

Computer Systems Performance Analysis and Benchmarking (37-235)

**Analytic Modeling
Simulation
Measurements / Benchmarking**

Lecture by:
Prof. Thomas Stricker

Assignments/Projects:
Christian Kurmann

Textbook:
Raj Jain, "The Art of Computer Systems Performance Analysis", 1991 Wiley & Sons, New York

Topic of Today:

- **Self Scaling Benchmarks**
SIGMETRICS Paper 1993 by P.Chen
- **Performance Modeling & Prediction**
SUPERCOMPUTING Paper 1998 by
M.Taufer

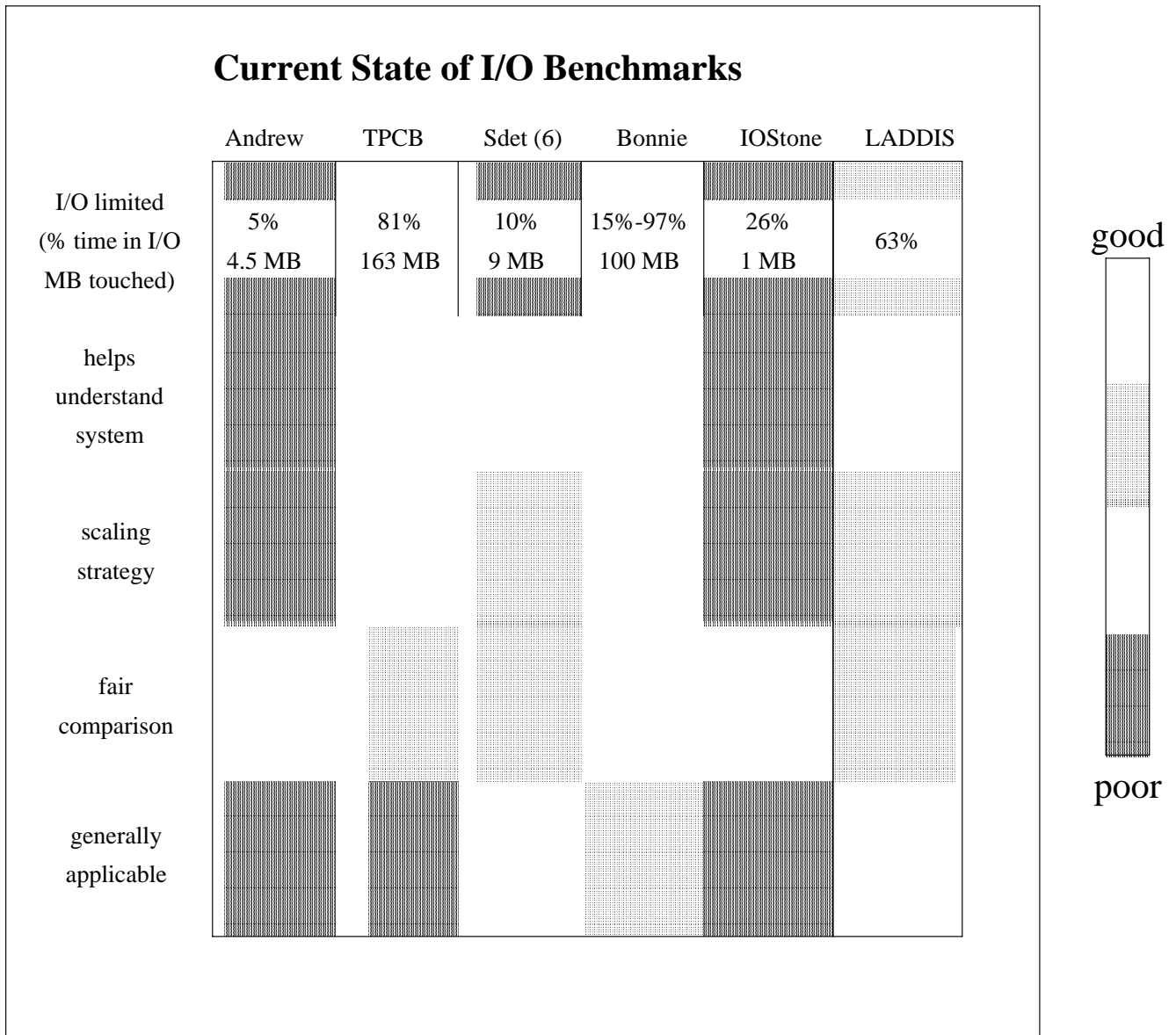
What's wrong w. I/O benchmarks

- Become quickly obsolete
i.e. Have no scaling strategy
- Do not stress the I/O system
- Do not help to understand IO
- Comparison for one workload only
i.e. don't allow conclusions about relative performance.
- Narrow application range
i.e. TPC-B is only debit/credit

Look at

- IO Percentage
- Maximal Working Set
- Scaling strategy
- Insight into system
- Suitability for comparison

Current State of Art (1993)



Workload Model

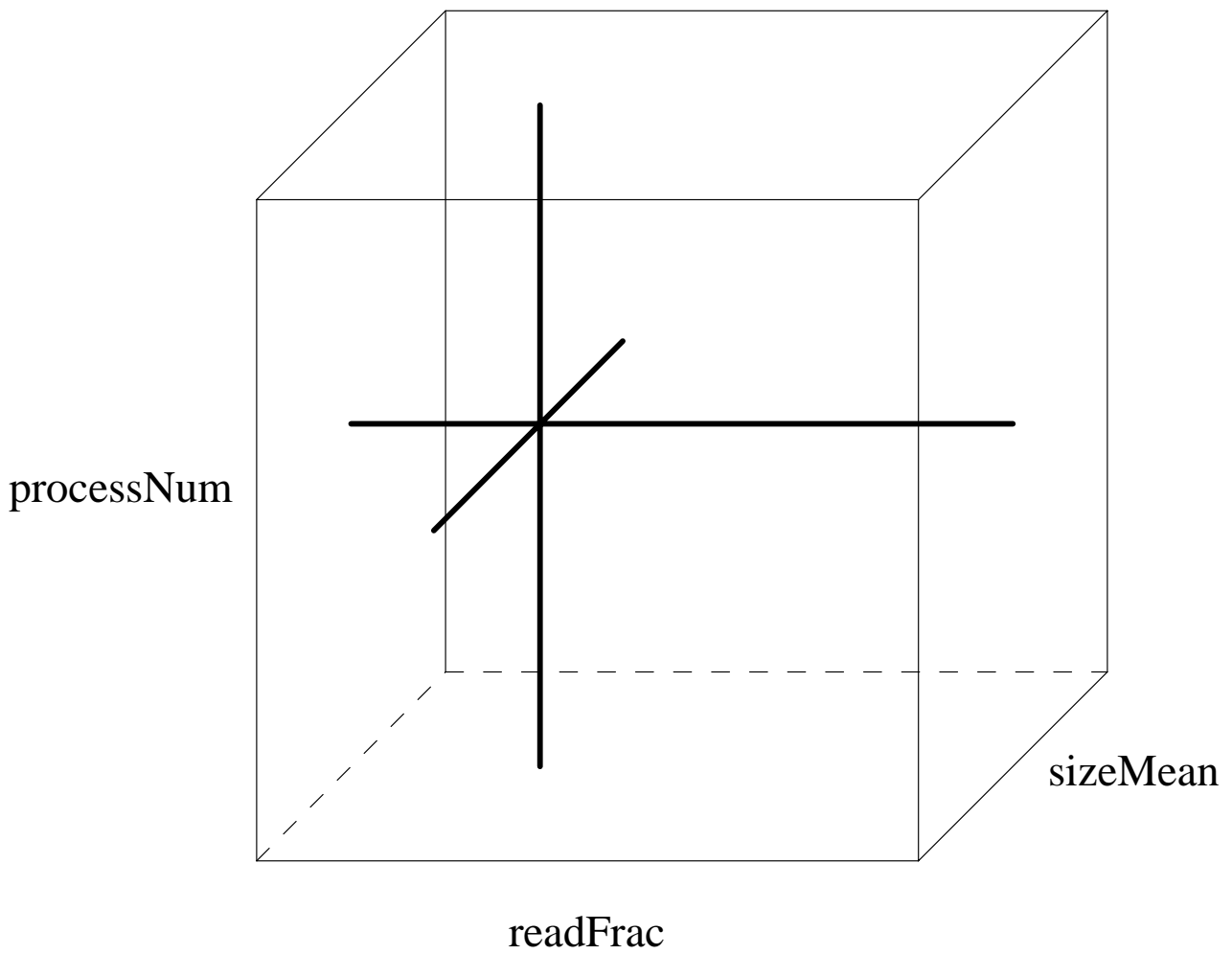
- uniqueBytes
 - working set
- sizeMean
 - size of I/O request
normal distribution with C.O.V of 1
- readFrac
 - percentage of reads vs. writes
- seqFrac
 - probability that next request follows the prior request
- processNum
 - multithreading, number of processes issuing I/O.

How accurately can we model real workloads?

