

Audio Latency on Linux Kernels

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Audio Transfer

■ Audio Buffer

- Split to "periods" (aka "fragments")
- DMA interrupt is generated at each period boundary

■ Cycle of audio application

- Fills the buffer and sleeps
- Soundcard generates interrupt at period
- Interrupt handler in the driver
- Wake up the app, go back to the first

Latency - Two Definitions

■ Audio Latency

- Programmed delay until data is processed
 - Playback latency: buffer size
 - Recording latency: period size
- Least full-duplex latency: period size x 2

■ System Latency

- Delay of system response
 - Interrupt -> Wake-up
- Must not greater than buffer size
 - Buffer underflow, overflow

Latency Problems

■ Real-time audio system (e.g. JACK)

- Uses VERY short interrupts (1-2ms)
- 2 periods ("double-buffer")
- Task switch latency is critical

■ Normal playback / record

- Dependent on kernel scheduler algorithm
- Larger buffer: less skips
- Improved by multi-threading and large intermediate buffer
 - xmms is more stable than mpg123

Improvement of Kernel Latency

■ Major latency sources

- Too long lock
- Too long codepath

■ 2.2 / 2.4 kernels

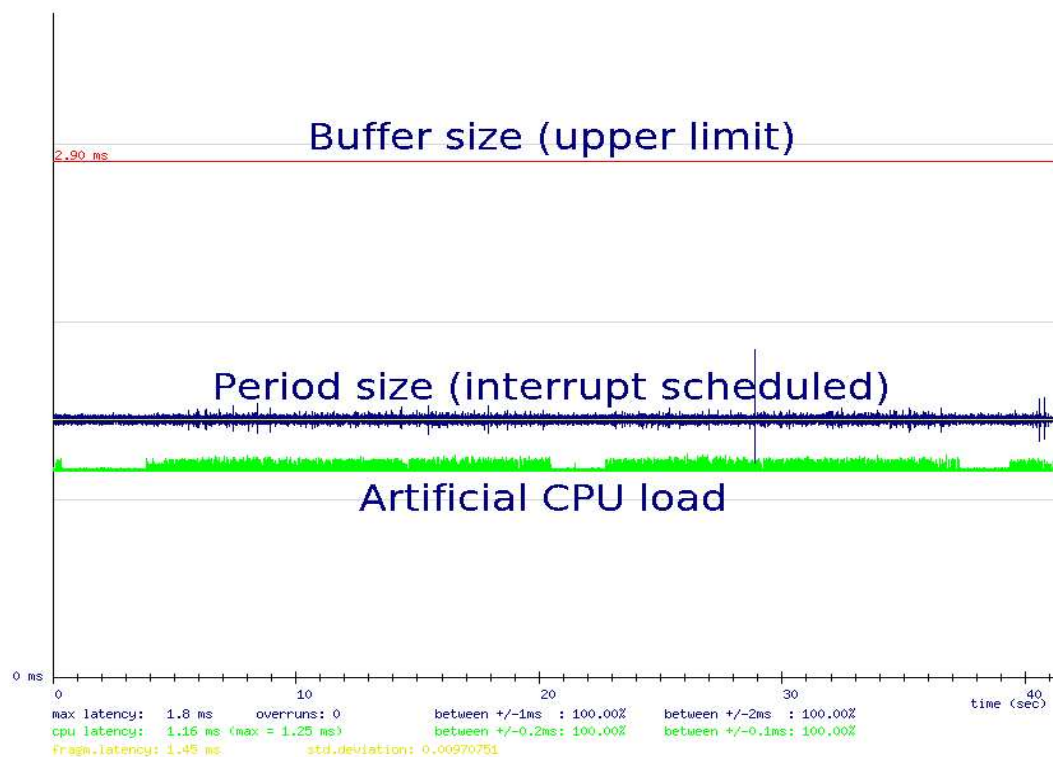
- Lowlatency patches by Ingo Molnar & Andrew Morton
- Split too long spinlocks
- Yield rescheduling if needed
- Rather heuristic

■ 2.6 kernels

- Kernel preemption by Montavista, Rovert Love
- Preemption disabled during spinlocks
 - Too long spinlock is still problematic

Audio Latency Test Suite

- Originally developed by Benno Senoner
- Measure interrupt response time
 - Issued periodically by soundcard
- Under different loads
 - Disk I/O, Procs, X, ...



Realtime Audio Tests

■ SCHED_FIFO

■ Small buffer

- 1.45 ms x 2 (256 bytes, 44.1kHz)

■ Loads:

- Disk I/O (2GB Read, Write, Copy)
- Procs access (top -d 0.1)
- X (x11perf scroll & shmput)

■ CPU load 80% (busy loop)

■ Different UP kernels

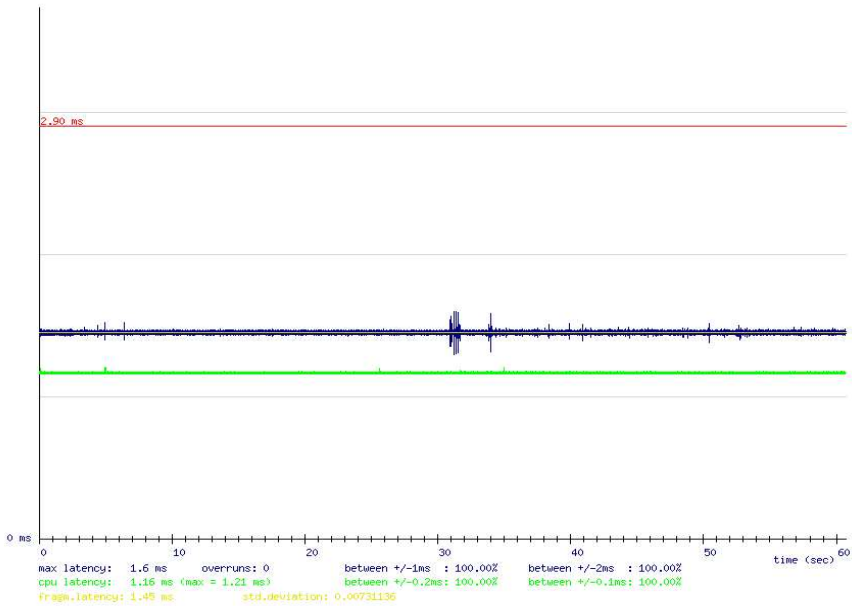
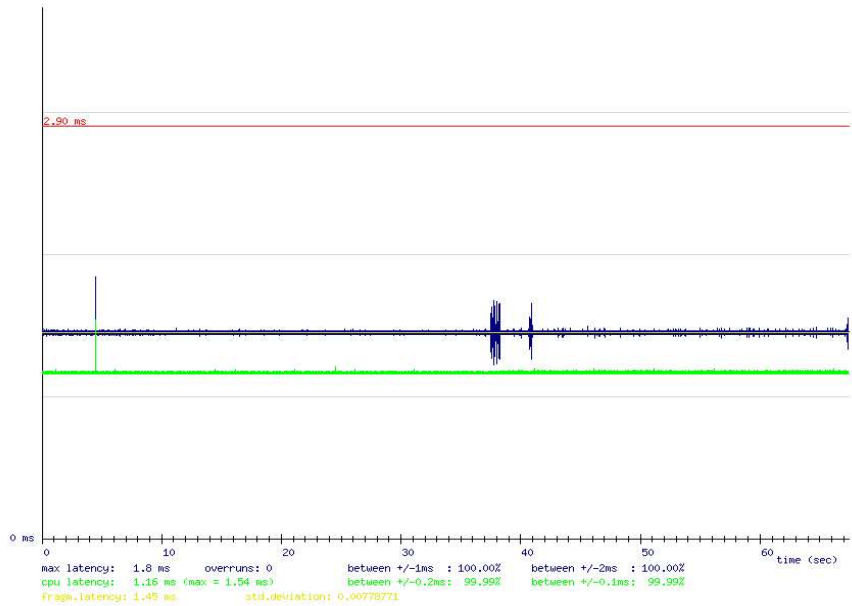
- 2.4: Vanilla 2.4.22, SUSE 2.4.21
- 2.6: 2.6.0-test9 Normal, Preemptive

■ Filesystems

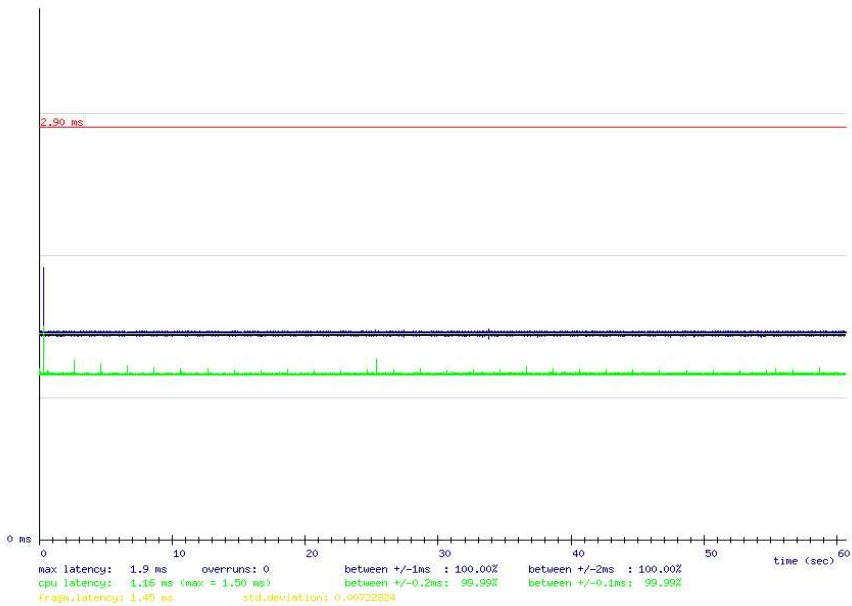
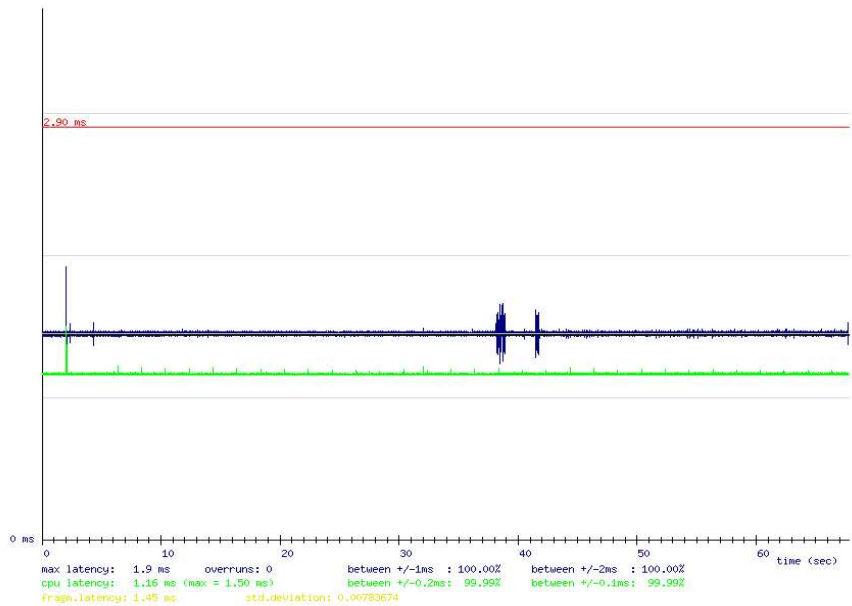
- Reiserfs and Ext3

