

Integrating Multimedia Applications in Hard Real-Time Systems

Ricardo Garibay-Martínez
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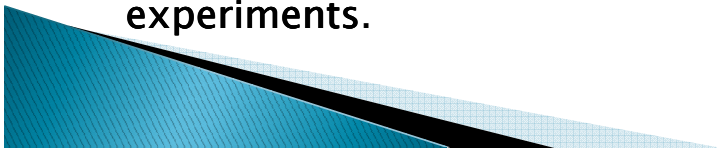
Outline

- ▶ Introduction
- ▶ Terminology and Assumptions
- ▶ The Constant Bandwidth Server (CBS)
- ▶ Simulation results
- ▶ Conclusions



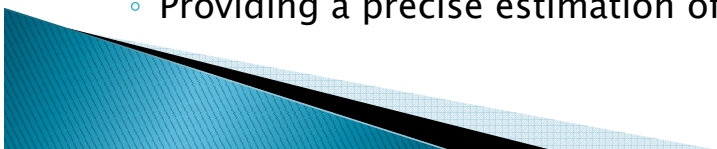
Introduction

- ▶ Support to **multimedia applications** in a real-time system: multimedia **soft** real-time tasks and **hard** real-time tasks.
- ▶ **Hard tasks** are guaranteed based on **worst case execution times** and **soft tasks** are served based on **mean parameters**.
- ▶ Scheduling soft and multimedia tasks **without jeopardizing** the a priori guarantee of hard real-time activities.
- ▶ The **performance** is compared with that of similar service mechanisms through **extensive simulation experiments**.



Introduction

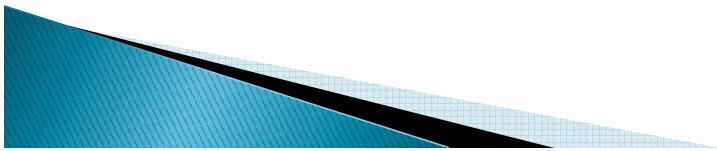
- ▶ Continuous Media (CM) activities, need real-time support because of their sensitivity to delay and jitter.
- ▶ The use of a hard real-time system for handling CM applications can be inappropriate:
 - If a multimedia compressed frames, coding/decoding can vary significantly, hence the worst case execution time (WCET) of the task can be much bigger than its mean execution time.
 - Providing a precise estimation of WCETs is very difficult.





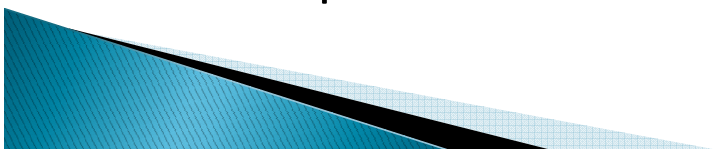
Introduction

- ▶ When data are received from an external device such data may not be deterministic, it may be impossible to determine a minimum inter-arrival time for such tasks.
- ▶ Advanced multimedia systems tend to be more dynamic than classical real-time systems.



Terminology and Assumptions

- ▶ Task: \mathcal{T}_i
- ▶ Jobs: $J_{i,j}$
- ▶ Arrival time: $r_{i,j}$
- ▶ Hard real-time task: (C_i, T_i)
 - WCET: C_i
 - Minimum inter-arrival time: T_i
 - Deadline: $d_{i,j} = r_{i,j} + T_i$
- ▶ Soft real-time task: Mean execution time and desired activation period.



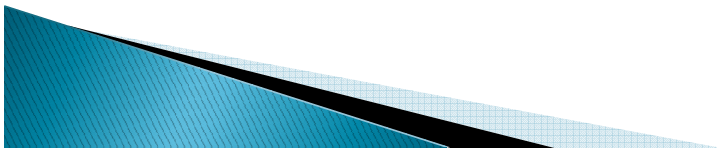


Terminology and Assumptions

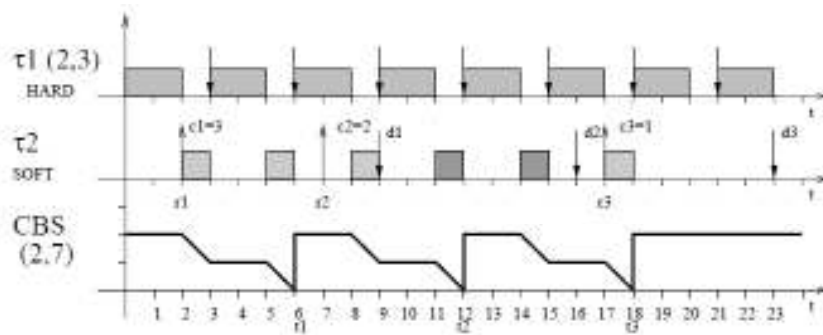
- ▶ The objective is to minimize the mean tardiness of soft tasks, without jeopardizing the schedulability of the hard tasks.

$$E_{i,j} = \max\{0, f_{i,j} - d_{i,j}\}$$

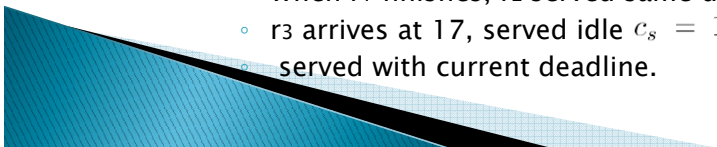
- ▶ This problem can be solved by a bandwidth reservation strategy, in order to increase CPU utilization.



