RTT TECHNOLOGY TOPIC
June 2011

3D 3G NANOTECHNOLOGY

Writing about the royal wedding last month prompted the question as to why televisions are becoming so HUGE.

The answer is of course that plasma screen technologies and LCD technologies and glass production technologies have combined together to produce a new generation of monstrously large televisions that do more than they used to. These devices do not only take information from a terrestrial or satellite broadcast but are also connected to the internet and more often than not also include one or more forms of wireless connectivity. Additionally they provide the option for 3D viewing combined with surround sound five channel stereo.

Televisions, set top boxes and home hubs are therefore now an integral part of the telecommunications value proposition though who owns what parts of that value remains open to debate as does the role of mobile broadband as a potential facilitator. The implications for delivery and storage cost and added value are profound. This provides the context for this month's technology topic.

Eighty years ago mechanical television systems designed by John Logie Baird in the UK and Charles Francis Jenkins in the US had screens an inch or so wide with a 30 line picture. US TV broadcasting was initially in the AM radio band between 550 and 1500 KHz. In 1930 the Federal Radio Commission allocated channels in the 2 MHz band to support higher resolution (45 and 60 line) pictures.

In the UK 30 line television programmes were broadcast by the BBC from September 1929. Most mechanical TV broadcasts in the US had stopped by 1933 but carried on in the UK until 1935 and until 1937 in the Soviet Union.

Electronic television required a number of enabling technologies including the valve but also a cathode ray tube to display the image and a camera tube to capture the image. The BBC set up a committee in 1935 to help decide between two electronic TV systems, a Baird 240 line system and an EMI system with 405 lines. The 405 line system was chosen as it worked better.

In the US the RCA Victor Company introduced electronic television at the 1939 World fair though even by 1940 there were only 2000 or so sets in use. During the war the UK stopped TV broadcasting as it was considered that the VHF transmission could be used by the German air force for direction finding. Post war 405 line broadcasts started again and carried on until January 3 1985 in the VHF band (Bands 1, 11 and 111 between 30 and 300 MHz). Band 111 was then reallocated to private mobile radio and later to digital audio broadcasting.

After the Second World War the BBC built a number of regional transmitters each on a different 8 MHz channel. The Bush Radio Company (named after the location of the original factory in Shepherd's Bush) produced the first television capable of being retuned if the owner moved house. It featured a nine inch screen and an aluminised cathode ray tube which meant that more of the light from the picture came into the room, producing a brighter image.

625 line/50 Hz TV was introduced into the UK in 1964 with colour transmission starting in 1967. The system known as PAL (phase alternating line) was developed by Telefunken in Germany. In the US a committee known as the National Television System Committee produced a standard in 1941 (the NTSC standard) that came to be used across most of Latin America and Canada with colour being introduced in 1953. This survived until the introduction of digital TV in 2009 standardized by the Advanced Television Systems Committee (ATSC). Standard definition digital TV still retains the 525 line/ 60 Hz resolution used by the NTSC system.

To be pedantic the visible scan lines for standard definition ATSC are 480, either interlaced or progressively scanned. ATSC high definition increases this to either 720 or 1080 with a 16 by 9 aspect ratio, closer to the natural field of view than a standard 4 by 3 aspect ratio. DVB T and DVB C and DVB S high definition is similar with a choice of 720, 1035, 1080 or 1152 scan lines.

Given that the human eye only has a certain amount of resolution there would be little point in having an HDTV picture on a small screen. It does however become progressively more useful as screen sizes increase.

Present large screen displays are either plasma or LCD. Plasma screens use fluorescent phosphors with each pixel having a red, green or blue light source which can be varied in intensity to produce a full colour range. Fluorescent phosphors go dim over time though the degradation is usually sufficiently slow not to be noticeable and they are brighter and have a wider colour range than LCD but use more energy. Samsung introduced a smart TV at CES this year with a viewable screen size of 59 inches. Similar LCD screen formats are available. All are remarkable thin, the LCD model having a depth of 0.3 inches.

The products with screen sizes of over 40 inches have smart TV features which include access to a Samsung application store and a touch screen control that allows users to watch TV while a Blu Ray movie is showing on the TV. Accessories include 3D glasses and a Skype certified high definition camera.

The HD Blue Ray player has a 3D sound effect that moves the sound to follow the 3D picture.