Representativeness of workload

Application	Throughput	Read Response Time	Write Response Time	Average Response Time
Sort	.20 MB/s	19.7 ms	1.6 ms	11.7 ms
Workload Model	.20 MB/s	20.0 ms	1.9 ms	11.0 ms
TPC-B	.13 MB/s	25.6 ms	1.3 ms	14.0 ms
Workload Model	.13 MB/s	22.1 ms	1.6 ms	12.3 ms

The Parameter Space



Terms

- Single Parameter Graphs
- Focal Point
- Focal Vector

Example

- uniqueBytes= 21MB
- sizeMean= 10 KB
- readFrac= 0
- processNum= 1
- sequFrac= 0

Full Fractional Design

- $6^5 = 8000$ points @ 10min = 2 Months

Reduced Design

- 30 points @ 10 min = 5 hours

Basic Version of Benchmark

- Take focal point somewhere at 75% of maximal performance of each factor

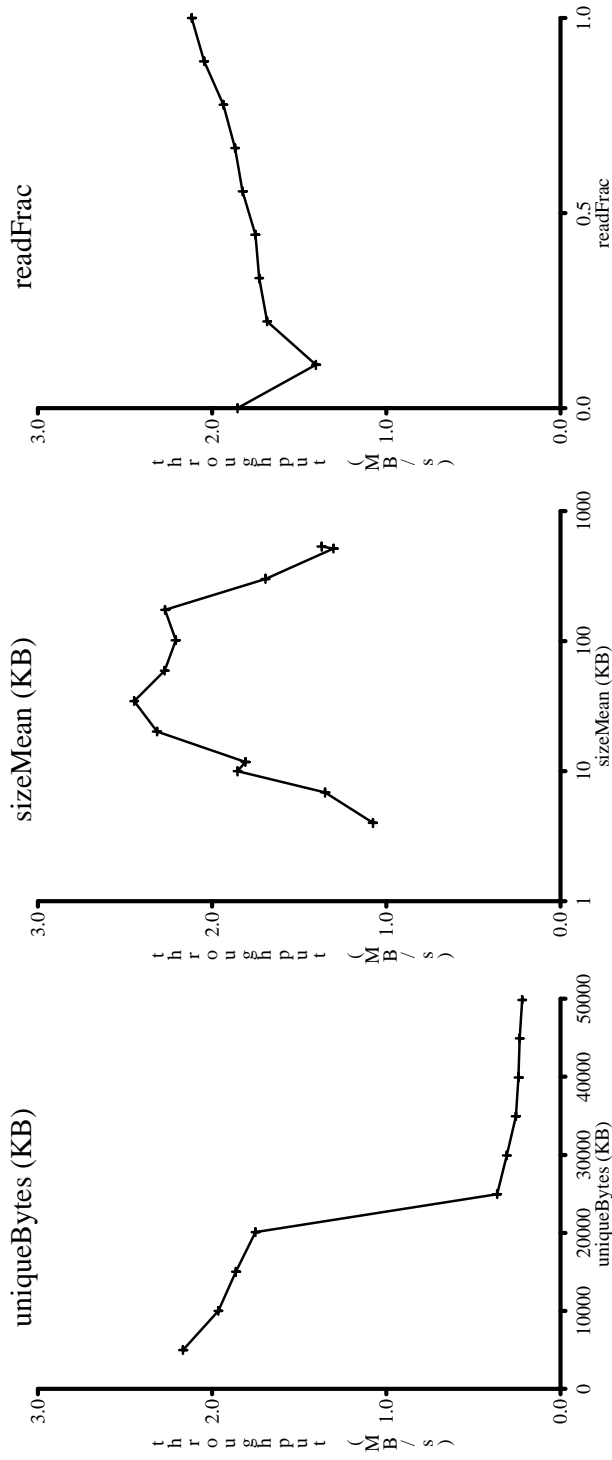
Problems:

- Focal points at outer limits
- Focal points set arbitrarily
- Focal point in an unstable area
- Not aware of plateaus

Improved Version of Benchmark

- Aware of plateaus
multiple focal points for uniqueBytes
- Focal points midway e.g. 0.5 for [0..1]

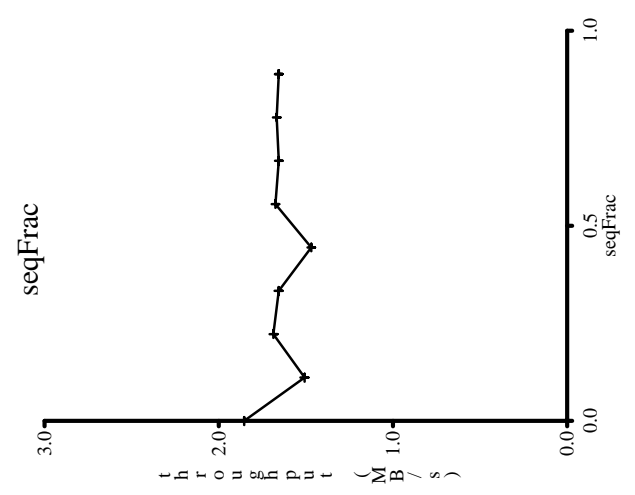
Scaling all Parameters [Sparc1]



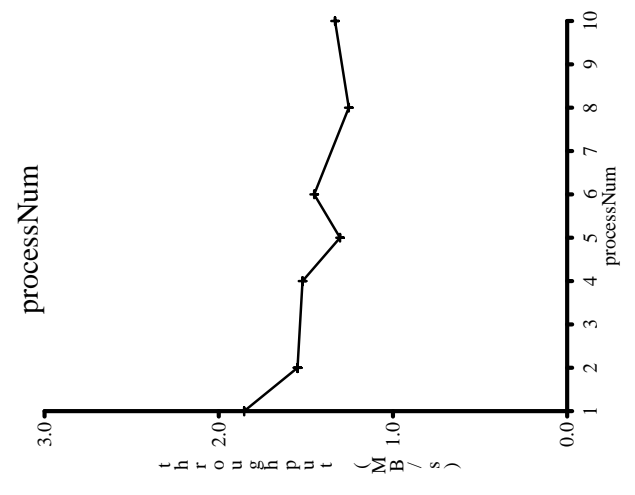
(c)

(b)

(a)

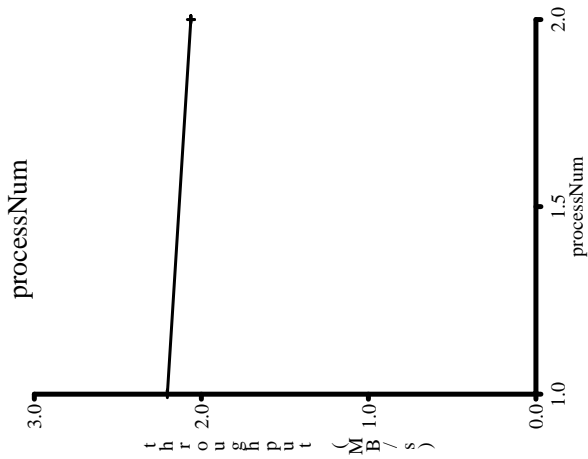


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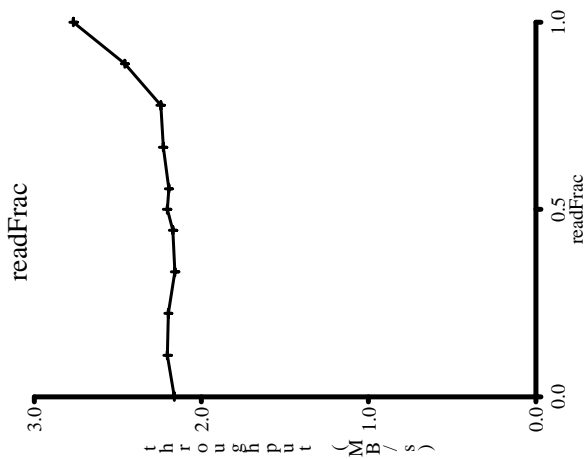


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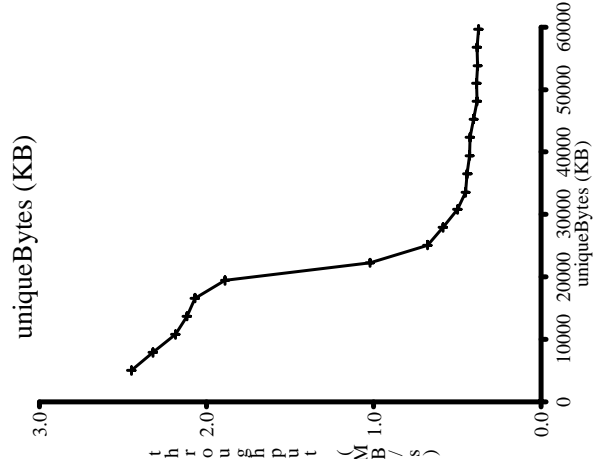
Plateau 1 [Sparc1]



