Operating Systems

Operating System Support for Multimedia

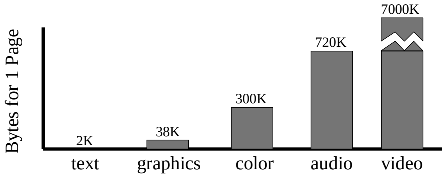
Why Study Multimedia?

- Improvements:
  - Telecommunications
  - Environments
  - Communication
  - Fun
- Outgrowth from industry
  - telecommunications
  - consumer electronics
  - television

Continuous Media

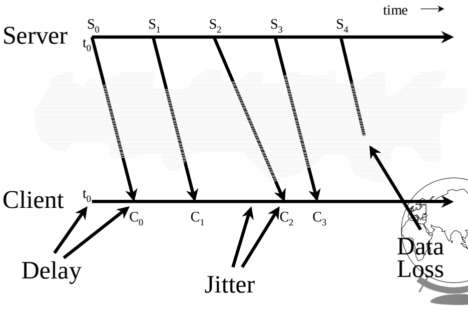
- Subset of multimedia
- Includes timing relationship between server and client
- Stream:
  - video: mpeg, H.261, avi, QuickTime, MediaPlayer
  - audio: MP3, μ-law

Multimedia Resource Requirements

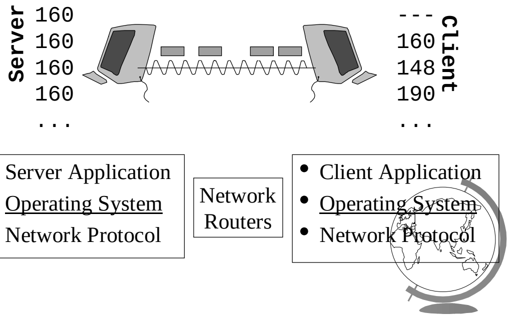


- Step up in media requires more bytes
- But not as much as some applications!
  - Graphics or transaction processing

Influences on Quality



An End-To-End Problem



- Server Application
- Operating System
- Network Protocol

Network Routers

- Client Application
- Operating System
- Network Protocol

Application Performance in the QLinux Multimedia Operating System

Sundaram, A. Chandra, P. Goyal,
P. Shenoy, J. Sahni and H. Vin

UMass Amherst, U of Texas Austin

In Proceedings of ACM Multimedia Conference
November 2000

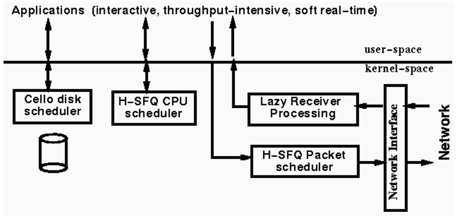
Introduction

- General purpose operating systems handling diverse set of tasks
  - Conventional best-effort with low response time
    - + Ex: word processor
  - Throughput intensive applications
    - + Ex: compilation
  - Soft real-time applications
    - + Ex: streaming media
- Many studies show can do one at a time, but when do two or more grossly inadequate
  - MPEG-2 when compiling has a lot of jitter

Introduction

- Reason? Lack of service differentiation
  - Provide ‘best-effort’ to all
- Special-purpose operating systems are similarly inadequate for other mixes
- Need OS that:
  - Multiplexes resources in a predictable manner
  - Service differentiation to meet individual application requirements

Solution: QLinux



- Solution: QLinux (the Q is for Quality)
  - Enhance standard Linux
  - Hierarchical schedulers
    - + classes of applications or individual applications
  - CPU, Network, Disk

Outline

- QLinux philosophy
- CPU Scheduler
  - Evaluation
- List of other topics in paper
  - Packet Scheduler
  - Disk Scheduler
  - Lazy Receiver Processing
- Conclusion

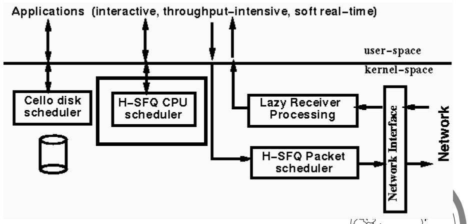
QLinux Design Principles

- Support for Multiple Service Classes
  - Interactive, Throughput-Intensive, Soft Real-time
- Predictable Resource Allocation
  - Priority not enough (starvation of others)
  - Ex: mpeg_decoder at highest can starve kernel
  - Not static partitioning since unused can be used by others

QLinux Design Principles

- Service Differentiation
  - Within a class, applications treated differently
  - Uses hierarchical schedulers
- Support for Legacy Applications
  - Support binaries of all existing applications (no special system calls required)
  - No worse performance (but may be better)

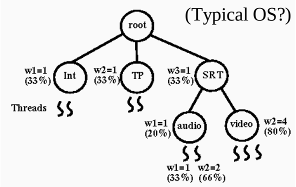
QLinux Components



Hierarchical Start-time Fair Queuing (H-SFQ) CPU Scheduler

- Uses a tree
- Each thread belongs to 1 leaf
- Each leaf is an application class
- Weights are of parent class

$$B_i = \left(\frac{w_i}{\sum_j w_j}\right) * B$$



(Typical OS?)

