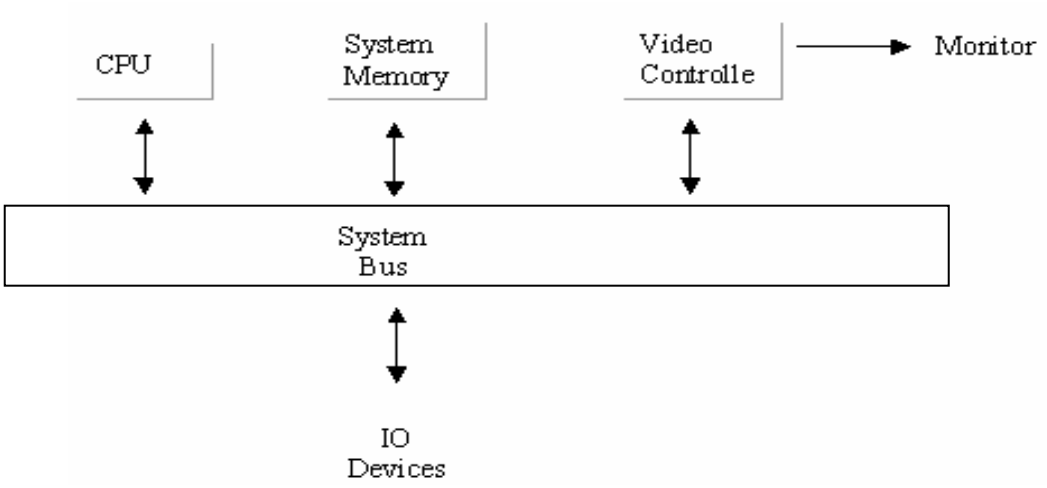
# Introduction to Computer Graphics
# ( C S 6 0 2 )
# Lecture No 03
# Graphics Systems

## 3.1 Raster-Scan Systems

Interactive raster graphics systems typically employ several processing units. In addition to the CPU, a special purpose processor, called the **video controller** or **display controller** is used to control the operation of the display device.

Organization of a simple raster system is shown in following figure. Here the frame buffer can be anywhere in the system memory, and the video controller accesses the frame buffer to refresh the screen.



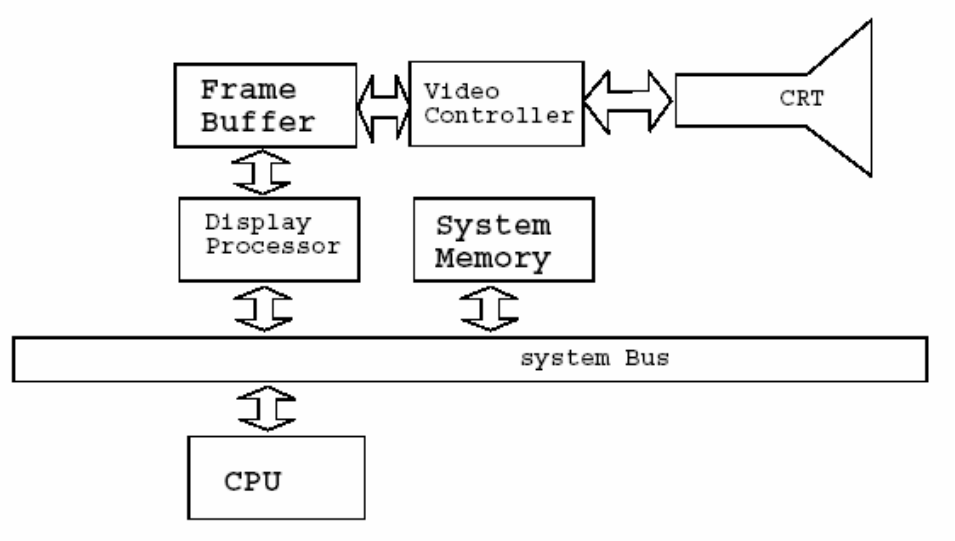

Architecture of a simple raster graphics system

In addition to the video controller more sophisticated raster systems employ other processors as coprocessors and accelerators to implement various graphics operations.

