Computação Gráfica

Computer Graphics

Engenharia Informática (14350) – 3° ano, 1° semestre

Chap. 1 – Raster Graphics

Overview

…:

- Display hardware

  - How are images displayed?

- Raster graphics systems

  - How are imaging systems organized?

- Raster versus vector graphics

Display hardware

Video display devices

- Cathode Ray Tube (CRT)

- Liquid Crystal Display (LCD)

- Plasma panels

- Thin-film electroluminescent displays

- Light-emitting diodes (LED)

Hard-copy devices

- Ink-jet printer

- Laser printer

- Film recorder

- Electrostatic printer

- Pen plotter

CRT

(Cathode Ray Tube)

- Shadow mask CRT
- Aperture grill mask CRT
- Slotted mask CRT

CRT

Brief history

– 1897, Karl Braun develped the first CRT in a controlled way.

– 1940, its use in TV.

– Until 2011, they dominate the market of display devices

Structure

– 1 glass envelope like a bottle

– 1 cathode (negative charge)

– 3 electron guns, each per primary color (RGB)

– 1 anode (positive charge)

– 1 phosphor layer with RGB spots

1. Electron guns
2. Electron beams
3. Focusing coils
4. Deflection coils

5. Anode connection

6. Mask for separating beams for RGB part of displayed image

7. Phosphor layer with RGB zones

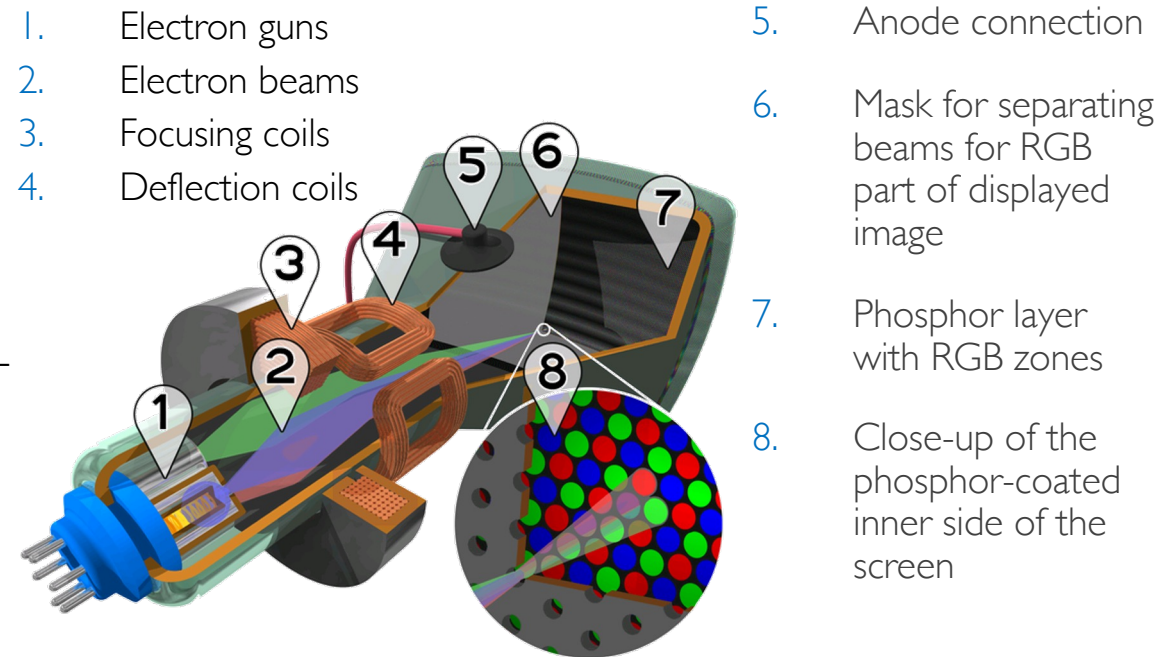8. Close-up of the phosphor-coated inner side of the screen

Image via Wikipedia: http://en.wikipedia.org/wiki/Cathode_ray_tube

Pixel, resolution, and dot pitch

Pixel:

- It is a set (triangle) of 3 phosphor spots, each per primary color: R (red), G (green), and B (blue)
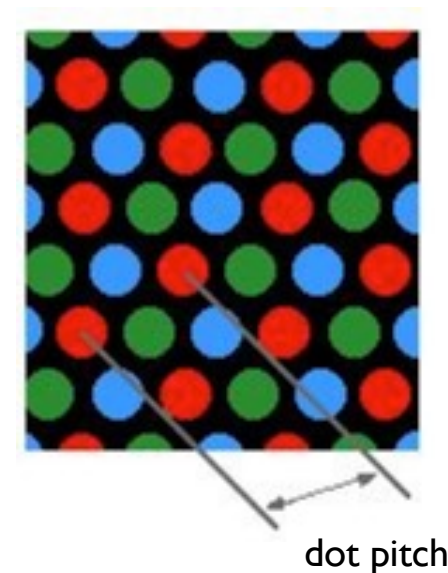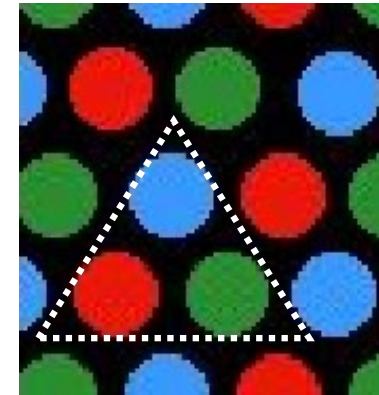
Phosphor:

- It is any material that emits visible light when exposed to radiation.

Resolution:

- VGA 640x480

- SVGA 800x600

- XVGA 1024x768

Dot Pitch:

- It is the distance between two neighbor phosphor spots of the same color.

