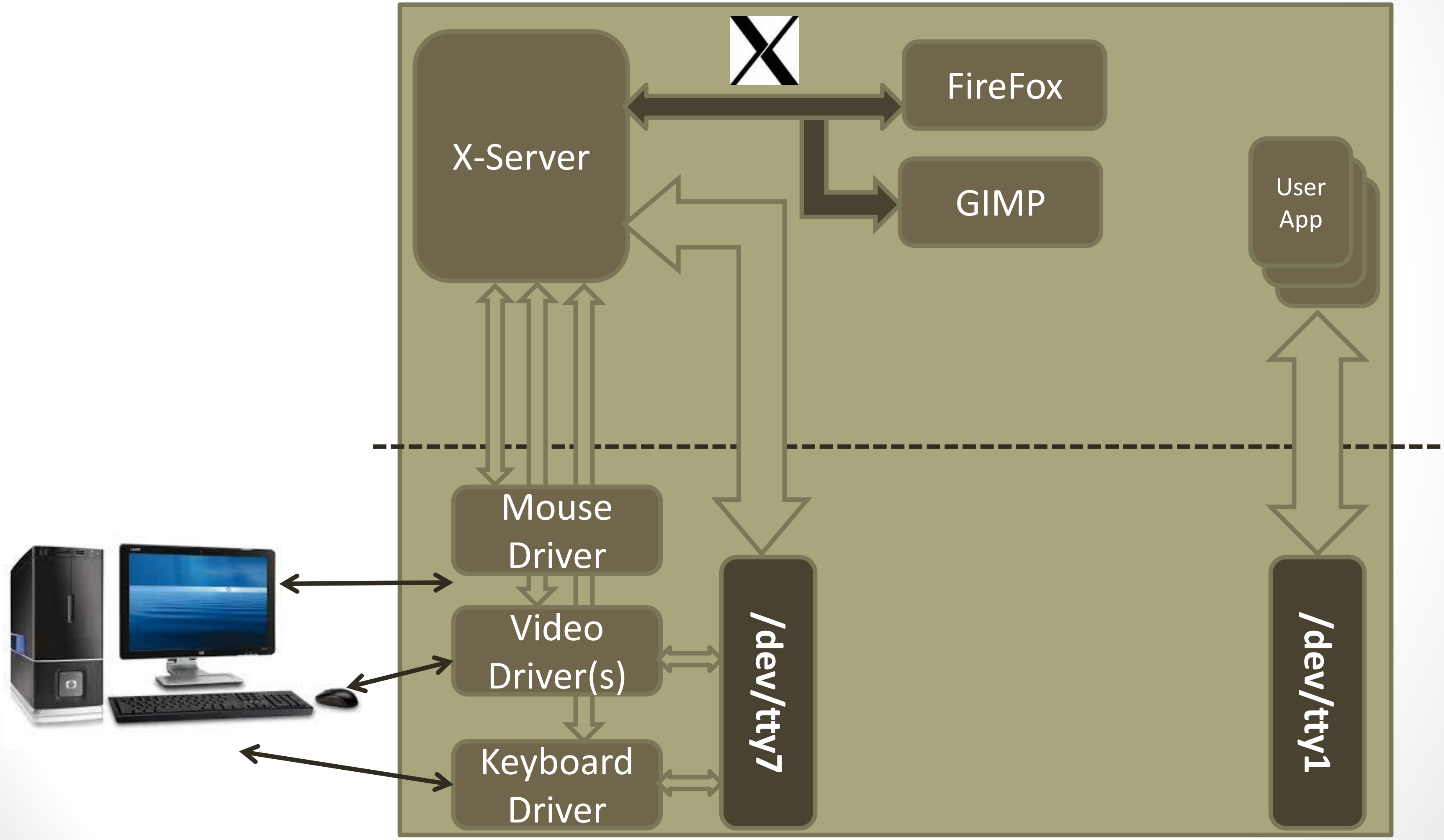
```
jan@jan-desktop2:~$
```

USING EMULATED TERMINALS

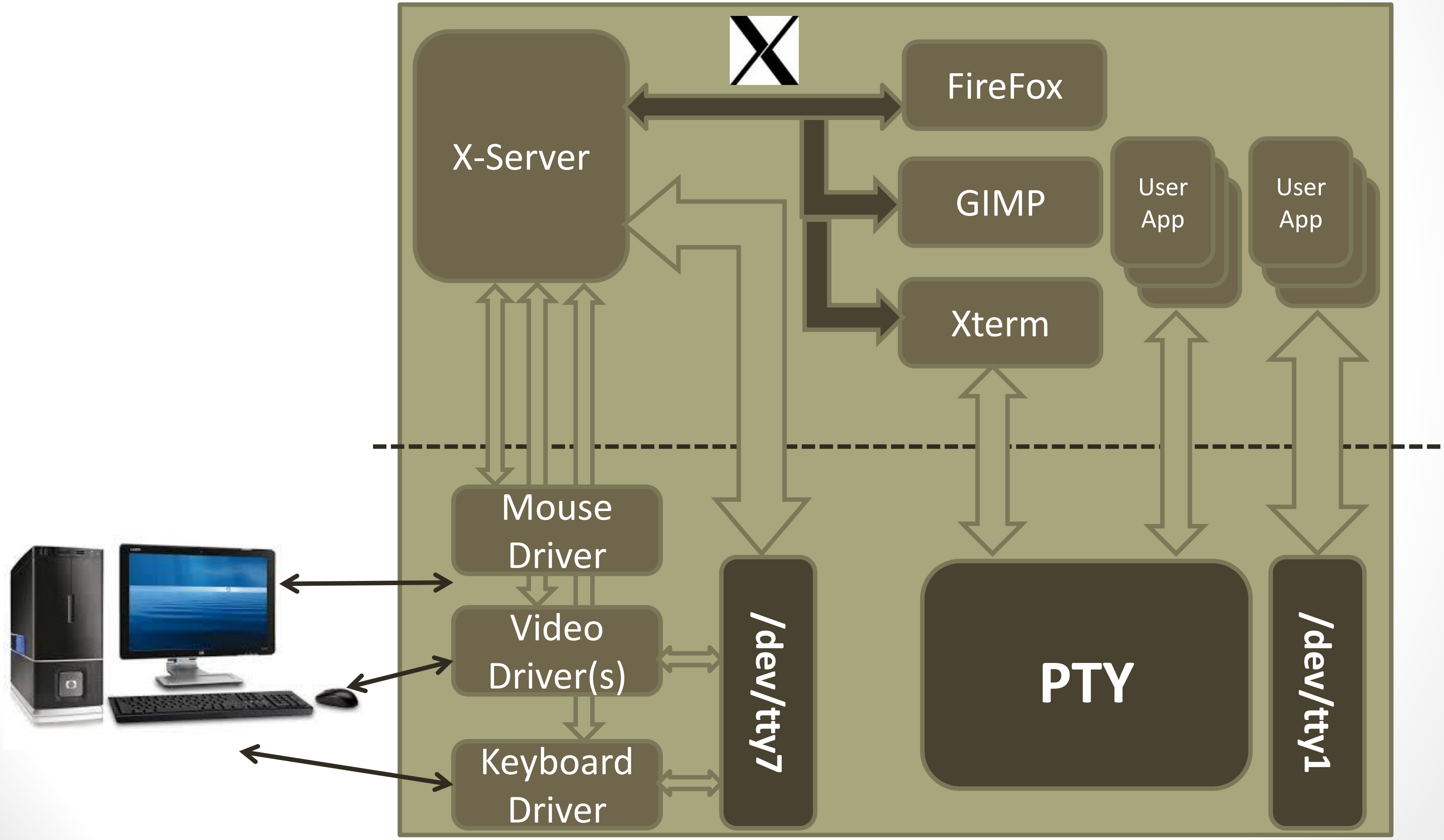
Emulated Terminals

- The next step is to use an emulated terminal from the GUI
- This means, to have an X-App that acts as a terminal
- There exists some terminal emulators that run as X-clients such as,
  - ***xterm***
  - ***Konsole*** (in KDE)
  - ***gnome-terminal*** (in GNOME)
- To support this concept, the Linux Kernel introduces the concept of Pseudo Terminals (PTY)