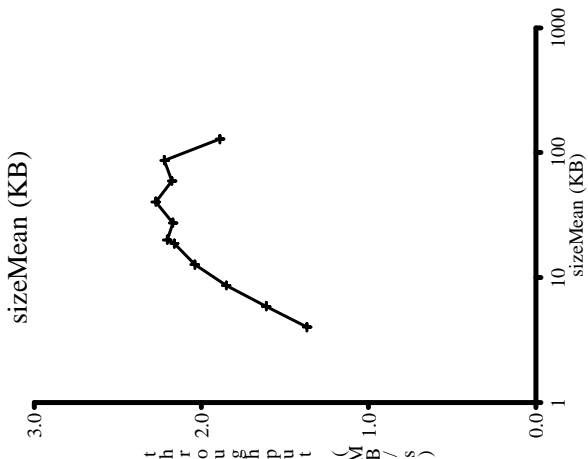
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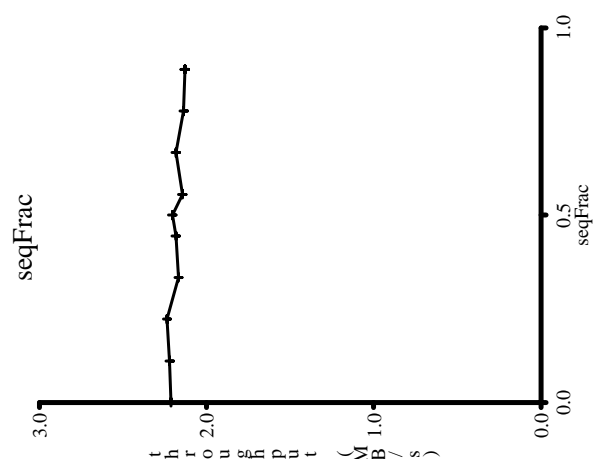
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(e)

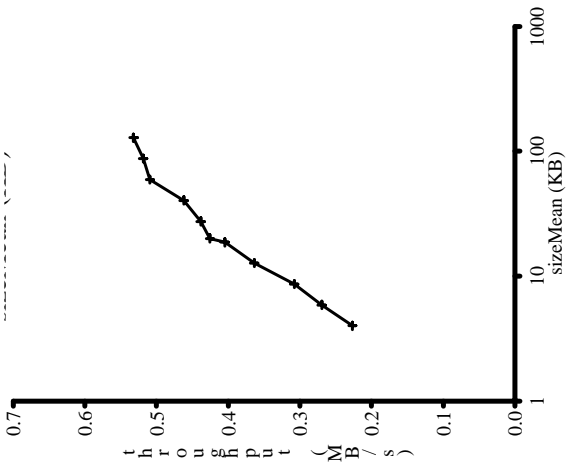


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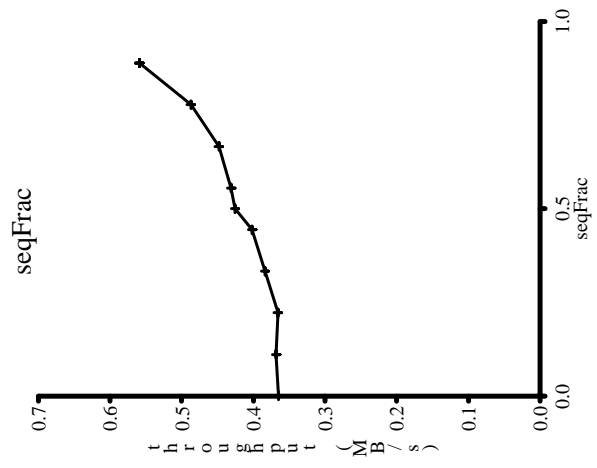


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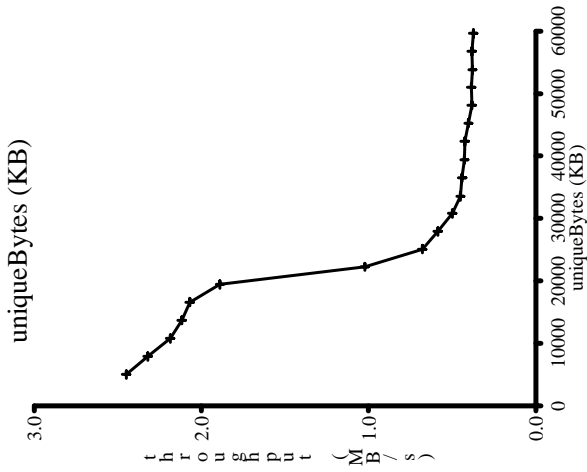
Plateau 2 [Sparc1]



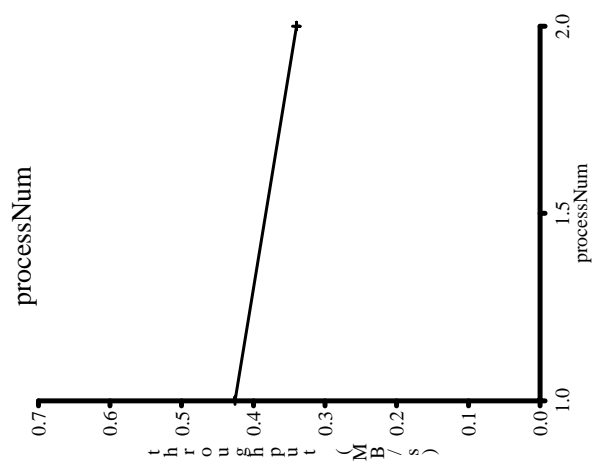
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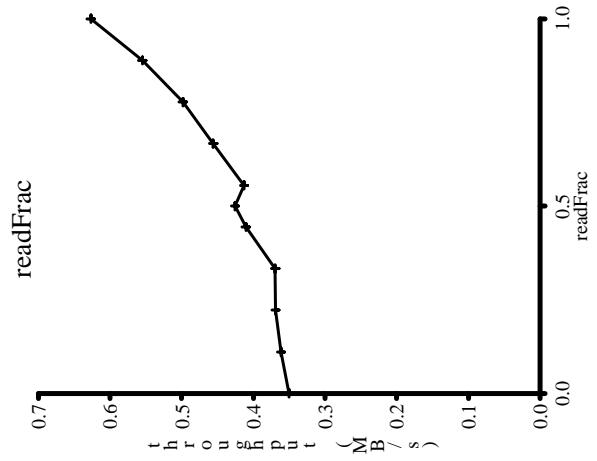
(i)



(e)



(h)



(g)

How to allow for comparisons?

Simple prediction component for any workload assumed

Big assumption

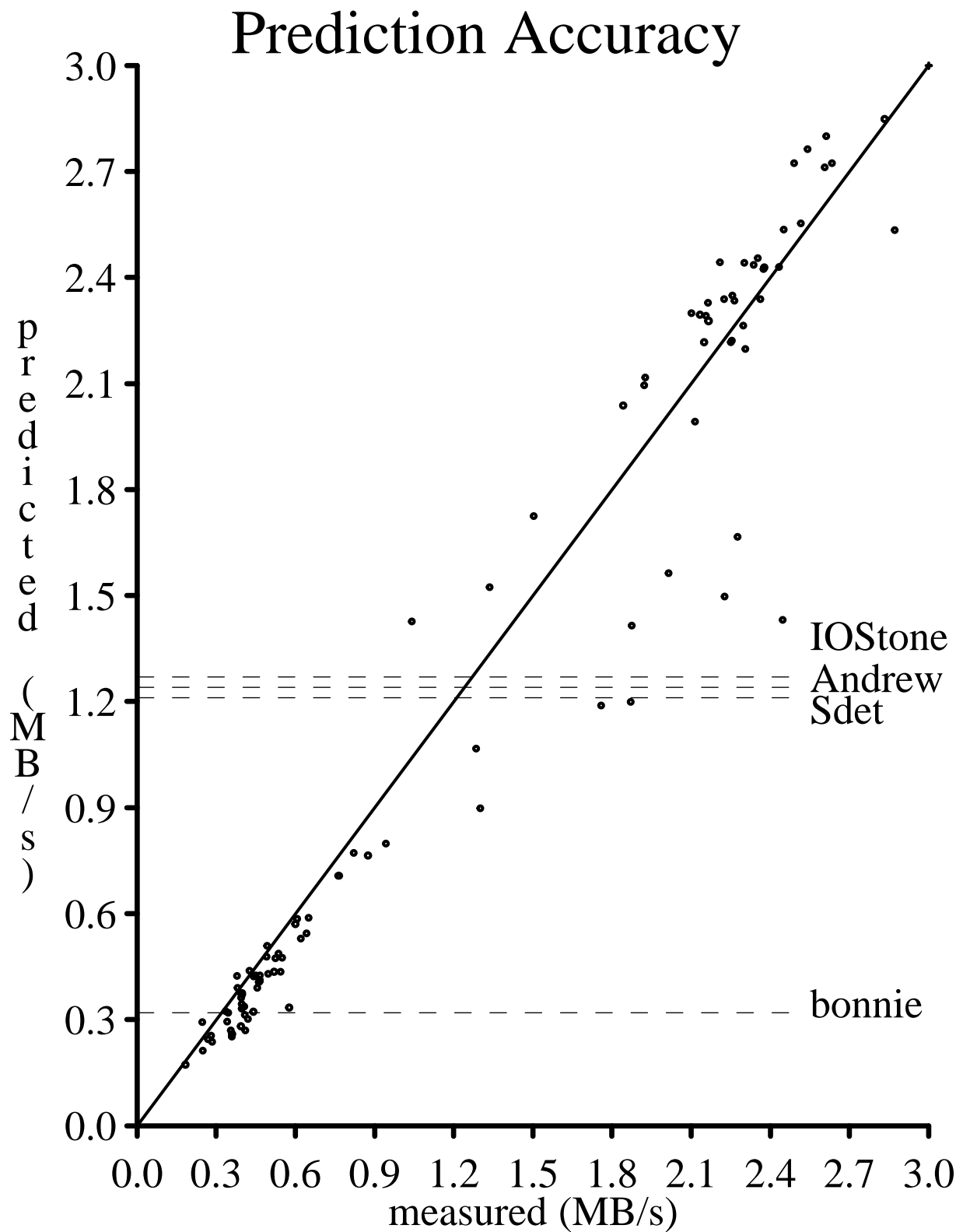
- Shape of single parameter curve does not change with focal point.
- Simple linear interpolation
- Multiplicative linear interpolation for multiple parameters

Clean evaluation of the error in the paper.