- Usually, it ranges between 0.22mm and 0.3mm.
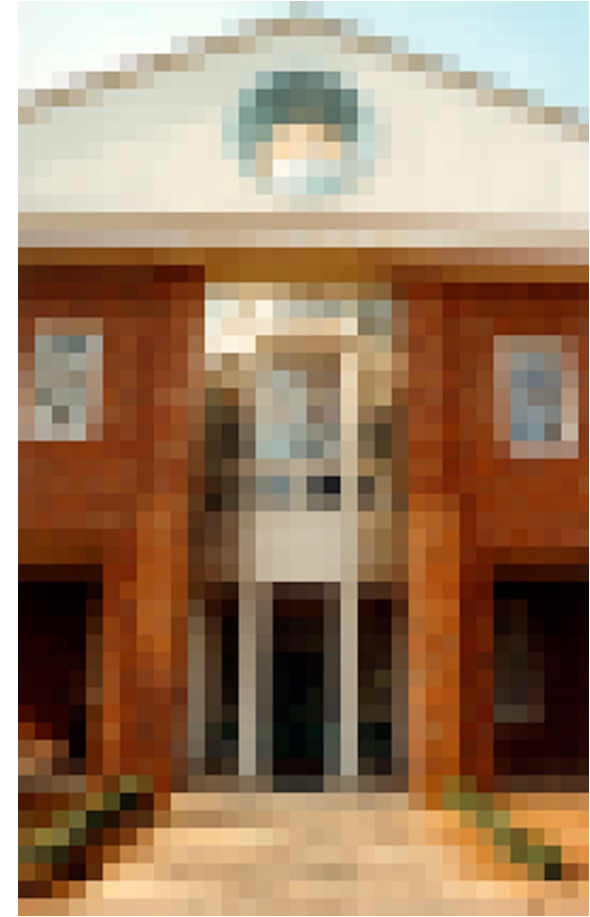
dot pitch

Resolution

- *It is the number of pixels to represent animage.*
- *It determines both the level of detail and the requirements of storage.*


272 × 416

136 × 208

68 × 104

Image formation through progressive scanning (*varrimento progressivo*)

Progressive scanning:

- The blue lines indicate that the electron beam (resulting from blending 3 electron beams) is exciting the phosphors; i.e., the beam is turned on.

- The dashed lines represent the repositioning of the beam on the left-hand side of the screen; i.e., the <u>horizontal retrace</u> with the beam off.

- The green line illustrates the <u>vertical retrace</u>, which takes place when the beam reaches the end of the last screen line and goes off to the beginning of the first screen line.

Frame:

- It can be defined as the image formed by the beam after the full scanning of phosphor layer of the screen.

©2000 How Stuff Works
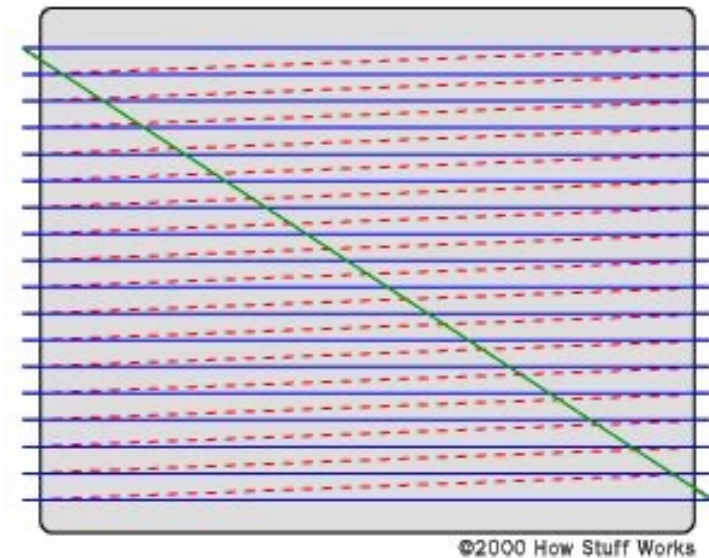
<u>Margin note</u>: the latest CRTs used interleaving scanning, which requires to scan the screen twice to form a frame.

Refresh rate

Refresh rate:

- It is #frames/second generated by the screen display.

Hertz (Hz):

- It is the unit to measure the refresh rate.

Flickering:

- This effect is noticeable when the refresh rate is not high enough.

- 75 Hz is the minimum refresh rate that is recommended for CRTs.

Maximum refresh rate:

VSF = HSF / #horizontal lines x 0.95

where:

VSF = vertical scanning frequency (refresh rate)

HSF = horizontal scanning frequency

Example:

Given the screen display with:

HSF = 96 kHz
resolution = 1280x1024

we have:

VSF = 96000/1024 x 0.95 = 89 Hz

Example :

Given the screen display with:

HSF = 96 kHz
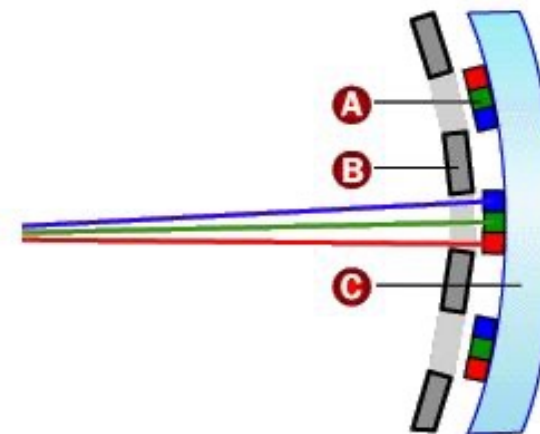resolução = 1600x1200

we have:

VSF = 96000/1200 x 0.95 = 76 Hz

Shadow mask CRT

- *The shadow mask is just before the phosphor layer.*
- *Each mask hole delimits each pixel to improve the image quality.*
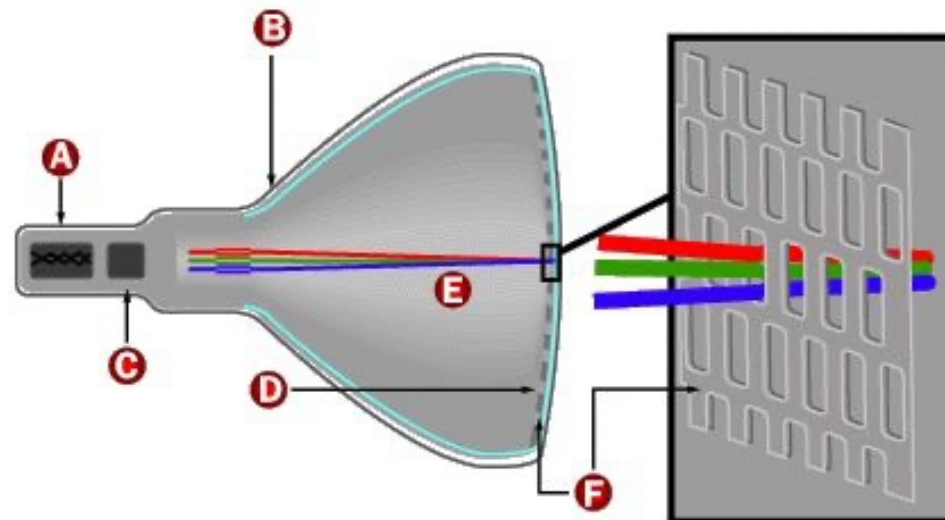
A Cathode
B Conductive coating
C Anode

