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Device Driven Value

This month's Hot Topic takes a look at some of the key enabling technologies that have generated industry value in the past and sets out to determine which technologies will likely deliver value in the future.

THE STORY SO FAR The cellular industry has always been an industry dependent on a number of discrete enabling technologies. These include the radio frequency components needed to amplify, filter and process signals at 900 or 1800 or 1900/2100 MHz and the baseband components needed to capture and process voice and video and other types of content.

Cellular phones were 'invented' in the Bell Laboratories in 1947. The concept depended on being able to choose from a relatively large number of discrete radio channels and to be able to move from channel to channel (frequency re-use). This required two sorts of enabling device -a low cost microprocessor and low cost RF devices (amplifiers and filters) that would work efficiently at microwave frequencies. These components only became available in the late 1970's.

These first generation (1G) cellular phones used FM modulation making them similar in some ways to the two-way radios used in the VHF and UHF bands. What made them different was that they were 'smart'. An AMPS or ETACS phone had about 10,000 lines of software code and a protocol stack that could manage seamless handover and all those clever mobility tricks that would drive user uptake (and mobile minutes) through the 1980's.

Then along came another enabling device - the low cost low power digital signal processor. Low cost DSP's meant that analogue voice processing could be replaced with speech synthesis codecs. These codecs were more bandwidth and power efficient and were and are used in all second generation (2G) phones including GSM, PDC in Japan and US TDMA and CDMA. The combination of digital voice encoding/decoding and error protection on the radio channel would yield the voice quality improvements and call consistency metrics that would drive user uptake (and mobile minutes) throughout the 1990's. The improvements in power efficiency combined with an increase in network density would over the next ten years increase the duty cycle to the point where talk times and standby times were and are today close to miraculous.

The DSP also helped to drive down component costs. Instead of expensive RF components, much of the signal processing moved to baseband. Delivering selectivity at baseband meant that the 1321 twenty-five kHz channels used in ETACS (expensive to manage in the handset, expensive to plan in the network) could be replaced with a smaller number of 200 kHz channels (easier to manage in the handset, easier to plan in the network). This step function reduction in radio component and planning costs went largely unreported in the marketing press but provided the basis for lower prices and higher margins which drove the growth of the industry in the late 1990's. In 1988 it took 8 hours to build and test and phone. By 1998 this had reduced to less than 80 seconds. For larger manufacturers, component and manufacturing costs decreased faster than realised prices.

In the meantime, the phone had also become smarter. 10, 000 lines of code had become 100,000 lines of code with a protocol stack that could manage all those clever SIM based services that would drive user uptake (and mobile minutes) through the 1990's. These value-added services would not have been possible without low cost low power solid state memory technologies.

So far so good- a classic example of a positive feed back business- new technologies realising additional business volume (minutes of use) and additional business value (lower costs and higher margins).

3G HANDSET VALUE

Can the trick be repeated for third generation phones?

Let's look at the enabling technologies presently being deployed into 3G handsets.

Part of the story is just existing device platforms moving forward. Better packing density for solid state memory, faster more power efficient silicon (getting CMOS to run at 5 GHz for 802.11a WiFi handsets), faster clock speeds (600 MHz processors in small form factor devices), and better antenna technologies (near field antennas using ceramic substrates).

The rest of the story revolves around peripheral device capabilities. It's useful to divide these components into uplink application bandwidth devices and downlink application bandwidth devices and to qualify the devices in terms of their ability to generate uplink and downlink value.

UPLINK BANDWIDTH DEVICES

Image sensors are an example of an uplink bandwidth device. Image sensing is either done with charge coupled devices (CCD) or CMOS. CCD devices have traditionally provided better resolution but are power hungry. However, CMOS based devices over the past 18 months have moved from 300,000 pixel to 1.3 Megapixel resolution, with 3 and 4 Megapixel resolution devices presently being sampled to the (larger) handset manufacturers. Note some of these devices can process 25 or 30 frames per second, some will work down to sub one lux light levels and consume less than 100 milliwatts. Imaging capability, particularly imaging power efficiency, self evidently determines the image and video capture capability of the handset which in turn determines the image and video capture functionality for the user which in turn determines uplink 'image and video value'. Solid state microphones capable of capturing signals up to 20 kHz perform the same function for uplink 'audio value'; 24 kbps wideband AMR codecs do the same for uplink 'voice value', high rate wireless keyboards do the same for uplink 'text value'. Note also the importance of 3Gtxt, the ability to add voice and simultaneous sub titling to a real time video in a conversational exchange with a third party.

DOWNLINK BANDWIDTH DEVICES

Same story with the downlink. As with the uplink, downlink 'voice value' is determined by the quality (i.e. bandwidth) of the codec being used, downlink audio value is determined by the quality of the headphones or speaker and speaker drivers in the handset, image and video downlink value is determined by the display and display drivers used in the phone. Display quality is determined by contrast ratio (brightness captures attention, contrast conveys information), resolution and colour depth and display refresh ratios. CIF or QVGA displays have been displaced typically by VGA displays, 8 bit colour depth (256 colour) displays have been displaced by 16 bit (65,000 colour) displays, 50 millisecond refresh ratios (12 frames per second) have been replaced by 25 second refresh ratio devices. Note also the importance of wide angle viewing capabilities, never a natural strong point with LCD's but now better than they used to be. Viewing angles and video and audio capabilities are particularly important for the 'gather round' effect, getting people around you involved in a voice and video exchange. The more people involved in a session, the longer the session will last - a (device enabled) increase in billable bandwidth. Note also that people will tend not to notice poor video quality video provided the audio quality is good.