Predicting Performance

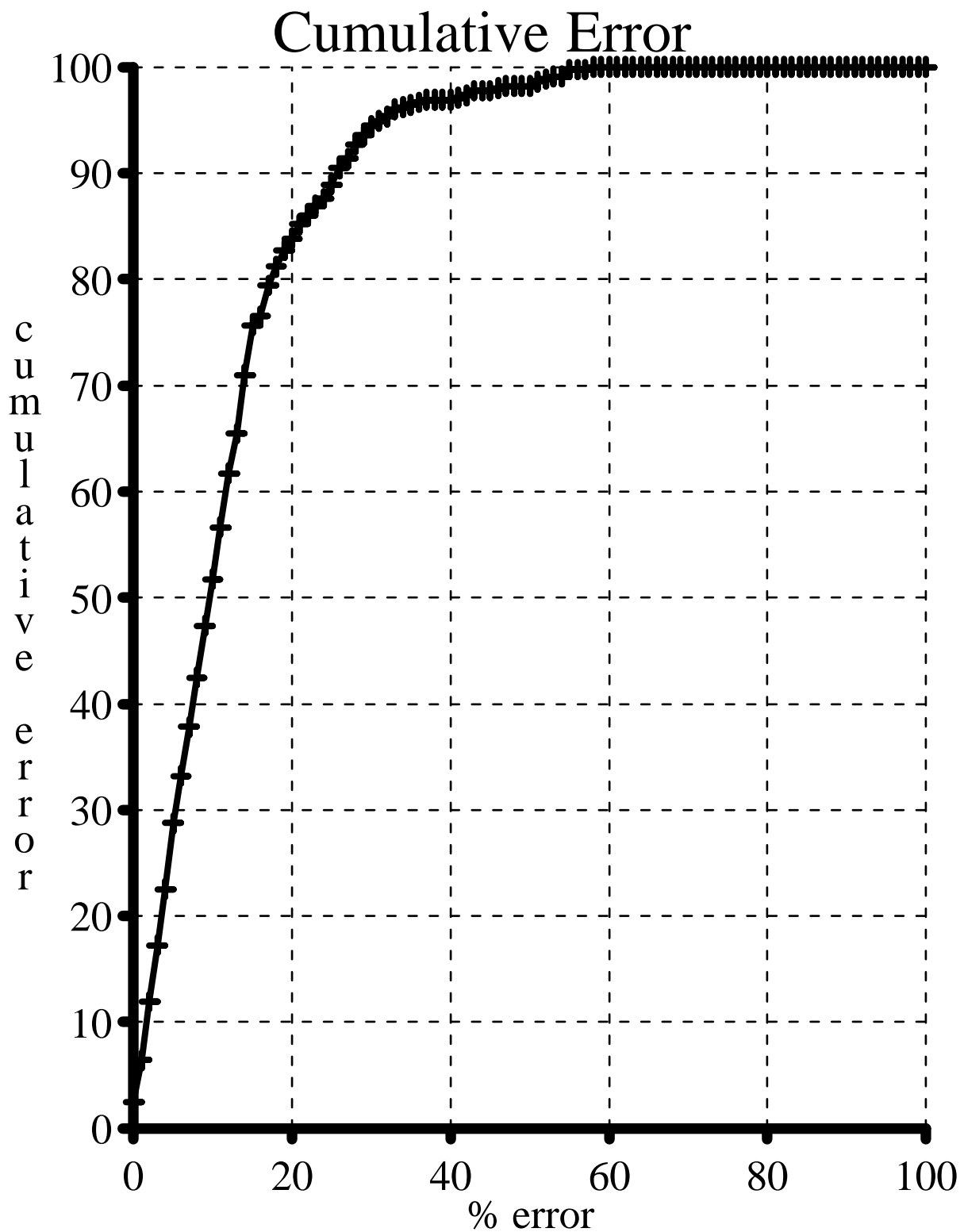


Accuracy of Prediction [Sparc1]



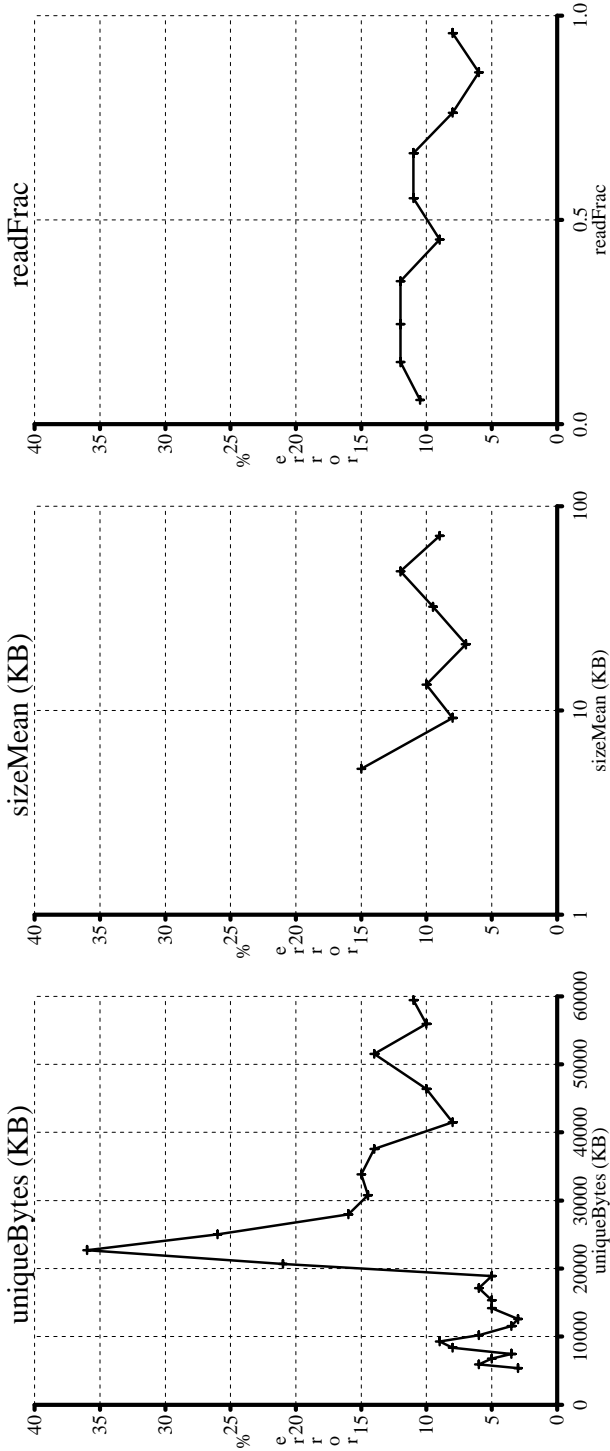
(a)

Error of Prediction [Sparc1]



(b)

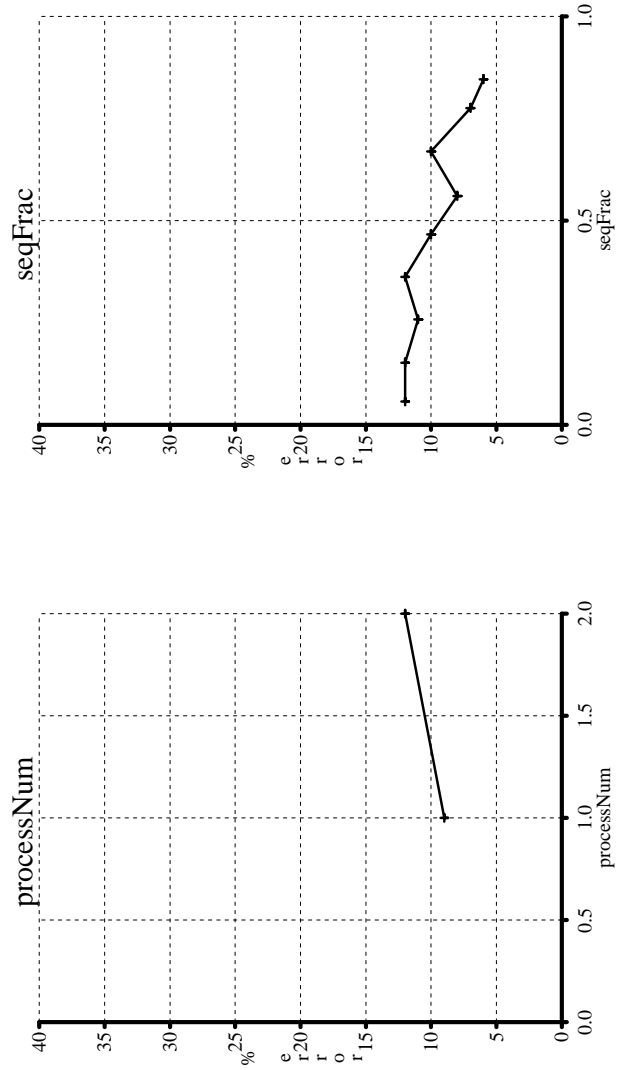
Parameters with error



(a)