The Constant Bandwidth Server (CBS)



- ▶ CBS: $Q_s = 2, T_s = 7,$
 - t_6 ; budget exhausted, then $d_{s,2} = d_{s,1} + T_s = 16$ and c_s replenished
 - When r_1 finishes, r_2 served same deadline.
 - r_3 arrives at 17, served idle $c_s = 1 < (d_{s,3} - r_3)U_s = (23 - 17)\frac{2}{7} = 1.71$
 - served with current deadline.





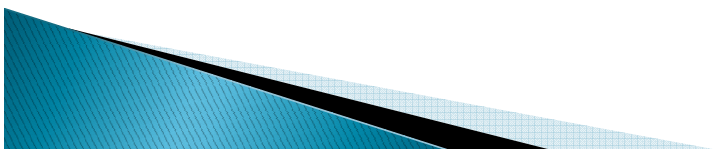
Simulation results

- ▶ Compare the CBS with the Total Bandwidth Server (TBS) and the Dynamic Sporadic Server (DSS).
- ▶ Difference between DSS and CBS is visible when the **budget is exhausted**.
 - DSS becomes **idle** until the next replenishing time (that occurs at the server's deadline).
 - CBS remains eligible by increasing its deadline and replenishing the budget immediately.
- ▶ The TBS does not suffer from this problem, however its **correct behavior** relies on the **exact knowledge of job's WCETs**, so it cannot be used for supporting CM applications.



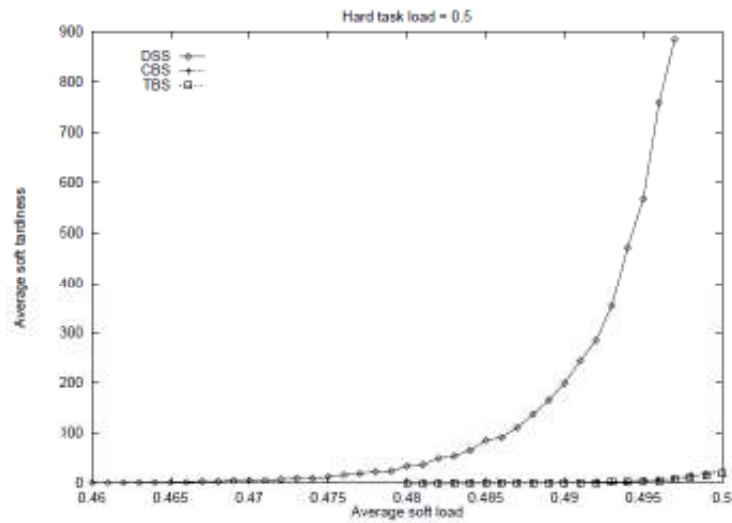
Simulation results

- ▶ Assumptions:
 - 5 periodic **hard tasks** with **fixed** parameters and 5 **soft tasks** with **variable** execution times.
 - The periods and the execution times of **hard tasks** are **randomly generated** in order to achieve a desired processor **utilization factor U_{hard}** .
 - The execution and inter-arrival times of the **soft tasks** are **uniformly distributed** in order to obtain a mean soft load. $1 - U_{hard}$.