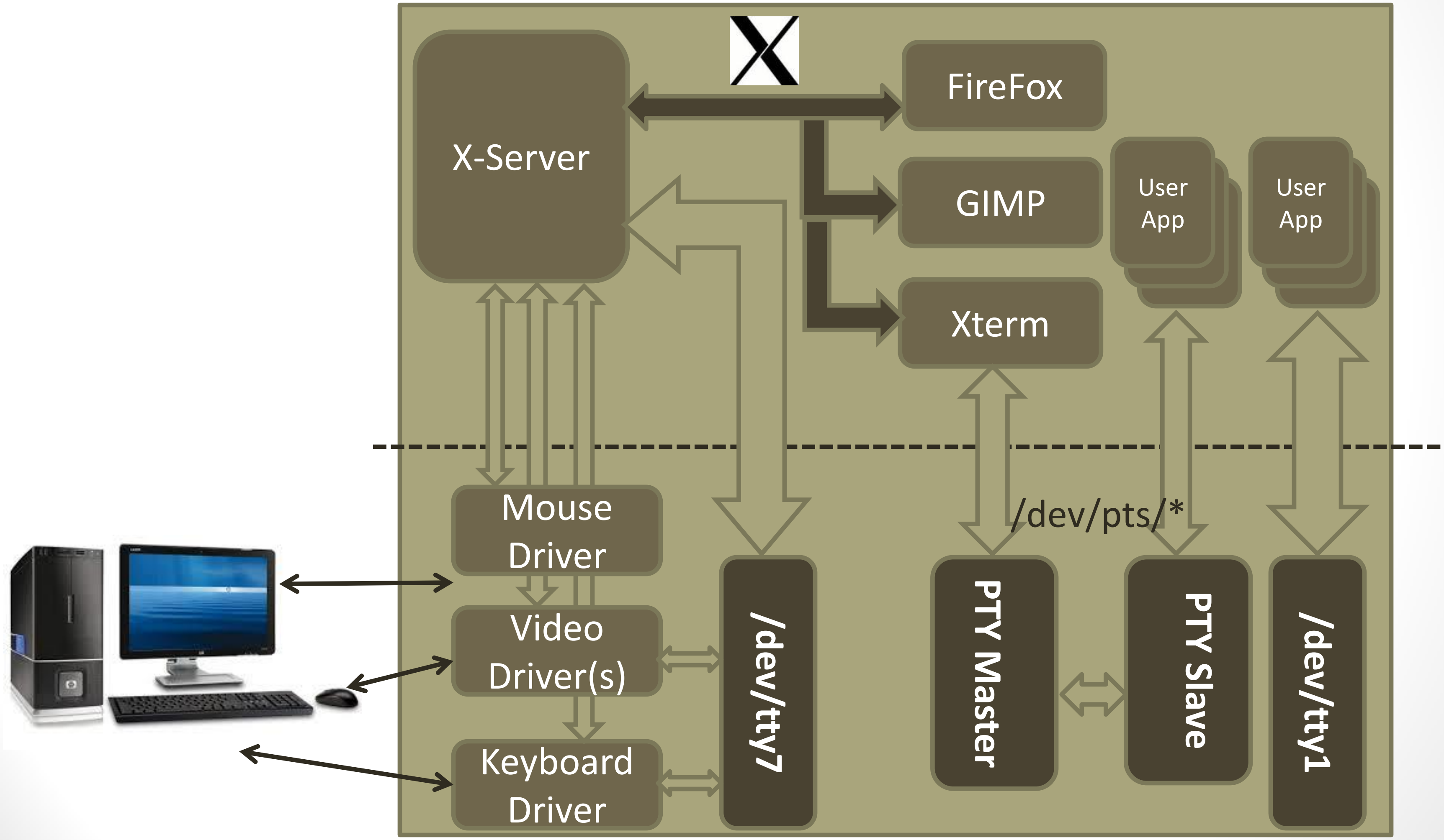
Using Emulated Terminals



Using Emulated Terminals

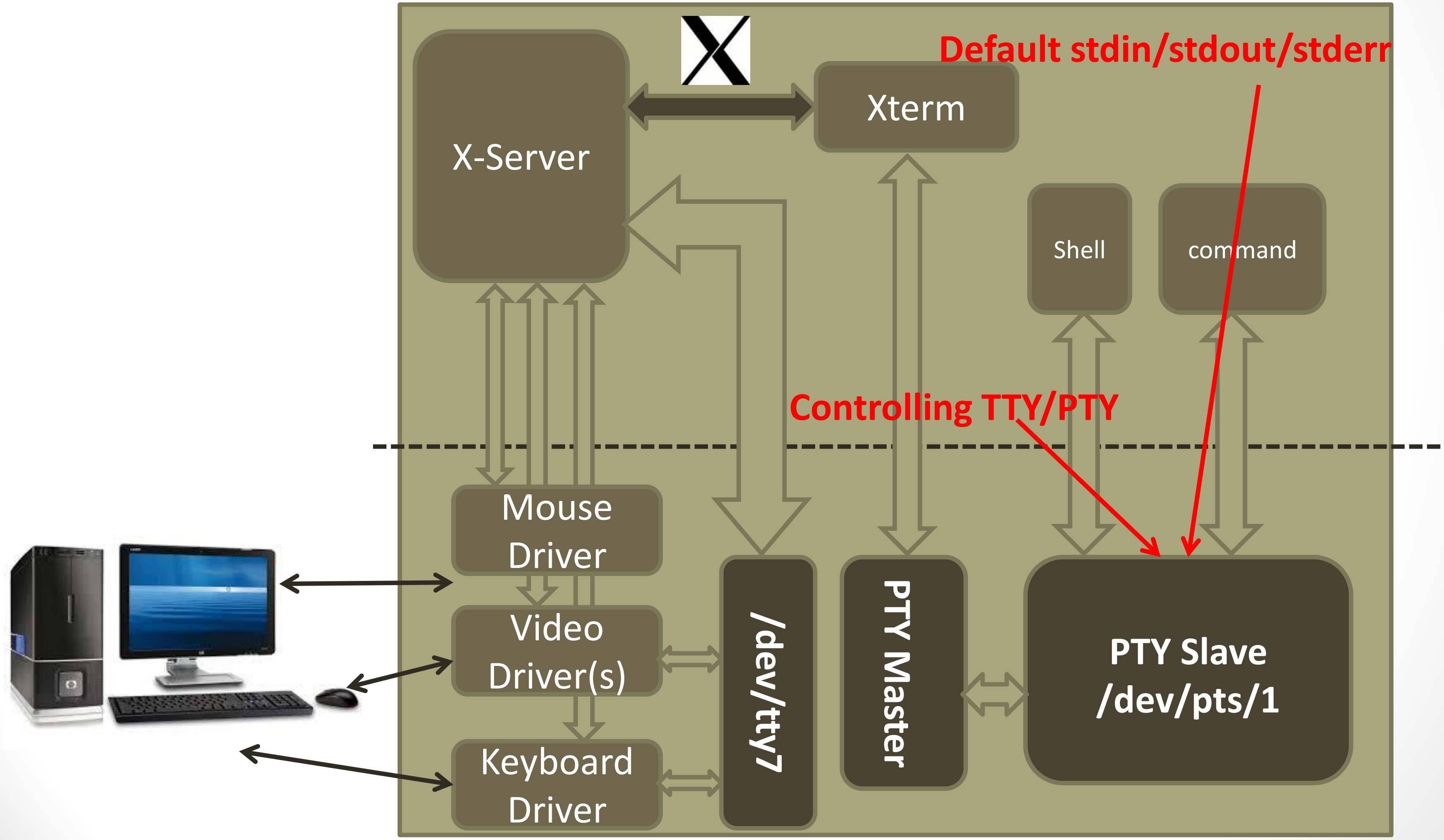


Using Emulated Terminals

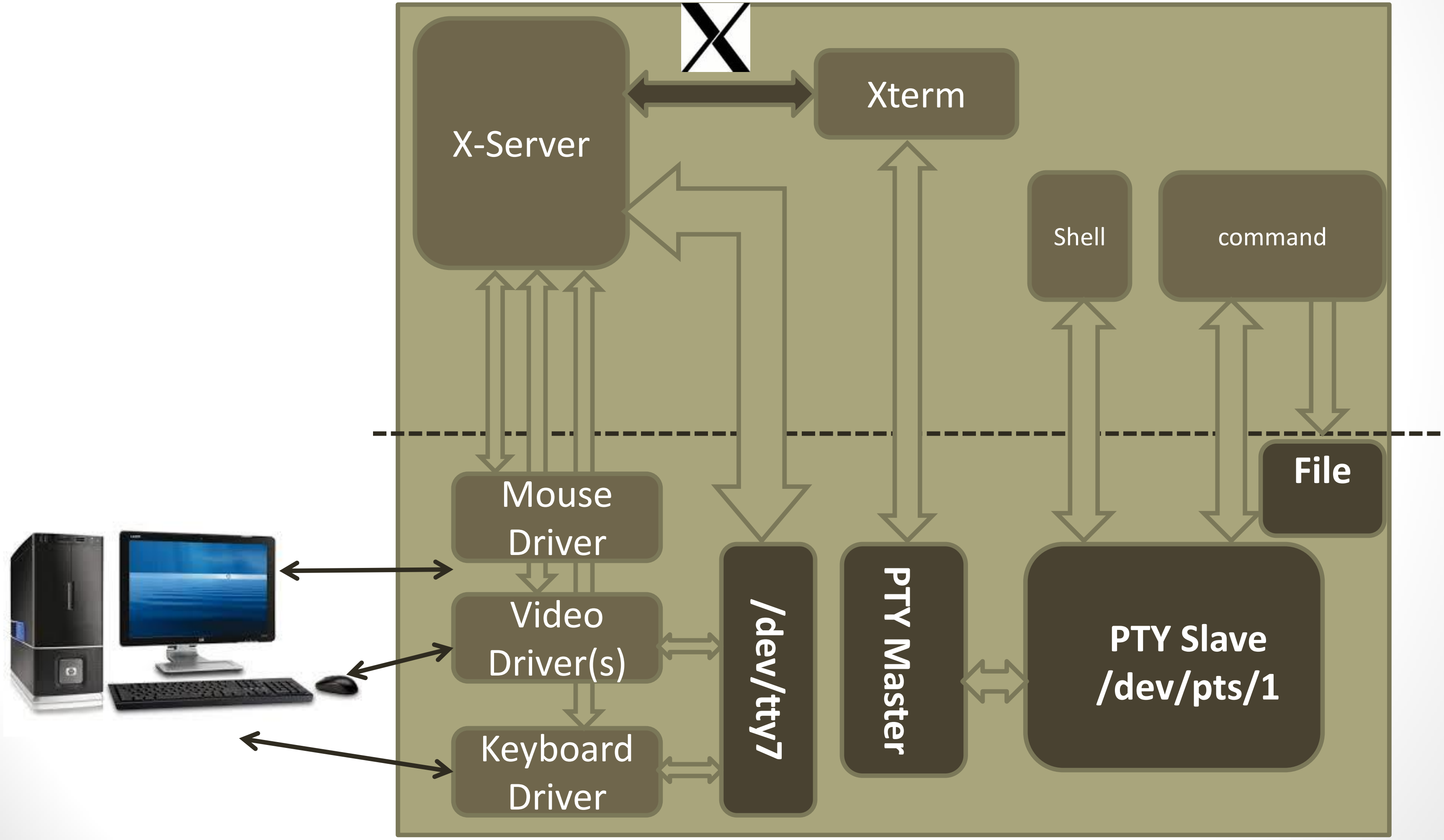


USE CASES