X Load Test

Vanilla 2.4.22 / SUSE 2.4.21



Normal 2.6.0-test9 / Preemptive 2.6.0-test9

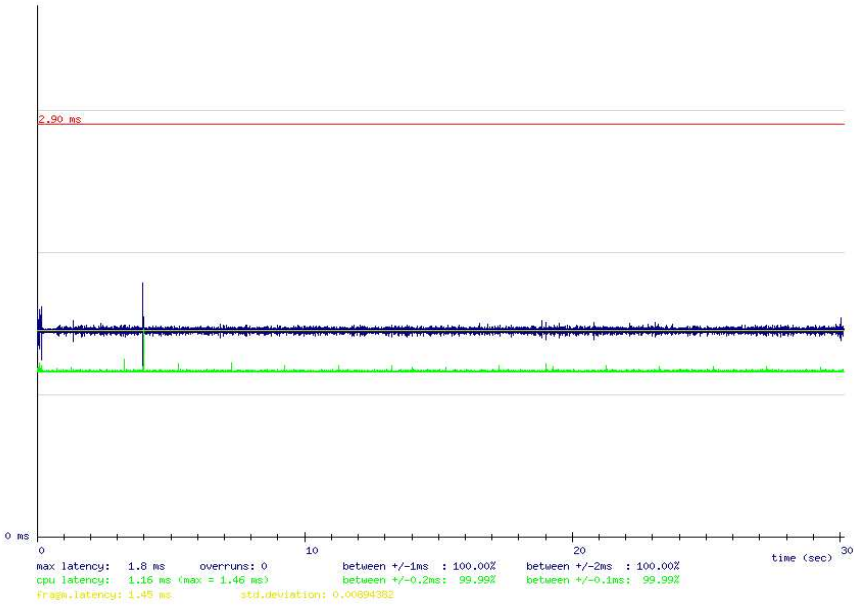


Proc Load Test

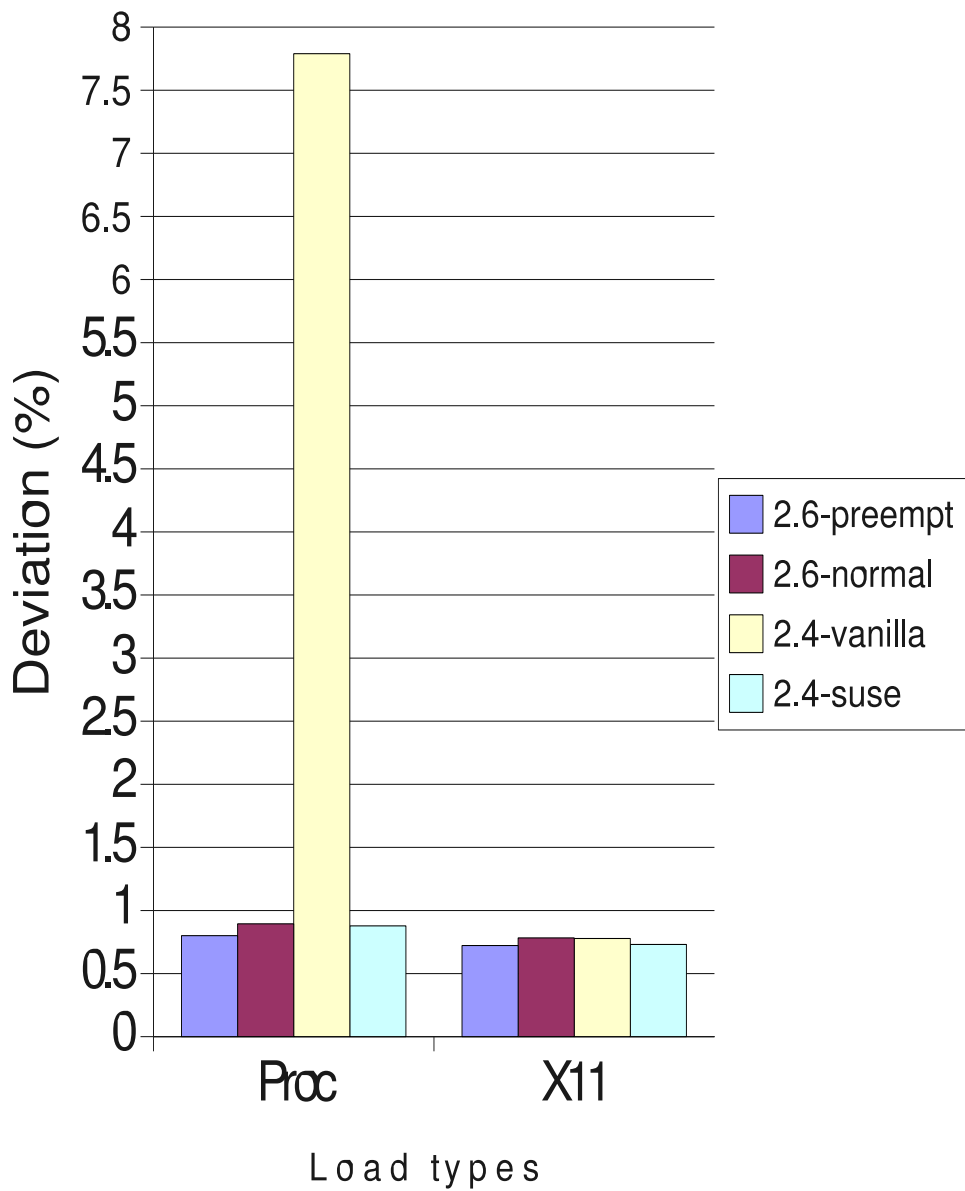
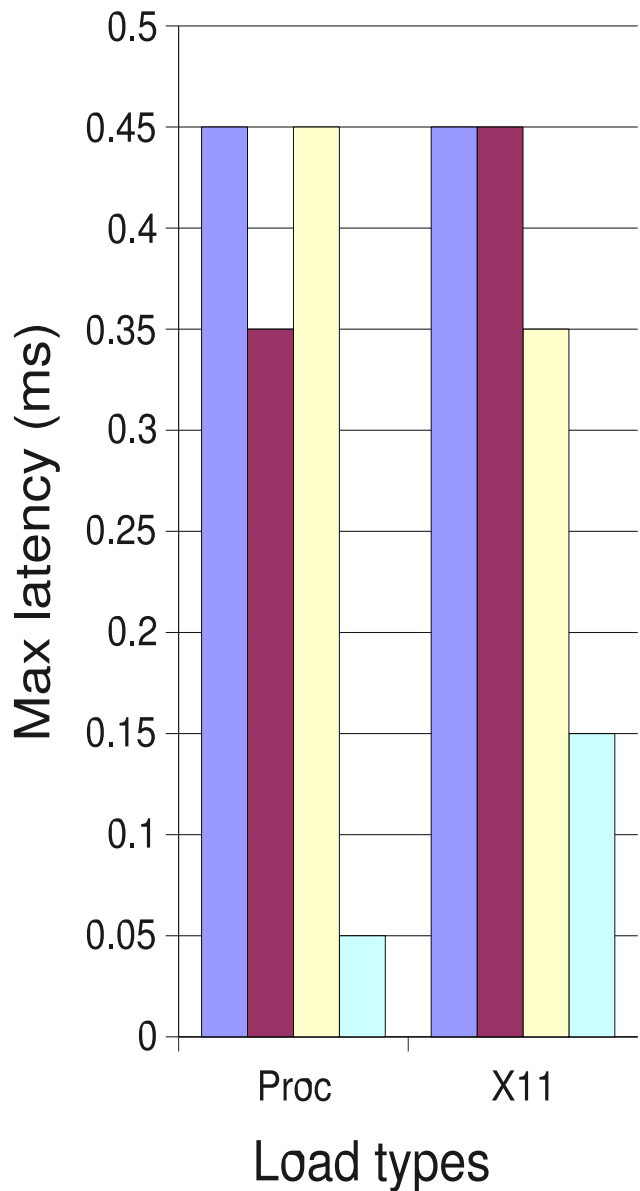
Vanilla 2.4.22 / SUSE 2.4.21



Normal 2.6.0-test9 / Preemptive 2.6.0-test9

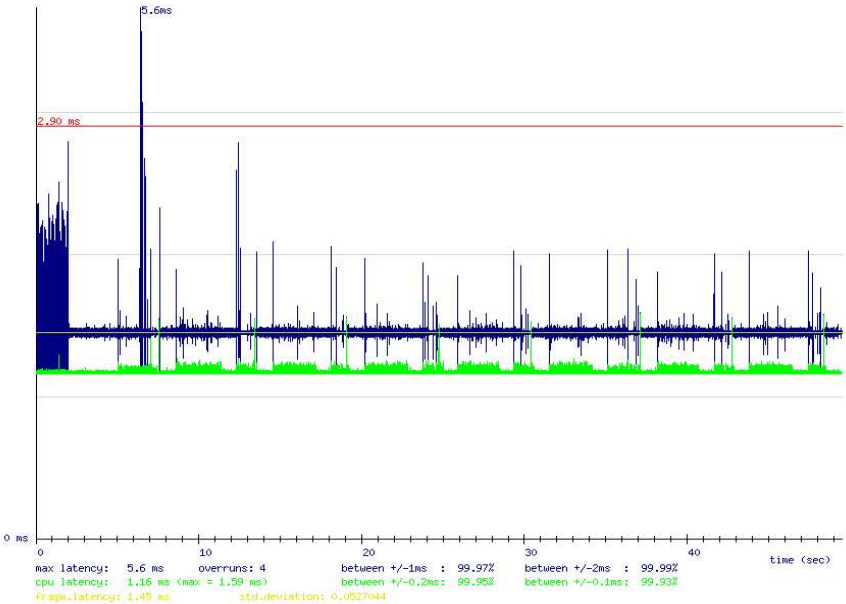
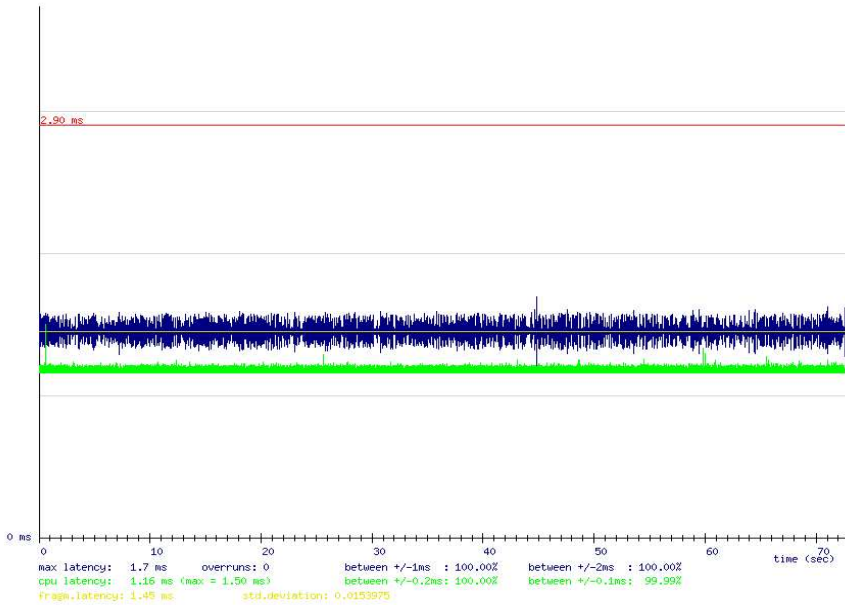
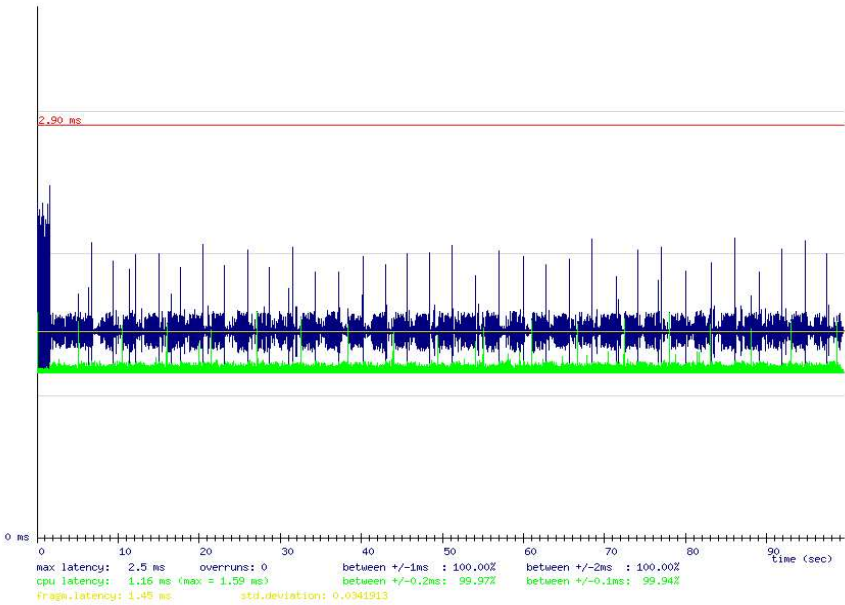