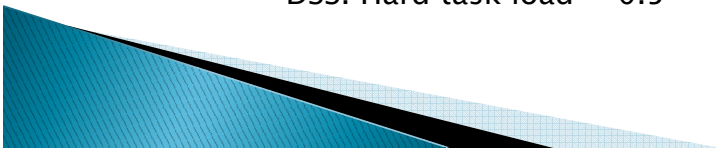




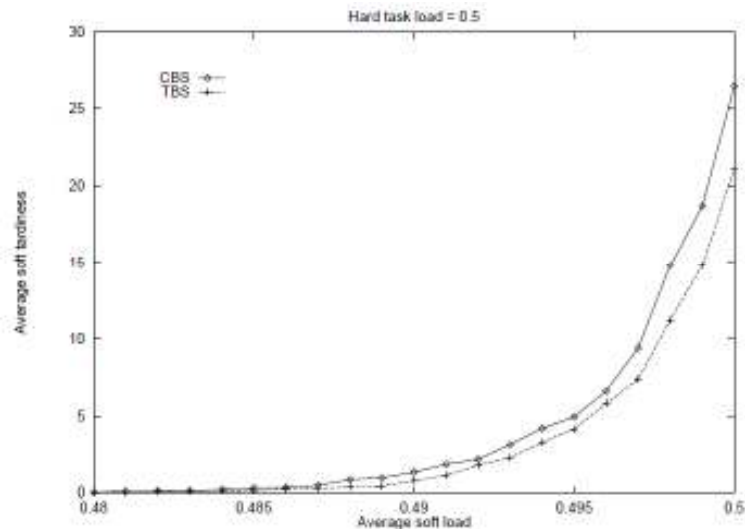
Simulation results



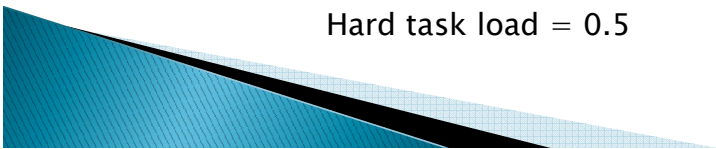
- ▶ Mean tardiness when served by CBS, TBS and DSS. Hard task load = 0.5



Simulation results

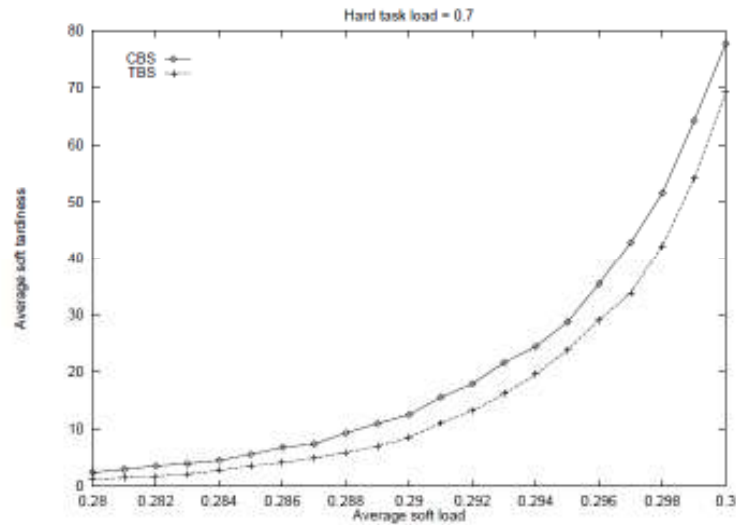


- ▶ Mean tardiness when served by CBS and TBS. Hard task load = 0.5





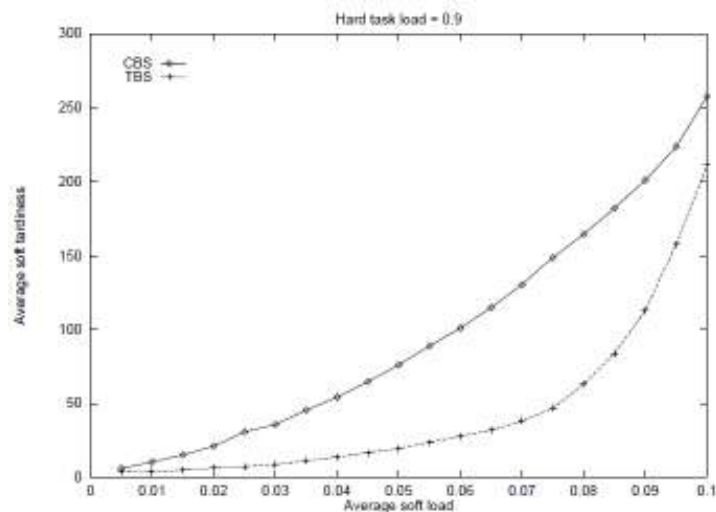
Simulation results



- ▶ Mean tardiness when served by CBS and TBS. Hard task load = 0.7



Simulation results

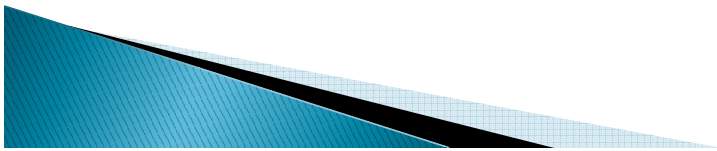


- ▶ Mean tardiness when served by CBS and TBS. Hard task load = 0.9



Simulation results

- ▶ Is presented a novel service mechanism the Constant Bandwidth Server (Abeni and Buttazzo, 1998), for integrating hard real-time and soft multimedia computing in a single system, under the EDF scheduling algorithm.



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Research Centre in
Real-Time Computing Systems
FCT Research Unit 608

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