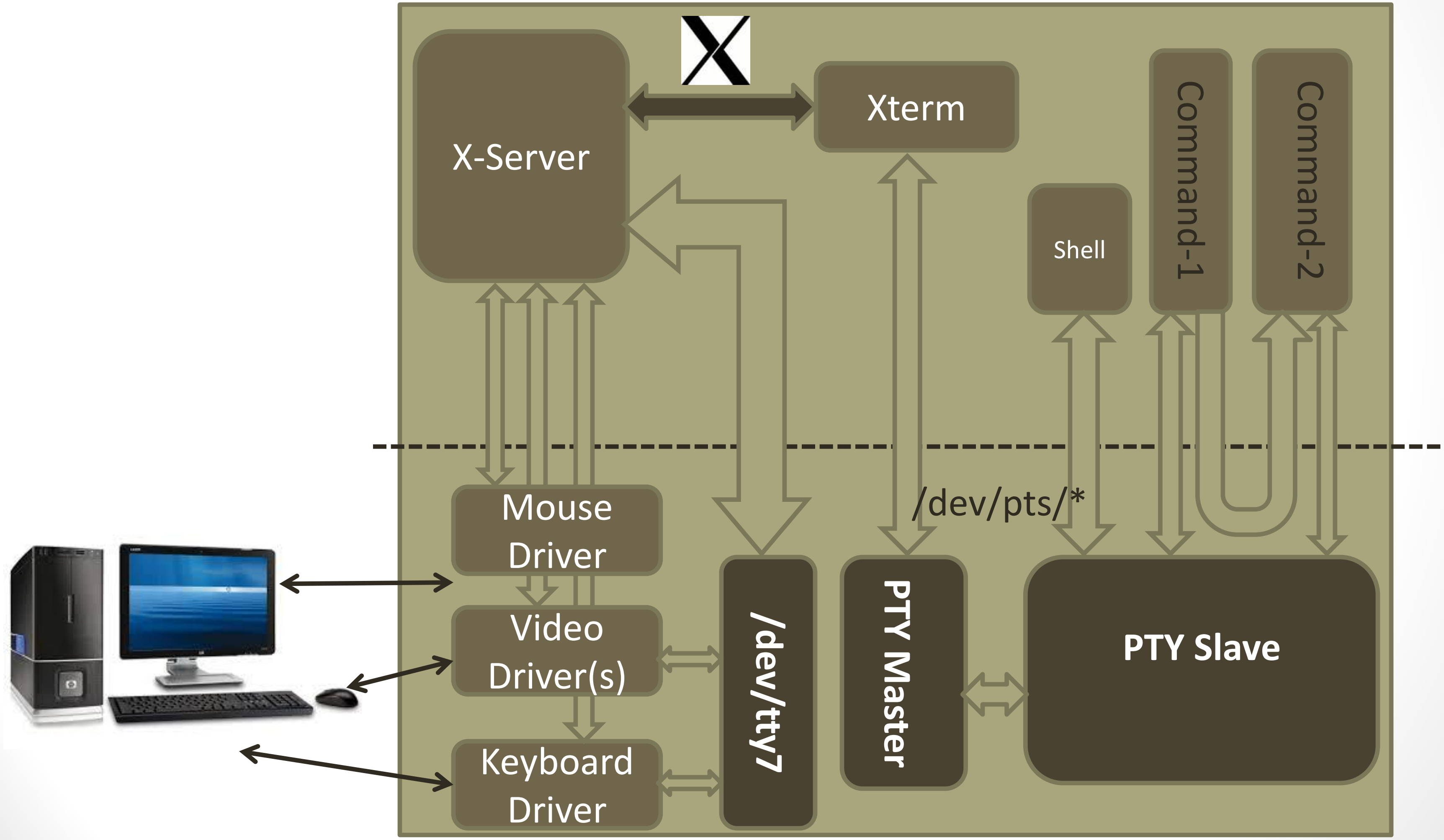
Running a Shell Command



Redirecting stdout to a File



Running a Piped Shell Commands



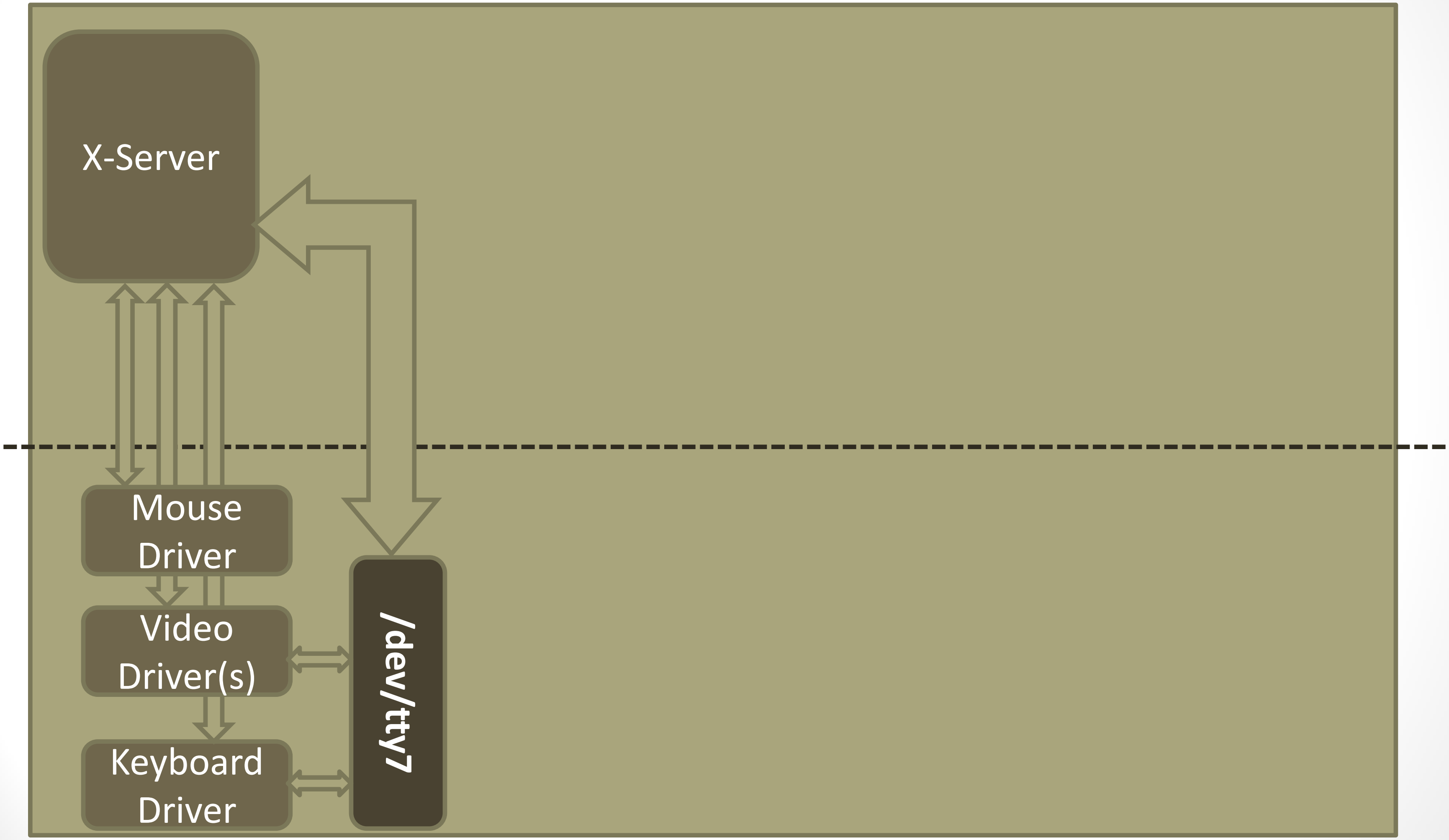
Identify The Controlling TTY/PTY Device (tty Command)

```
$ tty
```

