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

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