RTT TECHNOLOGY TOPIC
May 2004

Handset and network loading

Last Month's Hot Topic looked at how different phones from different manufacturers perform in different ways on different networks. Differences in RF performance (receive sensitivity) translate directly into a variation in dropped call rates and voice quality from phone to phone. The choice of phone, rather than the choice of network, dictates the quality of the user experience.

This month's Hot Topic studies the impact of handset hardware and handset software on the user experience and the related properties needed from the radio layer and the network.

The Graphical User Interface

The starting point is to compare some hardware and software form factors, using as an example some Symbian based devices based on Series 40/60/80 and 90 GUI's (graphical user interfaces).

Figure 1

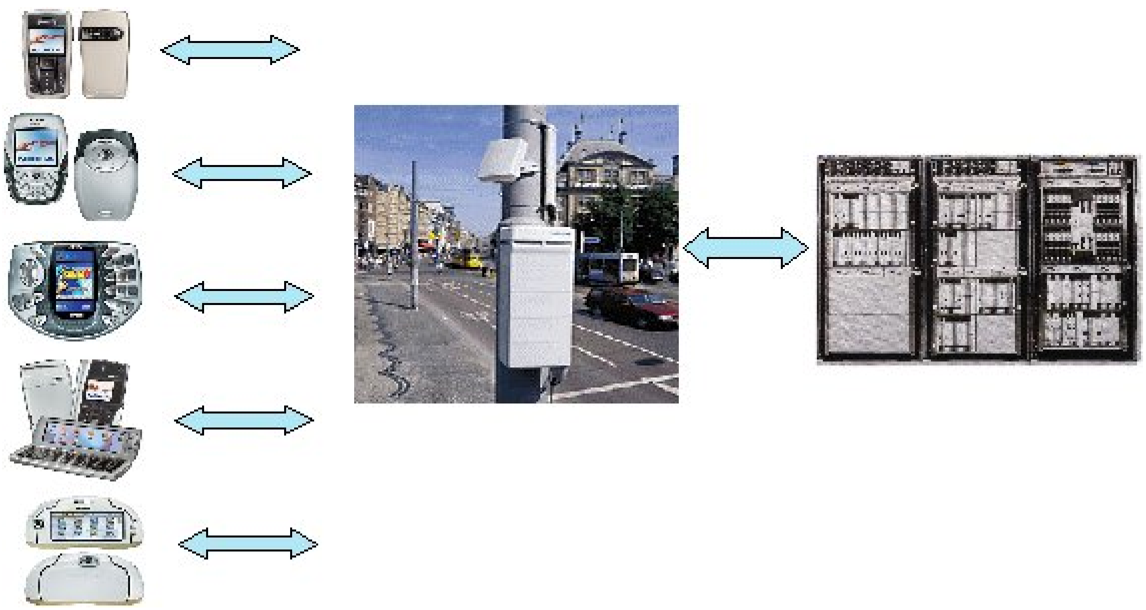

Figure 1 shows four types of handset, a Series 40 Nokia 6230 entry level camera phone, a Series 60 Nokia 6600 with memory expansion, a Series 60 N-Gage with memory expansion (the Panasonic X700 is another typical product in this category), a Series 80 Nokia 9500 communicator and a Series 90 Nokia 7700 media device.

The GUIs are determined by the hardware form factor of the phone. The distinguishing feature of the Series 60 platform for example is the expandable memory functionality. The N-Gage adds in gaming software and a stereo FM receiver (a good candidate for DAB/DVB-H connectivity), and support for EDGE circuit switched data and GPRS 2+2. The 9500 has a dual display, 128x128 pixels when closed (working as a Series 40 device) and 640 by 200 pixels when open (working as a Series 80 device). It has an integrated EDGE and wireless LAN transceiver. The 7700 Series 90 device has a 640 by 320 pixel touch sensitive screen, four-way rather than 5 way scrolling, integrated video camera, and music and video download. It is the device presently being used in the DVB-H trials in Finland (IP audio and IP video data casting).

Note these media devices can either handle MPEG4, MPEG3 or MPEG2. Although the radio and network bandwidth requirements of MPEG2 are higher than MPEG4, it is significantly easier to decode (less processor load in the device). The arrival of faster downlink options (EDGE, HSDPA and possibly DVB-H) makes standard MPEG2 a more practical proposition for mobile devices.

Memory Bandwidth Issues

However this in turn has a significant impact on the memory footprint needed in the device. Or, put another way, the memory footprint in the device determines the downlink bandwidth requirement.

Take as an example the I-Pod (not presently a wireless device but could be in the future).

Figure 2: I-pod

The I-pod is probably one of the most well known products with a hard disk, the 40 GB I-pod can hold 20,000 images, equivalent to 160 256MB memory cards or 10,000 songs. It weighs 5.6 ounces (156 grams), less than 2 Compact discs and supports MP3 up to 320 kbps and MP3 variable bit rate.

