RTT TECHNOLOGY TOPIC
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The impact of handset hardware on the offered traffic mix and offered traffic value

In this month's HOT TOPIC we revisit some of the topics addressed in our December HOT TOPIC (Session Power Budgets) but take a leap of faith. Assuming sufficient battery power and capacity can be made available in a sufficiently small space, in a sufficiently light package, at a sufficiently low cost, how will handset hardware change the offered traffic mix and offered traffic value.

The Uplink Offered Traffic Mix

Note our emphasis on offered traffic, ie traffic being fired **into** the network **from** subscribers rather than traffic delivered **from** the network **to** subscribers.

Uplink offered traffic is determined by the audio bandwidth, image bandwidth, video bandwidth and application bandwidth generated in the handset.

Audio bandwidth is a product of the codec used - either the selectable mode vocoder specified by 3GPP2 for 1xEV or the AMR-W codec specified by 3GPP1 for W-CDMA/UMTS. The AMR-W encoder encompasses 'CD quality' signals equivalent to a 16 kHz audio pass band rather than the 3 kHz audio passband generally regarded as acceptable for voice. Thus we have added a reasonably 'hi-fi' audio capture capability to our device.

The 'cost' is a 24 kbps source code rate which when channel coded will occupy at least 48 kbps of channel bandwidth (and usually more).

The point here is that if you have bothered to use processor bandwidth to capture decent audio quality, there is not much point if you throw that quality away during the process of transmission. This implies either a heavily coded channel (with masses of forward error correction) or a very good RF channel with minimal bit errors and burst errors. Note that it is not only the number of bit errors that is important, but the distribution of bit errors - errors occurring in bursts can easily degrade audio, image or video quality.

Thanks to the hi-fi industry, audio quality can be very precisely defined in terms of acoustic fidelity - frequency response, dynamic range, digital quantisation noise and analogue signal to noise are often used figures of merit.

J-PEG and M-PEG use Q factor. In J-PEG (image encoding), 8 x 8 pixel blocks are transformed in the frequency domain and expressed as digital co-efficients. A Q factor of 100 means that pixel blocks need to be identical to be coded as 'the same'. A Q factor of 50 means that pixel blocks can be quite different from one another but the differences are ignored by the encoder. The result is a reduction in image 'verity' - the image resembles the original but has incurred loss of information. In digital cameras, 90 equates to fine camera mode, a Q factor of 70 equates to standard camera mode.

These compression standards have been developed generally to maximise storage bandwidth. You can store more Q70 pictures in your camera than Q90 pictures. However choice of Q also has a significant impact on transmission bandwidth. An image with a Q of 90 (a 172 kbyte file) would take just over 40 seconds to send on a 33 kbps (uncoded) channel. The same picture with a Q of 5 would be 12 kbytes and could be sent in under 3 seconds. Our delivery cost has been reduced by an order of magnitude. The question is how much value has been lost from the picture. The question also arises as to who sizes the image and decides on its original quality, the user, the application, the user's device or the network.

Similar issues arise with video encoding excepting that in addition to the resolution, colour depth and Q comprehended by J-PEG, we have to add in frame rate.

Perceptions of quality will however be quite subtle. A CCD imaging device can produce a 3 Megapixel image at 24 bits per pixel. Consider sending these at a frame rate of 15 frames per second and you have a recipe for disaster. So we can compress the image and/or slow the frame rate. Interestingly with fast moving action (which looks better with faster frame rates) we become less sensitive to colour depth. Table 1 shows how we can exploit this. In this example, frame rate is increased but colour depth is reduced from 10 bits to 8 bits (and processor clock speed is doubled).

Note also how frame rates can potentially increase with decreasing numbers of pixels.

Example	**Frame Rates at 10 bits versus 8 bits per pixel output**	
	10 bits (@ 16 MHz)	**8 bits (@ 32 MHz)**
1280 x 1024	9.3	18.6
1024 x 768	12.4	24.8
800 x 600	15.9	31.8
640 x 480	19.6	39.2
320 x 240	39.2	78.4

Table 1: Pixel Resolution and Frame Rate

This gives us a wider range of opportunities for image scaling. The problem is to decide on proportionate user 'value' as quality increases or decreases.

Table 2 shows as a further example the dynamic range of colour depth that we can choose to support.

Colour Depth	Number of Possible Colours
1	2 (ie Black and White)
2	4 (Greyscales)
4	16 (Greyscales)
8	256
16	65,536
24	16,777,216

Table 2: Colour Depth Options

The M-PEG 4 core visual profile specified by 3GPP1 covers 4 to 12-bit colour depth. 24-bit is generally described as high colour depth and 32-bit colour depth is true colour. 32-bit is presently only used for high resolution scanning applications.

So potentially our quality audio stream can be coded on to an OVSF physical layer code stream, our high quality video stream can be coded on to a second OVSF physical layer code stream and background text can be coded on a third code stream - a complex high value time inter-dependent multimedia multiplex.

The Downlink Traffic Mix

Similarly handset hardware determines (or should determine) downlink traffic. There is not much point in delivering CD quality audio to a standard handset with low quality audio drivers. There is not much point in delivering a 24-bit colour depth image to a handset with a greyscale display. There is not much point in delivering a 15 frame per second video stream to a display driver and display that can only handle 12 frames per second.

Intriguingly, quality perceptions can also be quite subtle on the downlink. Smaller displays can provide the illusion of better quality. Also, good quality displays more readily expose source coding and channel impairments, or, put another way, we can get away with sending poor quality pictures provided they are being displayed on a poor quality display.

These hardware issues highlight the requirement for device discovery. We need to know the hardware and software form factor of the device to which we are sending content. It also highlights the number of factors that can influence quality in a multimedia exchange - both actual and perceived.

The Challenge for Quality Band Billing

So somehow we need to accommodate actual and perceived quality metrics as a foundation for quality based billing.

Some work has already been done in the digital TV industry, particularly apposite are the emerging DVB-T QoS standards differentiating low definition (LDTV), standard definition (SDTV) enhanced definition (EDTV) and high definition (HDTV) multiple and single channel streams.

In turn this points towards a convergence of digital TV and digital cellular billing methodologies at some future time.

Summary

Handset hardware - the audio, image and video encoders and CCD or CMOS imaging devices have a direct impact on uplink offered traffic and uplink traffic value. Similarly display and display drivers and audio amplifiers determine downlink bandwidth quality and downlink bandwidth value.

Quality in a multimedia exchange is hard though not impossible to define and can potentially encompass both actual and perceived quality metrics. Work already under way in the digital TV standards community points the way towards future 3G TV and 3G cellular billing and value integration.

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