Cheddar : an educational Ada Real time scheduling framework

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Introduction and motivations

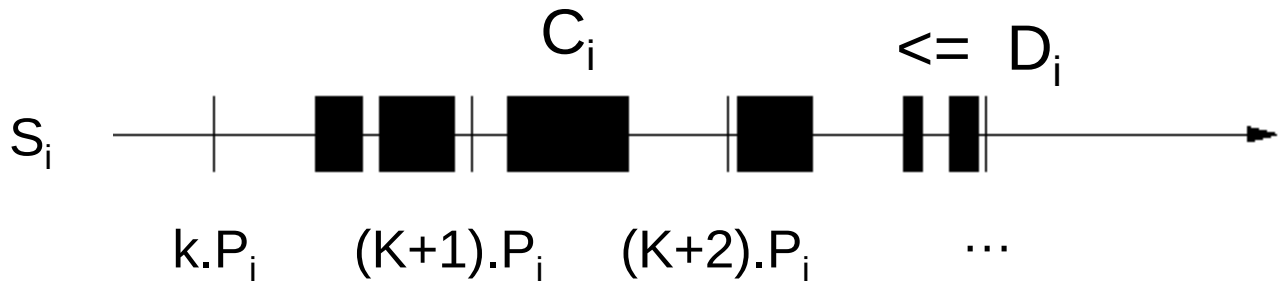
- **Real time scheduling Analysis** :
  - Aims to provide a way to predict if task temporal constraints will be met.
  - First results 30 years ago (Liu & Layland).
  - Still sometimes unapplied. Sometimes unpractical ? Unknown ?

  - *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

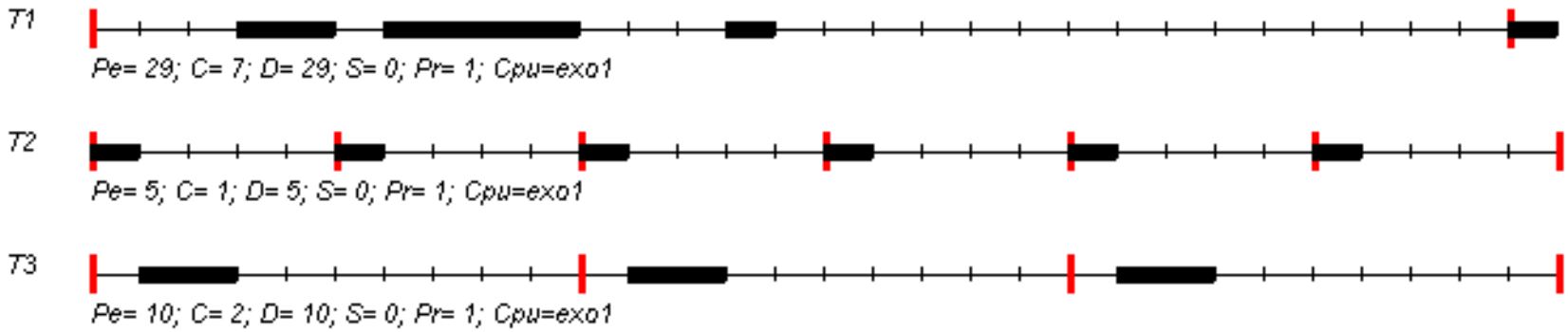
Real time scheduling (1/2)



- 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)

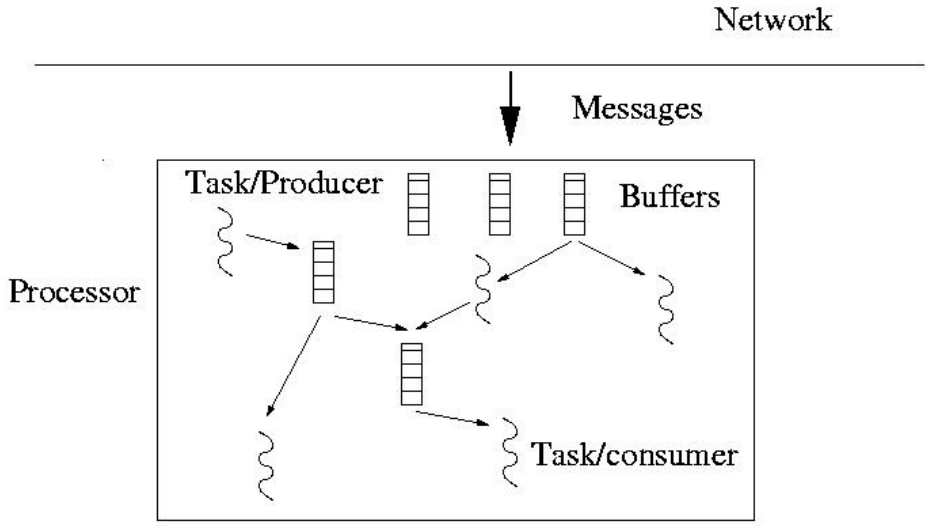
- **Simulation** : Rate Monotonic (RM, Liu & Layland 1974), run task with the smallest period