Proc/X Tests Statistics



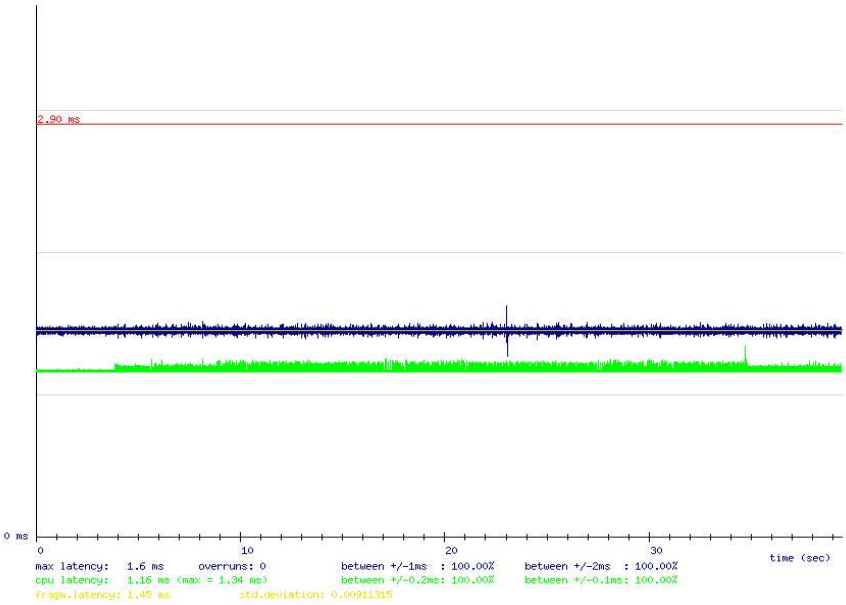
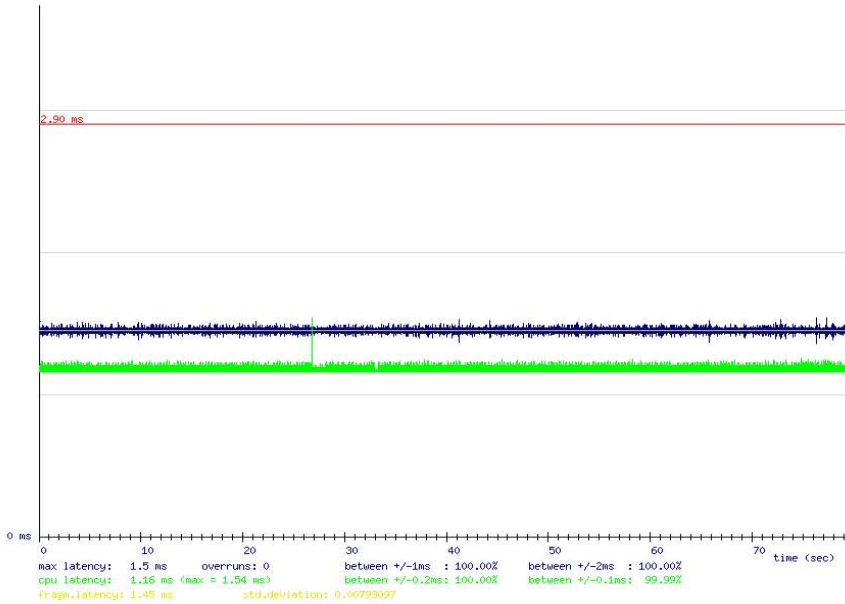
Vanilla 2.4.22 / Reiserfs

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



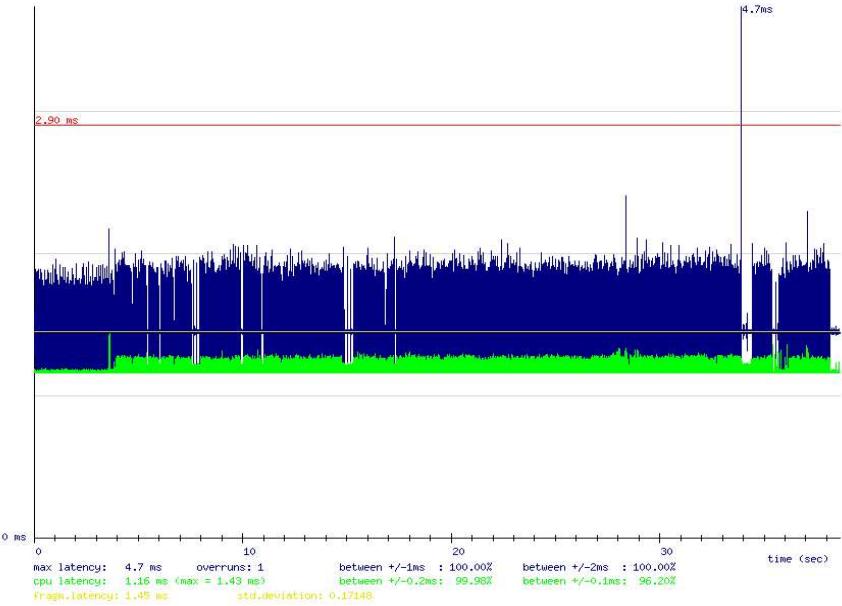
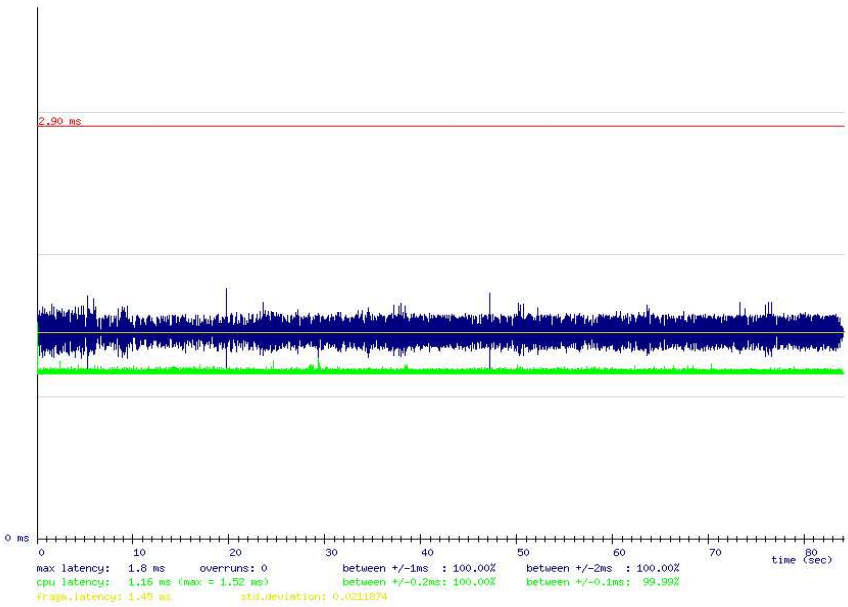
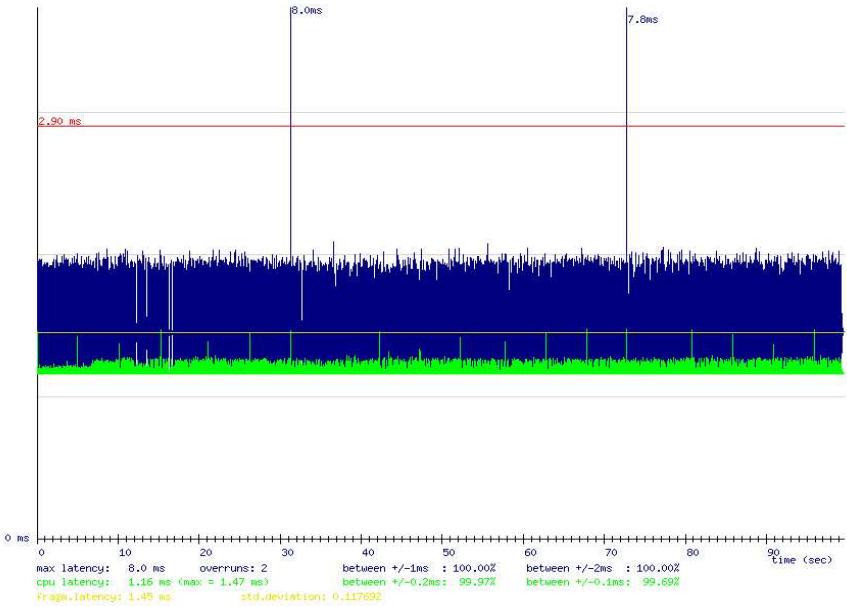
SUSE 2.4.21 / Reiserfs

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



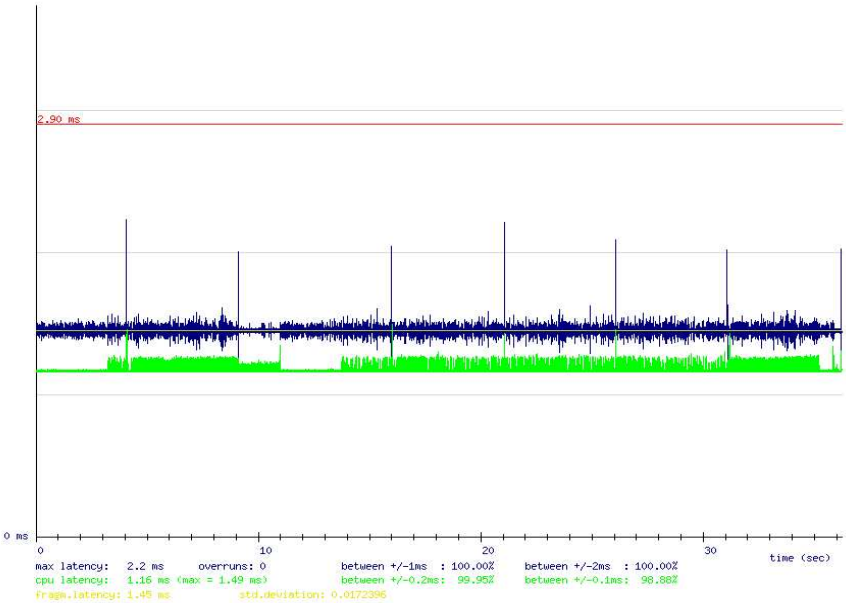
Normal 2.6.0-test9 / Reiserfs

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)

