A temporal QoS based CPU scheduling model for multimedia applications in general purpose operating systems

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Abstract

We present a CPU scheduling model aimed at satisfying multimedia presentation temporal QoS requirements. The model is based on a playout specification and a runtime application structure that allows workahead processing, and quality degradation for delay or overload situations.

Keywords

Operating system QoS support for multimedia, synchronization, CPU scheduling.

1 INTRODUCTION

Multimedia temporal QoS requirements include both individual stream's continuity and inter-stream synchronization. In order for an operating system to manage these QoS requirements, its CPU scheduler needs an explicit knowledge of data temporal characteristics to perform a scheduling aimed at respecting them. This is not the case in existing general purpose OSs (Nieh *et al.* 1993). Currently, application developers have to define application-specific temporal QoS enforcement methods which can result in unacceptable presentation quality, since CPU scheduling is decoupled from decisions taken within these methods (Bourges Waldegg *et al.* 1996).

In a general purpose OS, users may accept a degraded quality presentation under varying load conditions. Integrating synchronization and quality adaptation into the system scheduler can help to take more accurate decisions and to make a better use of the CPU resource. This integration also provides programmers with a generic support which they can use to build multimedia applications.

So we have developed a CPU scheduling model for adaptive multimedia presentation applications, that integrates synchronization and adaptation support. The model is composed of an application structure aimed at minimizing degradation for streams with intensive-CPU needs; a QoS and playout scenario specification to transmit QoS requirements to the kernel; and an on-line scheduling algorithm.

workahead state are scheduled in deadline order, the deadline being the lower bound of the *dynamic temporal validity interval* corresponding to the associated arc (whose values depend on the static interval and execution state). Reading/processing threads are scheduled for a duration of one time quantum, a value which reflects processing needs for each stream.

If at instant θ there are no reading/processing threads in nonworkahead state, workahead threads can start to be scheduled in a round robin basis.

In summary, the decision algorithm will schedule in priority:

- presentation threads when scheduling instant belongs to firing interval, in internal priority order;
- nonworkahead reading/processing threads in deadline order;
- workahead processing/reading threads in round-robin.

3 EXAMPLE

We illustrate our scheduling model with an audio/video software decoding/presentation application. Let us consider QoS demands as follows: 16 images/s, maximum skew between audio and video = 80 ms. The TSPN depicted in Figure 1 corresponds to this QoS specification, with a synchronization interval of half a second. The audio stream, which is more sensible to degradation than the video flow, is set as the master stream for inter-stream transitions. As video processing is more CPU demanding than audio processing, we fix the time quantum for video to be 30 ms, and the time quantum for audio to be 5 ms.

We consider that video images need the following reading/processing times: $v_1=120$ ms, $v_2=45$ ms, $v_3=45$ ms, $v_4=80$ ms, $v_5=45$ ms, $v_6=45$ ms and $v_7=120$ ms. Presentation threads need 10 ms each time an image is displayed or an audio block is sent to device. The audio block needs 40 ms to be processed. Note that these values are not known *a-priori* by the scheduler. We consider also that processing of image v_1 had been scheduled in a workahead basis, and at the time the synchronization interval starts, it has progressed 110 ms.

The schedule obtained with our algorithm is shown in Figure 2. Note that all video images excepting image v_7 are presented within their validity intervals even though some of their processing times exceed the stream's period. Image v_7 was not ready at time transition t_7 needed to be fired ($\theta = 427.5$ ms). A video degradation thread was thus scheduled, the degradation policy consists of just rejecting the image, and advancing to the reading/processing of the next image. At the end of the synchronization interval, audio block a_1 is ready for presentation, and inter-stream transition t_8 is fired at time $\theta = 472.5$, which is a temporally correct value.

4 CONCLUSION AND PERSPECTIVES

We have presented a QoS based scheduling model for adaptive multimedia presentation applications, which offers a support for synchronization and adaptation at a lower level, saving thus decision layers that can cause inaccuracy. Degradation decided by the scheduler is useful for a better resource utilization. Finally, with our run-time structure we allow for anticipation and workahead processing that can be useful

Figure 2 MPEG audio/video schedule.

in overload situations.

We are currently working on the implementation of our model in the Solaris operating system. Problems related to priority calculation costs are being analyzed.

5 REFERENCES

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6 BIOGRAPHY

Daniela Bourges Waldegg was born in Mexico City, in 1970. She obtained an Electrical Engineering degree in 1993 from the “Universidad Autónoma Metropolitana”, in Mexico City and a Computer Science “Diplôme d’Etudes Approfondies” from “Université de Rennes 1” in 1994. She is currently a PhD student at the Networks and Multimedia Department of the “Ecole Nationale Supérieure des Télécommunications de Bretagne” in Rennes, France, supported by a grant from the Mexican National Council for Science and Technology (CONACYT).