

Cheddar : an educational Ada Real time scheduling framework

Frank Singhoff
University of Brest, France
EA 3883

Introduction and motivations

⌘ Real time scheduling Analysis :

- ⊞ Aims to provide a way to predict if task temporal constraints will be met.
- ⊞ First results 30 years ago (Liu & Layland).
- ⊞ Still sometimes unapplied. Sometimes unpractical ? Unknown ?

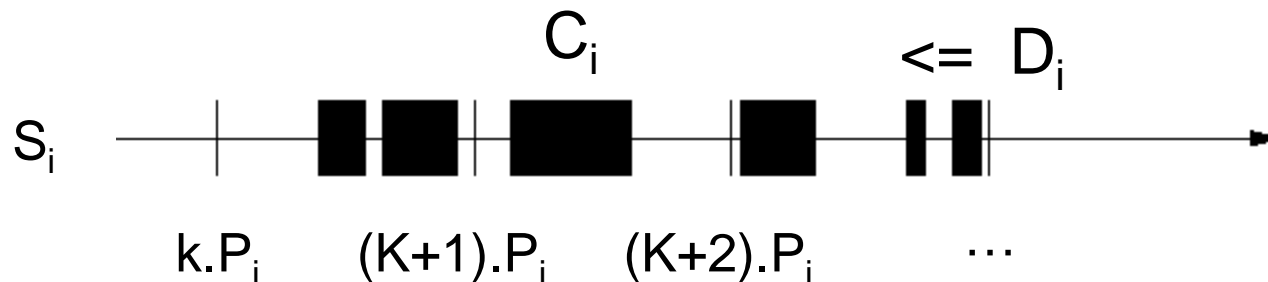
- ⊞ *Aims to provide educational tools to teach real time scheduling :*
 - ⊞ Simplicity of usage. Should contain foundation that students/engineers have to know.
 - ⊞ Also used to experiment new analysis features (ex : buffers).
- ⊞ *Aims to apply real time scheduling on practical cases :*
 - ⊞ How to study applications which are « outside » the theory ?
 - ⊞ How to extend real time scheduling analysis to take distribution and buffers into account ?

Talk overview



- ☒ Introduction and project motivations
- ☒ Overview of Real time scheduling analysis
- ☒ Examples of new buffer feasibility tests
- ☒ Cheddar basic services
- ☒ Conclusion and ongoing work

Real time scheduling (1/2)



⌘ The periodic task model : (Liu & Layland, 1974)

⊞ Bound on execution time (capacity) : C_i

⊞ Delay between two wake-up times (period) : P_i

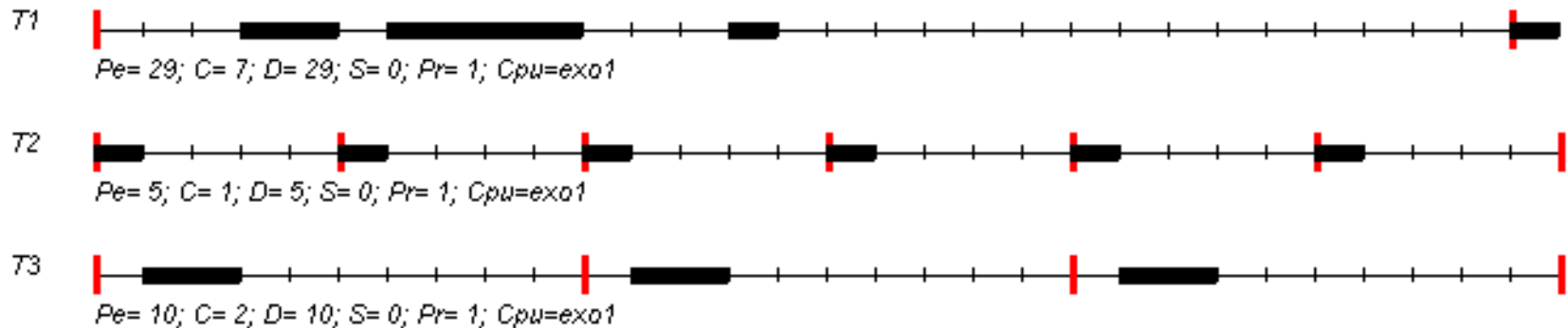
⊞ Temporal constraint to meet (deadline) : D_i

⌘ Classical real time scheduling algorithms : Rate Monotonic, Earliest Deadline First, ...