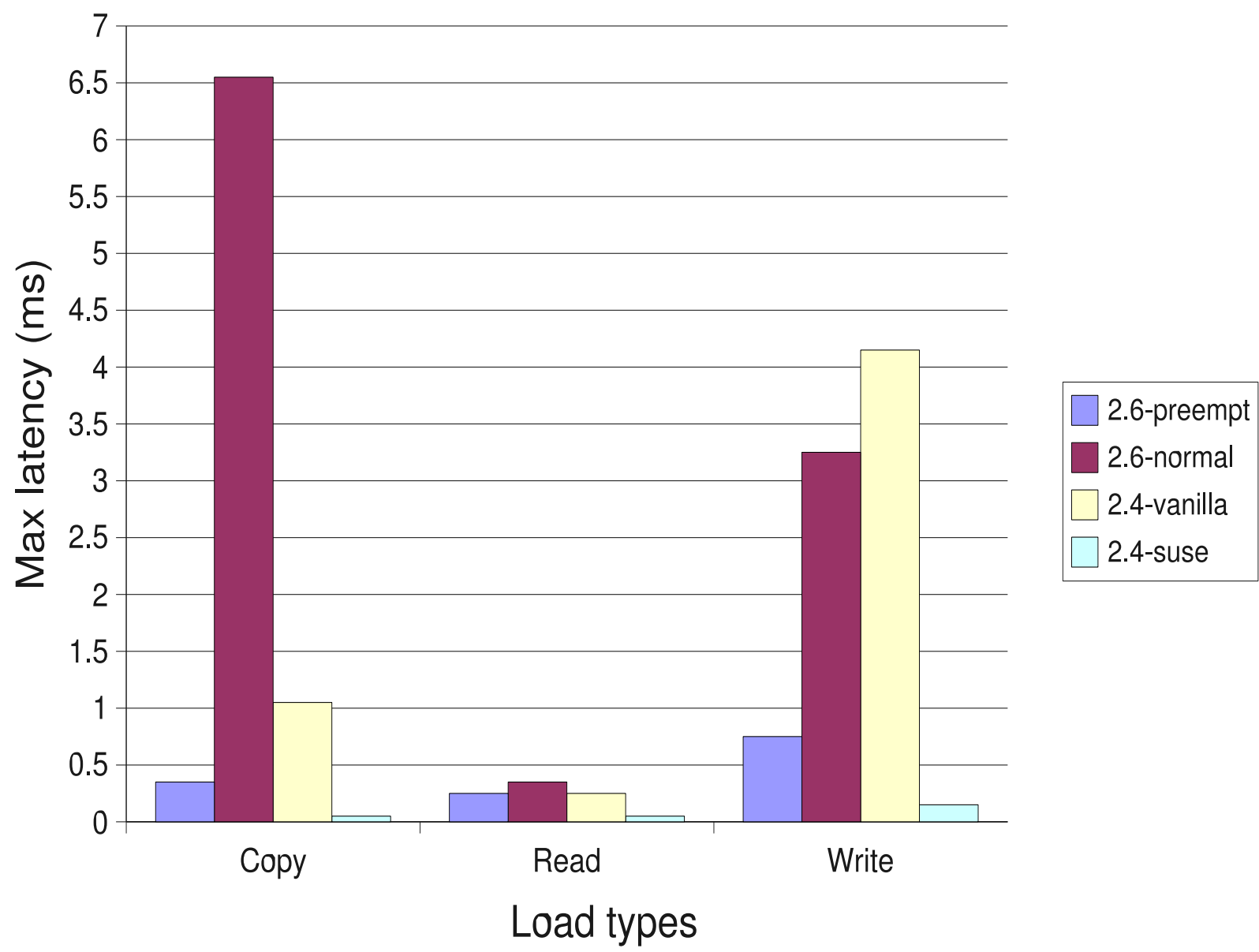


Preemptive 2.6.0-test9 / Reiserfs

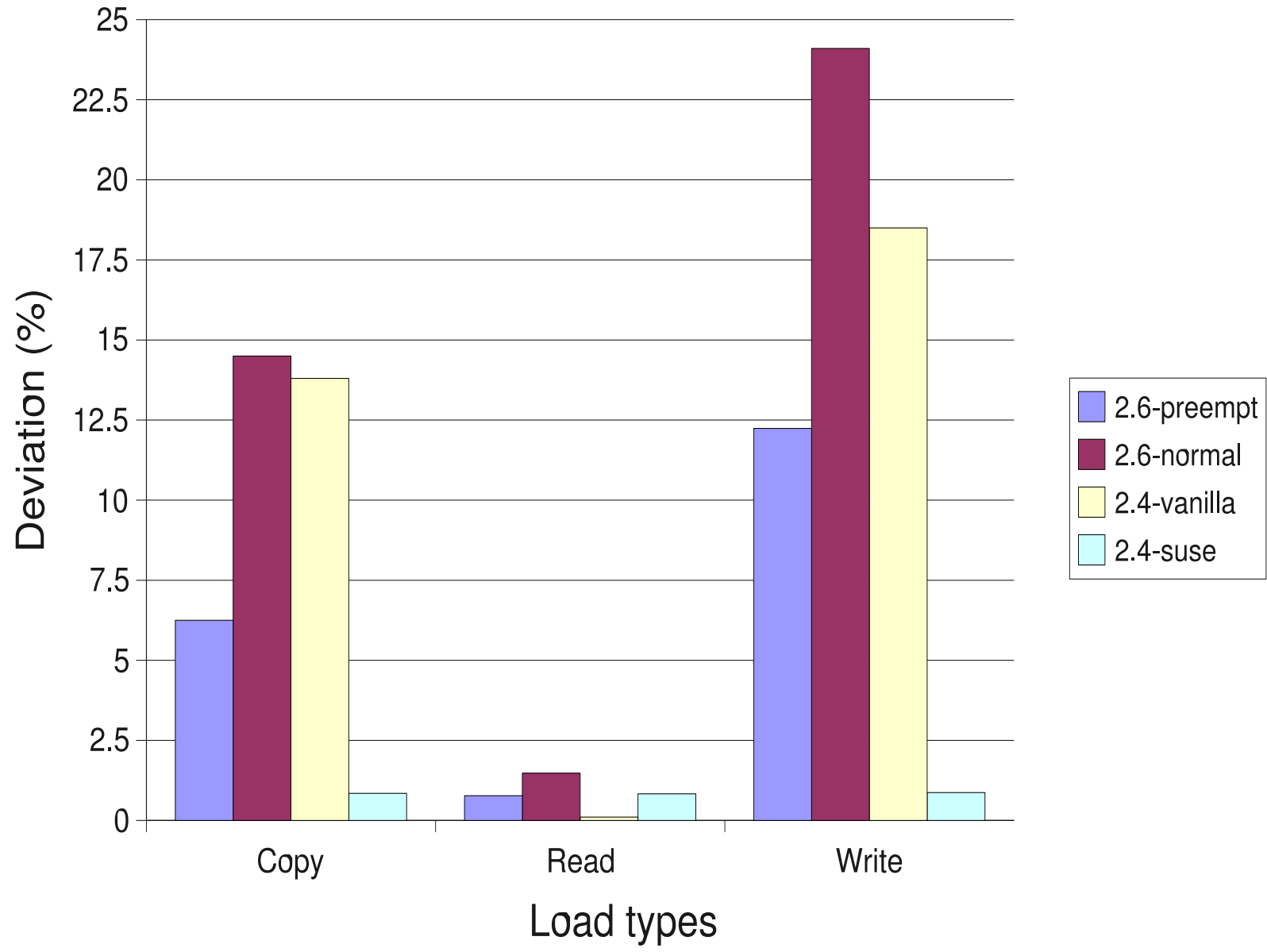
Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



Reiserfs Max Latency



Reiserfs Latency Deviation



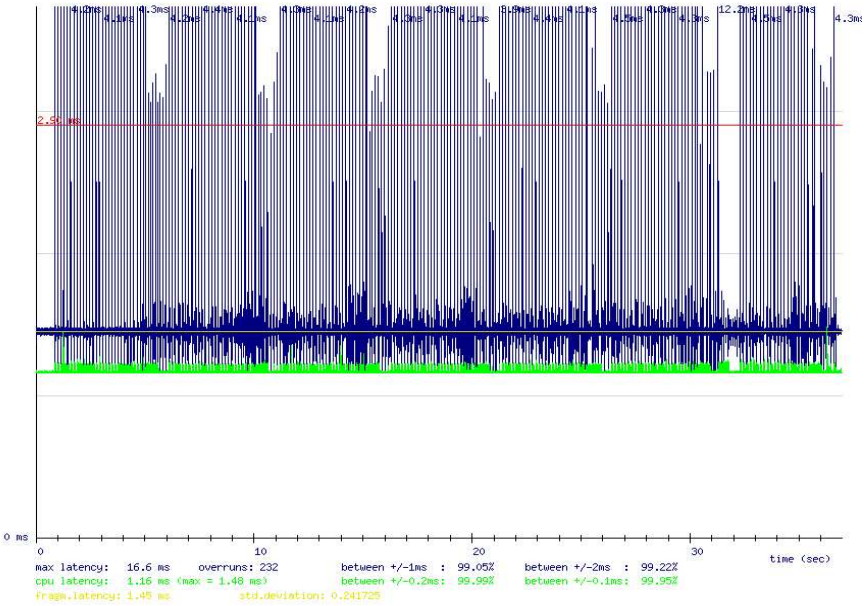
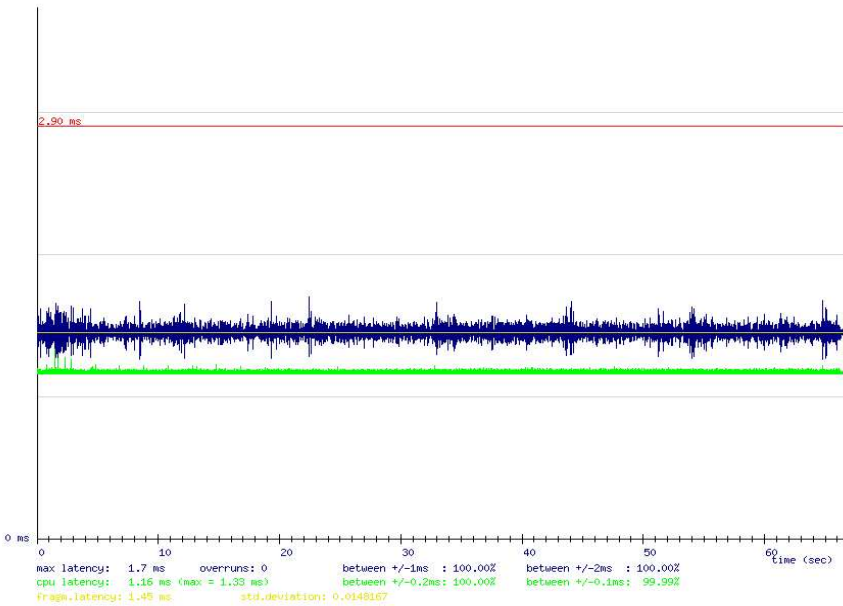
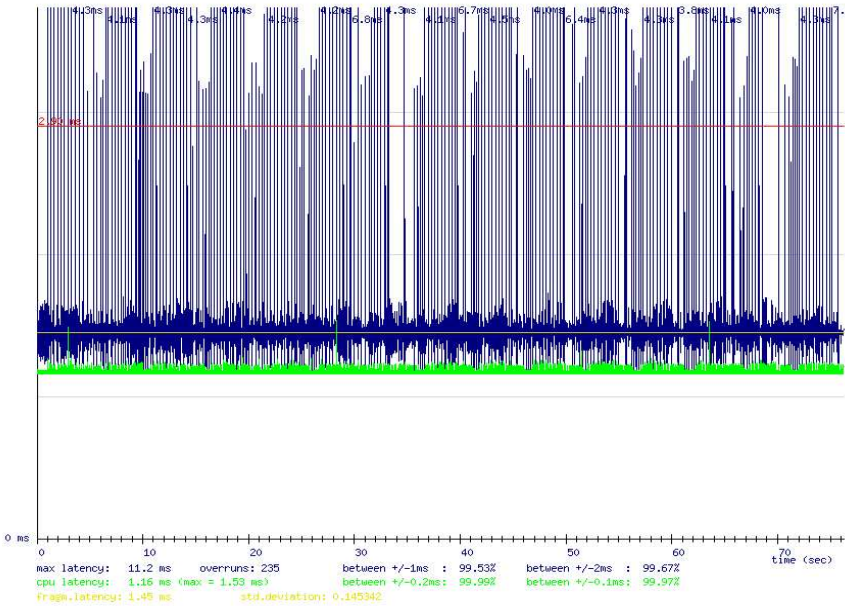
SUSE 2.4.21 / Ext3

