RTT TECHNOLOGY TOPIC
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# 3G Displays

Displays are memory devices! The image memory is captured and held between refresh frames in the phosphor state (CRT) or liquid crystal state. Display drivers will also need increasing amounts of memory bandwidth (for reasons which we will explain below).

Displays are one of the critical enabling technologies of the 3G transition – in particular, we need to qualify the performance needed to deliver and display fast moving complex content.

Let's start with computer displays. In 1987, IBM established an industry 'standard' called VGA – originally this meant Video Graphics Array, now generally it is the acronym for the 'video graphics adaptor'.

VGA in 1987 delivered 16 colours in a 640 x 480 pixel format. In 1990, XGA had arrived with 16 million colours.

Ten years later there are seven 'levels' of VGA:

| | **No of Pixels** |
|---|---|
| **VGA** | 640 X 480 |
| **SVGA** | 800 X 600 |
| **XGA** | 1024 X 768 |
| **SXGA** | 1280 X 1024 |
| **UXGA** | 1600 X 1200 |
| **HDTV** | 1920 X 1080 |
| **QXGA`** | 2048 X 1536 |

A QXGA image is a 3 megapixel image. Even higher resolution images (5 megapixel and above) are used for medical imaging.

VGA standards are now codified by the Video Electronics Standards Association (www.vesa.org). The significance is that user expectations of resolution (pixel density) have substantially increased over the past 10 years and will continue to increase. You may think this doesn't matter for small form factor displays but it does and it will. Other performance parameters such as refresh rate are equally critical.

Too low a refresh rate, and a fast moving image will blur. (If the compression artifacts haven't already ruined your picture – see last month's hot topic, then display artifacts will do the job for you).

Almost all computer monitors today, i.e. VGA/XVGA are analogue – the analogue RGB signal from the video card is modulated to express the colour balance.

This is changing. The digital displays working group (www.ddwg.org) proposes to try and standardize the digital display interface between a computer and it's display device. The computer may or may not be physically proximate to the display device – it could be on the other side of the world. What the ddwg is doing therefore has a direct impact on 3 wireless access and network design.

VESA and the DDWG are together setting out to characterise the performance parameters of narrow band and wideband displays. Their work as a standards entity is directly analogous to the work that MExE are undertaking to rationalize WAP. Note that micro-displays, defined as any display with an active diagonal size of less than 50 mm/2", are included in the VESA/DDWG standard.

In multimedia, performance is all about pixels – pixel density, pixel spacing, pixel refresh rate, pixel brightness, contrast ratio, pixel power budgets, pixel duty cycle (eg through life phosphor degradation), pixel address bandwidth.

Most display drivers (eg all existing computer monitors and TV sets) address pixels sequentially, down a line to the end, on to the next line, down to the end of the frame. The time taken for the 'dancing dot' to travel from the end of one line to the next and from the end of one frame to the next is called 'flyback time' – flyback time needs a blanking period. During a blanking period, you cannot address the pixels.

A 60 Hz SVGA monitor might have an address rate of 25 M/pix per second (million pixels per second). A 75 Hz CRT QXGA would have an address rate of 350 M/pix per second.

Pixel elements are made up of PELS – the singular red, green or blue value of an RGB pixel. The number of bits per pixel determines the amount of control or 'granularity' you have over the colour balance, 3 bits, 6 bits, 24 bits – more than 24 is described as higher colour depth. The bit rate is the number of pixels per second times the pixel address bandwidth (number of bits per pixel).

You can reduce this by having selective refresh. You only send information to the display if the information has changed. Note the parallel with differential coding at the compression level. This needs lots of memory in the display driver (which has to store the pixel stream for compression prior to sending).

The display driver also needs to take account of the aspect ratio of the screen. A square screen has a 1:1 aspect ratio. A standard TV is 4:3, a wide screen TV (like a cinema screen) is 16:9.

An image pixel is a single image unit on a horizontal scan line. It is **not** the same thing as a screen pixel. An XVGA card will send out 1024 x 768 screen pixels. If the image resolution is set to VGA (640 x 480), one image pixel is formed using more than one screen pixel.

Curiously this leads us to have square pixels and rectangular pixels. On a 4:3 screen, the image pixel is wider than it is taller. The screen pixel information stream has to be pre-distorted to correct for this aberration. (In 16:9, the correction is even more extreme).

Also, CRT monitors have a non-linear colour transfer function which requires pre-compensation of the input data to generate a normalized image (gamma compensation).

Delivering multimedia is a non-trivial design task.

So what display technologies do we have available to us for portable form factor devices?

Well, firstly, we have virtual displays, sometimes also described as eye contact display or eye proximate displays – ie they are postage sized or smaller and you need to peer into them.

The virtual performance of such devices is impressive – a 640 by 480 (VGA) pixel display (1:1) with a 60 Hz refresh rate, 4096 colours, a contrast ratio of 5000:1 and a power budget of 280 mWatts.

But not everyone wants to get so close to their display.

Direct view technology options presently include liquid crystal displays, polymer LED displays, reverse emulsion electrophoretic displays and thin CRT's..

Liquid crystal displays keep getting better and better – contrast ratios are increasing (from 50 to 1 to 200 to 1 or better), power consumption is going down, pixels per inch are going up (200 pixels per inch or more), refresh rates are improving and active matrix display drivers (where thin film transistors are used to provide latch circuits to maintain the correct potential at the liquid crystal cell through the refresh cycle) are transforming the image and colour quality (colour depth). The price is also coming down though production yields are still notoriously variable. The LCD display in your portable PC still accounts for over 25% of the total component cost.

Polymer LCD displays are promoted as one answer – these are polymers which conduct electricity and emit light. Philips will be using polymer LCD for back-lighting on mobile phones this year though initially on glass rather than a polymer substrate. In the longer term red/green/blue polymers are possible.

In parallel, reverse emulsion electrophoretic displays are another possibility.

Reverse emulsion involves using a polar solvent – a liquid with properties like water, a non-polar solvent – a liquid with properties like oil, one or more surfactants (detergents) and a dye which is soluble in the polar solvent, insoluble in the non-polar solvent. You end up with a lot of coloured droplets in a clear liquid. When you charge the droplets, they either spread out (produce colour) or compact (become transparent) – counter-intuitive but apparently correct. When you apply frequency modulation, the emulsion properties change – a kind of high tech lava lamp. If it works, it will be fantastic.

And finally, we have thin CRT's. This is basically a cathode ray tube flattened out to fit into a 3.5 mm thick wafer. It uses good old fashioned high voltage phosphors which deliver great colour depth and luminance (for a given input current) and a much faster response (5 milliseconds) than a typical LCD (25 millisecond).

Thin CRT's don't have any of the viewing angle constraints of LCD's and should have a lower power budget (approx 3.5 watts to drive a 14.1 inch display).

Any one of these technologies could potentially transform next generation appliance form factor and functionality. Watch this space.

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