3G Planning

Network density in a 3G cellular network is a function of the link level and system level noise floor which is a function of the property of offered traffic and offered traffic distribution. Offered traffic is a function of appliance hardware and software form factor and functionality.

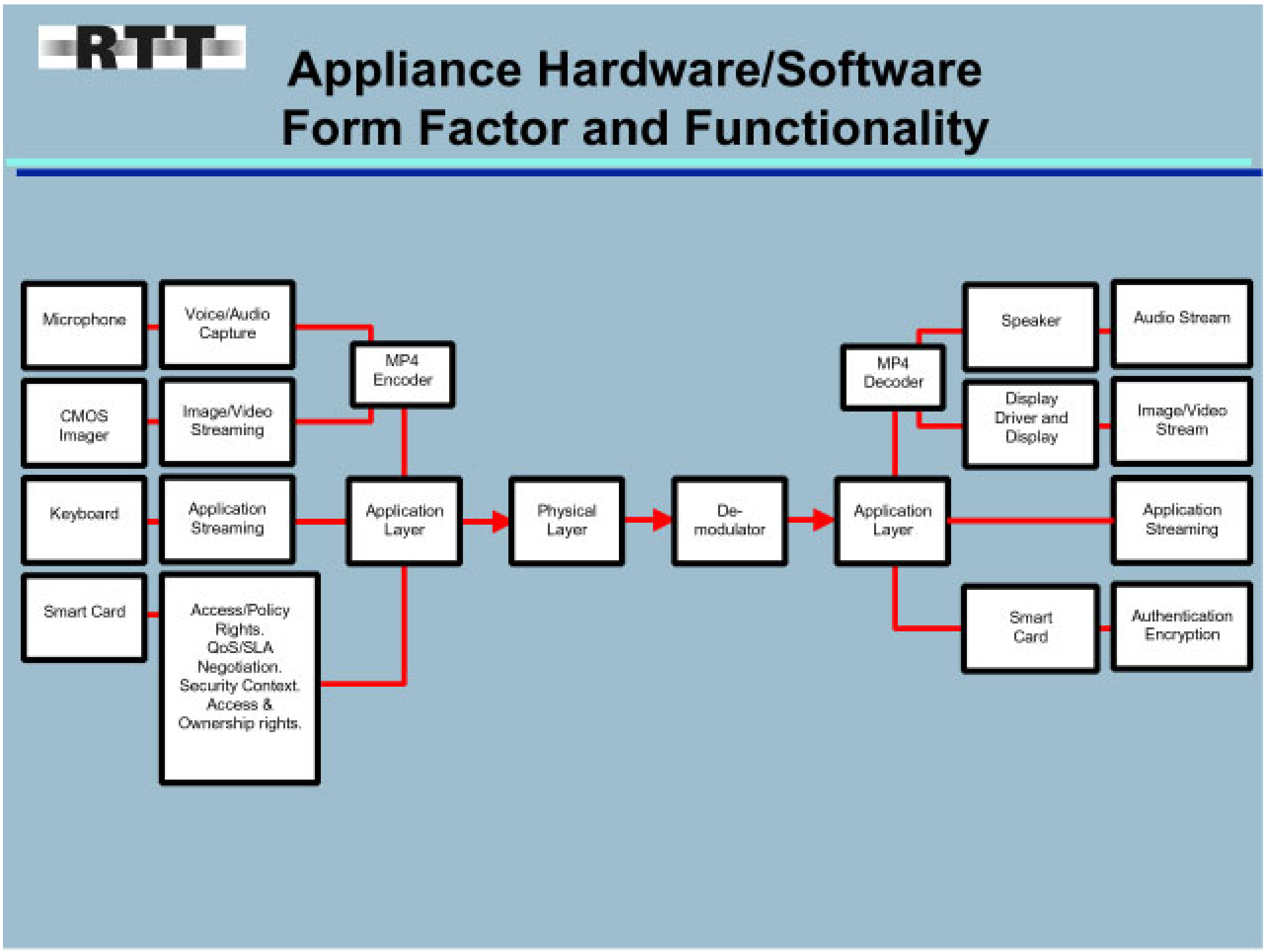


Figure 1

Figure 1 summarises the four inputs received into a 3G appliance - microphone (audio streaming), CMOS imaging platform (video streaming), keyboard (application streaming) and a smart card SIM (access rights, policy rights, QoS and SLA negotiation). Audio and image/video streaming is encoded via an MP4 encoder. Post demodulator in the receiver, the reciprocal process includes an MP4 decoder, a speaker to output the audio stream, display drivers and display (image/video stream) and a Smart card SIM (authentication and de-encryption).