## 3.2 Video Controller

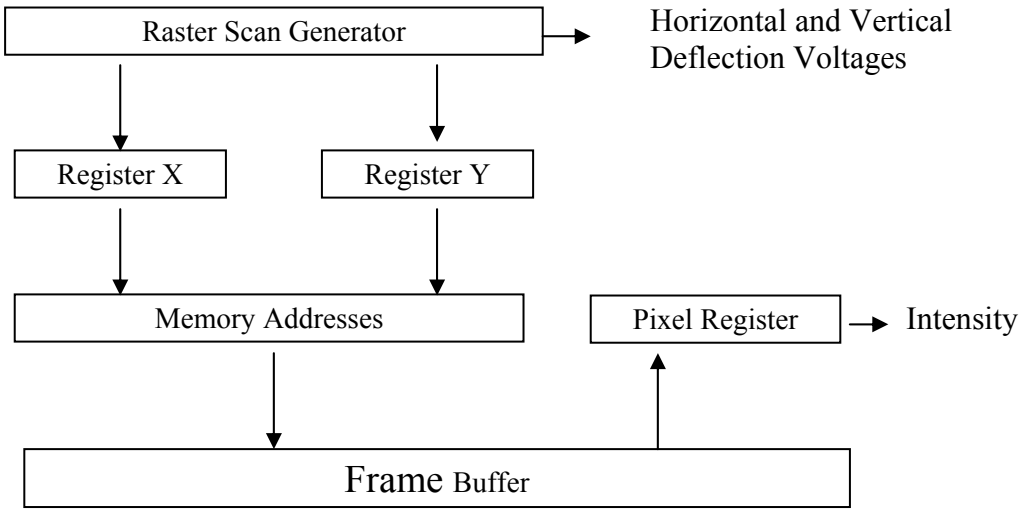
Following figure shows a commonly used organization for raster systems. A fixed area of the system memory is reserved for the frame buffer, and the video controller is given direct access to the frame-buffer memory.

Frame-buffer locations, and the corresponding screen positions, are referenced in Cartesian coordinates.




Architecture of a raster system with a fixed portion of a system memory reserved for the frame buffer.

In the following figure the basic refresh operations of the video controller are diagrammed. Two registers are used to store the coordinates of the screen pixels. Initially, the x register is set to 0 and the y register is set to $y_{max}$. The value stored in the frame buffer for this pixel position is then retrieved and used to set the intensity of the CRT beam. Then the x register is incremented by 1, and the process repeated for the next pixel on the top scan line. This procedure is repeated for each pixel along the next line by resetting x register to 0 and decrementing the y register by 1. Pixels along this scan line are then processed in turn, and the procedure is repeated for each successive scan line. After cycling through all pixels along the bottom scan line y=0, the video controller resets to the first pixel position on the top scan line and the refresh process starts over.