D Phosphor-coated screen
E Electron beams
F Shadow mask

©2000 How Stuff Works

A Phosphors
B Shadow mask
C Glass

©2000 How Stuff Works

Aperture grill CRT

Phosphor layer and wires

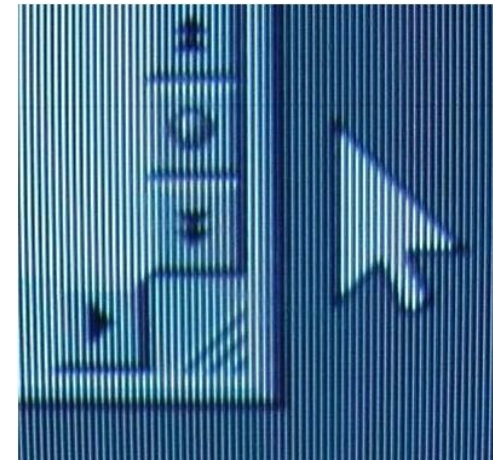*stripe pitch*

History:
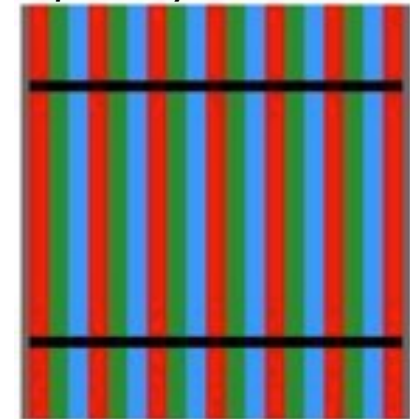
- In 1960s, Sony developed these aperture grill CRTs, whose technology was kown as Trinitron.
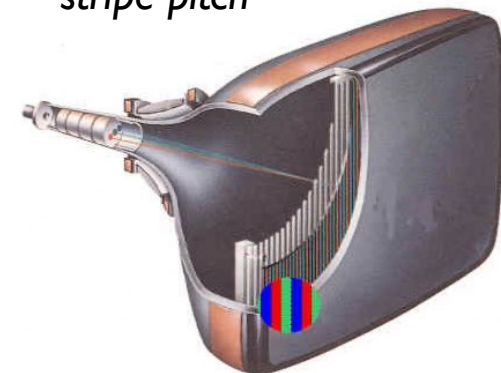
Technology:

- Instead of using a screen's spherical section, they used a screen's cylindrical section.

- Instead of using phospor spots, these screen displays (called Trinitron) used vertical stripes of phosphor.

- The aperture grill (*grelha*) thus consists of a set of vertical wires, and comes before the phosphor layer. Each wire is aligned with the frontier that separates a blue stripe from a red stripe. Also, there are two horizontal wires that stick vertical wires.
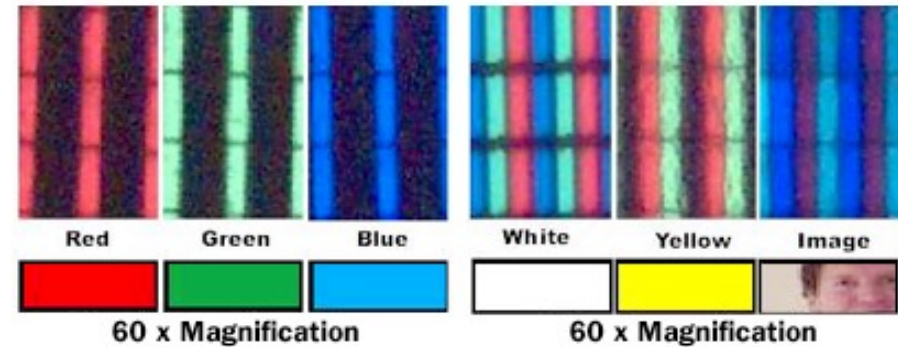
LCD

(Liquid Crystal Display)

- DSTN (Dual Scan Twisted Nematic)
- TFT (Thin Film Transistor)

LCD pixels

History:

- The liquid crystals were discovered at the end of the XIX century by the botanist Frieddrich Reinitzer
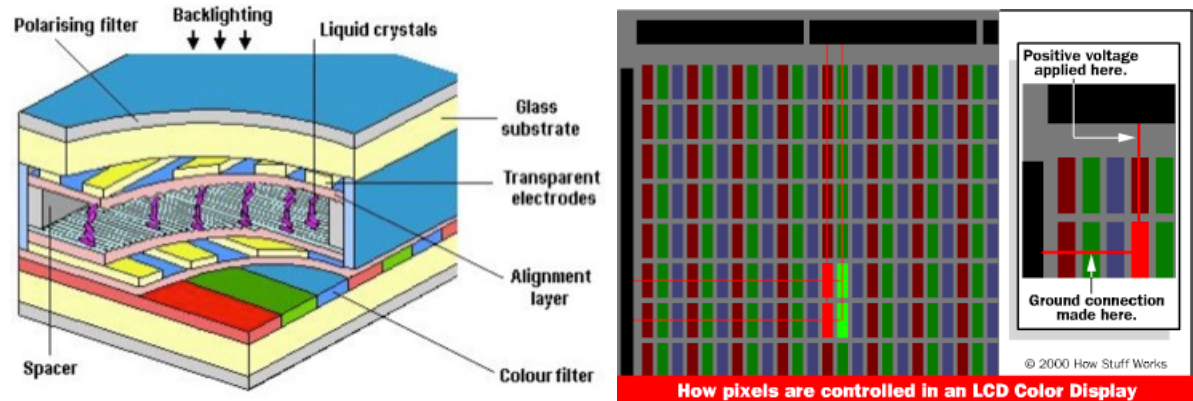
Principles:

- Liquid crystals are almost transparent substances which exhibit properties of solids and liquids.

- The passage of light through the liquid crystals causes the alignment of their molecules - a *property of the solids*.

- In 1960, it was discovered that the electric charge changed its molecular alignment, and consequently the way light passed through the crystals - a *property of liquids*.

Technology:

- LCD is a transmissive technology.

- An LCD works by varying amounts of white light of fixed intensity through a filter. The RGB elements of a pixel are obtained by filtering the white light.

- Liquid crystals are usually organic compounds that consist of molecules similar to the cones of the human eye. Therefore, liquid crystals function as color sensors when stimulated by light.