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

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

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 :

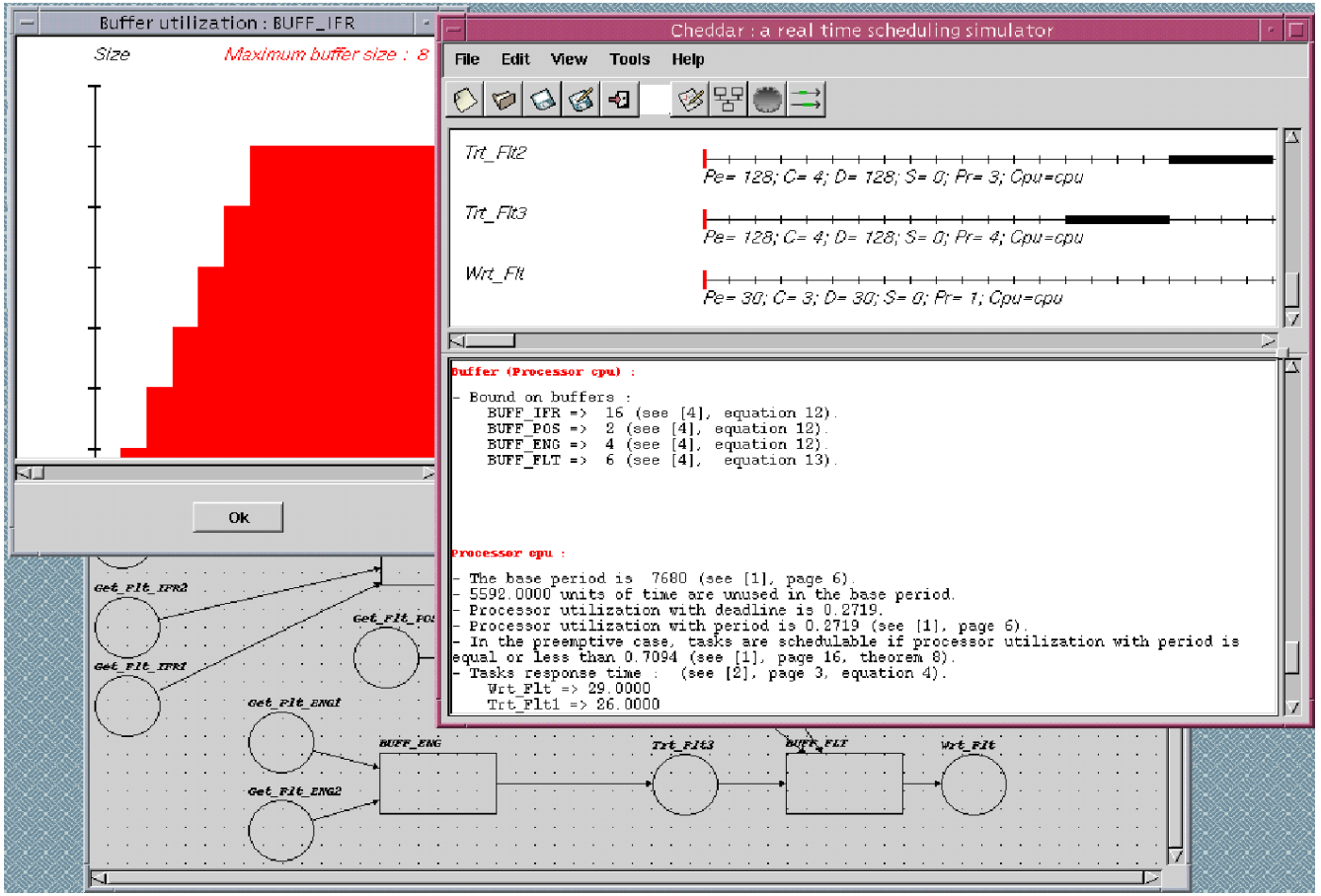
    - 2.N (harmonic task set)
    - 2.N+1 (other cases)

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)