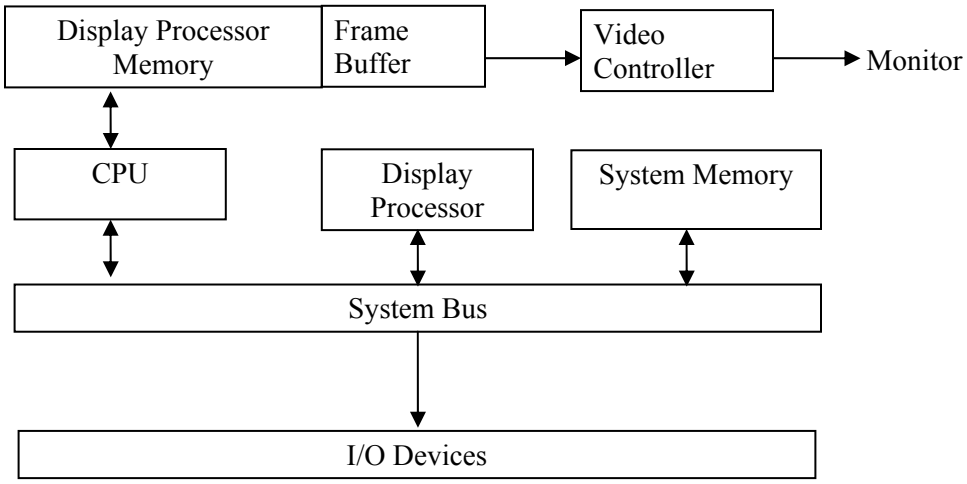

Basic Video Controller Refresh Operations

Since the screen must be refreshed at the rate of 60 frames per second, the simple procedure illustrated in above figure cannot be accommodated by typical RAM chips. The cycle time is too large making the process very slow. To speed up pixel processing, video controllers can retrieve multiple pixel values from the refresh buffer on each pass. The multiple pixel intensities are then stored in a separate register and used to control the CRT beam intensity for a group of adjacent pixels. When that group of pixels has been processed, the next block of pixel values is retrieved from the frame buffer.

## 3.3 Raster Scan Display Processor

Following figure shows one way to setup the organization of a raster system containing a separate **display processor**, sometimes referred to as a **graphics controller** or a **display coprocessor**. The **purpose** of the display processor is to free the CPU from the graphics chores. In addition to the system memory, a separate display processor memory area can also be provided.

A major task of the display processor is **digitizing** a picture definition given in an application program into a set of **pixel-intensity values** for storage in the frame buffer. This digitization process is called **scan conversion**.

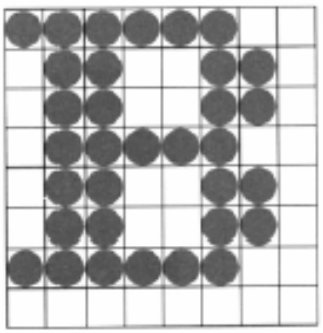



Architecture of a raster graphics system with a display processor

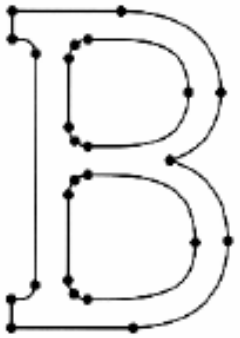
## 3.4 Raster-Scan Characters

Graphics commands specifying straight lines and other geometric objects are scan converted into a set of discrete intensity points. Scan converting a straight-line segment, for example, means that we have to locate the pixel positions closest to the line path and store the intensity for each position in the frame buffer. Similar methods are used for scan converting curved lines and polygon outlines.

Characters can be defined with rectangular grids, as shown in following figure, or they can be defined with curved outlines shown in the right hand side figure given below. The array size for character grids can vary from about 5 by 7 to 9 by 12 or more for higher-quality displays. A character grid is displayed by superimposing the rectangular grid pattern into the frame buffer at a specified coordinate position. With characters that are defined as curve outlines, character shapes are scan converted into the frame buffer.



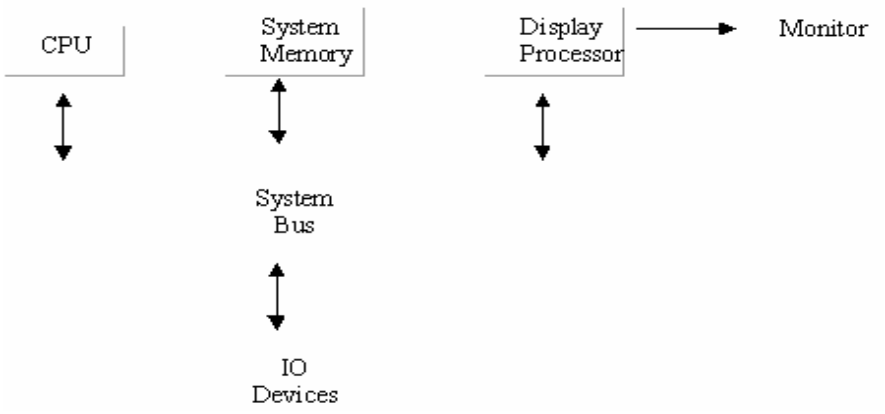
Defined as a grid of pixel positions



Defined as a curve outline

## Random-Scan Systems

The organization of a simple random scan system is shown in following figure. An application program is input and stored in the system memory along with a graphics package. Graphics commands in the application program are translated by the graphics package into a display file stored in the system memory. This display file is then accessed by the display processor to refresh the screen. The display processor cycles through each command in the display file program once during every refresh cycle. Sometimes the display processor in a random scan system is referred to as a **display processing unit** or **graphics controller**.