- Each node has own scheduler
- Uses Start-Time Fair Queuing at top for time for each

CPU Scheduler System Calls

- Nodes can be created on the fly
- Processes can move from node to node

System call	Purpose
hsfq_mknod	create a new node in the scheduling hierarchy
hsfq_rmnod	delete an existing node from the hierarchy
hsfq_join_nod	attach the current process to a leaf node
hsfq_move	move a process to a specified child node
hsfq_parse	parse a pathname in the scheduling hierarchy
hsfq_admin	administer a node (e.g., change weights)

- Defaults to top-level fair scheduler if not specified
- Utilities to do external from application

→ Allow support of legacy apps without modifying source

Experimental Setup

- Cluster of PCs
  - P2-350 MHz
  - 64 MB RAM
  - RedHat 6.1
  - QLinux based on Linux 2.2.0
- Network
  - 100 Mb/s 3-Com Ethernet
  - 3Com Superstack II switch (100 Mb/s)
- “Assume” machines and net lightly loaded

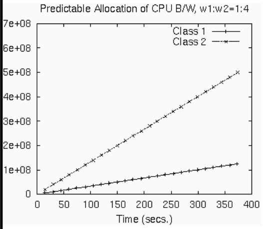
Experimental Workloads

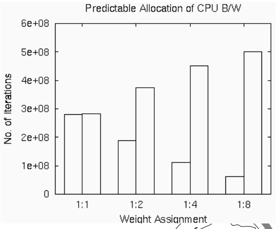
- *Inf*: executes infinite loop
  - Compute-intensive, Best effort
- *Mpeg_play*: Berkeley MPEG-1 decoder
  - Compute-intensive, Soft real-time
- *Apache Web Server and Client*
  - I/O intensive, Best effort
- *Streaming media server*
  - I/O intensive, Soft real-time
- *Dhrystone*: measure CPU performance
  - Compute-instensive, Best effort

CPU Scheduler Evaluation-1

- Two classes, run *Inf* for each
- Assign weights to each (ex: 1:1, 1:2, 1:4)
- Count the number of loops

CPU Scheduler Evaluation-1 Results



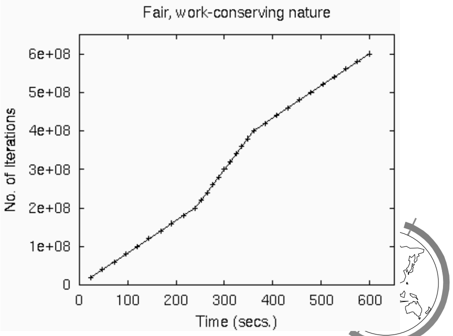


"count" is proportional to CPU bandwidth allocated

CPU Scheduler Evaluation-2

- Two classes, equal weights (1:1)
- Run two *Inf*
- Suspend one at t=250 seconds
- Restart at t=330 seconds
- Note count

CPU Scheduler Evaluation-2 Results

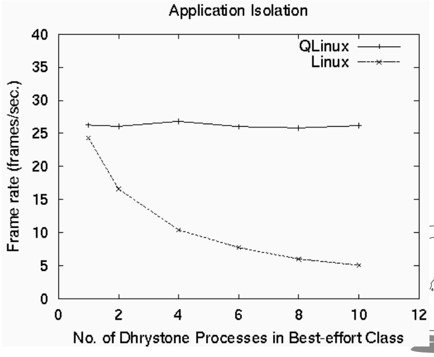


(Counts twice as fast when other suspended)

CPU Scheduler Evaluation-3

- Two classes: soft real-time & best effort (1:1)
- Run:
  - *MPEG_PLAY* in real-time (1.49 Mbps)
  - *Dhrystone* in best effort
- Increase Dhrystone's from 1 to 2 to 3 …
  - Note MPEG bandwidth
- Re-run experiment with Vanilla Linux

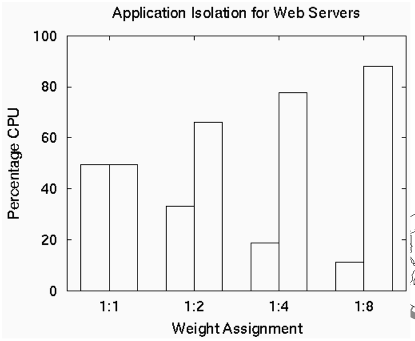
CPU Scheduler Evaluation-3 Results



CPU Scheduler Evaluation-4

- Explore another best-effort case
- Run two *Web servers* (representing, say 2 different domains)
- Have clients generate many requests
- See if CPU bandwidth allocation is proportional

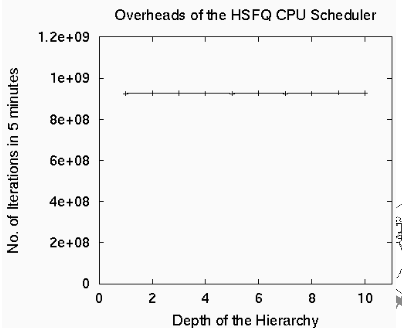
CPU Scheduler Evaluation-4 Results



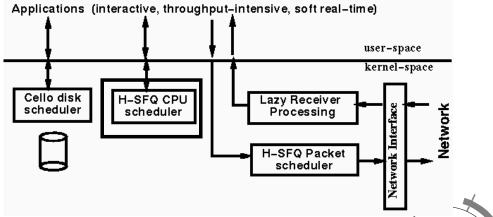
CPU Scheduler Overhead Evaluation

- Scheduler takes some overhead since recursively called
- Run *Inf* at increasing depth in scheduler hierarchy tree
- Record count for 300 seconds

CPU Scheduler Overhead Evaluation Results



QLinux Components


Applications (interactive, throughput-intensive, soft real-time)

user-space

kernel-space

Cello disk scheduler

H-SFQ CPU scheduler

Lazy Receiver Processing

H-SFQ Packet scheduler

Network Interface

Network

Disk
- Not evaluated
Packets
- Sending and "Lazy" Processing for Receiving

Conclusion

- Some improvement and some ideas
- Still Much work to be done
  - scheduling
  - memory management
  - network
  - disk
- M.S. Thesis
  - One piece in OS support puzzle