⌘ Simulation versus feasibility tests.

Real time scheduling (2/2)

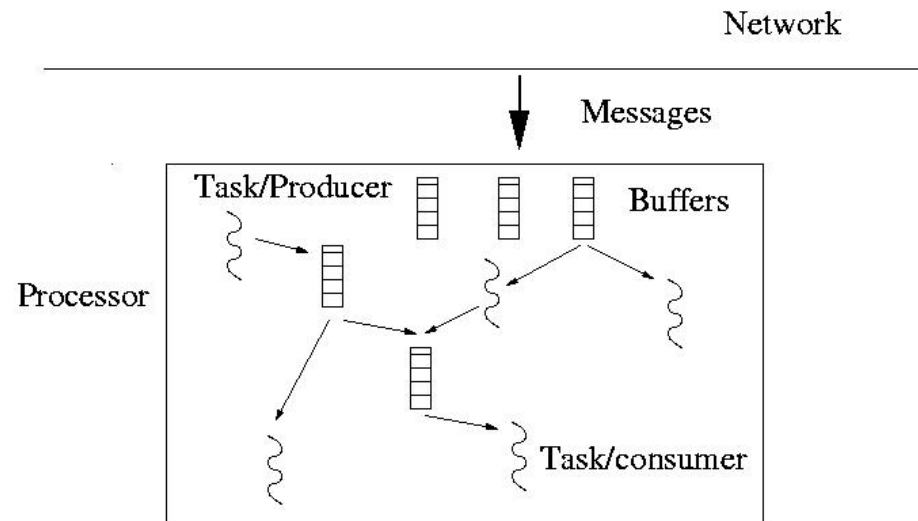
⌘ **Simulation** : Rate Monotonic (RM, Liu & Layland 1974), run task with the smallest period



⌘ **Feasibility tests example** : the processor utilization factor test

$$\sum_{i=1}^n \frac{C_i}{P_i} \leq n(2^{1/n} - 1) \approx 69\%$$

New buffer feasibility tests (1/3)



- ⌘ Feasibility tests and simulation have to be available for all resources. Example : how to evaluate the proper size of buffers shared by RM scheduled tasks (Legrand & Singhoff & Nana & Marcé 2003) ?
- ⌘ Feasibility analysis tests built with queueing systems (Kleinrock) :
 - ☑ Message arrival rate and message consumption rate : buffer utilization factor, message waiting time, overflow probability, ...

New buffer feasibility tests (2/3)

⊞ Consumers/Producers are periodic RM/EDF scheduled tasks :

- ⊞ Define a new consumption/arrival rate : the P rate.
- ⊞ Define new feasibility tests based on queueing systems.

⊞ Worst case analysis based on P/P/1 :

- ⊞ Periodic arrivals assumption : minimum time between 2 message arrivals is known. Worst case buffer size/message waiting time.
- ⊞ P/P/1 Resolution : based on ATM technologies.

⊞ Average case analysis based on M/P/1 :

- ⊞ Random arrivals assumption : mean time between 2 arrivals
- ⊞ M/P/1 Resolution : M/G/1 with P average service time.

New buffer feasibility tests (3/3)

⌘ Example of buffer feasibility test (P/P/1 queue) :

☒ Maximum size of a buffer shared by N producers and 1 consumer scheduled according to preemptive Rate Monotonic (with $D_i \leq P_i$) is :

- $2.N$ (harmonic task set)
- $2.N+1$ (other cases)

Cheddar basic services (1/2)

⌘ **Cheddar** : editor + framework providing a simulation engine and feasibility tests (portability with Ada95/XML).