Architecture of a simple random scan system

## 3.5 Graphics Card or Display Adapters

A video card is typically an adapter, a removable expansion card in the PC. Thus, it can be replaced!

A video display adapter which is the special printed circuit board that plugs into one of the several expansion slots present on the mother board of the computer. A video display adapter is simply referred as a video card.

The video card can also be an integral part of the system board; this is the case in certain brands of PCs and is always the case in laptops and clear preference for the replaceable video card in some PCs.

A number of display adapters are available with varying capabilities especially Intel systems support following adapters:

- Monochrome Adapter (MA)
- Hercules Adapter (HA)
- Color Graphics Adapter (CGA)
- Enhanced Graphics Adapter (EGA)
- Multicolor Graphics Adapter (MCGA)
- Video Graphics Adapter (VGA)

- Super Video Graphics Adapter (SVGA)
- Extended Graphics Adapter (XGA)

## 3.6 Monochrome Adapter

The simplest and the first available adapter is MA. This adapter can display only text in single color and has no graphics displaying capability. Originally this drawback only prevented the users from playing video games, but today, even the most serious business software uses graphics and color to great advantage. Hence, MA is no longer suitable, though it offers clarity and high resolution.

## 3.7 Hercules Adapter

The Hercules card emulates the monochrome adapter but also operates in a graphics mode. Having graphics capabilities the Hercules card became somewhat of a standard for monochrome systems.

## 3.8 Color Graphics Adapter

This adapter can display text as well as graphics. In text mode it operates in 25 rows by 80 column mode with 16 colors. In graphics mode two resolutions are available:

- Medium resolution graphics mode 320 * 200 with 4 colors available from palette of 16 colors
- and 640 * 200 with 2 colors

One drawback of CGA card is that it produces flicker and snow. **Flicker** is the annoying tendency of the text to flash as it moves up or down. **Snow** is the flurry of bright dots that can appear anywhere on the screen.

## 3.9 Enhanced Graphics Adapter

The EGA was introduced by IBM in 1984 as alternative to CGA card. The EGA could emulate most of the functions and all the display modes of CGA and MA. The EGA offered high resolution and was not plagued with the snow and flicker problems of CGA. In addition EGA is designed to use the enhanced color monitor capable of displaying 640 * 350 in 16 colors from a palette of 64.

The EGA card has several internal registers. A serious limitation of the EGA card is that it supports write operations to most of its internal registers, but no read operation. The result is it is not possible for software to detect and preserve the state of the adapter, which makes EGA unsuited for memory resident application or for multitasking like windows and OS/2.

## 3.10 Multicolor Graphics Adapter

The MCGA was designed to emulate the CGA card and to maintain compatibility with all the CGA modes. In addition to the text and graphics modes of the CGA, MCGA has two new graphics modes:
640 * 480 with 2 colors

320 * 200 in with 256 colors

## 3.11 Video Graphics Adapter

The VGA supports all the display modes of MA, CGA and MCGA. In addition VGA supports a graphics mode of 640 * 480 with 16 colors.

## 3.12 Super Video Graphics Adapter

The SVGA designation refers to enhancements to the VGA standard by independent vendors. Unlike display adapters discussed earlier SVGA does not refer to a card that meets a particular specification but to a group of cards that have different capabilities. For example one card may have resolutions 800 * 600 and 1024 * 768, whereas, another card may have same resolution but more colors. These cards have different capabilities, but still both of them are classified as SVGA. Since each SVGA card has different capabilities, you need special device driver programs for driving them. This means that unlike VGA cards which can have a single driver that works with all VGA cards, regardless of the vendor, each SVGA card must have a corresponding driver.

