Resource Management Issues for “Streaming” Multimedia Applications

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Requirements of Multimedia

• Quality of service
  – Multiple activities/applications
  – Coexistence of real-time and conventional
• Two scheduling approaches
  – SMART
  – GR3
1. The SMART Approach

Scheduler for Multimedia And Real-Time

- Simple application interface and scheduling algorithm
- Supports requirements of multimedia
  - Explicit management of time constraints
  - Dynamic feedback to allow real-time applications to adapt
  - Resource sharing across real-time and conventional applications
SMART Interface: Application Support

- Reduce the burden of application developer
  - **time constraint**: inform scheduler of deadline, CPU time estimate
  - **notification**: upcall to inform application of missed deadline

- End user need not be aware of application real-time requirements
SMART Interface: User Control

- Provide end user with flexible predictable control
  - **priority**: monopolize resource
  - **share**: proportional sharing

- Expected usage for most users
  - All applications at default priority with equal share
  - No user parameters required
SMART Algorithm: Overview

- Separate importance and urgency

real-time and conventional tasks

select candidates based on importance

resource allocation decision

priority, share

select among candidates based on urgency

satisfy more deadlines by real-time scheduling

time constraint
SMART Algorithm: Select Candidates

- Value-tuple
  - Priority: from user controls
  - Biased virtual finishing time: measure of weighted resource consumption
SMART Algorithm: Real-time Scheduling

- Execute candidate with earliest deadline without causing tasks with larger value-tuples to miss deadlines
  - Shed earlier deadline tasks if needed in overload to ensure larger value-tuple tasks can meet their deadlines
  - Reduces to earliest deadline scheduling in underload

![Graph showing biased virtual finishing time and deadline-order schedule](image-url)
SMART Summary

- High priority applications not degraded due to low priority applications
- Proportional sharing among real-time and conventional applications in the same priority class
- Graceful transitions during fluctuations in loads
- Satisfy real-time constraints in underload, optimally
- Trade off instantaneous fairness for better real-time and interactive response time
- Notification of resource availability
2. The GR3 Approach

- **Group Ratio Round Robin**
  - Simple proportional-share model
  - Fine-grain performance isolation
  - Accurate and scalable
  - O(1) scheduling overhead
GR3 Scheduling Algorithm

- Binary grouping
  - Group tasks by share $S$: $2^k < S < 2^{k+1}$
- Intergroup scheduling
  - Order groups by sum of shares in group
  - Select group based on ratio of group shares
  - Limited number of groups
- Intragroup scheduling
  - Modified round-robin within group
  - Limited share range within group
GR3 Scheduling Performance

- Linux
- WFQ
- WFQ O(log N)
- GR3

Graphs showing scheduling time (us) and scheduling error against the number of clients.

Scheduling time (us)

- Linux: Red dots
- WFQ: Yellow squares
- WFQ O(log N): Cyan crosses
- GR3: Green triangles

Scheduling error

- WFQ: Yellow squares
- GR3: Green triangles
What About Multiprocessors?

- Still need
  - Integrate real-time and conventional
  - Flexible control and efficient use of hardware
- But unanswered questions as well
  - Which processor to use for a given task?
  - How to balance load across processors?
  - No optimal real-time scheduling?
  - Resource sharing abstraction?
- Greater potential for mismanagement
Multi-resource Management Problem

- CPUs just one component in the system

- Need distributed resource management for superior end-to-end performance of multimedia applications
Other Streaming Research Areas

- Multimedia desktop streaming
- Transparent migration of streaming multimedia applications
- Flow computing streaming network system architecture
More Information

Networking Computing Laboratory

http://www.ncl.cs.columbia.edu