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



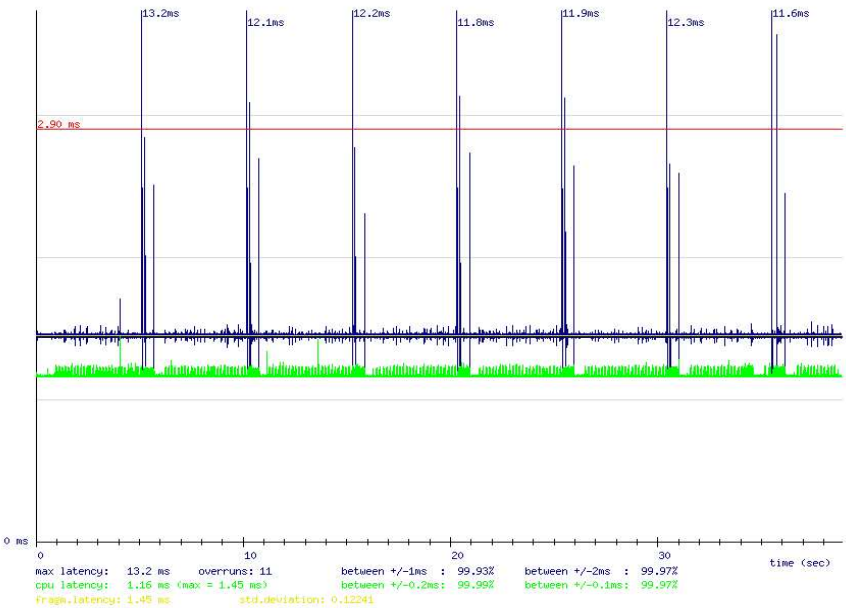
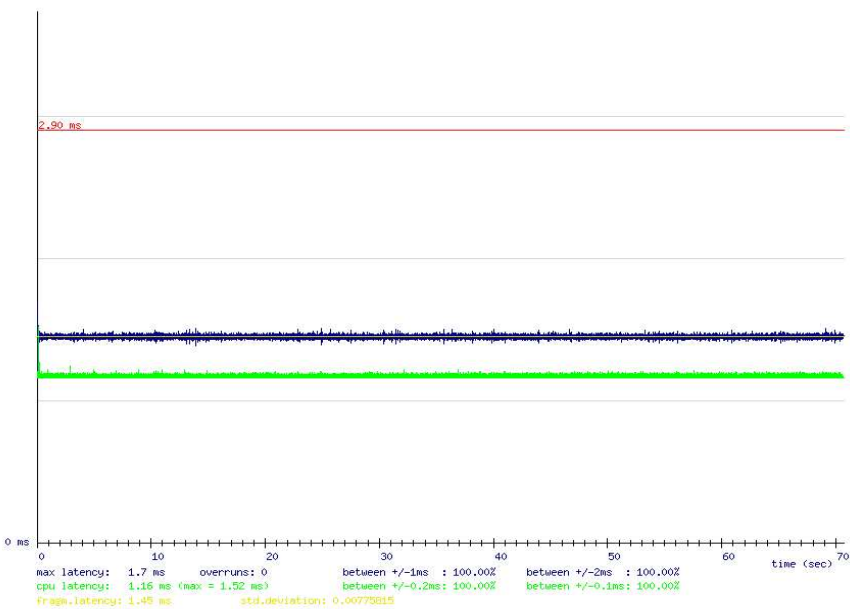
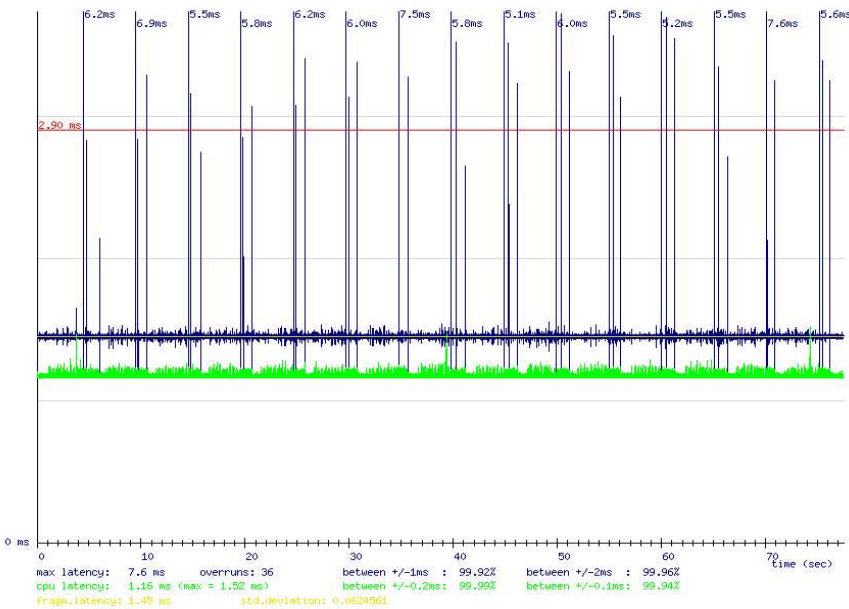
Normal 2.6.0-test9 / Ext3

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)

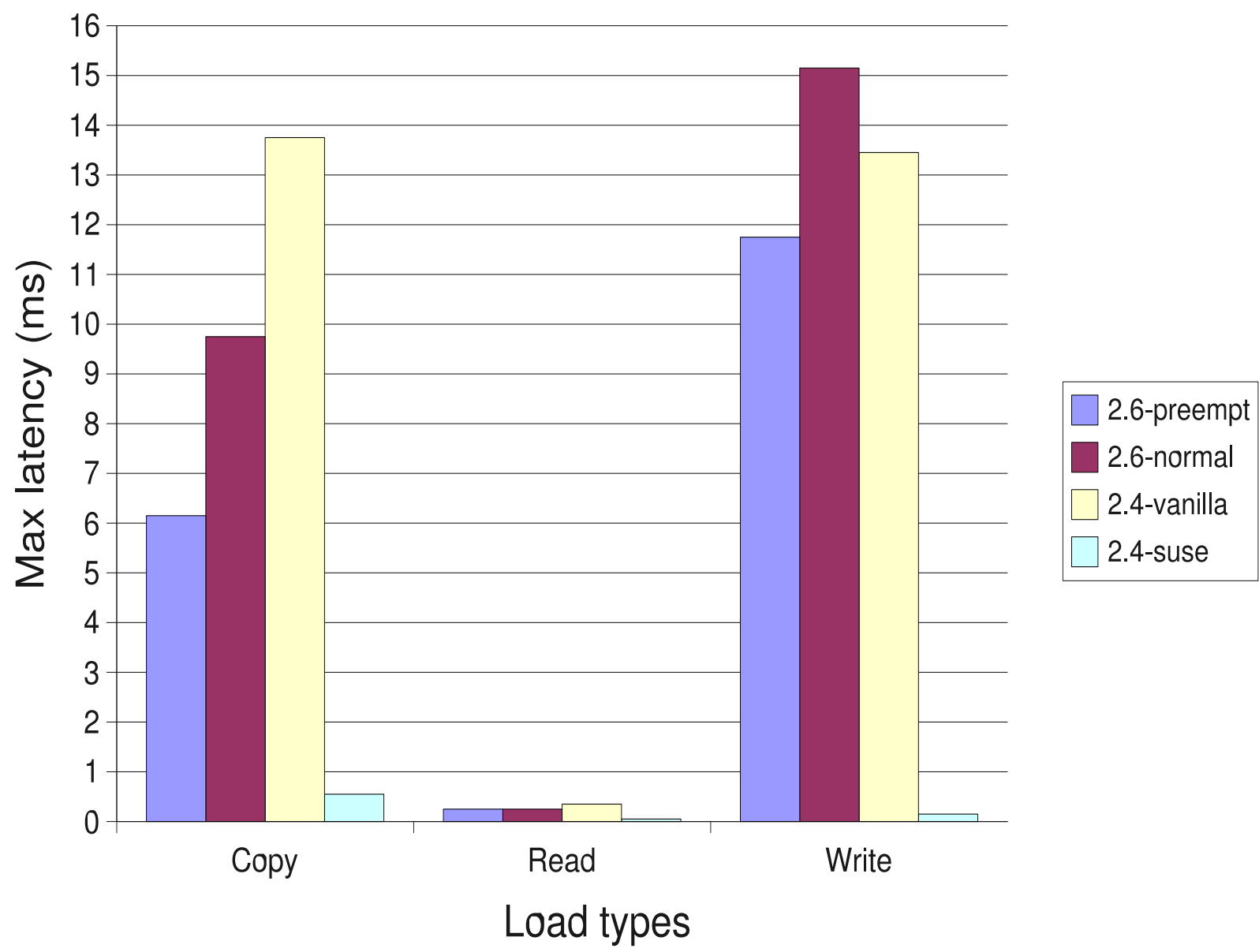


Preemptive 2.6.0-test9 / Ext3

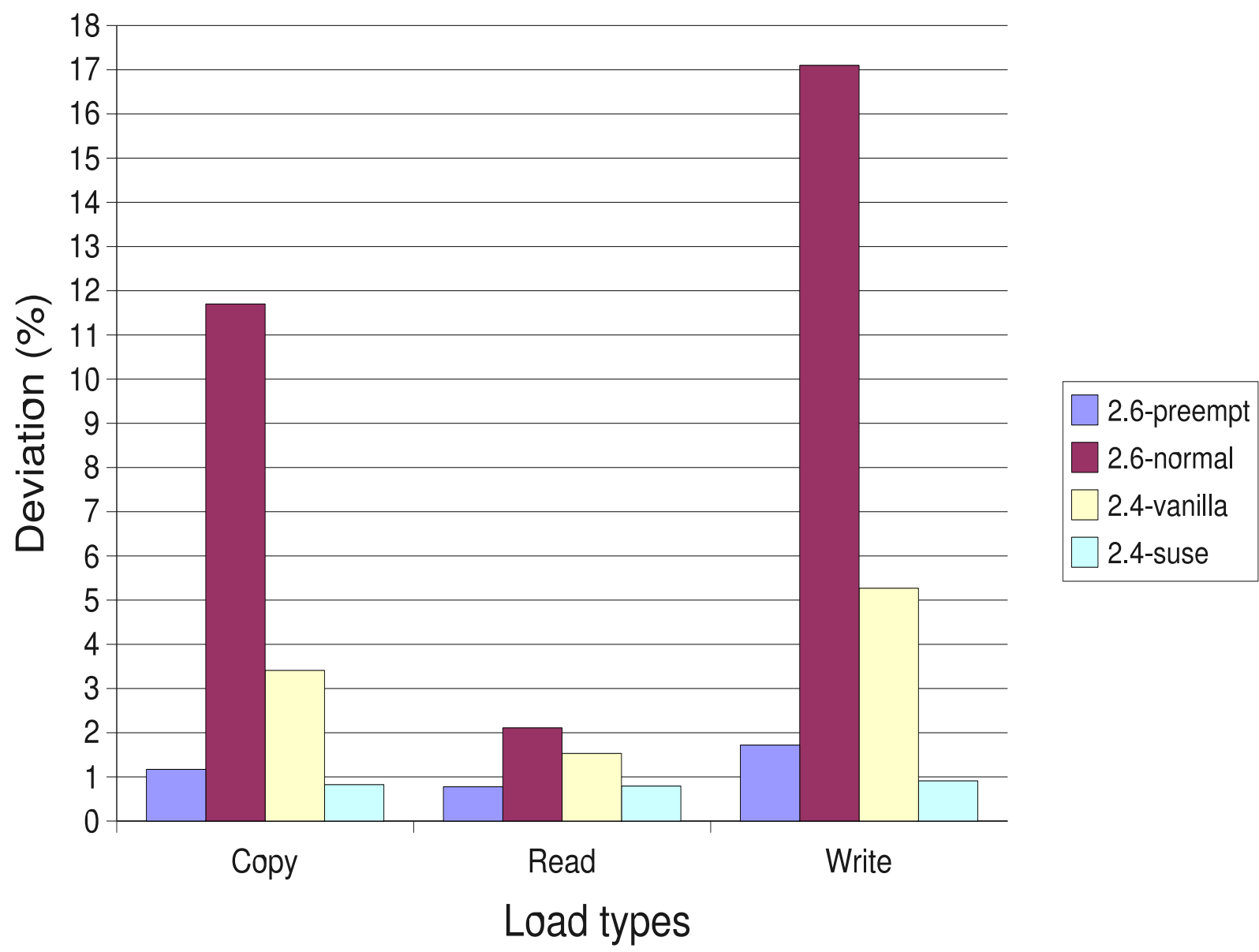
Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



Ext3 Max Latency



Ext3 Latency Deviation

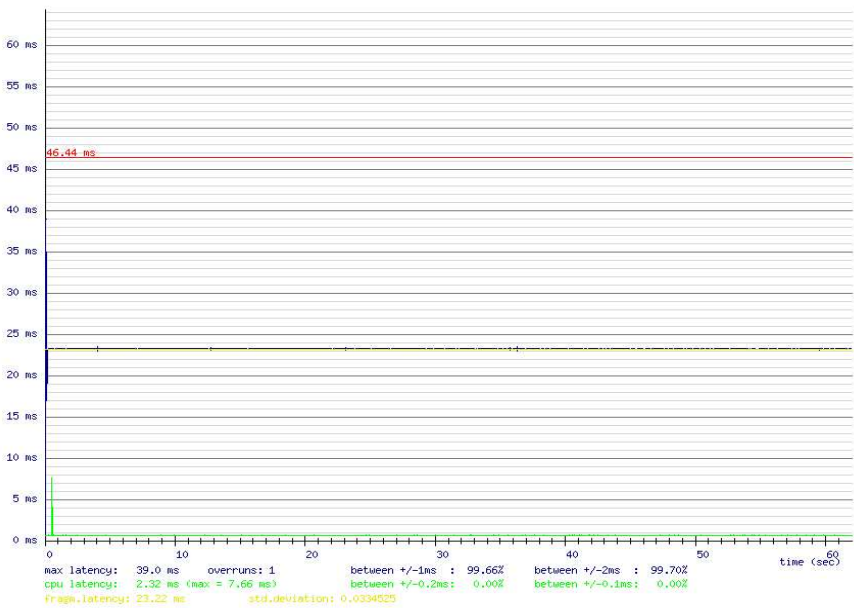


Normal Audio Tests

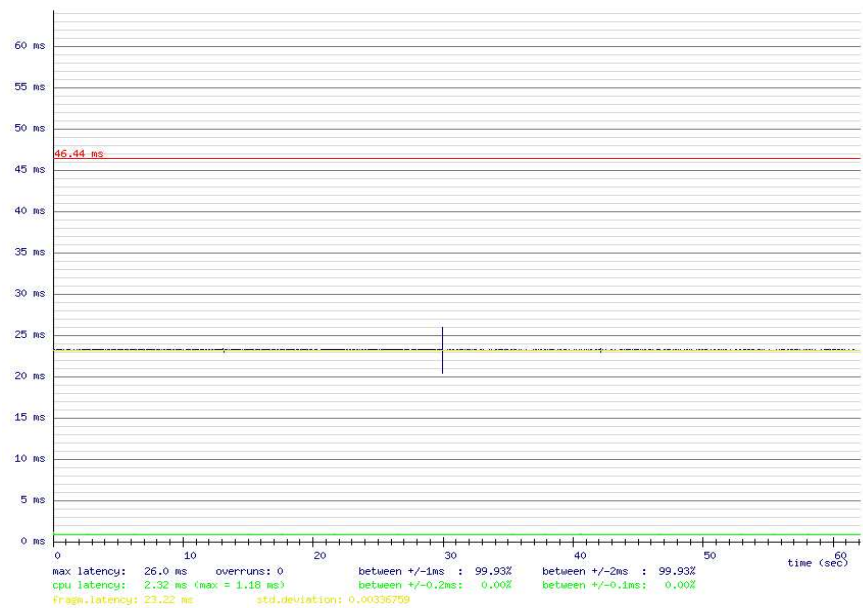
- Normal scheduling priority
 - A kind of interactivity test
- Large buffer
 - 23 ms x 2 (4096 bytes, 44.1kHz)
- Running 10 disk loads in parallel
- CPU load 10%
- Reiserfs only

