RTT TECHNOLOGY TOPIC
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End to end connectivity constraints

In our last Hot Topic (2G connectivity constraints) we identified connectivity constraints across the physical layer - wireless access delay and delay variability, bit error rates and error variability.

In this month's Hot Topic, we set out to define other factors which impact end to end delay and end to end delay variability.

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In our 'creation appliance' model (the 3G PC) the user's device has 4 inputs - a microphone for voice/audio streaming, a CMOS image capture platform for image/video streaming, a keyboard for application streaming and a smart card for access/policy rights and QoS/SLA (service level agreement) negotiation. Given that this is primarily an information delivery platform, we will describe it as a server.

The four parallel inputs are combined into a MPEG4 encoder which arbitrates and decides on the QoS (quality of service) attributes needed to deliver (and preserve the value) of the complex content session stream.

The MPEG4 encoder source codes the content and produces single or multiple differentially encoded variable rate information bit streams. These are presented to the MAC layer (Layer 2) for channel coding and physical layer multiplexing. The traffic streams are then QPSK modulated on to an RF carrier, for example, in IMT2000DS, on to multiple code streams on the RF channel to support multiple per user information streaming.

At this stage there will already be some quality impairments imposed on the source encoded data including encoder noise and time, frequency and phase ambiguity in the RF transmission/modulation process - impairments which, for the sake of clarity we will describe as 'micro jitter'. In addition, the application O/S may in it's own right

be generating variable application server delay.

The channel streams then set off on a voyage across the physical layer, suffering the indignity of slow fading, fast fading, free space and incident propagation loss. The bits arrive at the receiver, eg a base station, which we will describe in this instance as an 'intermediate' client. In the process of demodulation, further impairments are introduced (front end noise, filtering imperfections and frequency, phase and time domain ambiguity in the demodulator}. Post demodulator coding gain will reduce the bit error rate, but residual bit error rate may still be relatively high.

The bit stream then starts its journey through the fixed line network. If the packet stream is following a known and defined trajectory through the network, delay and delay variability should be predictable and bounded providing no congestion occurs at any point. If congestion occurs, a variable delay will be introduced. If the delay is sufficient to fill and overflow localized buffer bandwidth (for example router memory bandwidth), then packet loss will occur. If packet loss occurs, a send again protocol will be triggered which will increase delay variability - the macrojitter delay budget.

If the content stream then needs to be delivered to a wireless device, the information will need to be re-multiplexed and modulated on to a new RF channel and delivered to the client transceiver where further impairments will be added - front end noise and demodulator errors. Post demodulation coding gain will reduce the bit error rate though residual error rates may still be relatively high.

The content streams will be delivered to the audio drivers, display drivers and application and security O/S (operating system). Even at this stage, limited display driver bandwidth or refresh rate limitations could compromise display quality and variable application delay could occur.

Complex content thus passes across a complex delivery channel in which microjitter and macrojitter conspire to produce variable end to end delay - the summation of access latency, network latency, application latency creating access jitter, network jitter and application jitter which in turn compromises the quality of highly compressed differentially encoded information streams - the end user experience will likely be highly variable and made worse by any inherent variability in the wireless access channel - thus highlighting the need for good quality consistent wireless access connectivity.

The complexity of the delivery channel also highlights the need for an end to end performance measurement protocol. From the user's perspective, the critical measurement (proof of performance point) is application delay/application response time. If application response is measured as being unacceptably slow (outside pre-determined delay and latency parameters), the performance measurement must be used to identify the source of the problem which could, in practice be any point in the complex delivery channel.

This highlights the need for a holistic approach to test and measurement and end to end delivery diagnostics.

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