(b)

(c)



(d)

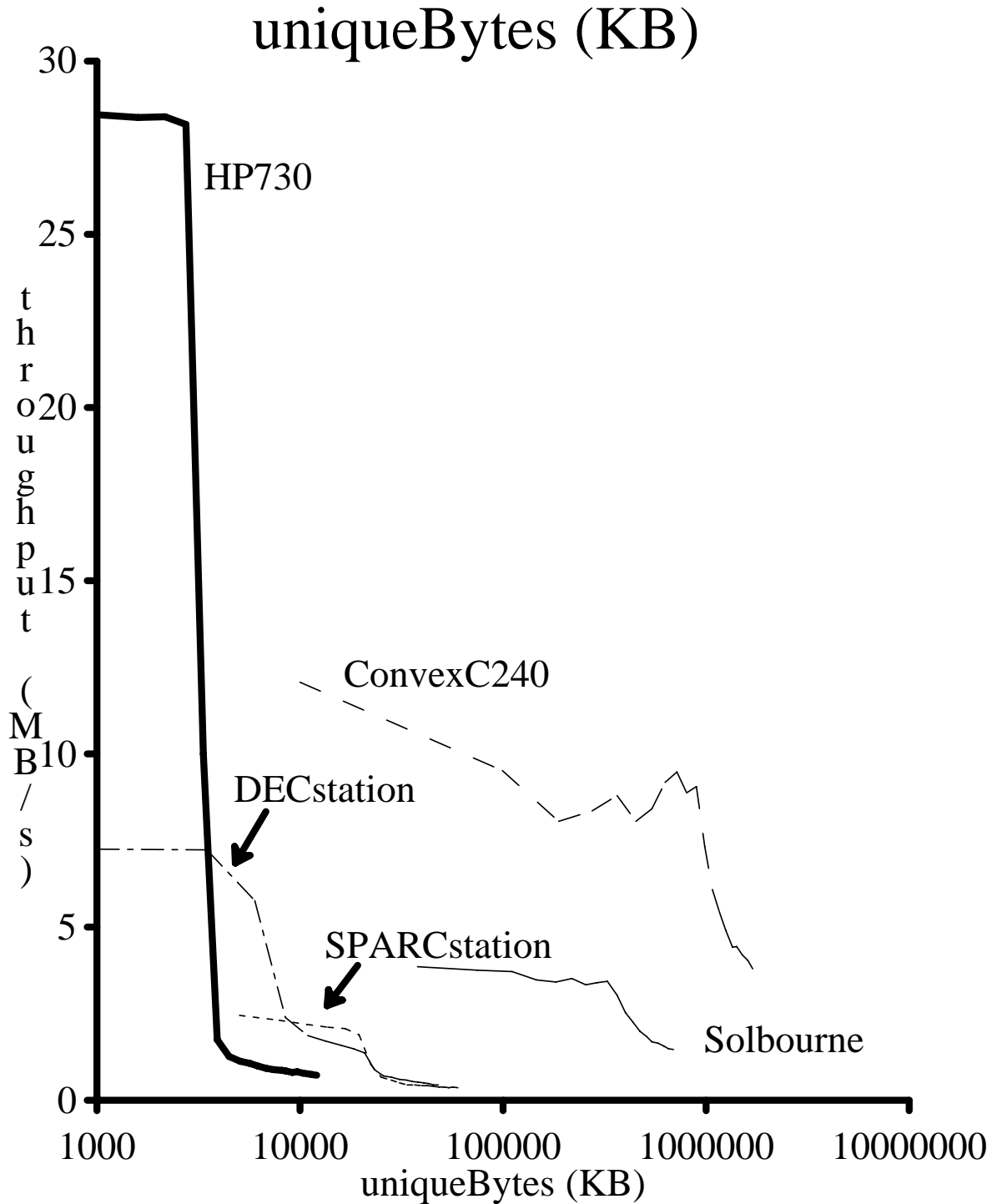
(e)

Discussion of Machines

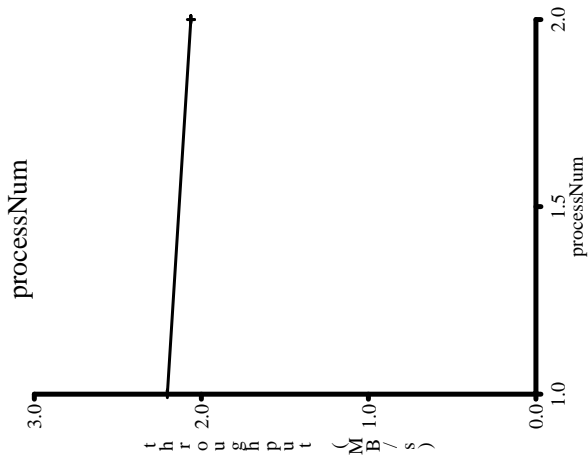
System Name	SPARCstation 1+	DECstation 5000/200	HP 730
Year Released	1989	1990	1991
CPU	SPARC	MIPS R3000	PA-RISC
SPECmarks	8.3	19.9	76.8
Disk System	CDC Wren IV	3 disk (Wren) RAID 0	HP 1350SX
I/O Bus	SCSI-I	SCSI-I	Fast SCSI-II
Mem. Bus Peak Speed	80 MB/s	100 MB/s	264 MB/s
Memory Size	28 MB	32 MB	32 MB
Operating System	SunOS 4.1	Sprite LFS	HP/UX 8.07

System Name	Convex C240	Solbourne 5E/905
Year Released	1990 (???)	???
CPU	C2 (4 processors)	SPARC (?? processors)
Speed	220 MIPS	???
Disk System	4 DKD-502 RAID 5	4
I/O Bus	IPI-2	IPI
Memory Bus Peak Speed	200 MB/s	128 MB/s ??
Memory Size	1024 MB	384 MB
Operating System	ConvexOS 10.1 (BSD derived)	SunOS 4.1A.2 (revised)

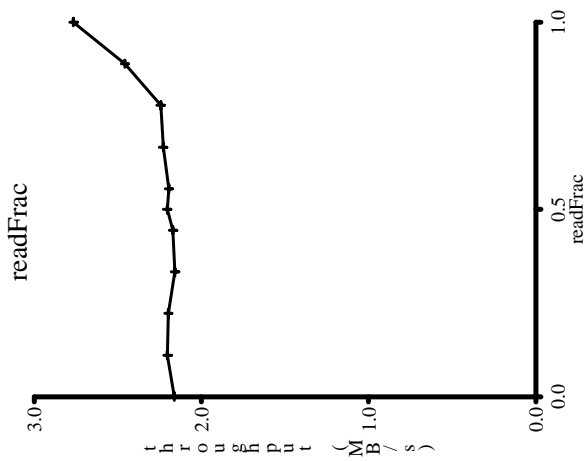
Storage Hierarchies



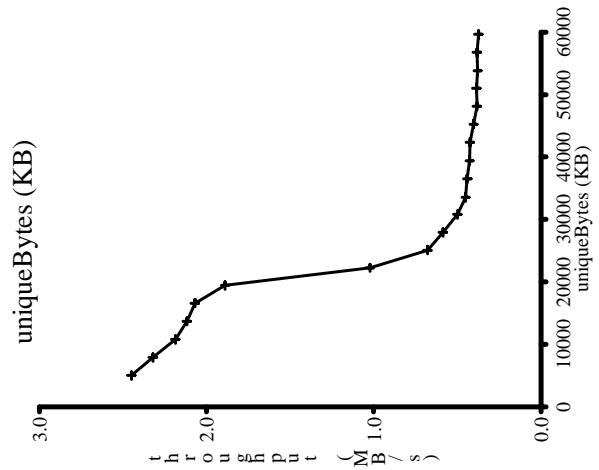
Plateau 1 [Sparc1]



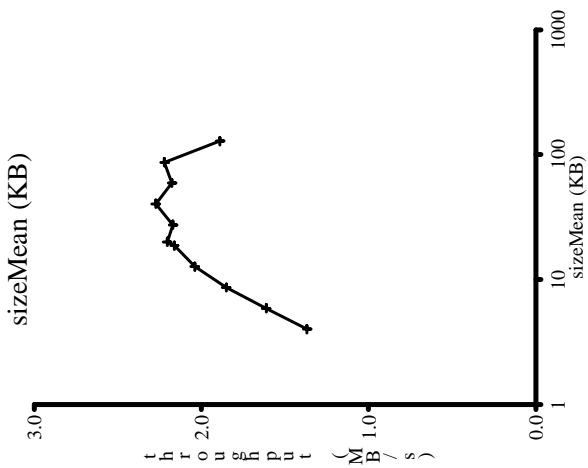
(c)