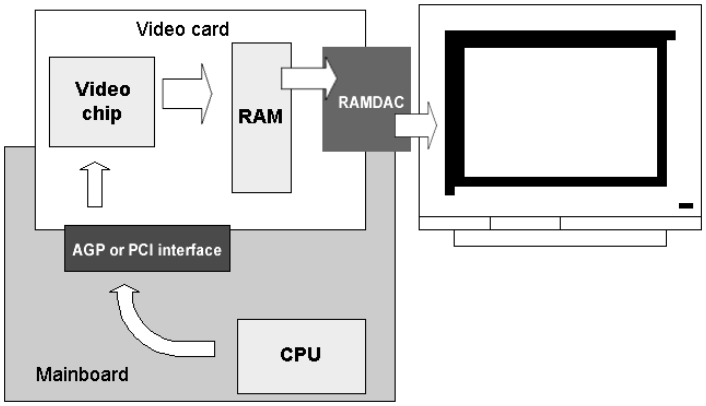
## 3.13 Extended Graphics Adapter

The XGA evolved from the VGA and provides greater resolution, more colors and much better performance. The XGA has a graphics processor bus mastering. Being a bus master adapter means that the XGA can take control of the system as though it were the mother board. In essence, a bus master is an adapter of the mother board. The XGA offers 2 new modes:

640 * 480 with 16 bit colors (65536 colors)
1024 * 768 with 8 bit colors (256 colors)

## 3.14 Video Card Supports the CPU

The video card provides a support function for the CPU. It is a processor like the CPU. However it is especially designed to control screen images.




## 3.15 RAM on the Video Card

Video cards always have a certain amount of RAM. This RAM is also called the

frame buffer. Today video cards hold plenty of RAM, but earlier it was more important:

- How much RAM? That is significant for color depth at the highest resolutions.
- Which type of RAM? This is significant for card speed.

Video card RAM is necessary to keep the entire screen image in memory. The CPU sends its data to the video card. The video processor forms a picture of the screen image and stores it in the frame buffer. This picture is a large bit map. It is used to continually update the screen image.

## 3.16 3D - lots of RAM

Supporting the demand for high quality 3D performance many new cards come with a frame buffer of 16 or 32 MB RAM and they use the AGP interface for better bandwidth and access to the main memory.

## 3.17 VRAM

Briefly, in principle all common RAM types can be used on the video card. Most cards use very fast editions of ordinary RAM (SDRAM or DDR).

Some high end cards (like Matrox Millennium II) earlier used special VRAM (Video RAM) chips. This was a RAM type, which only was used on video cards. In principle, a VRAM cell is made up of two ordinary RAM cells, which are "glued" together. Therefore, you use twice as much RAM than otherwise.

VRAM also costs twice as much. The smart feature is that the double cell allows the video processor to simultaneously read old and write new data on the same RAM address. Thus, VRAM has two gates which can be active at the same time. Therefore, it works significantly faster.

With VRAM you will not gain speed improvements increasing the amount of RAM on the graphics controller. VRAM is already capable of reading and writing simultaneously due to the dual port design.

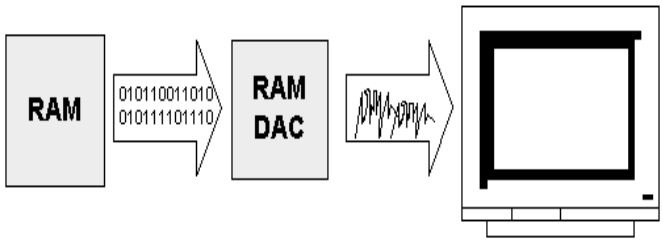
## 3.18 UMA and DVMT

On some older motherboards the video controller was integrated. Using SMBA (Shared Memory Buffer Architecture) or UMA (Unified Memory Architecture) in which parts of the system RAM were allocated and used as frame buffer. But sharing the memory was very slow and the standards never became very popular.

A newer version of this is found in Intel chip set 810 and the better 815, which also integrates the graphics controller and use parts of the system RAM as frame buffer. Here the system is called Dynamic Video Memory Technology (D.V.M.T.).

## 3.19 The RAMDAC

All traditional graphics cards have a RAMDAC chip converting the signals from digital to analog form. CRT monitors work on analog signals. The PC works with digital data which are sent to the graphics adapter. Before these signals are sent to the monitor they have to be converted into analog output and this is processed in the RAMDAC:




The recommendation on a good RAMDAC goes like this:

- External chip, not integrated in the VGA chip
- Clock speed: 250 - 360 MHz.

## 3.20 Heavy Data Transport

The original VGA cards were said to be "flat." They were unintelligent. They received signals and data from the CPU and forwarded them to the screen, nothing else. The CPU had to make all necessary calculations to create the screen image.