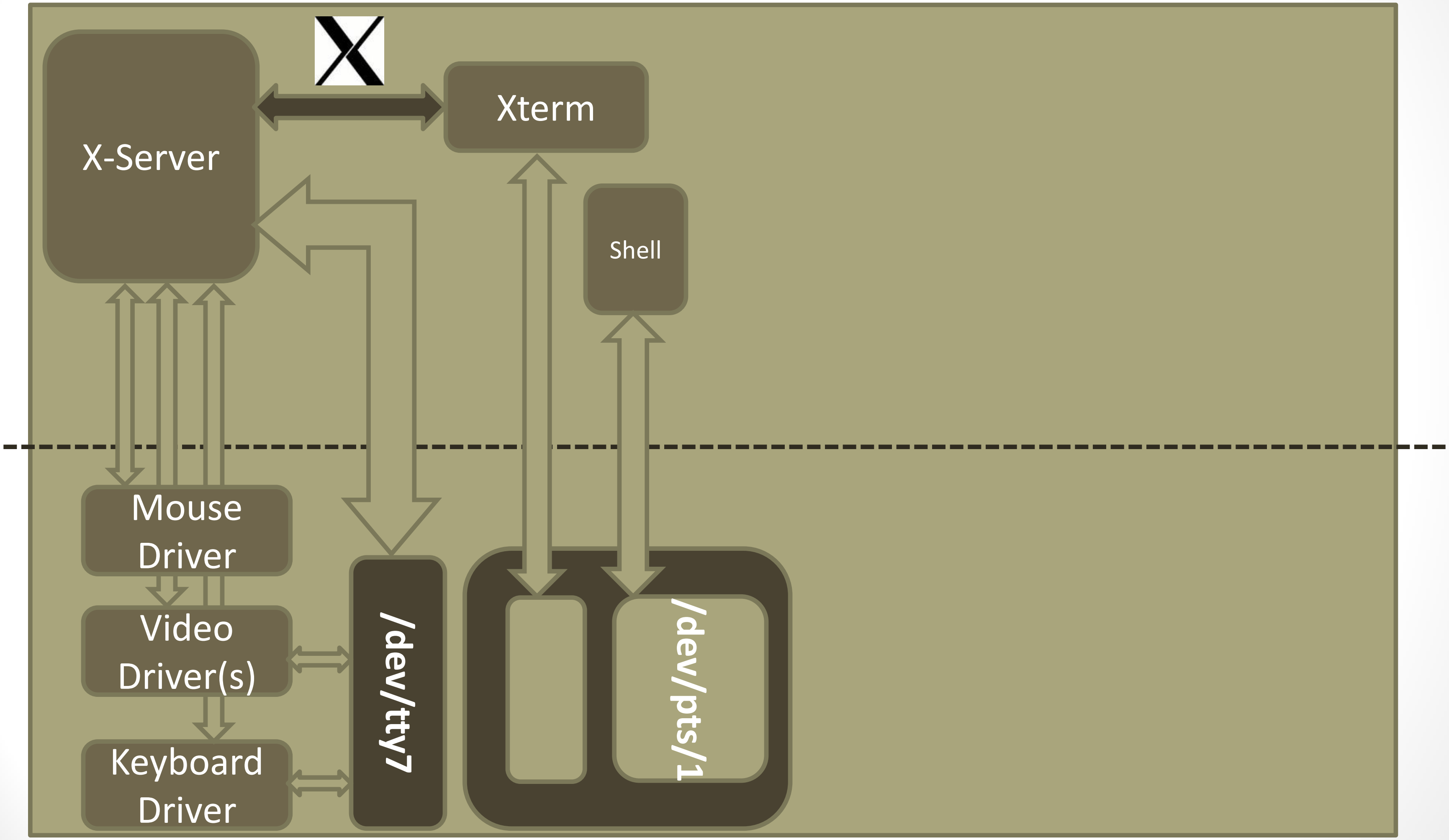
- If you run this command from any terminal (Physical/Virtual/Emulated), you will get the TTY/PTY device associated with it