X Load Test

Vanilla 2.4.22 / SUSE 2.4.21

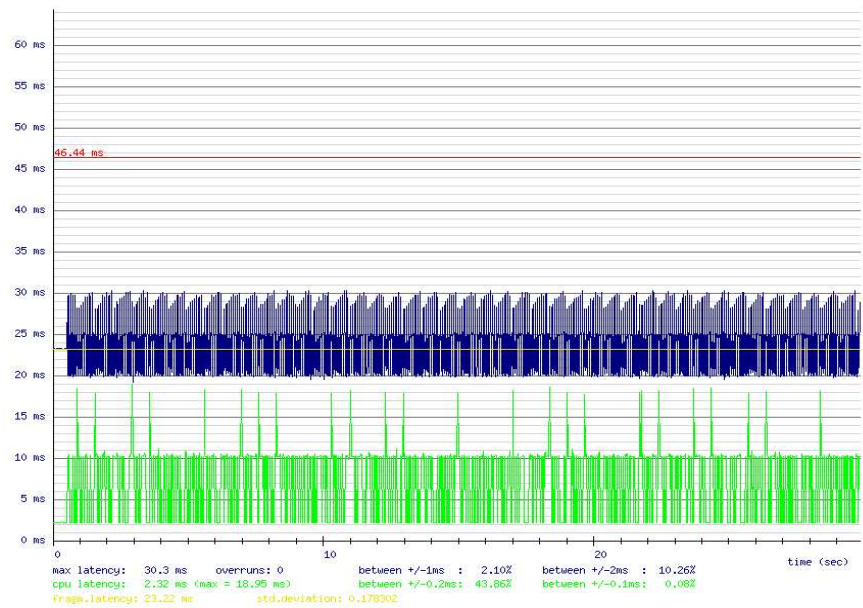


Normal 2.6.0-test9 / Preemptive 2.6.0-test9

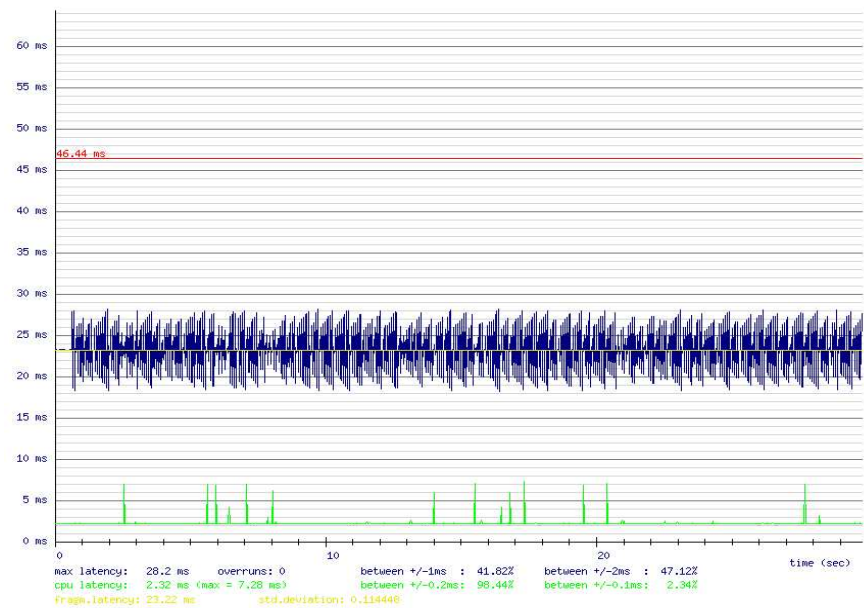
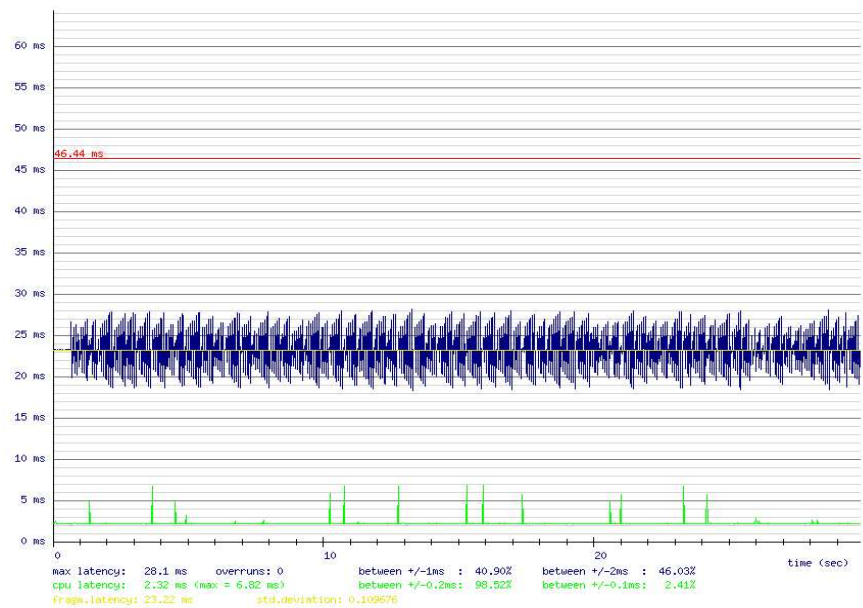