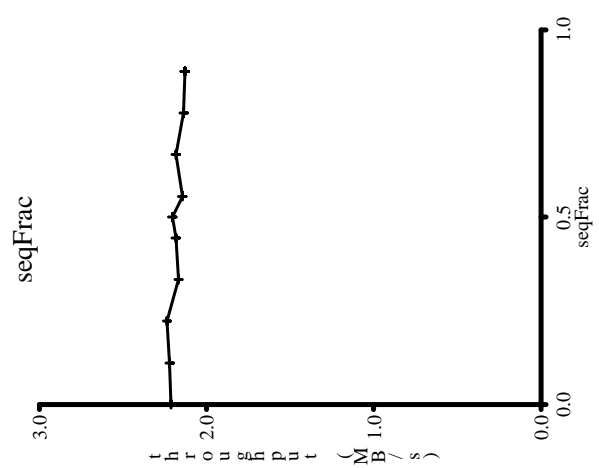
(b)



(e)

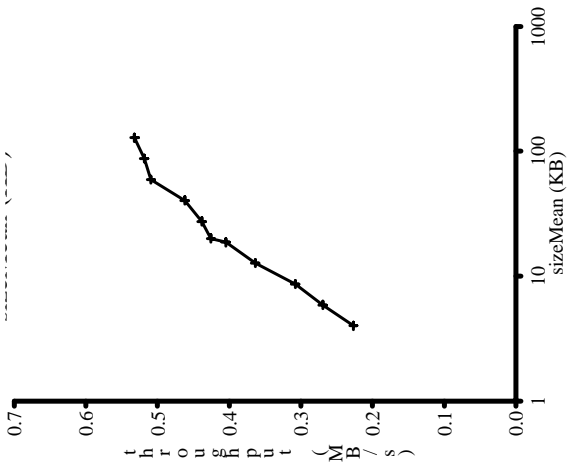


(a)

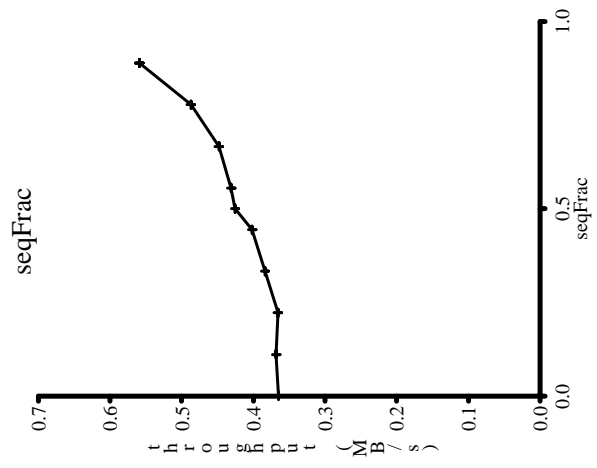


(d)

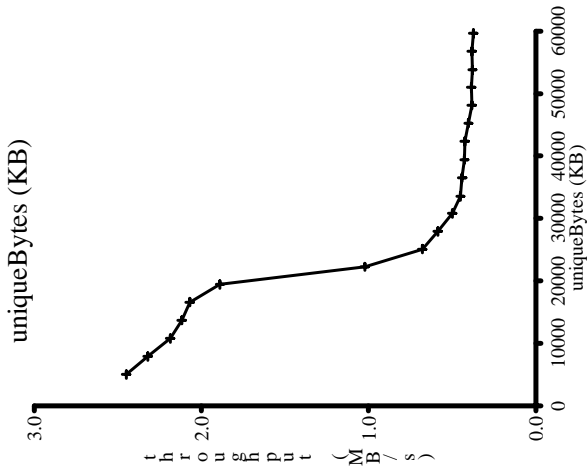
Plateau 2 [Sparc1]



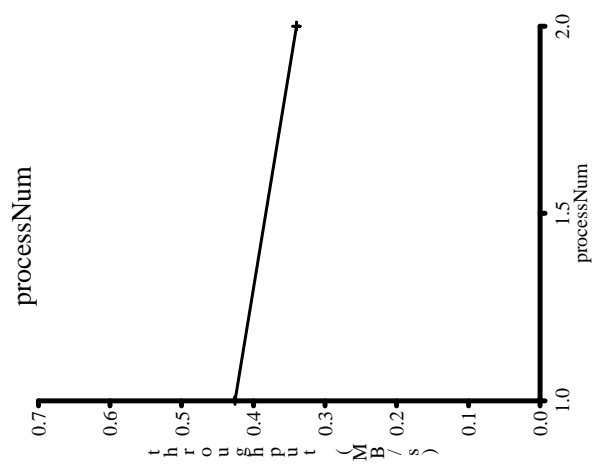
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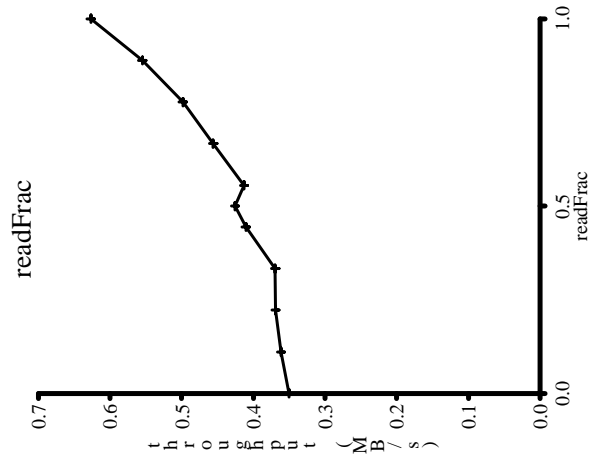
(i)



(e)

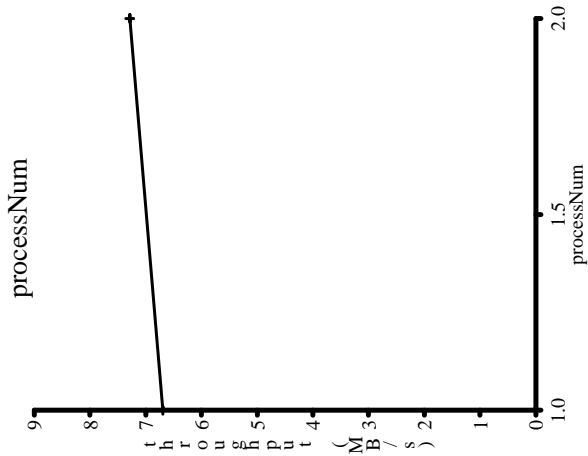


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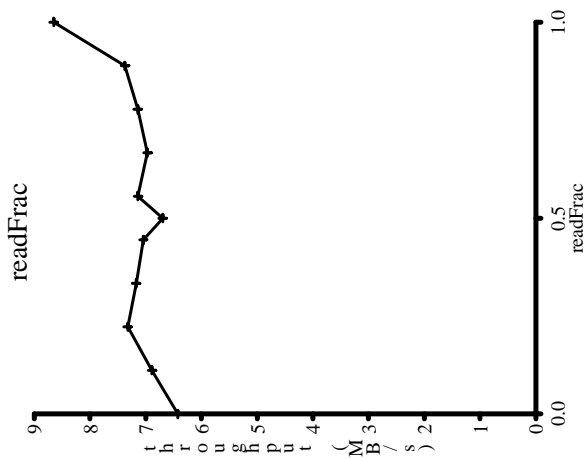


(g)

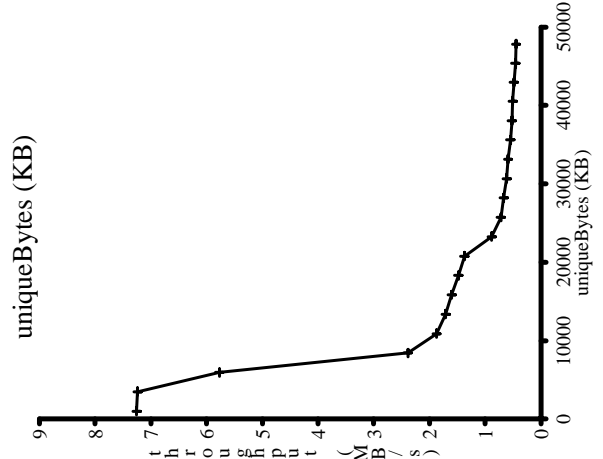
Plateau 1 [DEC 5000]