MANAGING EMULATED SESSIONS
THE SCREEN COMMAND

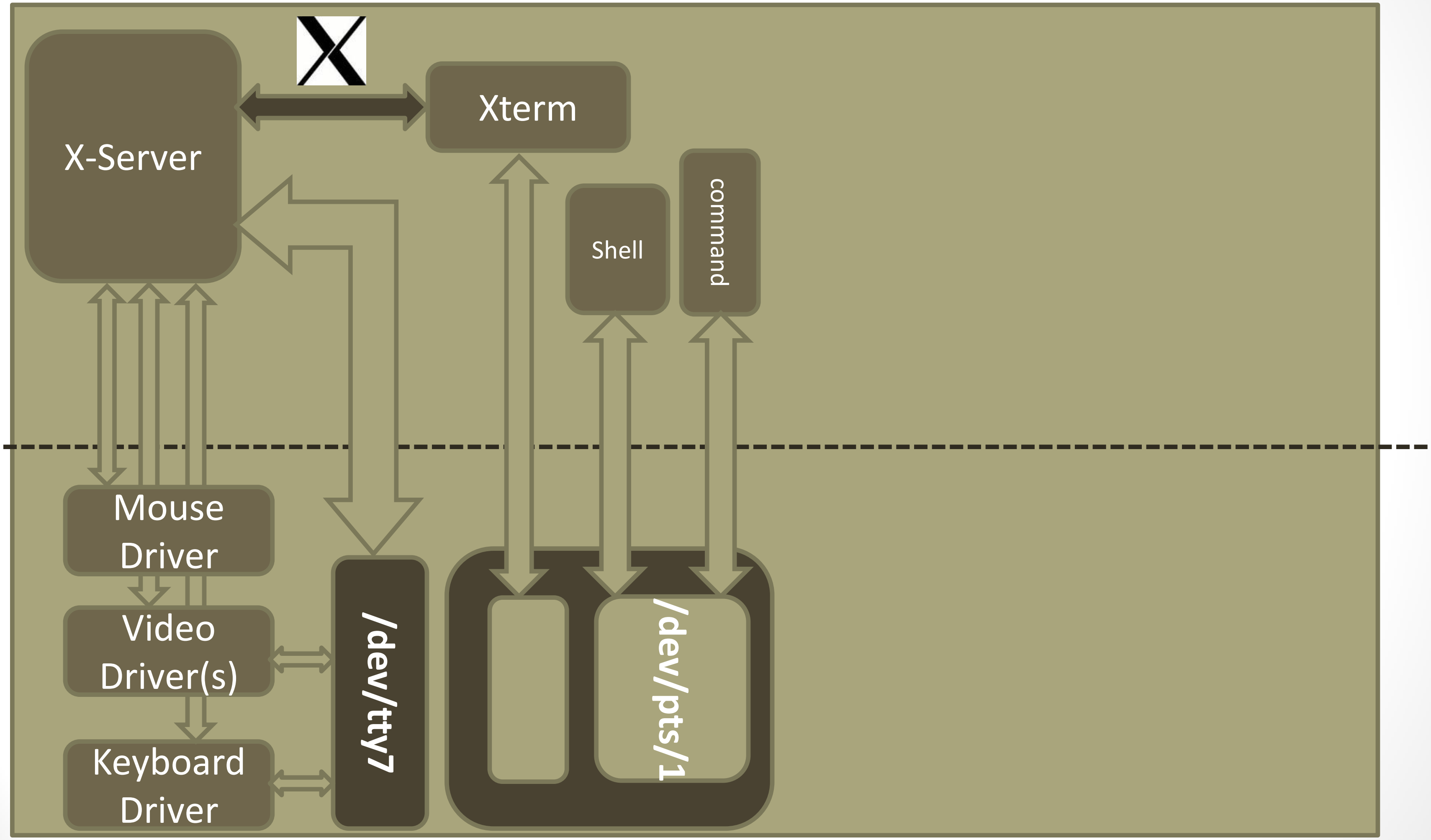
Working with the Screen Command



Working with the Screen Command

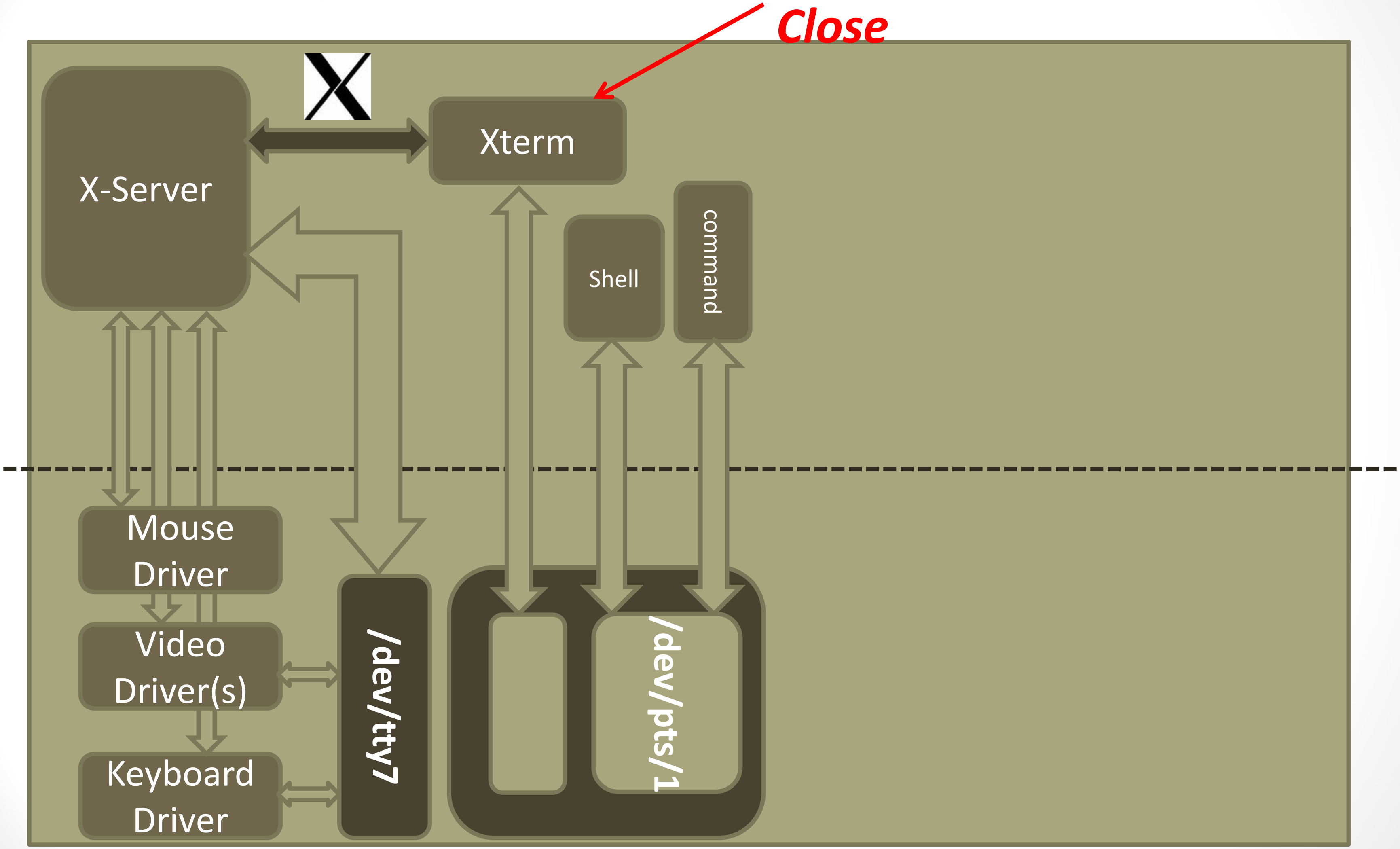


Working with the Screen Command

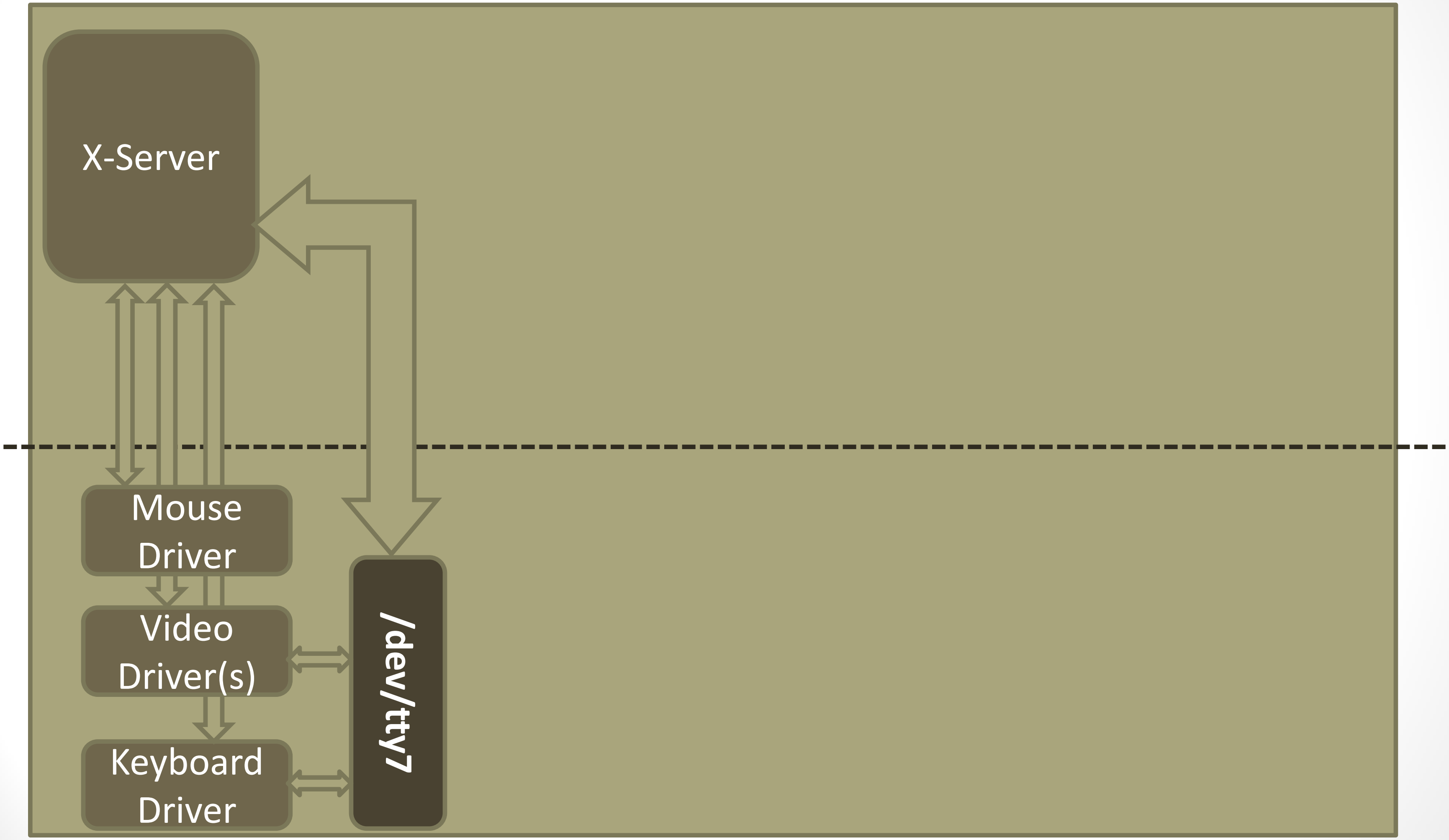


$ command

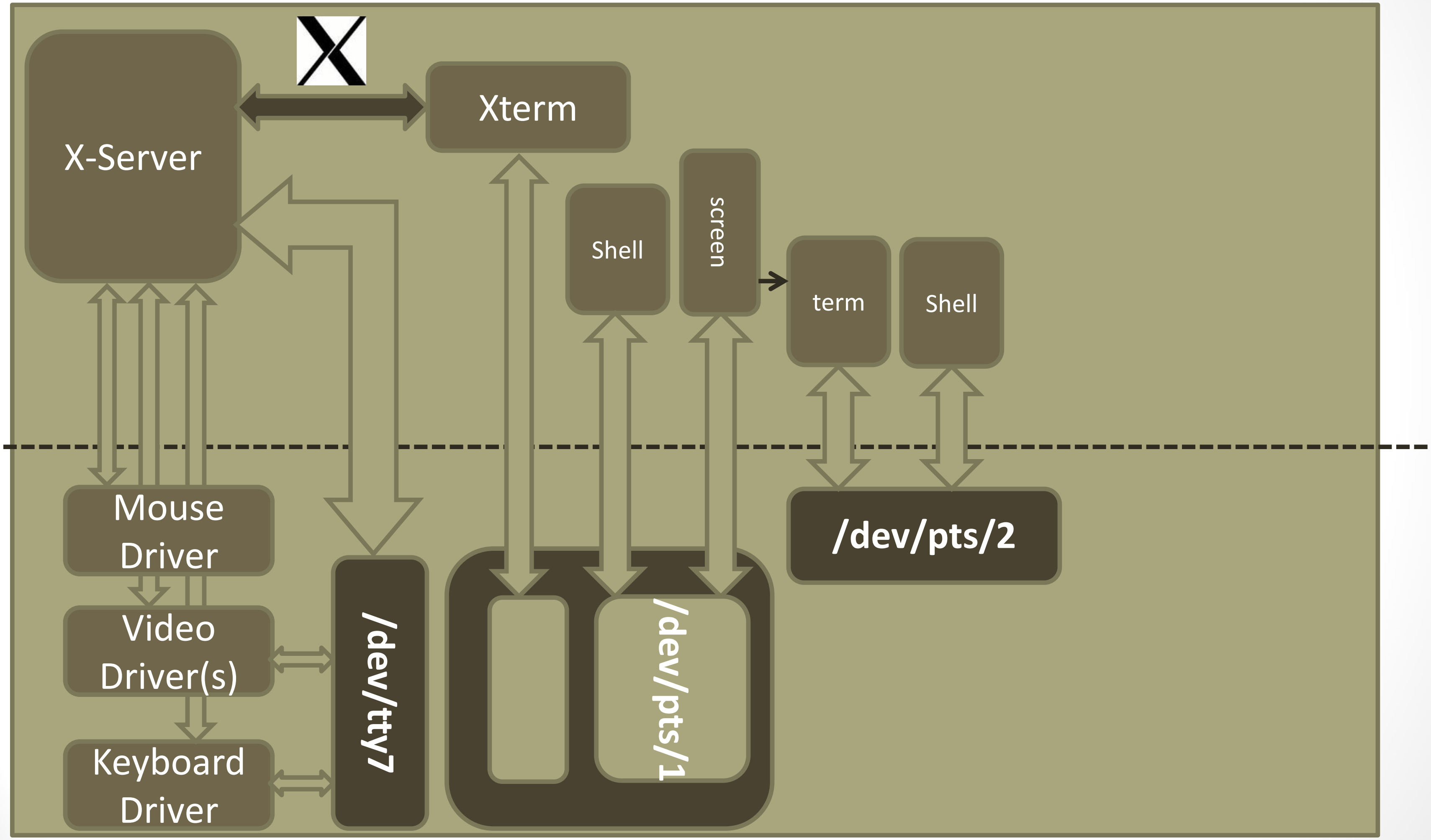
Working with the Screen Command



Working with the Screen Command