Image bandwidth is determined by the dynamic range of the CMOS imaging platform and the encoder. Figure 2, a DVD video example, shows a typical trace from an MPEG encoder, complex scenes generate a fast encoding rate, simple scenes a slow encoding rate. The maximum to minimum bit rate amplitude can vary by a ratio of up to 64:1, equivalent to moving from 16 kbits to 1 Mbit and back again from 10 ms frame to 10 ms frame, equivalent to an amplitude component (ie dynamic range) of 18 dB.

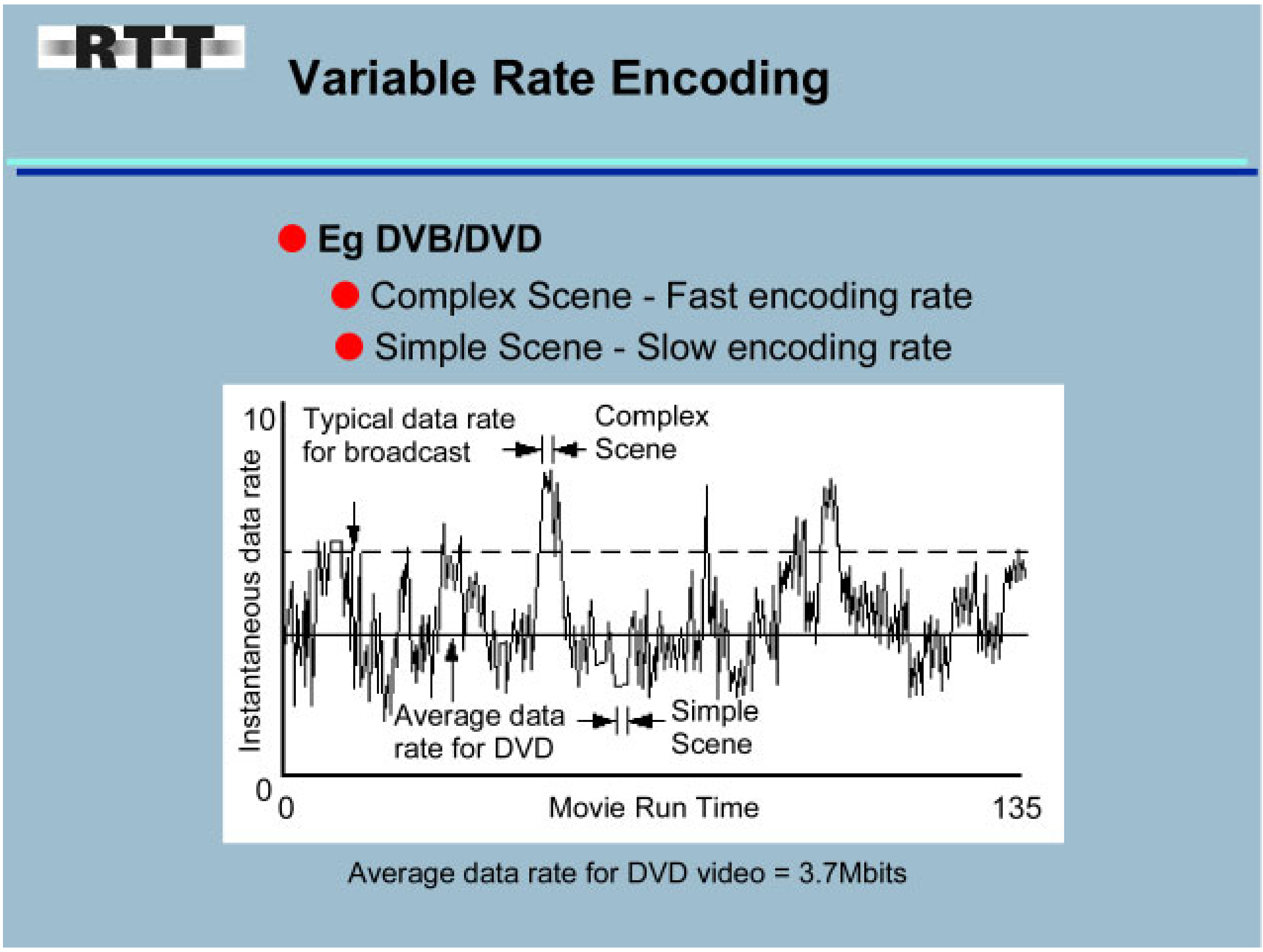


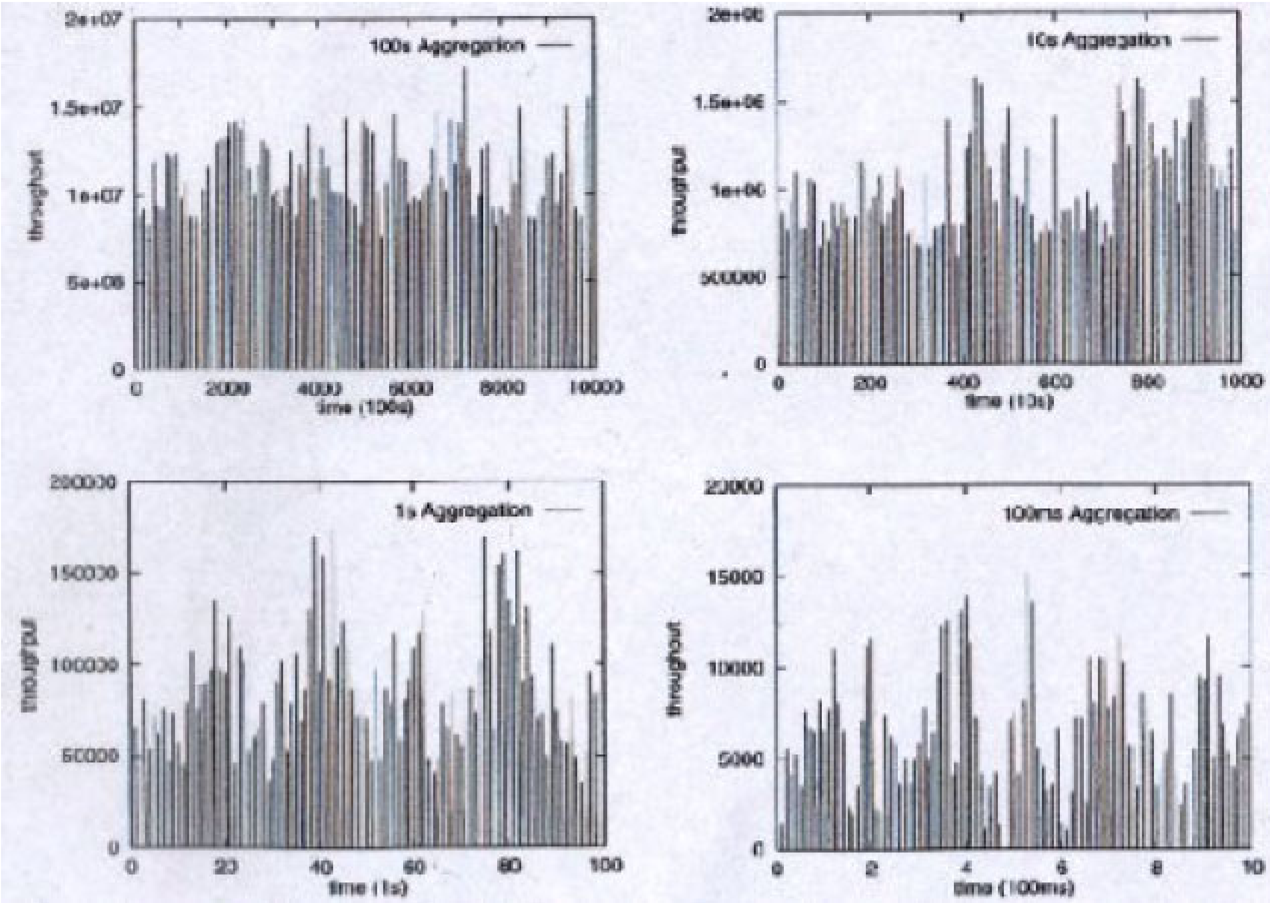
Figure 2

This is the source of the burstiness exhibited in offered traffic being sent to the network from a user's appliance. It is possible to band limit this burstiness but the result will be a loss of content quality.

Note also that the video stream may be multiplexed with audio and application streaming which may add extra burstiness to the signal.

This is why traditional traffic loading and queuing theory cannot be applied to multi-media/mixed media/rich media modelling.

Inconveniently, when users are multiplexed together, both across the physical layer and network / transport layers, the burstiness refuses to disappear - a phenomena known as 'burstiness preservation'. Figure 3 shows how 'burstiness' is maintained across a range of time scales - milliseconds, seconds, tens of seconds and hundreds of seconds. The network loading is described as exhibiting self-similarity' (ie self-similar across a wide range of time scales).