The blue bit of the Blu Ray player refers to the laser wavelength of 505 nanometers (>500 THz). The shorter wavelength compared to the 630 nanometer/400 THz red lasers used in standard DVD's means that up to 27 GB of high definition or 3D video can be stored on a single disk, enough for a HDTV feature film or two hours of recorded high definition content.

This begs the question as to whether it is going to be economic to stream files of this size over the internet let alone over mobile broadband networks. The BBC iPlayer for example is better than standard definition but falls short of high definition and is certainly not 3D capable.

3D comes in two flavours each of which has different delivery and storage bandwidth implications. Blu-ray 3D uses a sequential system in which the video is produced at 1080p resolution at 24 frames per second, per eye; or 48 frames per second. Streamed 3D at present uses a side by side system in which a 1080p frame holding both the right and left eye images is sent at 24 frames per second. The TV splits each single frame into two frames and then displays them sequentially with a consequent loss of quality.

Even so the bandwidth requirement is substantial and the delivery economics at best uncertain. As at mid 2011 there are about 200,000 homes in the UK with 3D capable televisions of which about a third are signed up to 3D TV services from Sky or Virgin Media. Whether this market can scale is dependent on achieving step function decreases in the cost of delivery and storage bandwidth which implies step function increases in storage and delivery bandwidth efficiency including guided media (fibre, cable, copper) and unguided media (wireless).

The set top box/personal video recorder market is presently moving in parallel with the integrated smart TV market with features such as triple tuning (the ability to record two channels while watching stored content) or quadruple tuning (dual satellite and terrestrial tuning). Typical storage is about 250 GB though this is steadily increasing over time.

This brings us to portable entertainment systems, lap tops marketed as entertainment centres rather than business aids and the possible relevance of this product sector to the mobile broadband industry or at least the smart phone and tablet bit of the mobile broadband industry.

The Vaio F Series is an example of a high end large lap top form factor product from Sony with up to 750 GB of hard disk memory or a 256 GB flash drive. It is one of the first lap tops capable of showing 3D graphics and converting HD content to 3D with support for active (powered as opposed to passive) 3 D glasses via a Bluetooth connection. The LCD-equipped lenses pass different images to each eye in succession (alternate-frame sequencing.) Each lens can be made transparent or completely opaque by varying the amount of electric voltage sent to the glass. The LCDs are synchronized with the screen's 240 Hz refresh rate. When running in 3D mode, the display inserts a black screen before it draws the scene for the subsequent eye. To make sure that this black is truly black, the panel's LED backlight goes dark. The device includes an 802.11b/g/n WiFi transceiver with integrated 3G Mobile Broadband connectivity in some markets (Verizon in the US for example).

It would seem obvious to throw in a DVB T2 and ATSC demodulator for terrestrial broadcasting reception but frustratingly flux densities are not adequate to make this an acceptable technical and commercial proposition. Additionally the power drain and associated duty cycle of these devices can be problematic with some user forums complaining of duty cycles of less than an hour, a compelling reason not to add mobile broadband connectivity. Just make sure you are never too far away from a mains socket.

This caveat aside, these devices and Smart TV's as well are natural hosts for user generated HD content captured from high end smart phones and transferred via a High Definition Multi media interface (HDMI).

These interfaces are critical to realising user value and have to evolve continuously to match the bandwidth capabilities of the devices sitting either side of the connector. For example the pixel clock rate of HDMI has increased from 165 MHz to 340 MHz to support resolutions up to WQGGA (2560 by 1600 pixels).

The Nokia N8 is an example of a high end phone capable of capturing high definition video transferable via an HDMI output port and it is reasonable to assume that the capability of high end smart phones to capture user content for onward delivery to huge televisions and lap top and tablet based entertainment centres will become more important over time. It can be also be assumed that at least some of the capabilities of the high end Sony Vaio device will be included in future lower cost smaller form factor tablet devices.

However the problems to solve include the technology and energy economics of delivery and storage bandwidth and for portable products (smart phones, tablets and lap tops) battery density and heat dissipation.

Old and new innovations suggest a way forward.

The production scaling of solid state memory combined with improved compression techniques provided the basis for Apple to develop the iPod introduced in 2001 and creating a new market sector which closely mirrored Sony's invention of the Walkman twenty two years before.

