CABI (CPU Accounting and Blocking Interfaces) CPU Resource Management System in Embedded Linux

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Midori Sugaya[1], Tohru Nojiri[2], Takaaki Kasuga[3], Takeharu Kato
Waseda University[1], Hitachi[2], Lineo Solutions[3]

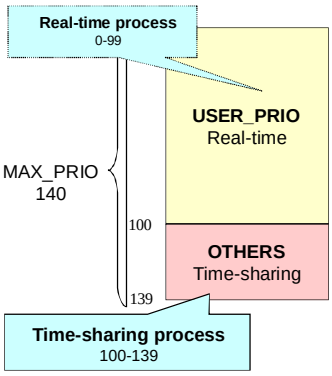
doly @dcl.info.waseda.ac.jp

Requirements for embedded system

- Advanced embedded system
  - Expansion of application field
    - Complication GUI, Network
  - More complicated, grow up code sizes
    - Car navigation system, cellular telephone, digital TV
- The requirements of embedded system
  - Real-time
    - Multimedia applications
      - In order to process video, audio streams, it needs soft real-time control.
      - Even in overload condition, predictable control is necessary for them.
  - Responsiveness
    - Key inputs
      - Even if the multimedia applications are running in the foreground, the responsiveness is required.
  - Avoid CPU occupation
    - Real-time applications
      - In case of the download, the programs would be buggy or malicious, they will use up the whole system resources,
      - Resource protection mechanism is needed especially for real-time applications
- Appropriate CPU resource management system is needed

Linux Scheduling policies

policy		contents	priorities
Real-time	SCHED_FIFO	First in first out	0-99
	SCHED_RR	Round robin	
Time-sharing	SCHED_OTHER	Time-sharing	100-139



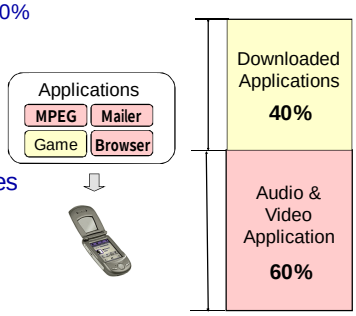
Real-time (static priority)
- Static Priority (POSIX 1003.1b)

Time-sharing (dynamic priority)
- At regular time interval (time slice)
- Switch processes compared with their priorities
- Priority is decided by the execution + sleep time
- Set higher priority to the interactive process

Default policy is timesharing
RT scheduling policies are used with system call.

CABI (CPU Accounting and Blocking Interfaces)

- Purpose
  - Provide a framework for the CPU resource management
- Approach
  - Control the consumptions of the CPU resources quantitatively
    - CPU should be limited for each application or application groups
    - e.g.) The audio video application → 60%
      The downloaded applications → 40%
- Design policy
  - Fine-grained
    - With High Resolution Timer
  - Simple
    - Easy to use the interfaces and services
  - Independent from the scheduler
    - Not change the Linux scheduler

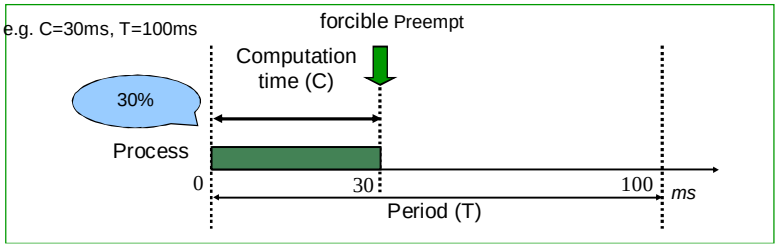


Accounting model

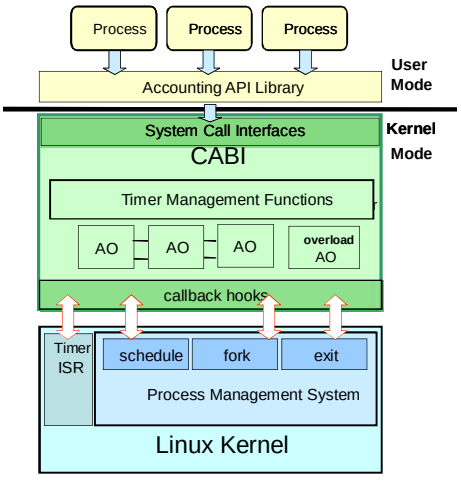
- Two parameters : T (period), C (computation time)
  - needed to control the execution time of the application

$$\text{The CPU usage (\%)} = \frac{\text{Computation time}}{\text{Period}} \times 100$$