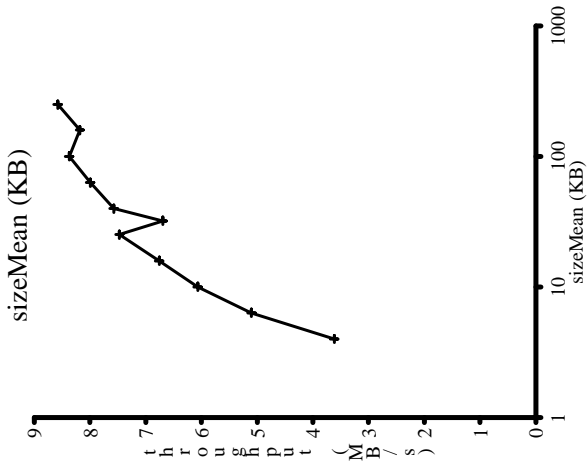
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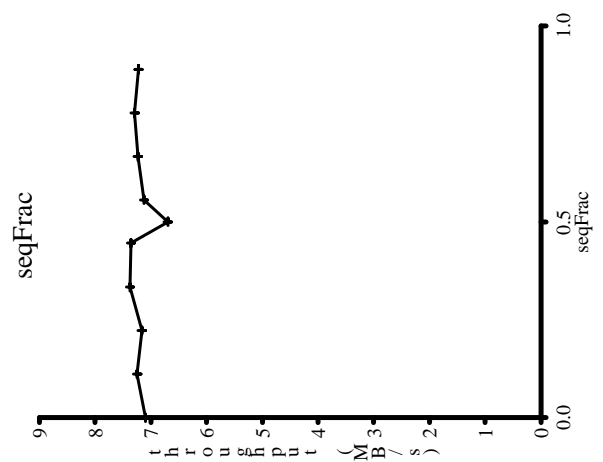
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(e)

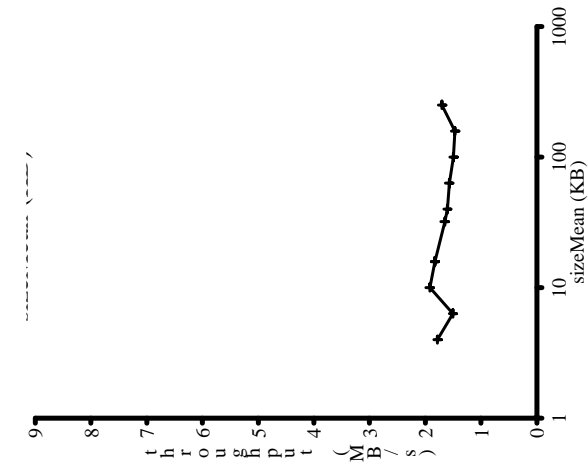


(a)

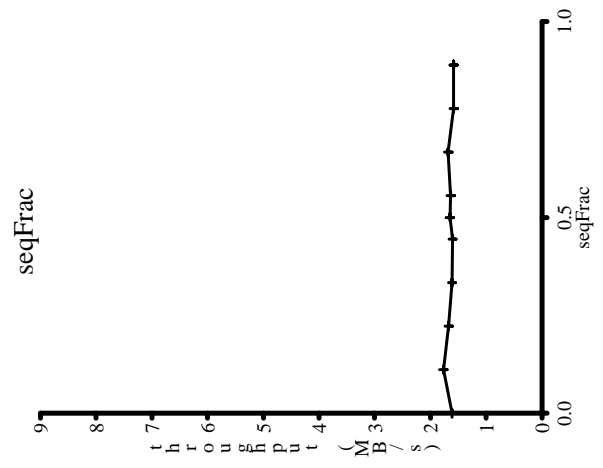


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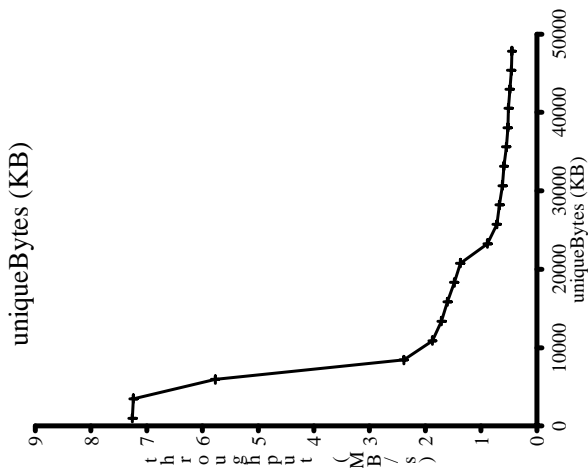
Plateau 2 [DEC 5000]



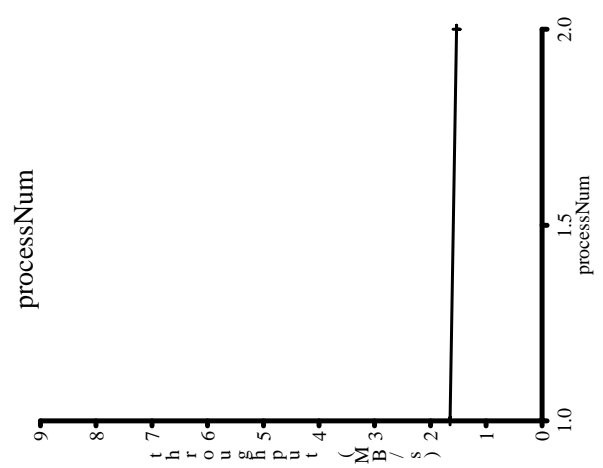
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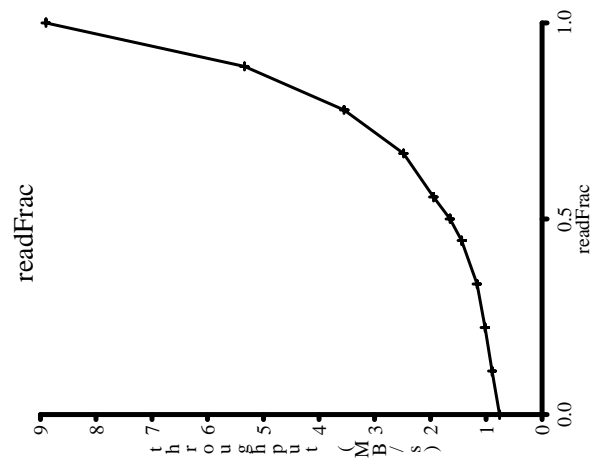
(i)



(e)

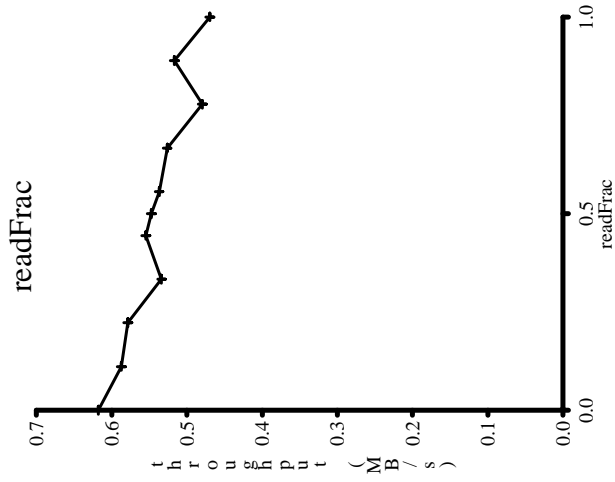


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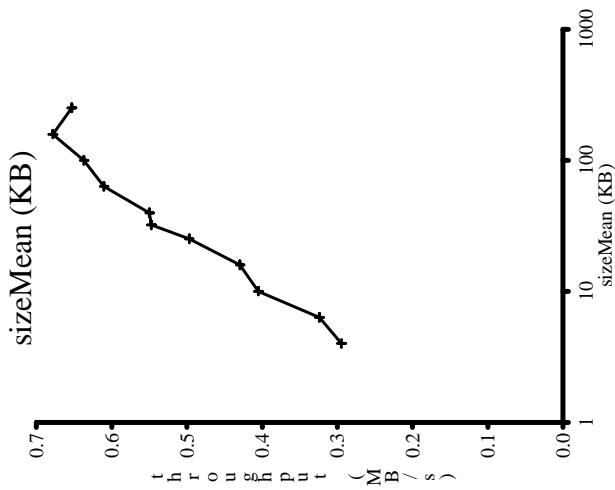
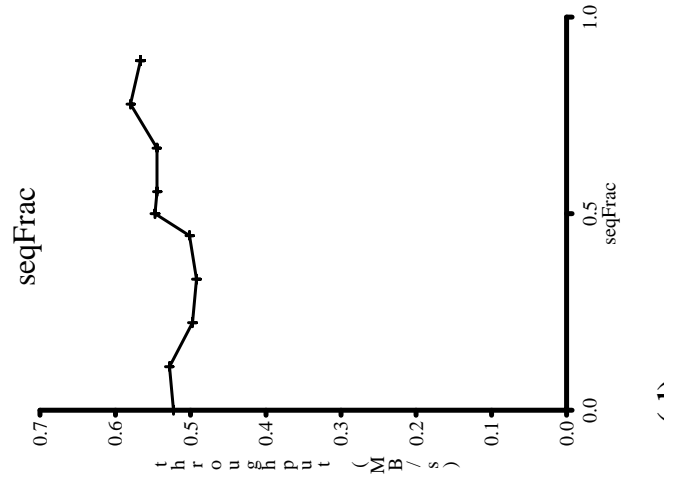