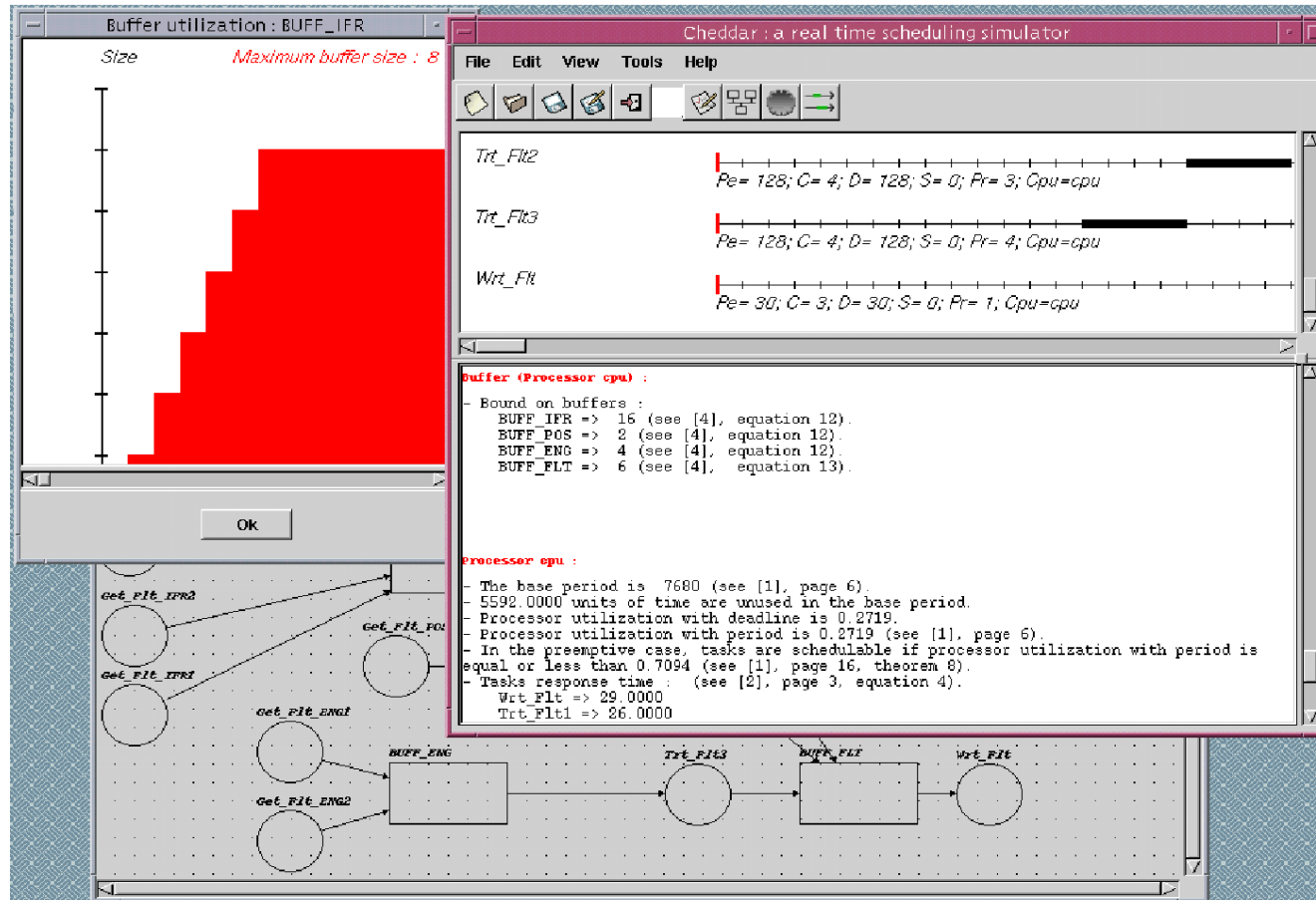
⌘ Feasibility tests on different resources :

- ☒ Tasks : utilization factor, response time...
- ☒ Buffers : size, waiting time ... (P/P/1, M/P/1, M/M/1, ...).
- ☒ Shared resources ...

⌘ Extensible Simulation services :

- ☒ Compute scheduling time lines (processors, messages, buffers, task precedencies...)
- ☒ Time line analysis (ex : response time, blocking time, deadlock, buffer access, message scheduling, priority inversion ...).
- ☒ User-defined Ada-like scheduler/task/analyzer extensions.

Cheddar basic services (2/2)



Conclusion and ongoing works



- ☒ Cheddar :
 - ☒ Provide feasibility tests and simulation features on different resources. Mostly for educational purposes.
 - ☒ Distributed since october 2002. Used at Rhode Island University, Monash University, ...
- ☒ First buffer feasibility tests. Should be extended to more general task models. Need to be validated with an industrial case study.

- ☒ Stood (TNI HOOD editor) and Cheddar interoperability :
 - ☒ TNI-Europe/ENST Bretagne/Deimos Space project.
 - ☒ How to perform buffer feasibility analysis with AADL ?
 - ☒ Industrial case study.
- ☒ How to compare performance of Ada-like user-defined extensions such as schedulers ? (PVS theorem prover)