  - Process or process group can not excessively use the CPU resources than their proportion



System Architecture



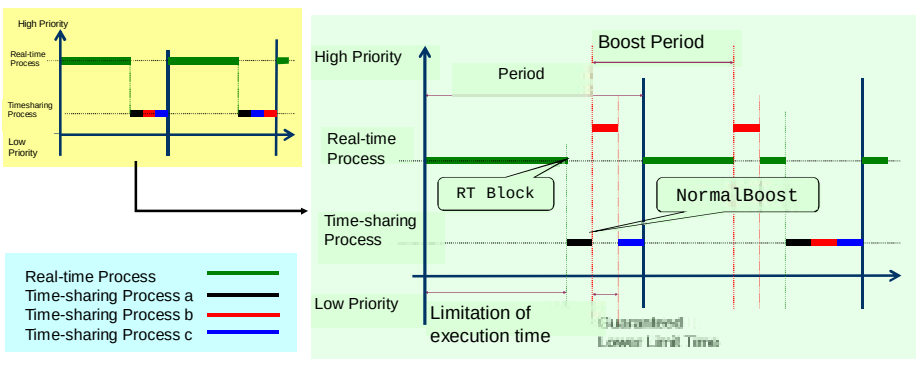
- Interfaces
  - Accounting API Library
  - System Call Interfaces
- Functions
  - Timer Management
  - AO Management
- It independent from the kernel
  - Only a few hooks
    - Schedule, fork, exit
    - ISR

Guaranteed responsiveness is required for TS applications

- CABI provides a framework for building real-time system
  - Set appropriate priorities for real-time applications
    - By using algorithms like Rate Monotonic, EDF, with admission control
    - Developer can give guarantees for real-time applications
- There are no guarantees for time-sharing applications
  - Recently, embedded developers are tend to use the time-sharing (normal) to develop a new embedded application
    - Because no need to adjust their priorities
  - Time-sharing applications can't get responsiveness
    - If real-time application is running in foreground
    - The priorities of time-sharing are always lower than the real-time applications
      - Linux scheduler constraints
    - Need a function to set higher priorities and guarantee them to use some resource

CPU Reservation

- Priority Boost approach
  - Time-sharing processes are boosted temporarily to real-time processes, and minimum resource is reserved
  - CPU resource to a particular process which takes care of GUI
  - Responsibility of time-sharing process is increased



Conclusion

- Background
  - Overview of the embedded system resource requirements
- Proposal
  - CABI (CPU Accounting and Blocking Interfaces)
    - This can effectively control the CPU consumption of a process or processes
  - Priority boost approach
    - It provides CPU Reservation especially for time-sharing application
- Demonstration
  - Penguin will show you how our system control the applications

Thank you!

Source and Documentations

- Source and example applications
  - Sourceforge
    - JP: http://www.sourceforge.net/cabi/
    - US: http://sourceforge.jp/
  - Emblix
    - http://www.emblix.org
- Documentations
  - Specification
  - TEST specification
    - Sourceforge
- Papers
  - Accounting System: A Fine-Grained CPU Resource Protection Mechanism for Embedded System. 9th IEEE ISORC, April 2006.
  - Design and Implementation of Accounting System for Information Appliances. EUC, December 2005.
- Patch release
  - Kernel 2.4
    - ppc, sh, mips, arm, x86
  - Kernel 2.6 :
    - sh, mips, arm