Stochastic self-similarity - ie 'burstiness preservation' - across time scales 100s, 10s, 1s, 100 ms (top left, top right, bottom left, bottom right).

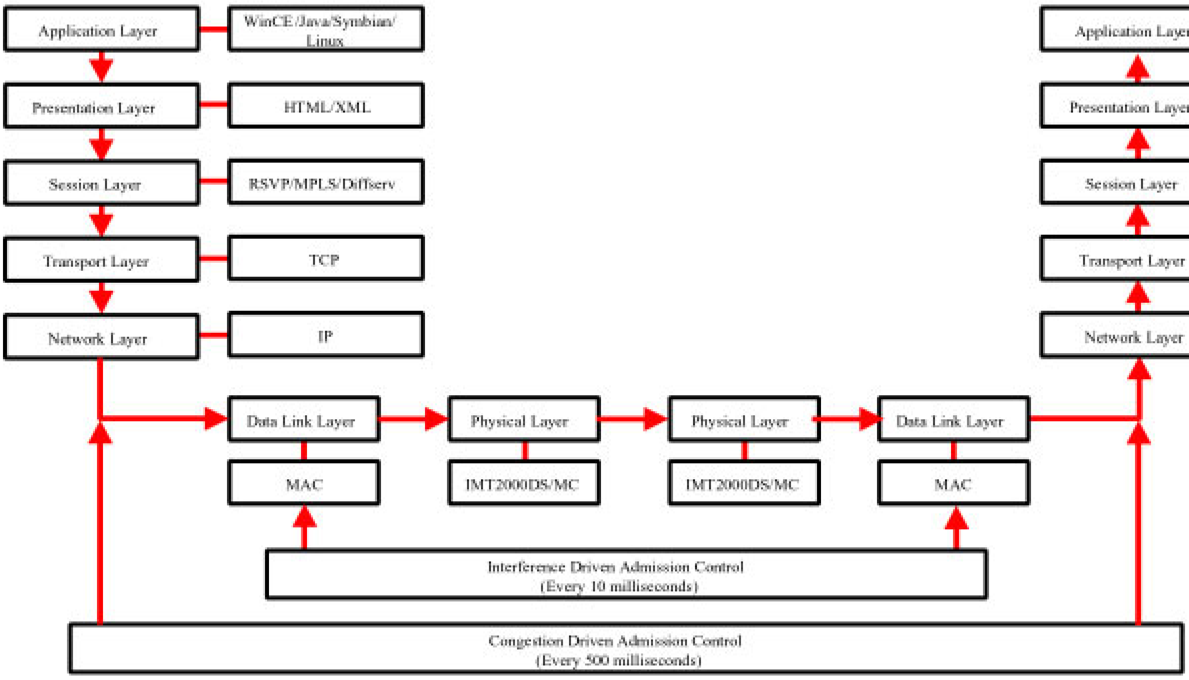
Figure 3
Self-Similar Network Traffic and Performance Evaluation
Park and Willingen, Wiley - ISBN 0-471-31974-0

The distribution of burstiness on a per user and multi-user basis can be described as having a 'heavy tailed distribution' - the information content is characterised by having a small but significant percentage of very high values.

In the example above, we have described the heavy tailed' distribution which results from the encoding process but similar heavy tailed distributions occur for parameters such as file size and session length - HTTP web files for example are becoming increasingly heavy tailed as web sites become increasingly 'rich' in terms of media components.

The impact of heavy tailed distribution (burstiness, file size and session length) on radio and network planning is substantial. At any given moment, a small but significant percentage of 'extreme' users will have a disproportionate amount of RF power allocated to them (ie will be major contributors to noise rise and OVSF code allocation). At the network layer, these users will be adding disproportionately to network congestion.

In practical terms this requires feed back control to manage the impact of these 'high dynamic range' users.



Admission Control
Figure 4

Figure 4 shows the two levels of admission control applied in a 3G network, congestion driven admission control (with a 500 millisecond control loop) interacting with the TCP/IP protocol stack and RSVP/MPLS/Diffserv traffic shaping protocols and interference driven admission control (with a 10 millisecond control loop) interacting with the data (MAC) physical layer protocols, effectively an ATM available bit rate (ABR) admission protocol.

The impact of these two levels of admission control on the 'properties' of heavy tailed traffic is still incompletely understood. The fact that control loop optimisation will be critical to delivering a consistent rich media experience for end users is however beginning to be fully acknowledged and is presently the subject of much study

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