As each screen image was a large bit map, the CPU had to move a lot of data from RAM to the video card for each new screen image.

The graphic interfaces, like Windows, gained popularity in the early nineties. That marked the end of the "flat" VGA cards. The PC became incredibly slow, when the CPU had to use all its energy to produce screen images. You can try to calculate the required amount of data.

A screen image in 1024 x 768 in 16 bit color is a 1.5 MB bit map. That is calculated as 1024 x 768 x 2 bytes. Each image change (with a refresh rate of 75 HZ there is 75 of them each second) requires the movement of 1.5 MB data. That zaps the PC energy, especially when we talk about games with continual image changes.

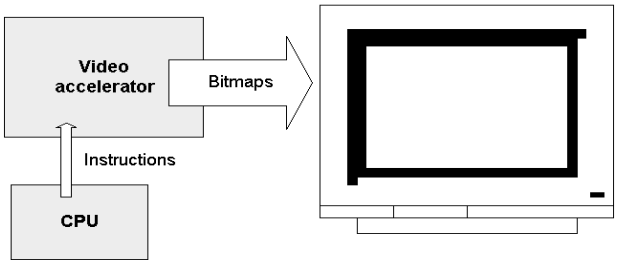
Furthermore, screen data have to be moved across the I/O bus. In the early nineties, we did not have the PCI and AGP buses, which could move large volumes of data. The transfer took place through the ISA bus, which has a very limited width. Additionally the CPUs were 386's and early 486's, which also had limited power.

## 3.21 Accelerator Cards

In the early nineties the accelerator video cards appeared. Today all cards are accelerated and they are connected to the CPU through high speed buses like PCI and AGP.

With accelerated video chips, Windows (and with that the CPU) need not calculate and design the entire bit map from image to image. The video card is programmed to draw lines, Windows and other image elements.

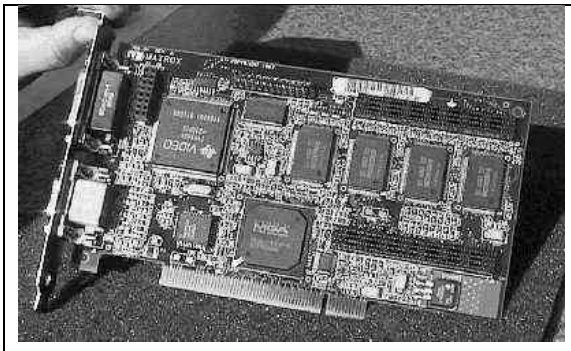
The CPU can, in a brief code, transmit which image elements have changed since the last transmission. This saves the CPU a lot of work in creating screen images. The video chip set carries the heavy load:




All video cards are connected to the PCI or the AGP bus, this way providing maximum data transmission. The AGP bus is an expanded and improved version of the PCI bus - used for video cards only.

Modern video cards made for 3D gaming use expensive high-end RAM to secure a sufficient bandwidth. If you for example want to see a game in a resolution of 1280 x 1024 at 80 Hz, you may need to move 400 MB of data each second - that is quite a lot. The calculation goes like this:

1280 X 1024 pixels x 32 bit (color depth) x 80 = 419,430,400 bytes
419,430,400 bytes = 409,600 kilobytes = 400 megabytes.



## 3.22 Graphics Libraries

Graphics developers some time use 2D or 3D libraries to create graphics rapidly and efficiently. These developers include game developers, animators, designers etc.

The following libraries are commonly used among developers:

- FastGL
- OpenGL
- DirectX
- Others

## 3.23 Advantages of Graphics Libraries

These libraries help developers to create fast and optimized animations and also help to access features that are available in video hardware.

Hardware manufacturers give support in hardware for libraries

Famous manufacturers include SIS, NVIDIA, ATI, INTEL etc.

## 3.24 Graphics Software

There is a lot of 2D and 3D software available in the market. These software provide visual interface for creation of 2D and 3D animation / models image creation. These tools are under use of movie makers, professional animators and designers.

These tools are flash, maya, 3D studio max, adobe photo shop, CorelDraw, image viewer, paintbrush etc.