Passive matrix LCD (DSTN)

Polarising filter — Backlighting — Liquid crystals — Glass substrate — Transparent electrodes — Alignment layer — Spacer — Colour filter

Positive voltage applied here.
Ground connection made here.
© 2000 How Stuff Works
How pixels are controlled in an LCD Color Display

LCD types:

- There are 2 main types of LCDs used in computers: passive matrix (DSTN) and active matrix (TFT).
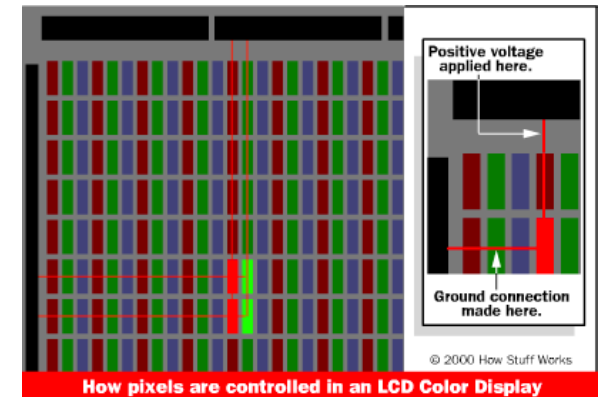
Composition:

- Passive matrix LCDs comprise a set of layers. It has 2 layers of glass called substrates.

- To each substrate is connected a set of transparent electrodes consisting of conductive material, which is usually indium-tin oxide.

- The electrodes of one substrate are perpendicular to the electrodes of the other substrate. There are, therefore, line-electrodes and column-electrodes. The rows and columns are linked to integrated circuits that control when a charge passes through a column and line.

- The liquid crystals are bonded between the two substrates.

Turning on pixels:

- The activation of a pixel (which is located at the intersection of a column with a line) is made by applying a voltage to the integrated circuit associated with the respective column.

Active matrix LCD (TFT)

How pixels are controlled in an LCD Color Display

Composition:

- The active matrix LCDs are basically dependent on thin film transistors (TFT).

- TFTs are transistors (switches) and tiny capacitors. They are matrixed in a glass substrate - one transistor per primary color (RGB) of each pixel.

- TFTs control the intensity of the color elements of each pixel..

Turning on pixels:

- The activation of a pixel (which is located at the intersection of a column with a line) is made by applying a voltage to the integrated circuit associated with the respective column.

- Turning on a pixel is done by activating its line, after which a charge is applied to its column. Since all other lines are disabled, only the capacitor of that pixel receives the charge, which holds it until the next refresh cycle.

- The response time is 25ms for the active matrix, whereas it is 300ms for passive matrix.

Light-emission diode (LED)

History:

- Light-emitting diodes (LEDs) came into existence in 1962 by Nick Holonyak in 1962 at General Electric.

- The first practical LED display was developed at Hewlett-Packard (HP) and introduced in 1968 under the leadship of Howard C. Borden and Gerald P. Pighini.

- A claim for the 'first all-LED flat panel television screen' is due to James P. Mitchell in 1977.

Principles:

- A LED display is a flat panel display that uses an array of light-emitting diodes (LEDs) as pixels for a video display.

- Principle of electroluminescence: On passing a current through the diode, energy is released in the form of light photons.

Technology:

- LED is a transmissive technology.
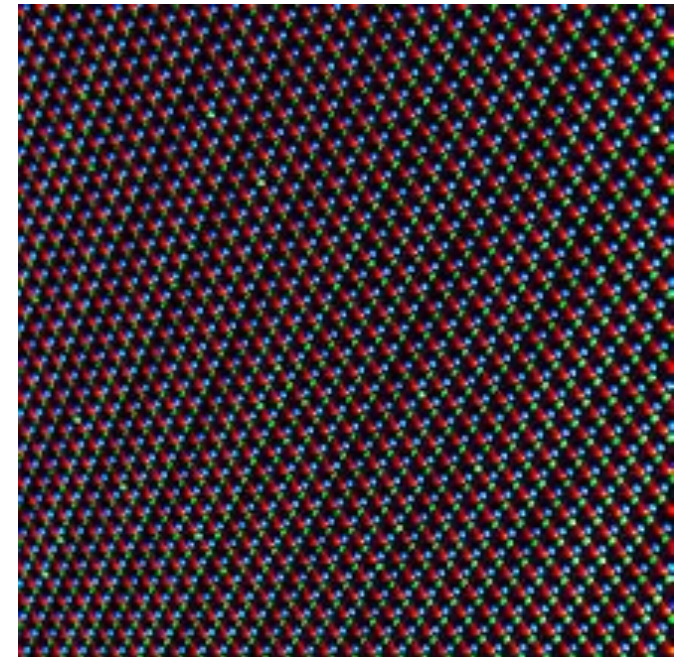
The 40m large LED display at the Armin Only event in April 2008 in the Jaarbeurs Utrecht

Graphics Cards

Major components of a graphics card

- *Graphics processor or graphics processing unit (GPU)*
- *Memory*
- *Digital-to-analogue converter (RAMDAC - random access memory digital-to-analogue converter): tends to disappear!*
- *Driver software*

https://www.akshatblog.com/graphics-card-components-explained-in-detail/
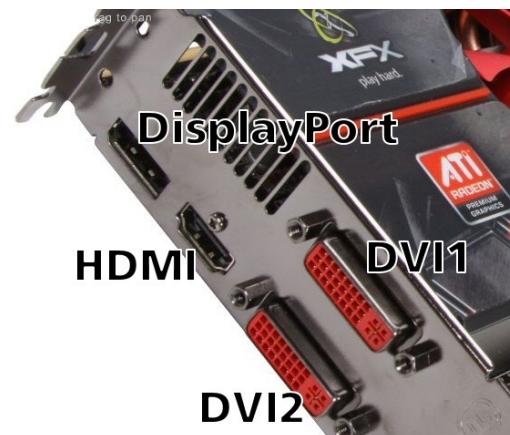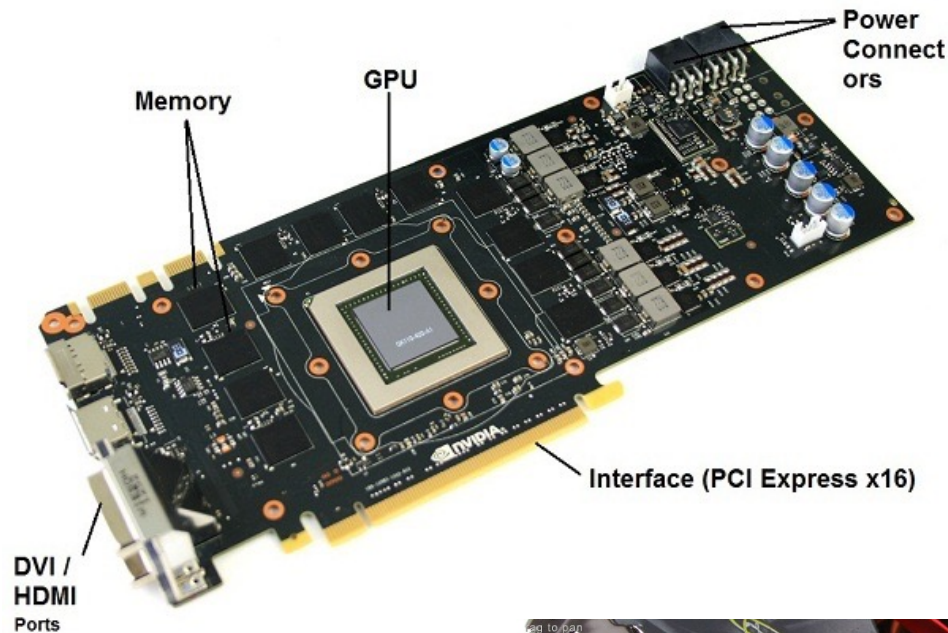
# Bus (or *barramento*, in Portuguese): PCI, AGP e PCI Express