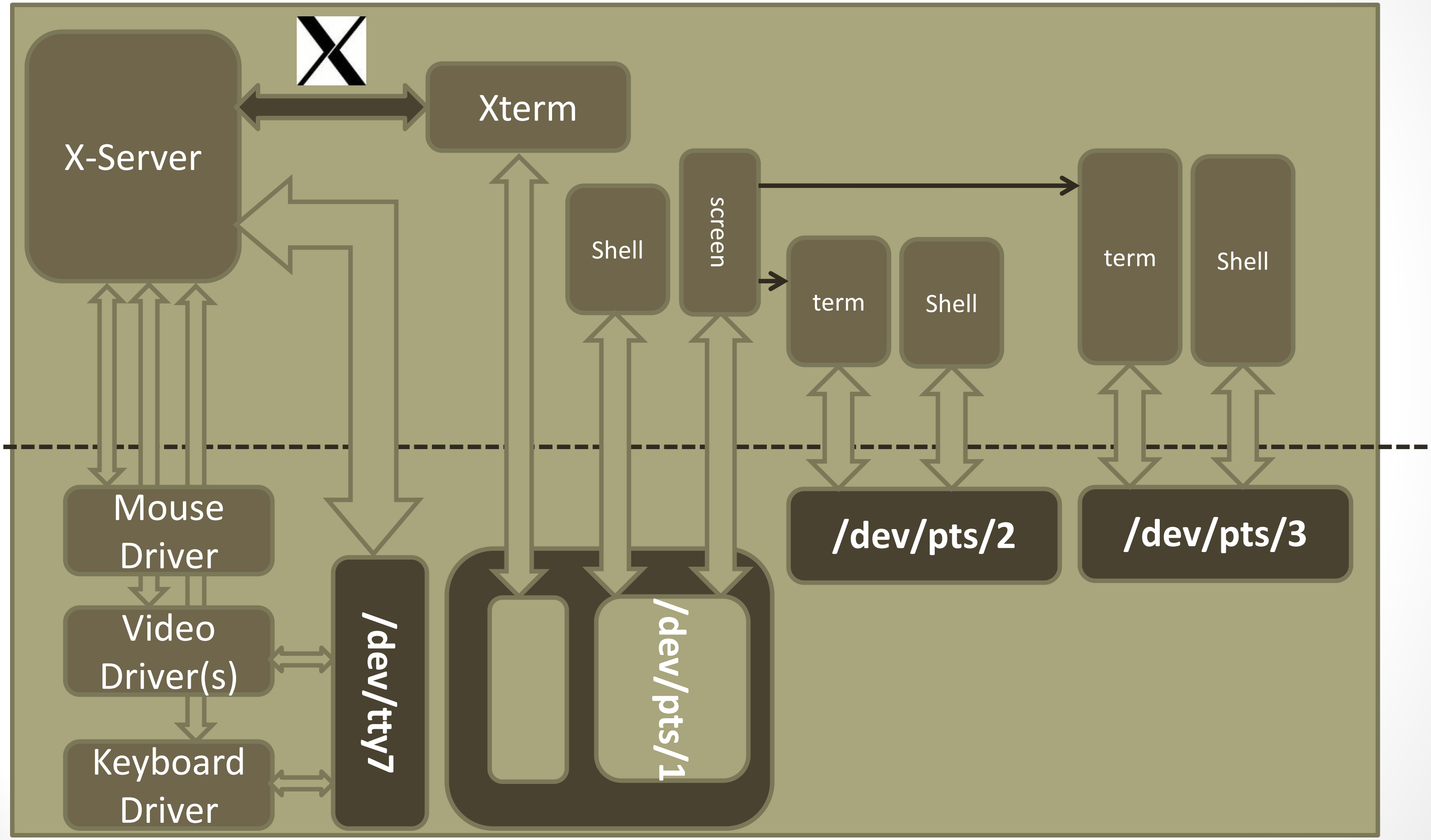


Working with the Screen Command



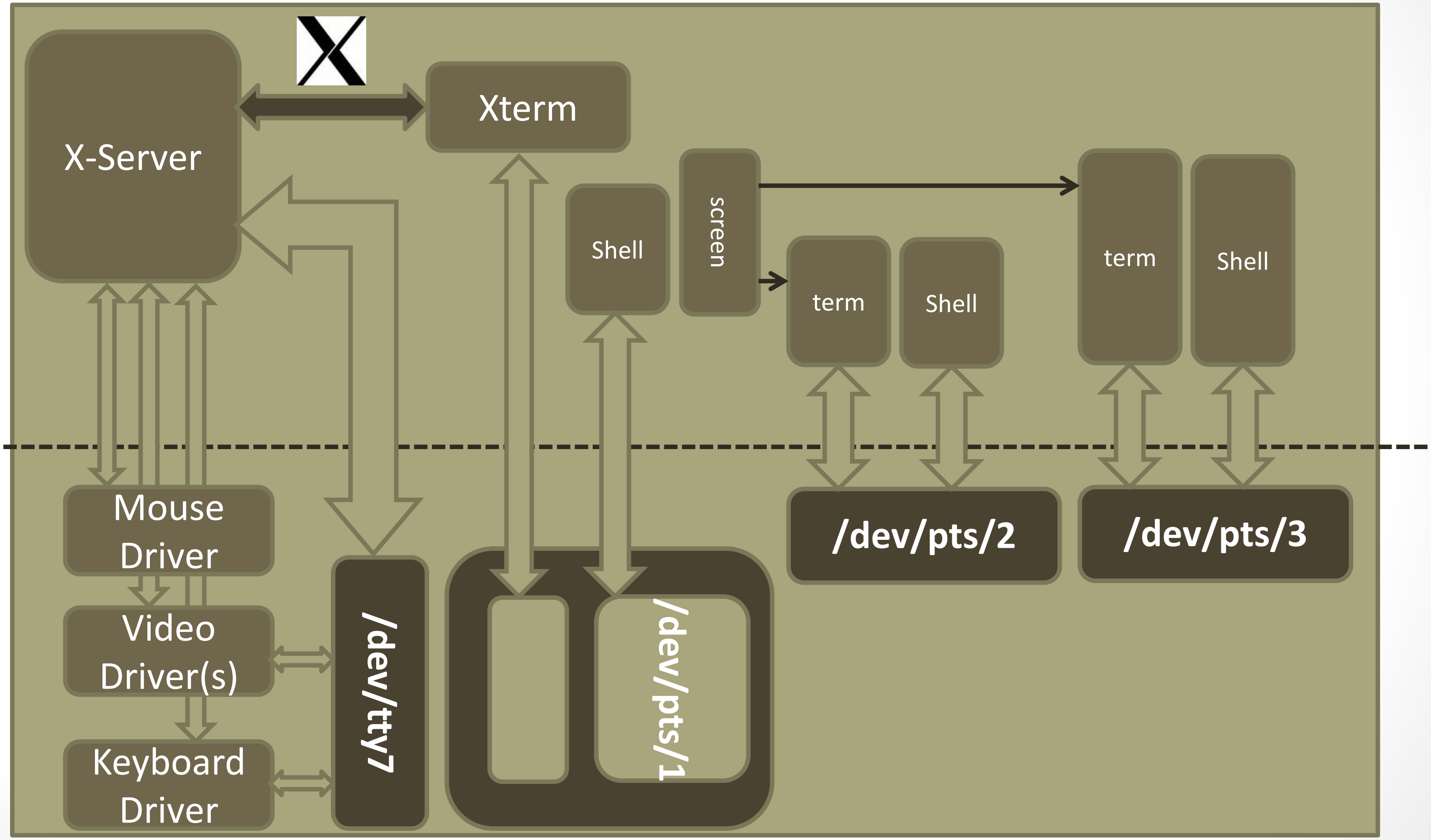
$ screen

Working with the Screen Command



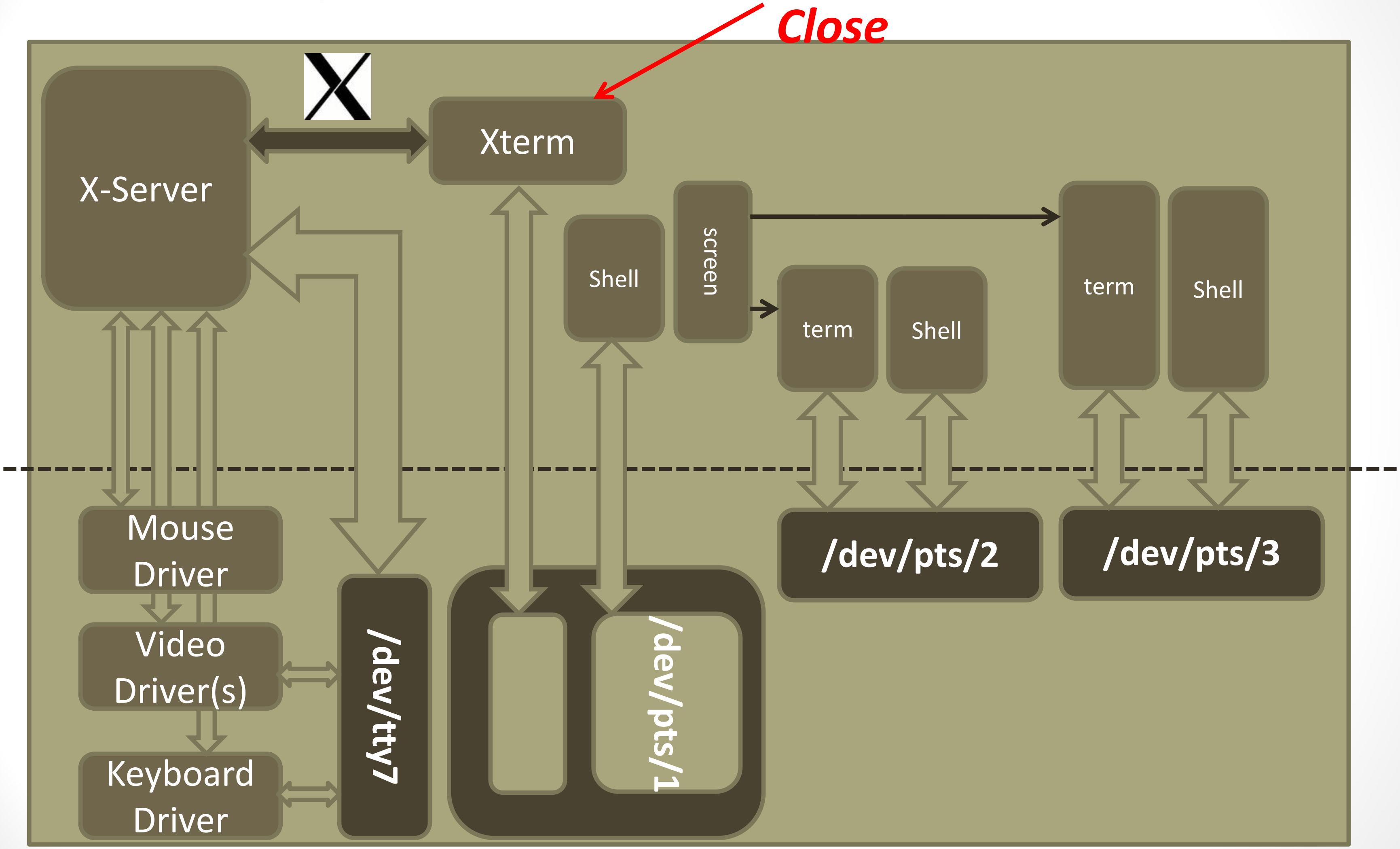
Ctrl-A c

Working with the Screen Command

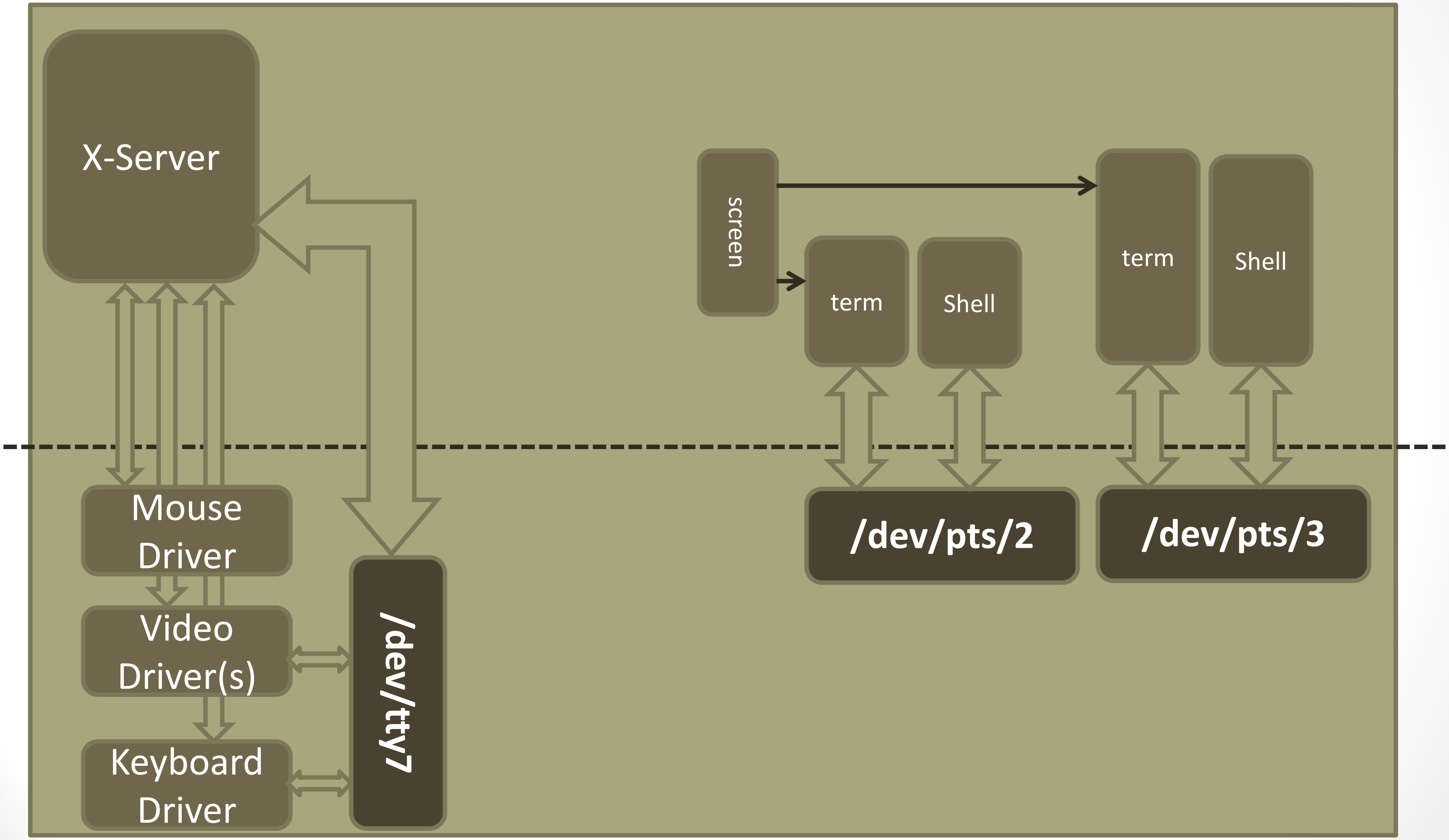


Ctrl-A d

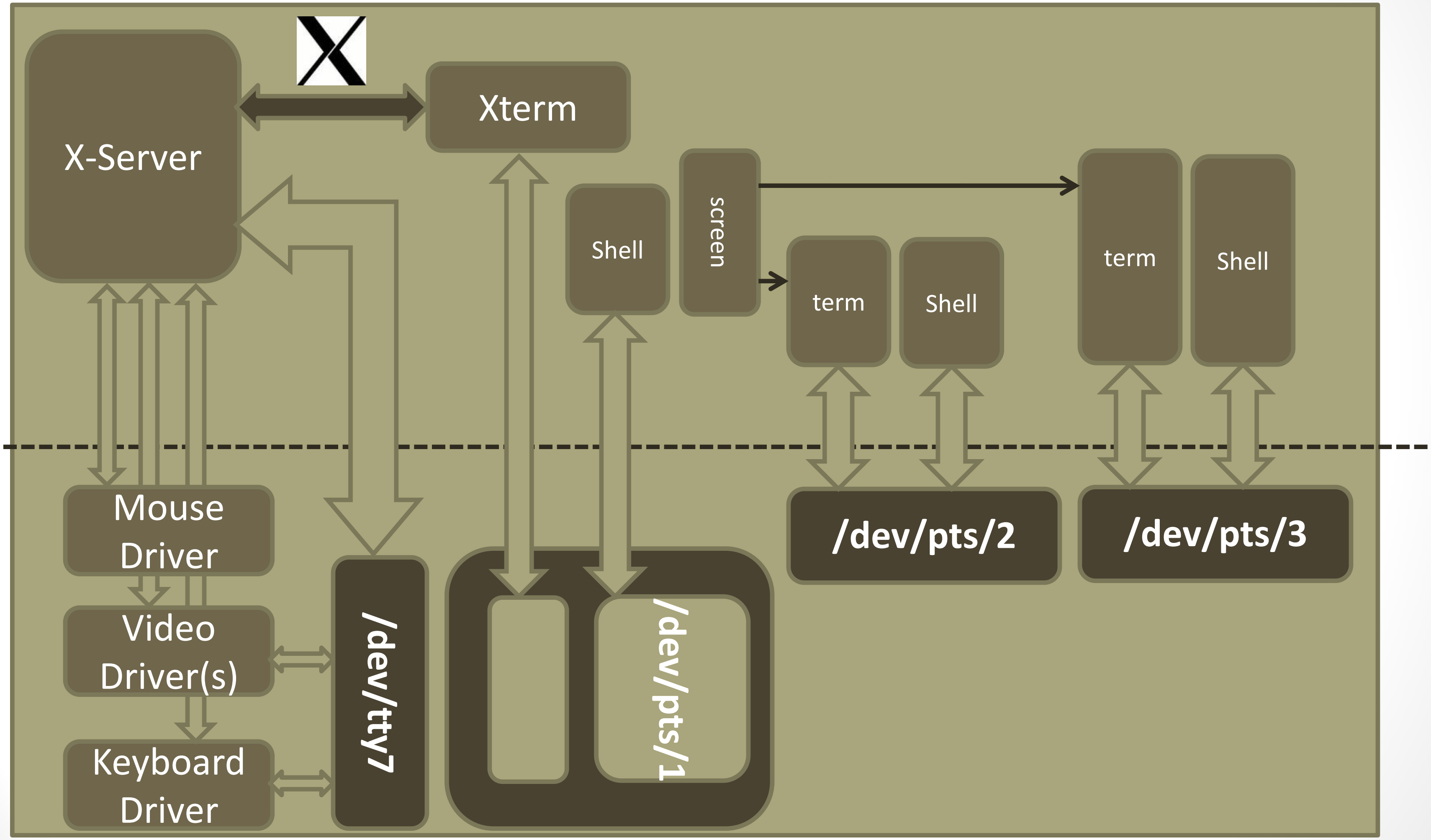
Working with the Screen Command



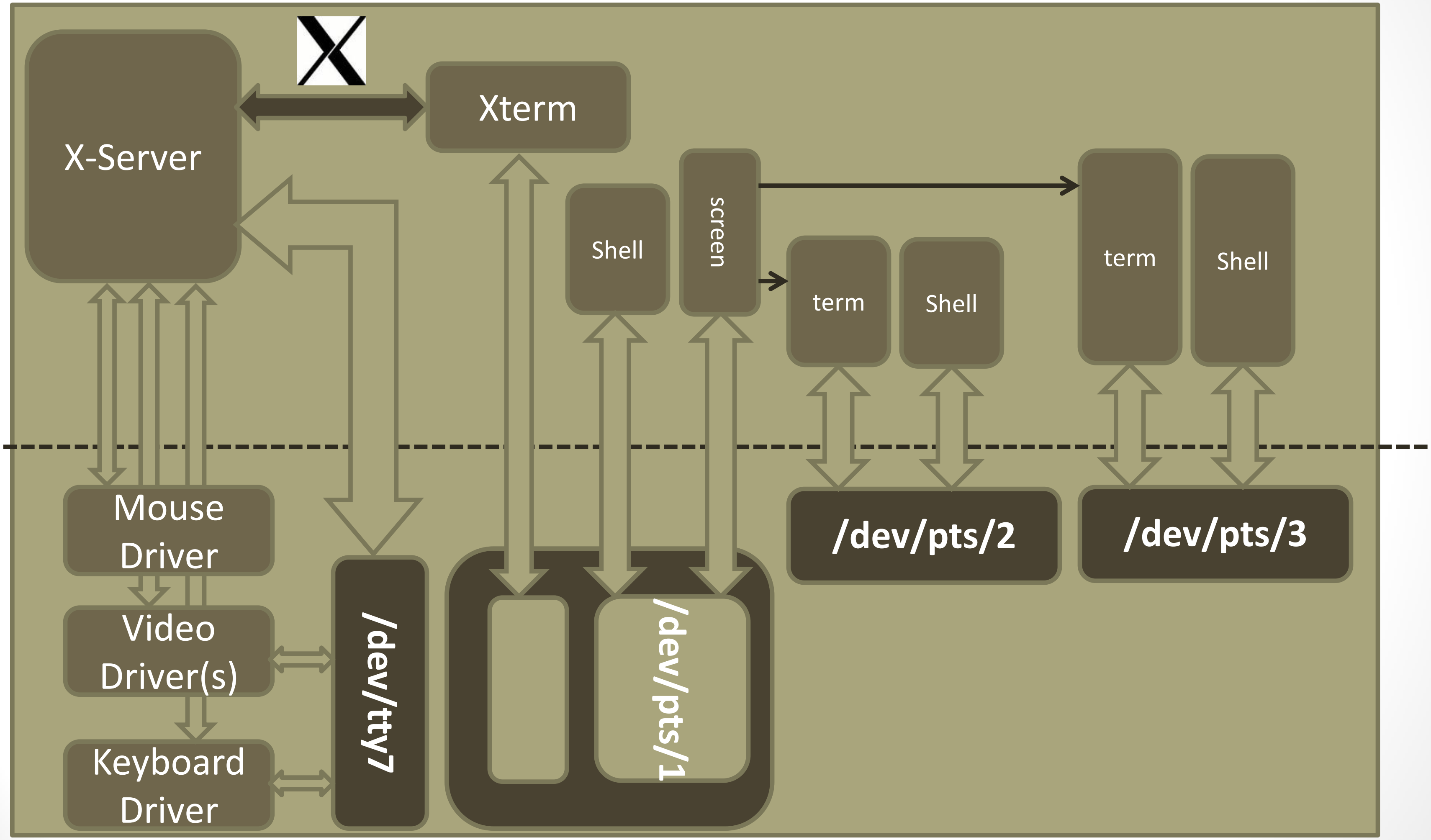
Working with the Screen Command



Working with the Screen Command



Working with the Screen Command



```
$ screen -r
```

Managing Emulated Terminals (screen Command)

```
$ screen
$ screen -r
```

- The ***screen*** Command is an Emulated Terminal Manager
- It enables the user to create multiple emulated terminal sessions (***Ctrl-A c*** to create a new session)
- It then enables the user to move between the different sessions (***Ctrl-A n*** to move to next sesseion)
- The user can detach the screen command from its controlling TTY (***Ctrl-A d***).
- This is a very useful tool, now the controlling terminal can close without affecting the sessions running under screen
- To regain control of the screen sessions, perform

```
$ screen -r
```

Linux4

Embedded Systems

http://Linux4EmbeddedSystems.com