UPLINK/DOWNLINK BANDWIDTH

Devices such as cameras and high-end displays are therefore bandwidth generation devices and should (hopefully) also be value generation devices. Application value is the sum of voice value, audio value, image value, video value, text value and data value. Note also that much of the application value is intuitively bi-directional and intuitively symmetric in terms of uplink and downlink loading. Voice is bi-directional and symmetric, simultaneous voice and video is bi-directional and symmetric, simultaneous voice, video and sub titling is bi-directional and symmetric. Don't even assume that audio will be asymmetric on the downlink. The most successful audio sites on the web are sites aimed at people wanting to upload their content ie it's audio capture capability that counts (back to those solid state microphones), which brings us to the radio layer.

FLEXIBLE PHYS AND MULTIPLE PHYS

DSP's have helped to transform voice coding, audio and image coding but they have also helped to transform the radio physical layer (often described as the PHY). The whole point for example of the UMTS radio layer is not so much the headline data rates achievable but the fact that multiple per user data streams can be handled on separate code streams and that each code stream can be variable rate- really the only way to get power budgets down to an acceptable threshold. However, it is important to note that most handsets now have one PHY for wide area, one PHY for local area and, increasingly, a third PHY for personal area networking, all capable, potentially of working at the same time. This is the 'enabling technology' behind the various ' personal mobile gateway' initiatives presently being promoted within the industry;

We have covered these PHY characteristics in earlier Hot Topics but as a brief recap, consider:

The Bluetooth PHY

Bluetooth now has a new PHY extension known as EDR (enhanced data rate). The significance of EDR is not so much the higher headline data rate so much as the ability to support multiple simultaneous data streams - voice and image combined with wireless mouse and or wireless keyboard support for example.

The WiFi PHY

Presently undergoing a major transformation, the wireless media extensions (EDCA and HCCA) are specifically designed for mixing background and best effort traffic with real time voice and video both for home networking and for mobile Personal Area or Local area application context.

The UWB PHY

From a hardware (enabling technology) perspective, as CMOS geometries have reduced, it has become practical to build low cost pulse train generators and detectors with the bandwidth effectively dictated by the rise time of the IC process. A nanosecond pulse width occupies one GHz of radio spectrum, the only issue then being how you co-exist with other proximate spectral users. There are also two competing PHY proposals - the DS-UWB PHY (www.uwbforum.org) and the Multiband OFDM PHY (www.multibandofdm.org) but both are targeted at the high data rate personal area networking space (see the September Hot Topic on the RTT web site www.rttonline.com for a more detailed explanation.)

802.15 PHY/MAC INTEGRATION

We also highlighted the need find some way of allowing WiFi, Bluetooth and UWB devices to work together. In principle this is what 802.15 is supposed to be doing. 802.15-2 addresses the co-existence of wireless personal area networks and wireless local area networks. 802.15-3 is setting out to establish an agreed standard for high rate (20 Mbit/s or greater) PANS and DANS or in other words UWB and/or WiFi based PAN/DAN topologies. 802.15-4 addresses low rate low power applications which could potentially be Bluetooth and/or WiFi and/or UWB.

MULTIPLE PHYS AND APPLICATION VALUE

WiFi (802.11 a, b and g), Bluetooth (1.2 and EDR) and UWB (DS UWB and Multiband OFDM UWB) are all evolving both in terms of PHY and MAC functionality. New capabilities open up new application opportunities both in home networking (the moving of audio and video between multiple devices) and in personal area networking.

As often happens, we are spoilt for choice in terms of radio layer and MAC layer options, any of which are capable of fulfilling the application requirement. It comes down to cost versus capability.

SUMMARY
All of these capabilities are only made possible by the underlying functionality of the devices available to us at any given time. The DSP, fast (high clock speed) host processors and dense non volatile power efficient memory together with image capture and display technologies and voice and audio components are the basic building blocks which underpin application value.

And yet there's a snag.

A recent survey by the Semiconductor Industry Association pointed out that although (good news) battery power and capacity was increasing at an annual rate of 15-20%, mobile system power requirements were increasing at an annual rate of 35 to 40 %. This is bad news for network loading and network value. A 'rich media' phone with a flat battery will not make anyone happy.

This is a whole subject in its own right. Suffice it to say that a whole barrage of enabling techniques (rather than enabling technologies) are presently being focussed on trying to solve this (very important) problem with much attention being paid on the demand side to reduce power drain by using adaptive voltage and adaptive frequency scaling and on the supply side to increase battery capacity.

Network value is ultimately determined by how many watts we can pack into a mobile device and how many megabytes we can move per watt - the single biggest technology challenge for our industry today.

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RTT, the Shosteck Group and The Mobile World are presently working on a number of research and forecasting projects in the cellular, two way radio, satellite and broadcasting industry.

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