The development of resistive capacitive and multi touch interactive displays similarly developed new markets which Apple Inc has been astoundingly successful at exploiting. The Apple touch screen might be considered to be the secret sauce of the success of the iPhone and iPad but it is the algorithmic innovation behind the screen that defines the user experience and which gave Apple the first mover advantage in a newly created and remarkably profitable smart phone market sector.

But generically transformative change is normally coupled to more fundamental device innovation.

In 1876 the German physicist Ferdinand Braun demonstrated a rectification effect that could be recreated at the point of contact between metals and certain crystal materials, in effect a semiconductor device. Just over 70 years later in 1947 John Bardeen and Walter Brattain built the first transistor, a device with a gate that could be used to control electron flow. Eleven years later in 1958 Jack Kilby invented the integrated circuit and in 1961 Fairchild Semiconductor produced the first planar transistor in which components could be etched directly on to a semiconductor substrate.

This would suggest that every fifty years or so a fundamental discovery is made at materials level which has a truly transformative effect on the telecommunications industry. Rather like a dormant volcano it must be nearly time for the next big discovery or more likely the discovery has already been made but we have not yet fully recognised its significance.

And actually it may be a process of rediscovery rather than discovery as we begin to realise that the behaviour of common place materials and or combinations of materials can change fundamentally when assembled at molecular nanoscale level.

Graphene is a possible candidate, a form of carbon constructed as a flat layer of carbon atoms packed into a two dimensional honey comb arrangement, practically transparent due to its thinness. As a conductor of electricity it performs as well as copper at a fraction of the cost. As a conductor of heat it outperforms all other materials. At molecular scale grapheme potentially enables a new generation of ultra fast transistors and a new generation of super capacitors and related energy storage solutions.

Batteries have many similarities with memory devices. Both are storage devices and both achieve performance gain through materials innovation, packaging and structural innovation.

As with material behaviour, electro chemical reactions at the nanoscale are different from electro chemical reactions at the micro or macro scale. In particular the small particle size of nano scale materials allows short diffusion distances which means that active materials act faster. In lithium batteries for example, nanoscale manufacturing techniques potentially increase surface area and allow for the faster absorption of lithium ions which results in increased reactivity which means that batteries can store more energy, absorb energy faster and release energy faster when required.

Carbon nano tubes are being proposed as anodes and 3D metal oxide structures have been shown to have a reversible energy capacity of more than 1000 mAh/g, exactly what those hefty lap top and entertainment tablets need for them to be useful and useable. Those graphene based nano structures could then be used to dissipate the heat generated from all that extra available energy.

Last but not least there is the memristor. The concept of resistance with memory was theorised in 1971 in a paper by Professor Leon Chua, from the University of California Berkeley and was premised on the basis that circuit design has three elements, a resistor, capacitor and inductor but four variables with the fourth being a combination of resistance and memory not realisable from any combination of the other three elements.

The device remained as a theoretical concept up until 2008 when HP Labs demonstrated a nanotechnology scaled titanium oxide structure with atoms which moved when a voltage is applied. The device opens up the prospect of a step function increase in the energy efficiency of computing and switching systems and the opportunity to create memories that retain information without the need for power.

It would appear that very small devices constructed as 3D structures at molecular level may well be the key enablers for large and or complex products connected to large and or complex networks and may make the delivery of 3D images to portable and mobile devices via mobile broadband networks more cost and energy economic than presently expected.

Study from RTT
RTT has produced a 70 page study on LTE user equipment and LTE network economics. The study is written by RTT with statistics and economic modelling from **The Mobile World** and is sponsored by **Peregrine Semiconductor** and **Ethertronics.**

The study, 'LTE User Equipment, network efficiency and value' is available free of charge from the linked web site **www.makingtelecomswork.com**

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An additional level of detail on this topic and related topics can be accessed via the **Resources section** of our linked web site **www.makingtelecomswork.com**

www.makingtelecomswork.com provides a cost and time efficient way in which telecommunication engineers, product managers and policy makers can access **technical information and advice not readily available elsewhere in the public domain.**

The web site also provides information on RTT workshops, **Making Telecoms Work Europe**, **Making Telecoms Work Asia** and **Making Telecoms Work in the US.** The workshops demonstrate how engineering issues can be practically resolved and how performance gains and cost savings can be achieved. European work shops are held at the Science Museum in Kensington West London. **Information on the next workshop is available here.**

A number of sponsorship opportunities are available linked to the web site and related Science

Museum telecom industry educational initiatives.

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