Proc Load Test

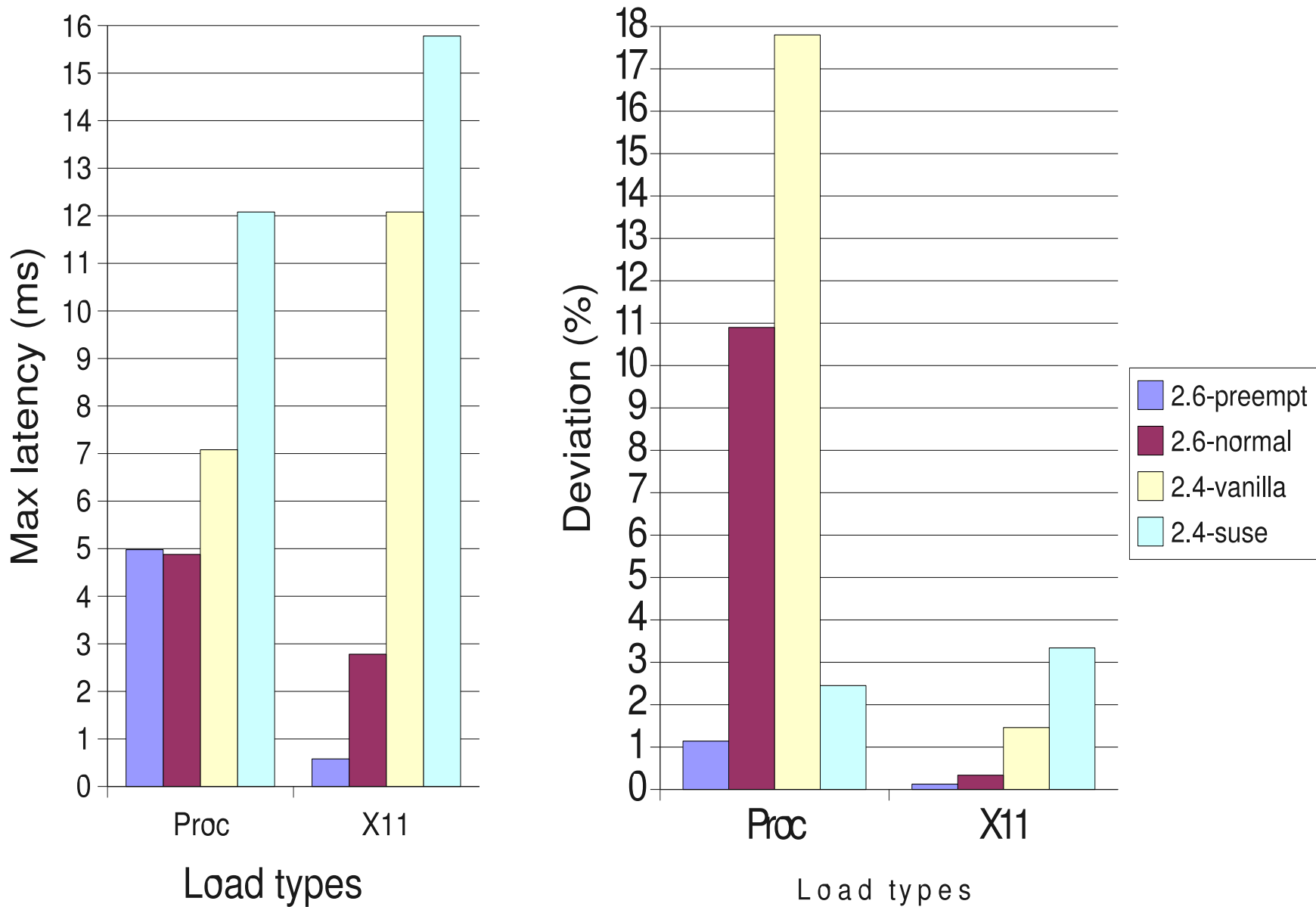
Vanilla 2.4.22 / SUSE 2.4.21



Normal 2.6.0-test9 / Preemptive 2.6.0-test9

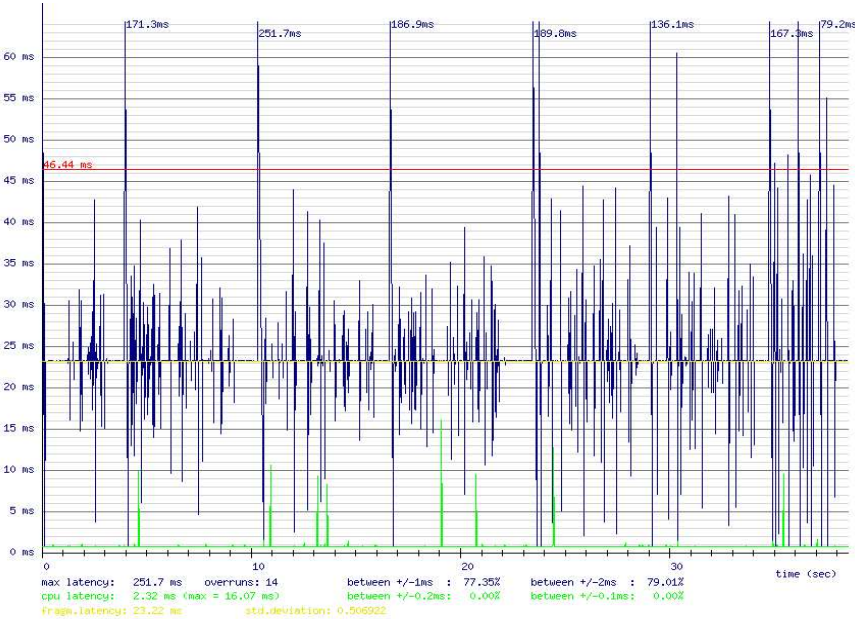
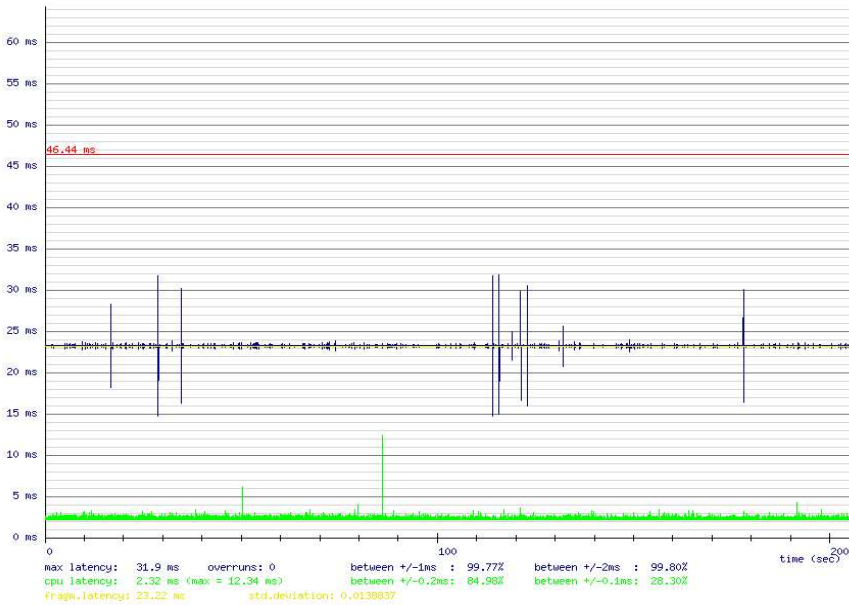
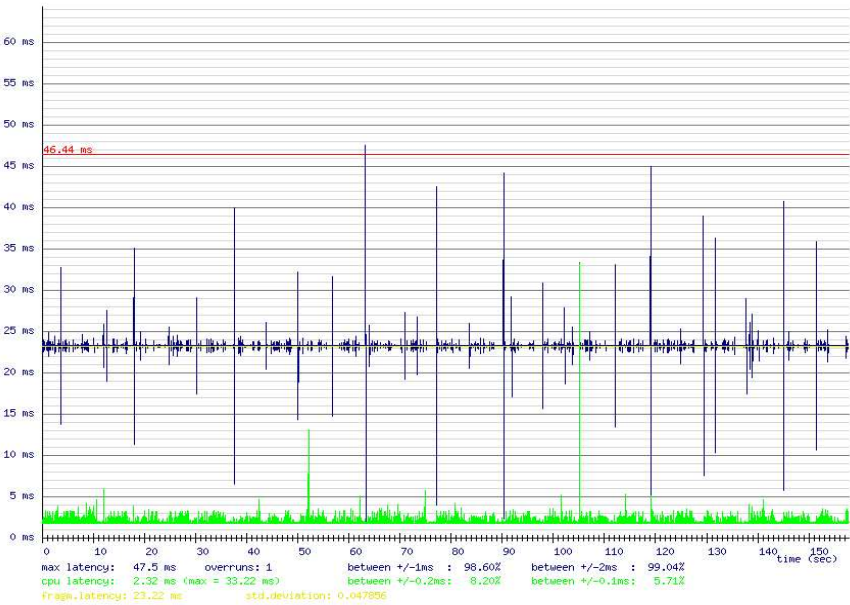


Proc/X Tests Statistics



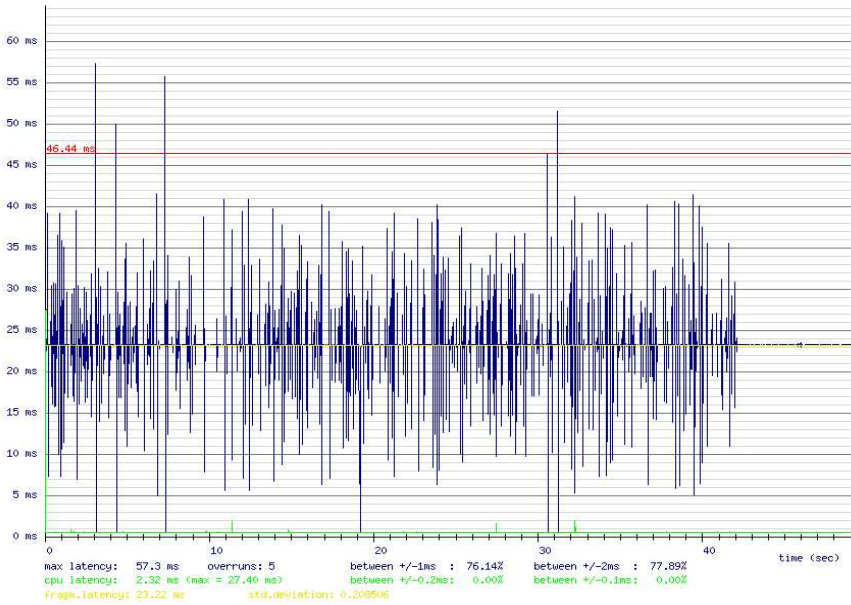
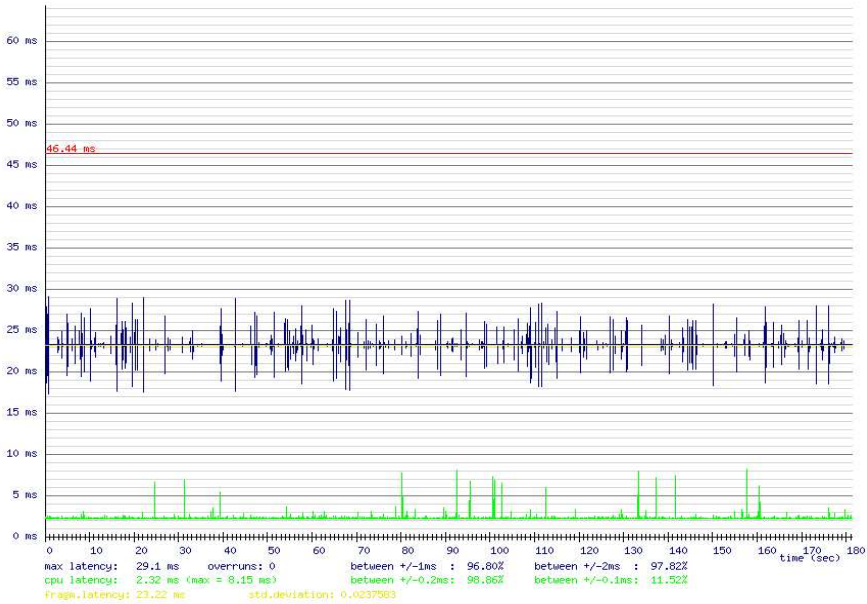
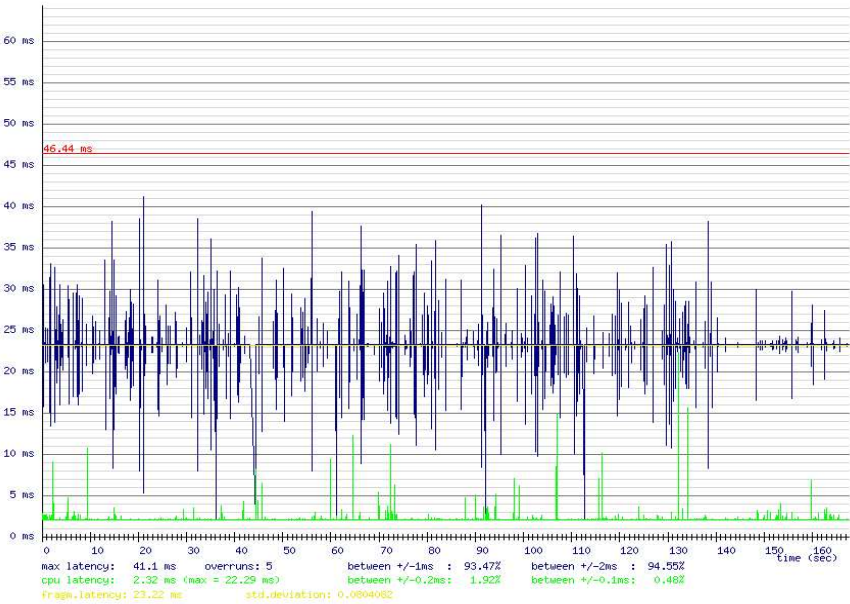
Vanilla 2.4.22 / Reiserfs

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



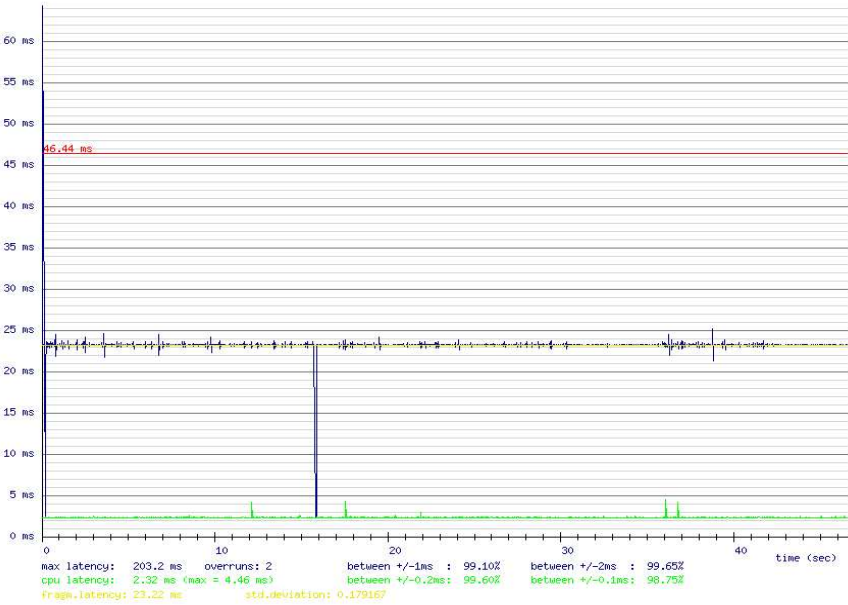
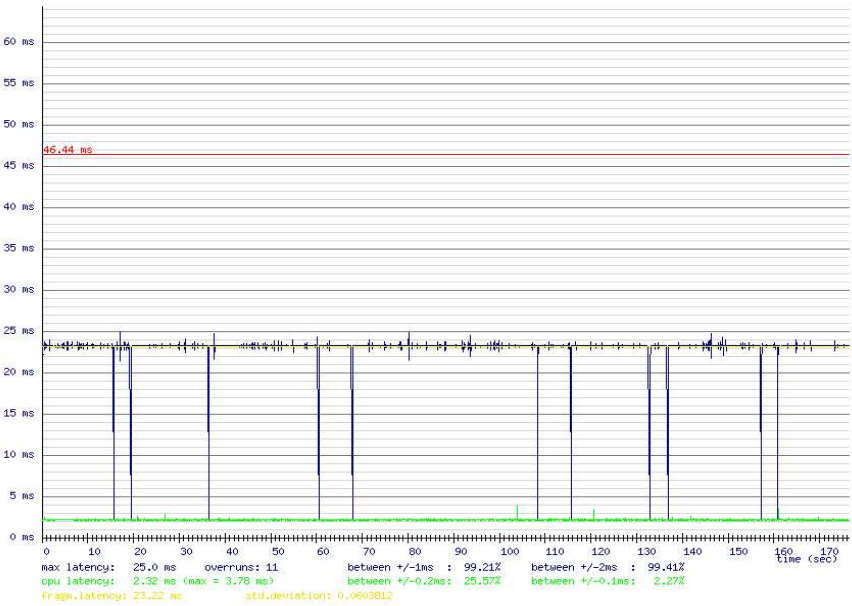
SUSE 2.4.21 / Reiserfs