Definition:

- Collection of conductive wires (in printed circuit) through which data is transmitted from one part to another inside the computer.

- That is, we can see the bus as the highway on which data travels inside the computer.

History:

- PCI (Peripheral Component Interconnect)

  - Introduced by Intel in the early 1990's. It's the highway used for all peripherals that attach to the motherboard. This means that a PCI graphics card has to share the bus bandwidth with other peripherals (sound card, modem, etc.), but data transfer is done without CPU intervention.

- AGP (Accelerated Graphics Port)

  - Introduced by Intel in 1996 and is supported by most motherboards. It's a bus dedicated to graphics. The big advantage is the large bandwidth available, which means that more data can be processed.

- PCI Express

  - Introduced by Intel, IBM, AMD and Microsoft in 2003.

Bus:
PCI, AGP e PCI Express

graphics card
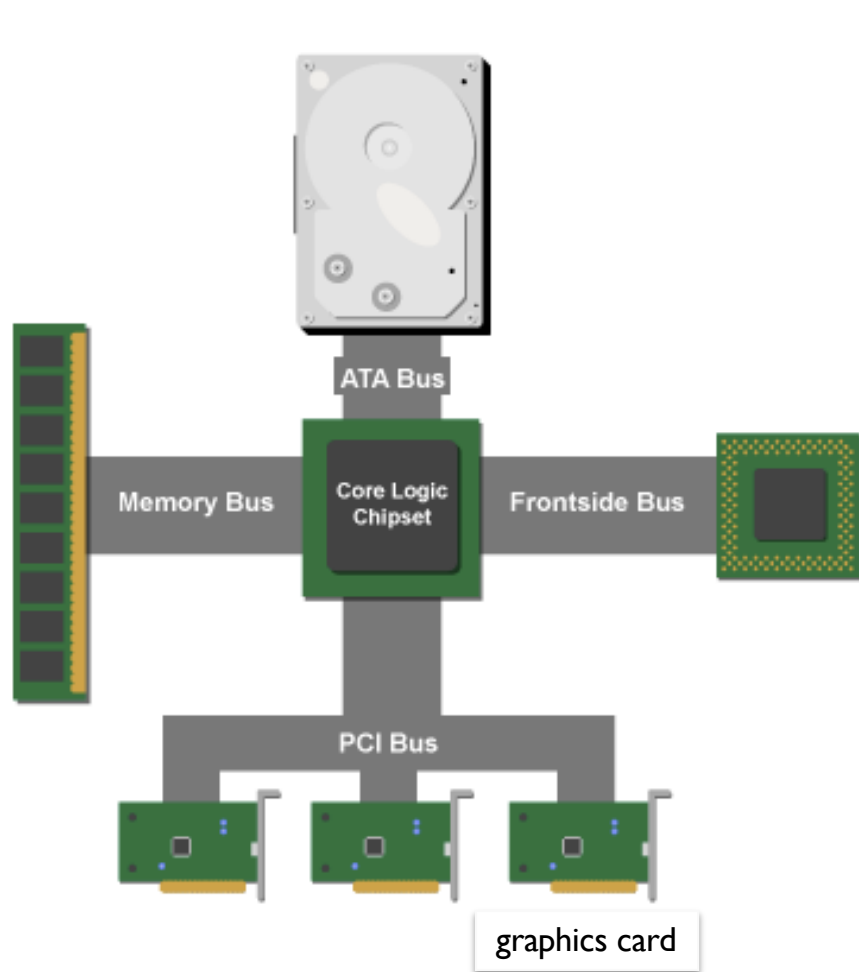
PCI graphics architecture
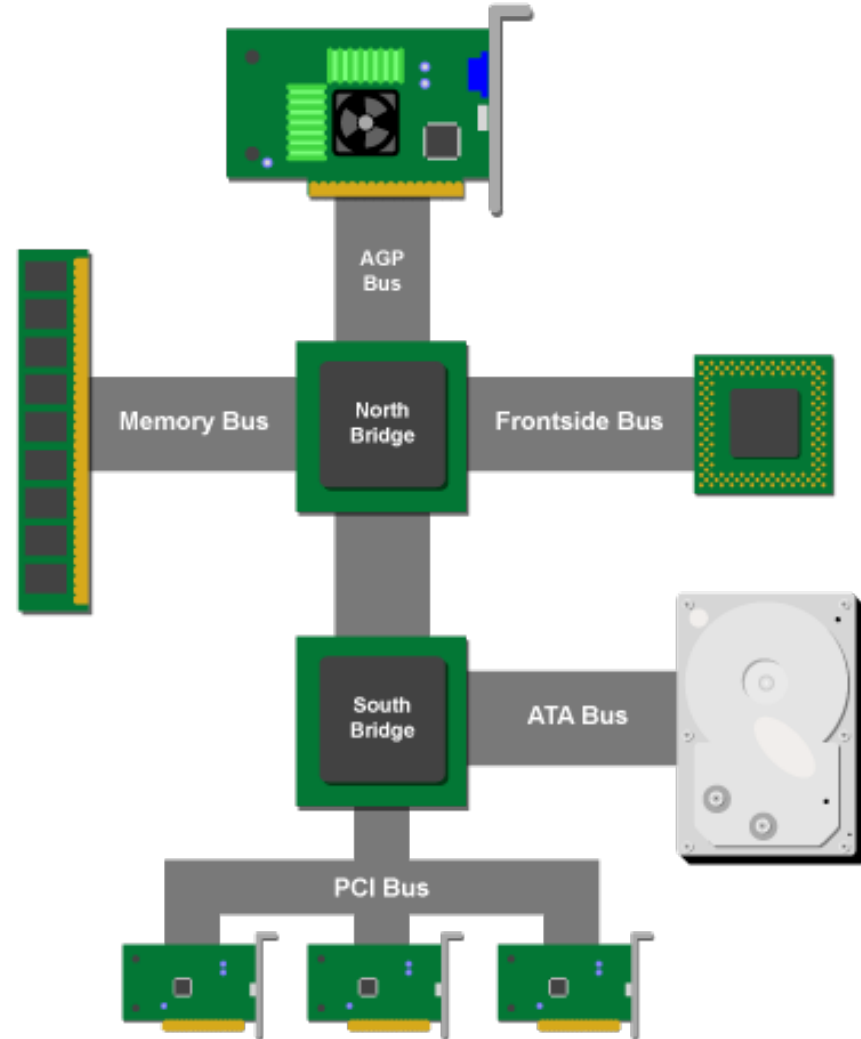
AGP graphics architecture