Note also the extended frequency response for the headphones (20 Hz to 20,000 Hz.) Similarly, solid state microphones are now available with an input response up to 20 kHz (www.zarlink.com and www.national.com).

Nokia also have an image album with a 20 GB hard disk drive offering some of the same storage functionality.

In the US, I-Pods are used to access content from the I- tunes music store which because of arcane licensing laws is not available in Europe (need to wait for I-tunes music store Europe).

Alternative sources in Europe include www.Mperia.com, Spanish based weblisten.com and Russian based Allofmp3.com. Allofmp3.com charges 15 dollars for 1000 MP3 file downloads a month at up to 384kbps.

Philips have similar personal video player products based on Nexperia which will handle MP3, AAC audio, MPEG2, MPEG4 and DivX video.

Note that AAC is an open standard MPEG-4A and competes (or complements) the Windows Media Audio format - devices do not necessarily support both formats. The same applies to some of the so-called' I-pod killer' products, for example the products from I-river that support Windows Media but not MPEG download formats.

Connectivity Requirements

But back to access issues. Figure 3 shows how long it would take to fill a 40GB I-pod on a 384 kbps radio channel .The time depends on the level of channel coding needed but assuming a rate 1/3 coded channel, it would take a month.

Figure 3

Rate 1/1(Uncoded)	Rate 1/2	Rate 1/3
10 days	20 days	30 days

It is not just an issue of bandwidth quantity; it is also an issue of bandwidth quality. Some applications will be download applications (filling the I-pod), but others will be interactive or conversational and (as a result) will be time and rate dependent and two-way. Note also that the properties of the traffic coming to and from these devices are quite complex.

Figure 4

Content	Codecs	Channel	
		Radio layer	Network
Per User Multiplex	**Source Coding**	**Channel coding and modulation**	
Text	Compression and concealment	Continuity and Consistency	Continuity and Consistency
Voice			
Audio			
Image			
Video			
Data			
	Source Adaptation	**Link Adaptation**	**Network Adaptation**

For a start, there are potentially six individual content streams that a device can simultaneously transmit and receive, text, voice, audio, image, video and data. Any one of these streams may be variable rate and may need to maintain time dependency with one another (lip synching voice to video for example). The streams can be time multiplexed together or kept separate and delivered over separate code channels on the radio layer (six OVSF codes per user) and then over virtual circuits over virtual paths through the network. The disadvantage with time multiplexing is that it introduces additional delay into the end to end channel.

The source codecs compress (and optionally multiplex) each data stream and provide some forward error protection. There are then three requirements, source adaptation, link adaptation and network adaptation. The codecs need to be capable of adapting to changes in the dynamic range of the source-coded content (simple scenes and complex scenes in video for example). By implication, the source codecs are therefore variable rate (they do not have to be but are more efficient if they are). The radio layer needs to be able to respond to the changes in data rate coming from the source coders, and the network needs to preserve the properties of the offered traffic, particularly the time domain characteristics of the content.

The properties required from the radio layer and the network are continuity and consistency. These multiple data streams, particularly conversational multiple data streams, are implicitly delay sensitive and are very sensitive to delay variability (jitter in the end to end channel).

The radio layer has evolved to meet these needs. Release 99 made the upper layer protocols and physical layer and logical channel more responsive to the radio channel (link adaptation). It does a better job of protecting the application layer from the affects of a fading channel. Release 4, 5 and 6 make the protocols and physical and logical channels more responsive to changing user data rates and (in the case of UMTS) more flexible in the way that the radio layer can accommodate multiple per user data streams. Release 6 has introduced some IP voice protocol optimisation, which will make it more practical to realise the IP voice, IP audio and IP video services described in the IP multimedia subsystem (IP MMS) specifications. Generically, the changes in the physical layer are described as Flexible Layer One (FLO) evolution.

Summary

The hardware form factor of the handset determines the shape and property of the graphical user interface, which in turn determines how the handset is used, and the content that it produces. This content can potentially consist of text, voice, audio, image, video and data. These six information streams may need to be sent and received simultaneously. This either requires the provision of multiple physical channels (multiple time slots in EDGE dual transfer mode or multiple uplink and downlink OVSF codes in WCDMA) or requires a time multiplex/demultiplex in the encoder/decoder (which introduces delay).

The memory capabilities of products like the I-pod highlight some of the present limitations of the radio downlink and offer some justification for the present focus on high speed downlink delivery including EDGE, HSDPA, broad band Wi fi and DVB. However many of the user interfaces are as likely to be used in symmetric applications where uplink loading will be similar or occasionally greater than downlink loading. In either direction, the particular properties needed from the radio layer and the network include bit rate flexibility and (for conversational services) close control of end to end delay and delay variability. The network has to be capable of handling multiple per user bi-directional channel streams that have to be carried in virtual containers in virtual circuits over virtual paths (or the IP equivalent).

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