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



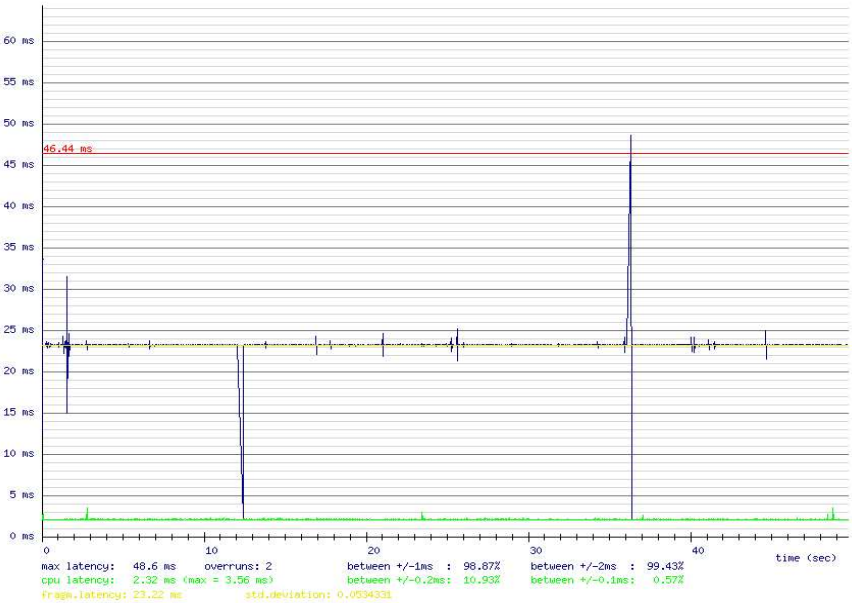
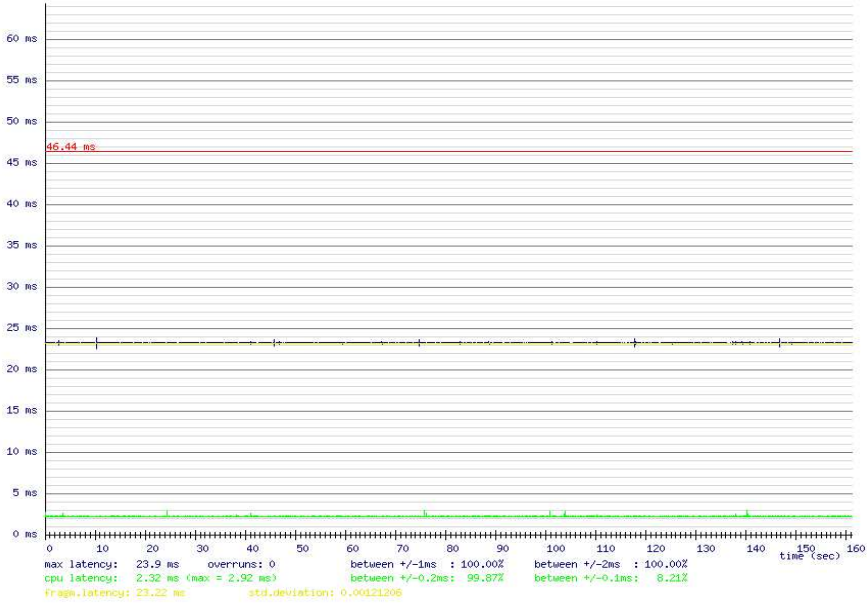
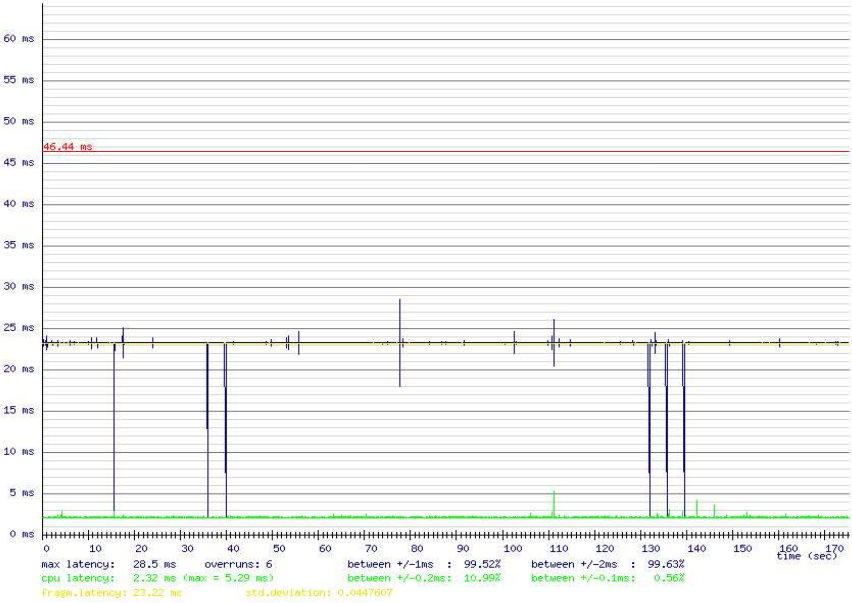
Normal 2.6.0-test9 / Reiserfs

Disk Copy (UL) / Disk Read (UR) / Disk Write (D)

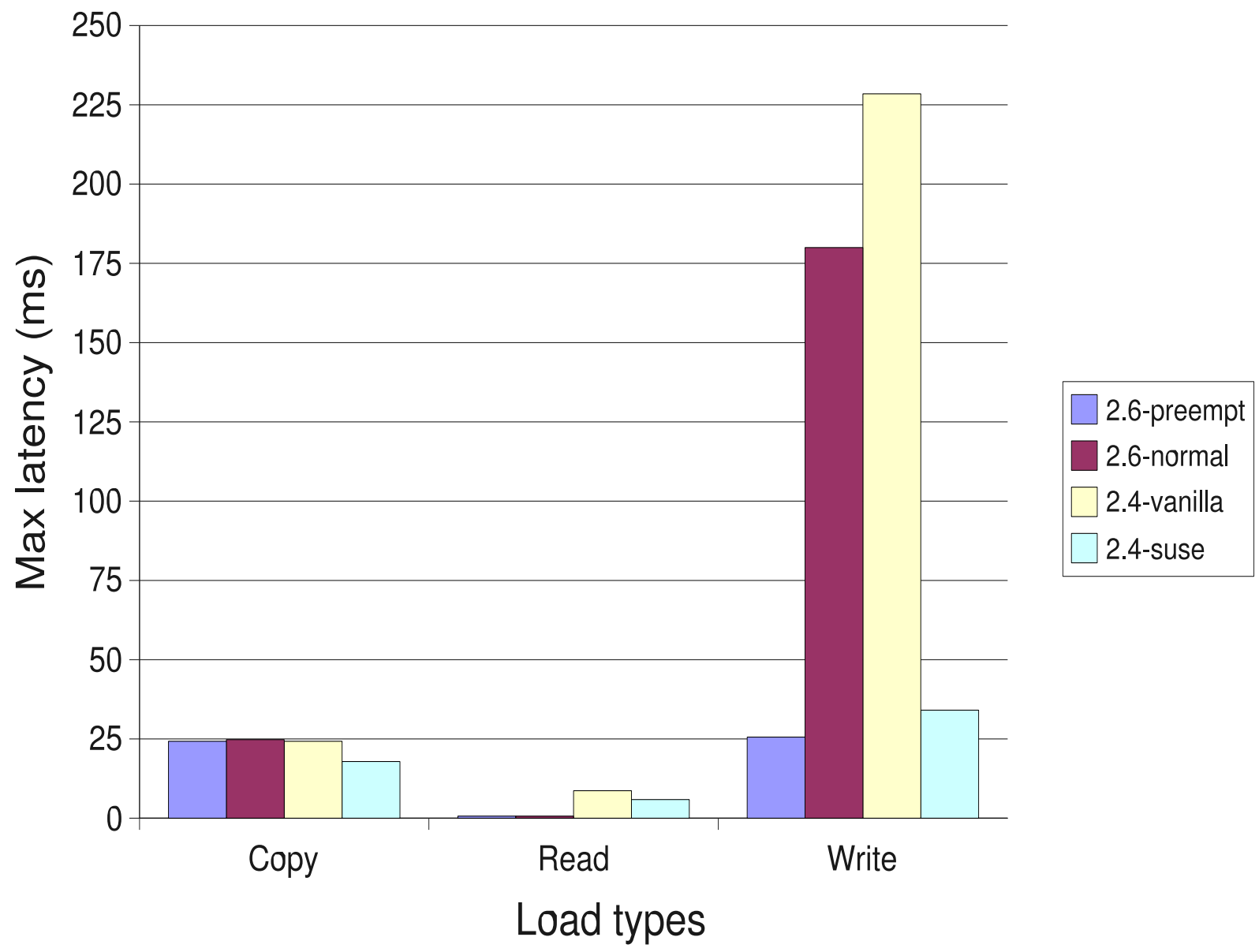


Preemptive 2.6.0-test9 / Reiserfs

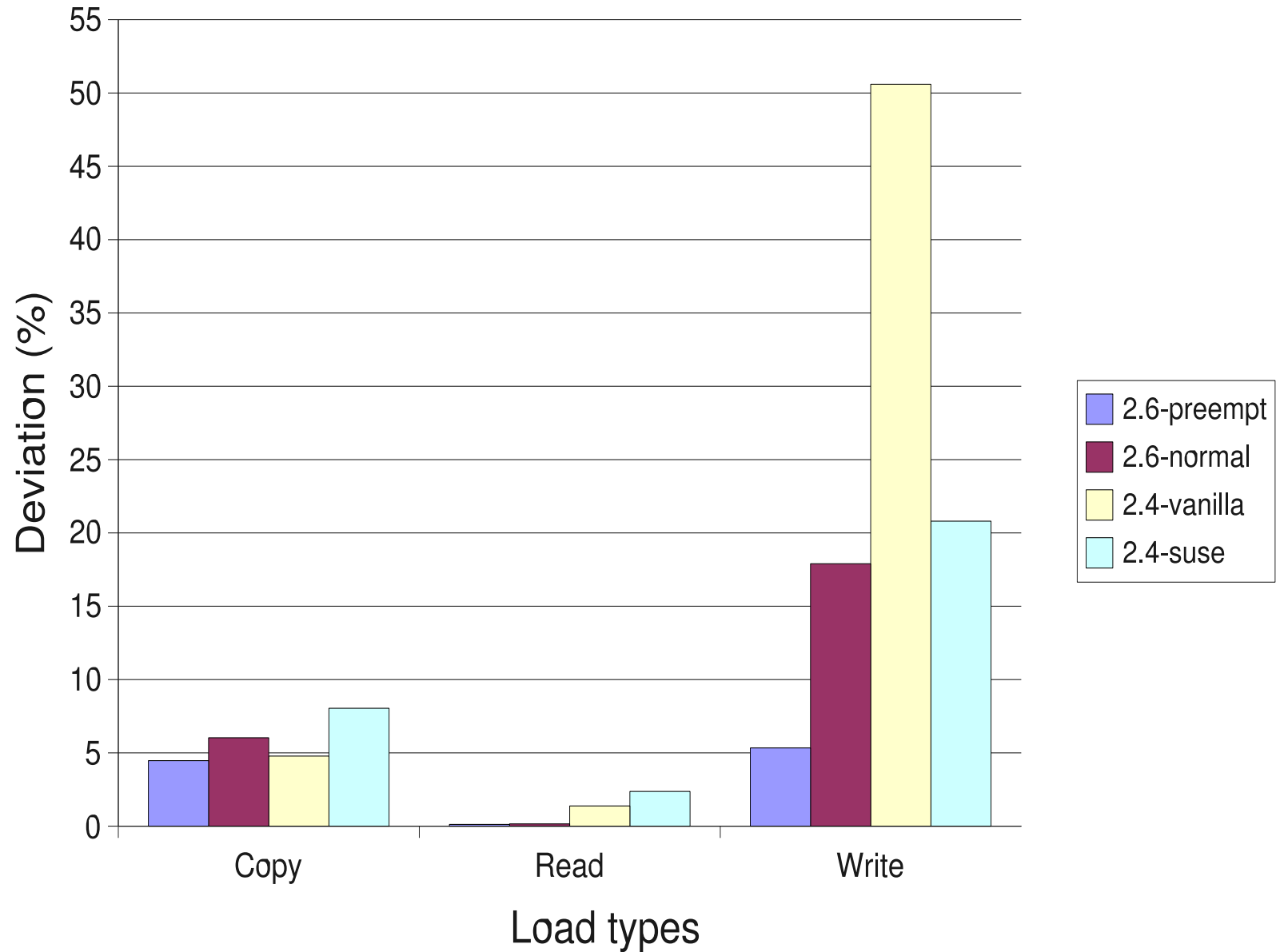
Disk Copy (UL) / Disk Read (UR) / Disk Write (D)



Interactive Max Latency



Interactive Latency Deviation



Conclusions

- 2.4 SUSE kernel: best RT-audio performance
 - followed by 2.6-PE, 2.4-vanilla, 2.6
 - 2.6-PE kernel still has several peaks
- Procs & X latencies: enough small
- Ext3: much worse than Reiserfs
 - Found even on 2.6-PE -> spinlocks?
- 2.6 kernels: better interactive latencies
 - Normal 2.6 still has a high peak