Bandwidth:
PCI, AGP e PCI Express (PCI-e)

Bandwidth (PCI vs. AGP):

- The AGP 1X mode data rate (66MHz = 264MB / sec) is 2 times faster than PCI (33MHz = 132MB / sec), while AGP 2X mode (133 MHz = 528MB / sec) is 4 times faster, and AGP 4X is 8 times faster..

- That is, we can see the bus as the highway on which data travels inside the computer.

Bandwidth (AGP vs. PCI Express):

- With PCI Express no longer bus sharing.

- The connection between two devices is done point-to-point. In other words, each PCI Express slot uses a unique path to communicate with the motherboard chipset.

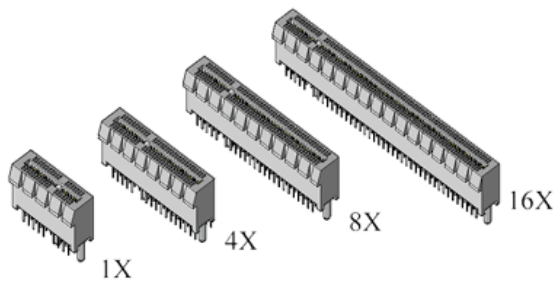| AGP	PCI Express
AGP 1X: 266 MB por segundo	PCI Express 1X: 250 MB por segundo
AGP 4X: 1064 MB por segundo	PCI Express 2X: 500 MB por segundo
AGP 8X: 2128 MB por segundo	PCI Express 8X: 2000 MB por segundo
	PCI Express 16X: 4000 MB por segundo

PCI Express 2.0

History:

–   Introduced in 2007.

–   The latest version is the PCI-e 4.0.

Bandwidth:

–   Each lane was able to transmit up to 500 MB per second, that is, double the speed of the Express 1.1 version. With this, a 16X slot, for example, will be able to work with a data transfer rate of up to 8 GB per second.
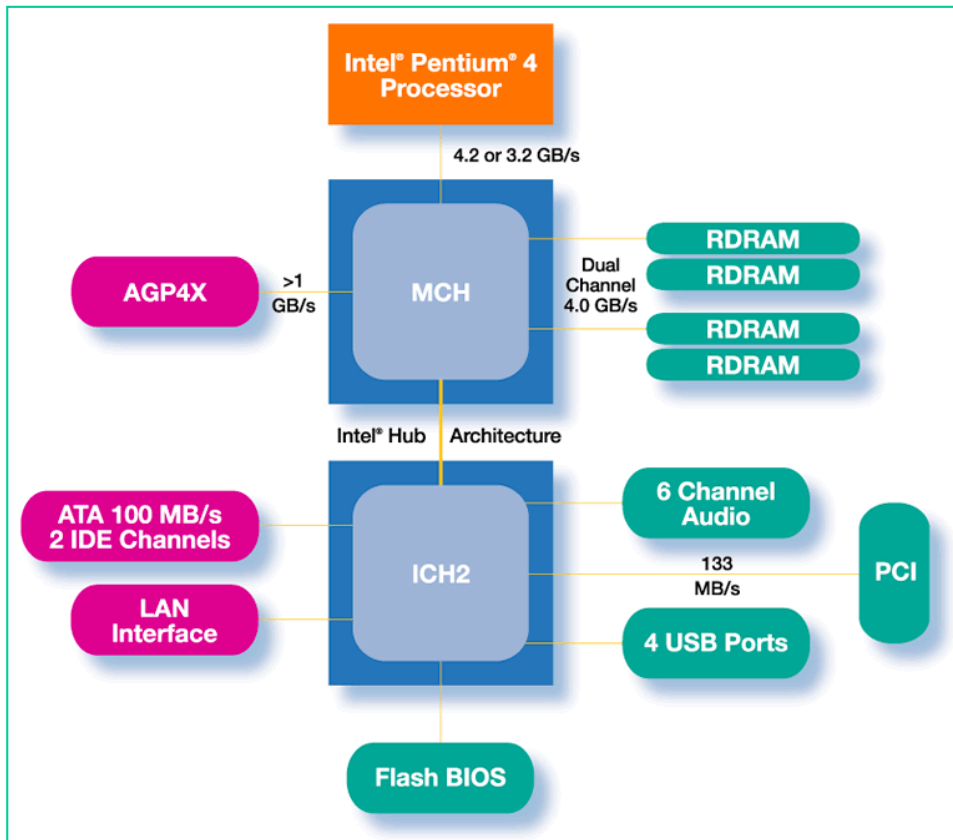
Connectors:

3D Asus graphics card Asus, model Extreme AX800XT PE/2DHTV, which uses the PCI Express 16X bus
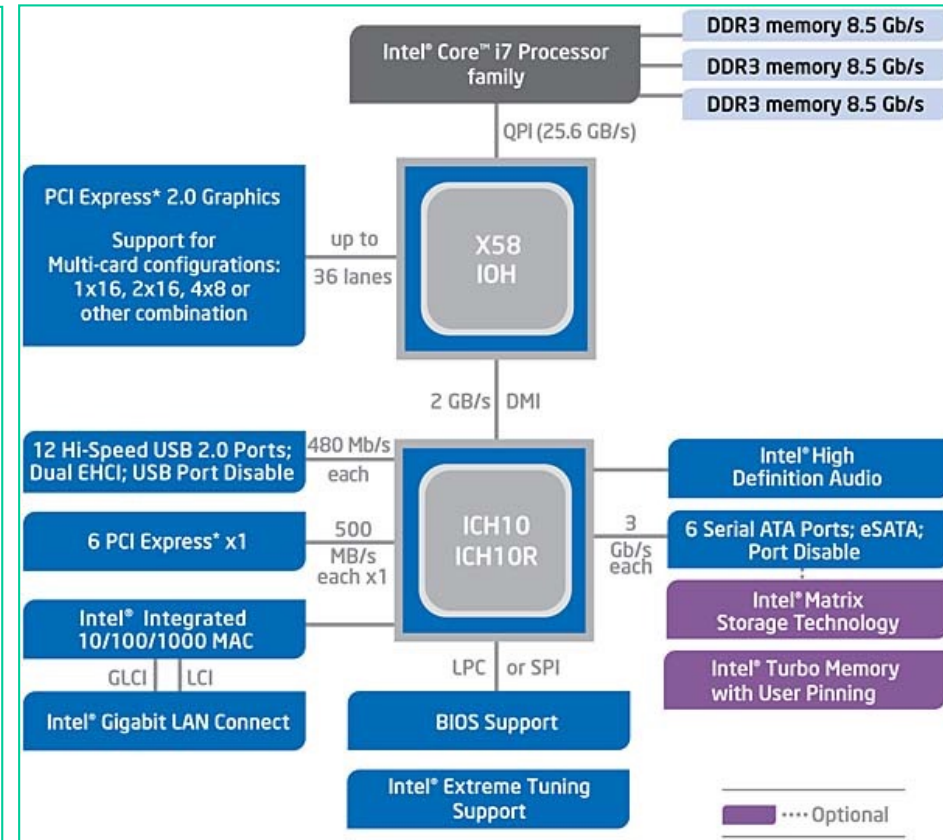
Motherboard with 2 PCI Express slots. The white socket is a PCI Express 16X, while the smaller black is a PCI Express 1X slot

# Chipsets:
Pentium & i7

Intel© 850 Chipset

Intel© X58 IOH Chipset
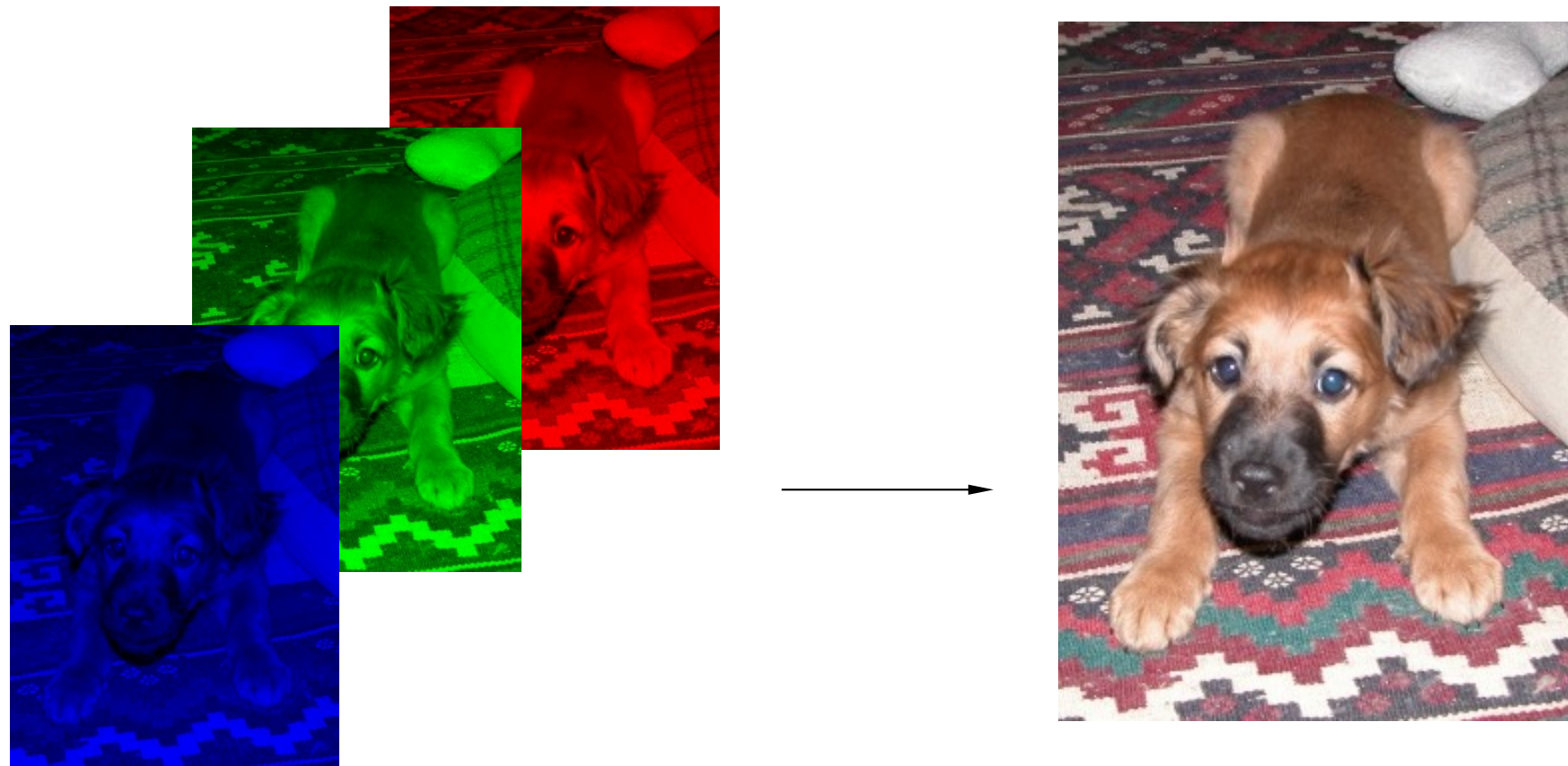
Raster graphics subsystem

– A _frame buffer_ is a large, contiguous piece of computer memory. At a minimum there is one memory bit for each pixel in the raster; this amount of memory is called a bit plane. The picture is built up in the frame buffer one bit at a time.

http://ecomputernotes.com/computer-graphics/basic-of-computer-graphics/what-is-frame-buffer
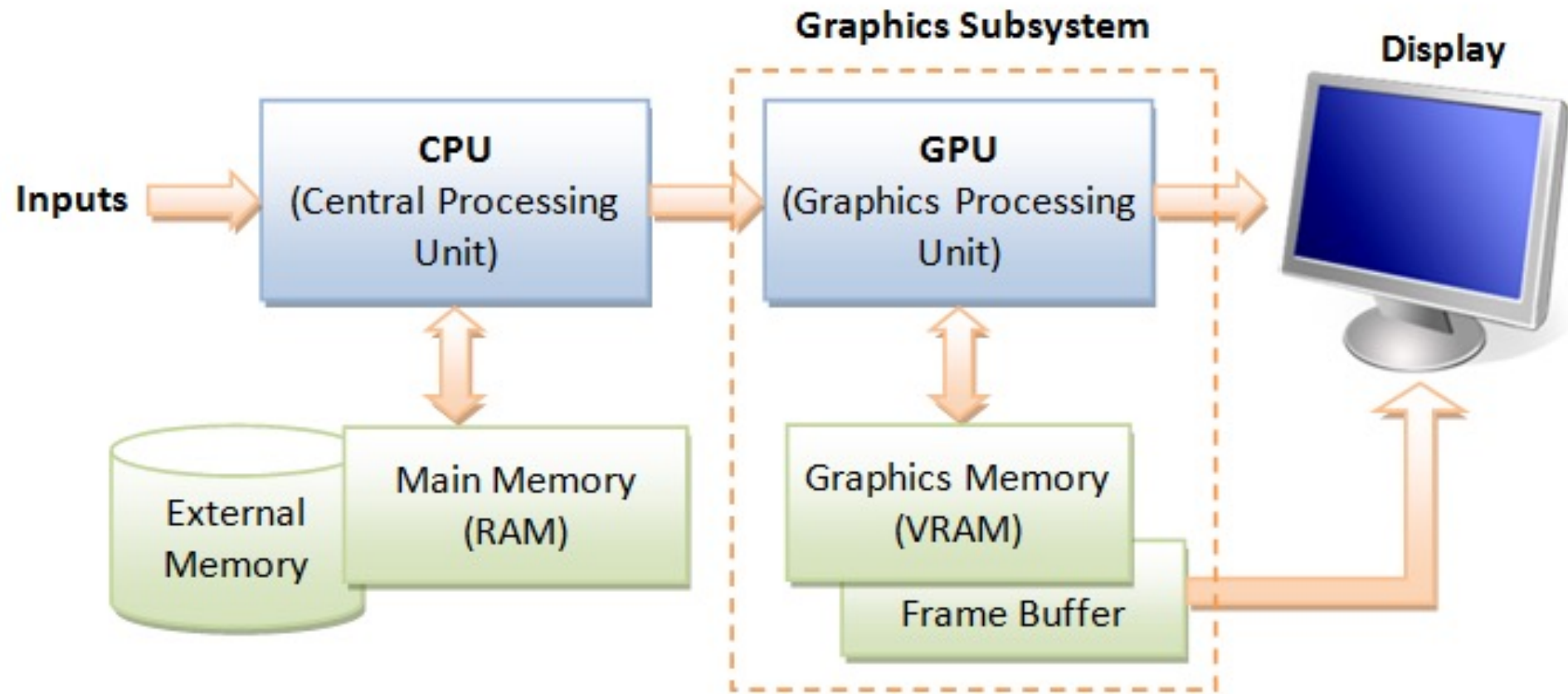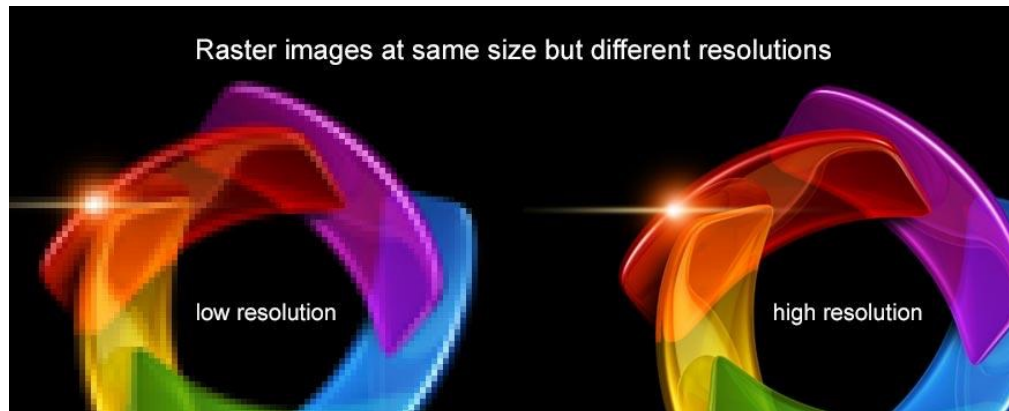
Direct color framebuffer

- – *Store the actual intensities of R, G, and B individually in the framebuffer*
- – *Framebuffer depth = 24 bits per pixel = 8 bits red, 8 bits green, 8 bits blue*
- – *Store indices (usually 8 bits) in framebuffer*
- – *Display controller looks up the R,G,B values before triggering the electron guns.*

Raster vs vector graphics

painting with pixels drawing with vectors

vector-conversions.com
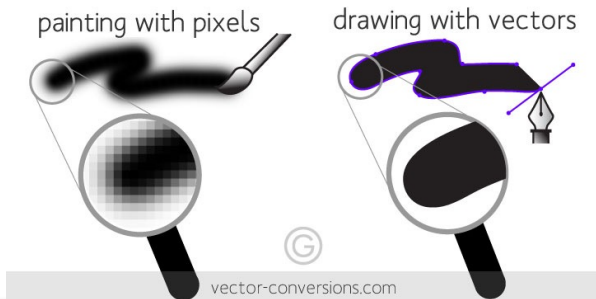
- – *There are two main type of image files: **raster** (or bitmap) and **vector**.*
- – *Raster images are created with pixel-based programs or captured with a camera or scanner (jpg, gif, png, etc.).*
- – *Raster graphics allow us to <u>paint images</u> much like to dipping a brush in paint and painting. That is, we can blend colors to soften the transition from one color to another.*
- – *Vector graphics are based on mathematical formulas of shapes. They allow us to <u>draw the outline of shapes</u> much like to creating an image with tiles of all different shapes and sizes. e.g. an eye shape, a nose shape, a lip shape. These shapes called objects display one single color each.*

Raster images at same size but different resolutions

low resolution   high resolution

https://pixellogo.com/blogs/pixellogo-blog/raster-vs-vector-graphics

- – *Raster images do not scale well.*
- – *Vector images are not photo-realistic.*

raster image made with pixels   vector graphic

vector-conversions.com

https://vector-conversions.com/vectorizing/raster_vs_vector.html

Summary

…:

- Display hardware
  - How are images displayed?

- Raster graphics systems
  - How are imaging systems organized?

- Raster versus vector graphics

FIM