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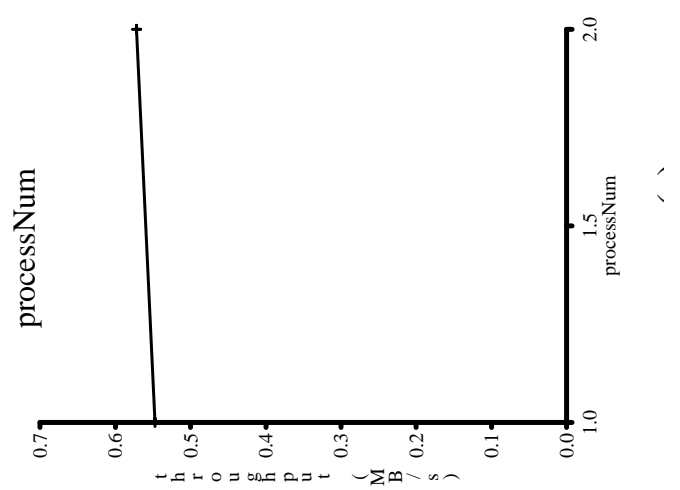
Plateau 3 [DEC 5000]



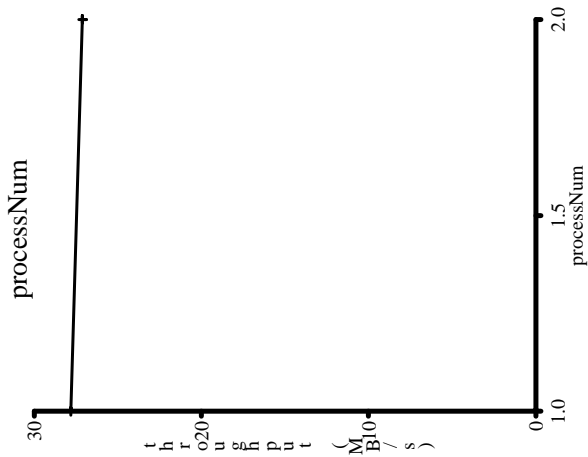
(b)



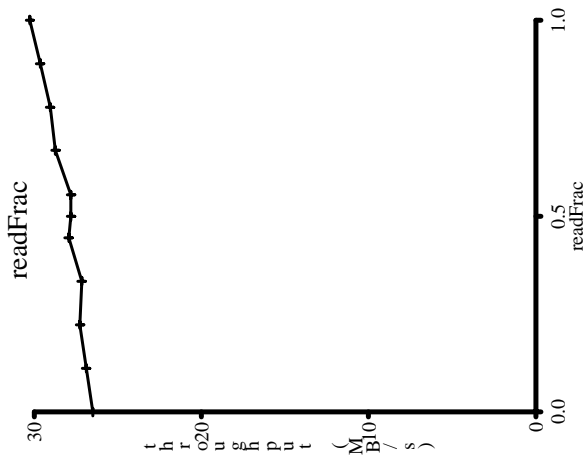
(a)



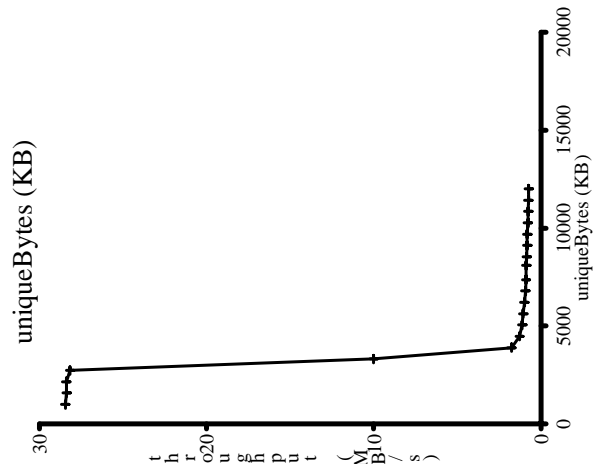
Plateau 1 [HP 730]



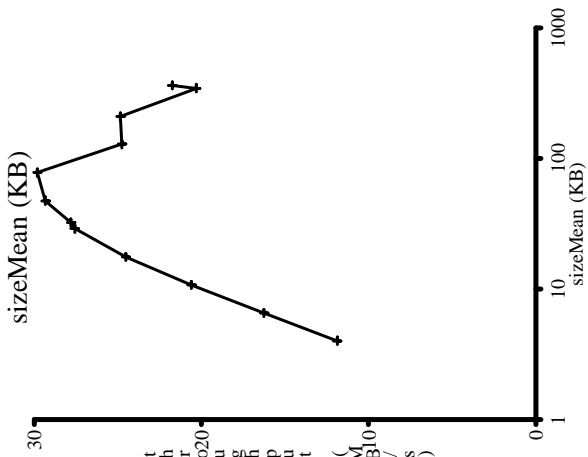
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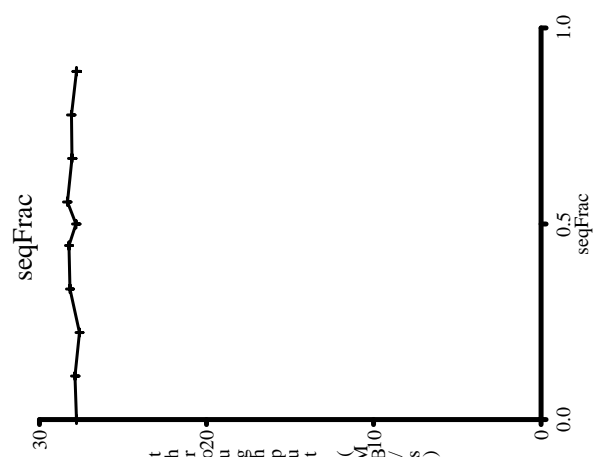
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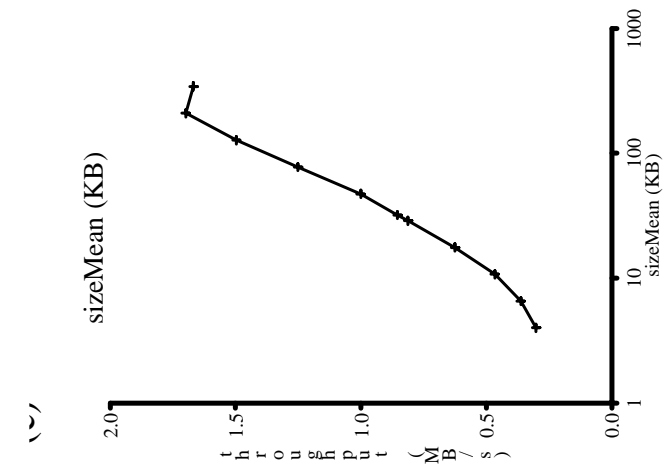


(a)

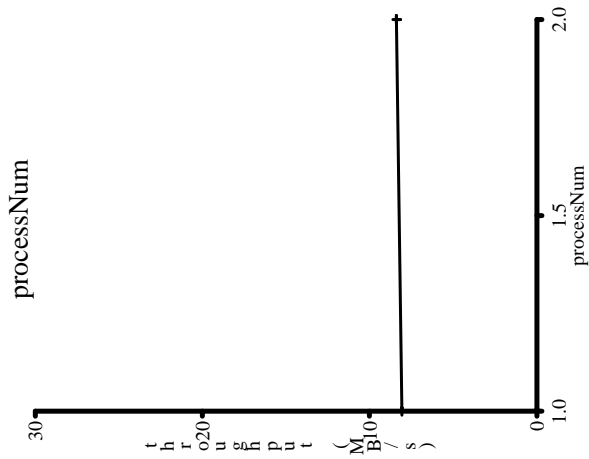


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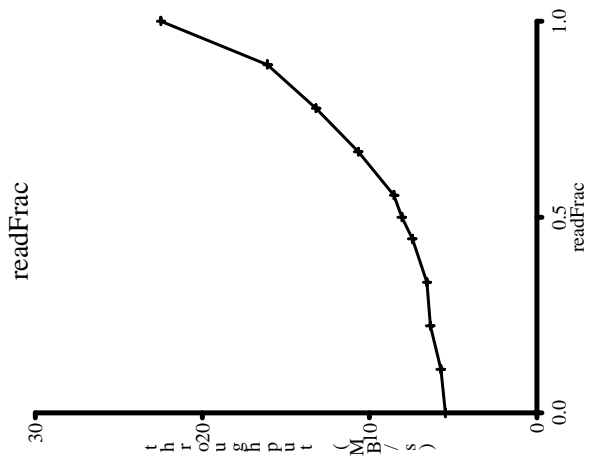
Plateau 2 [HP 730]



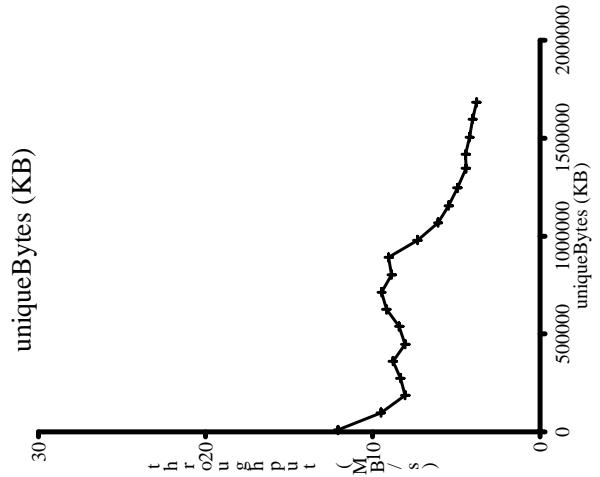
Plateau 1 [Convex C240]



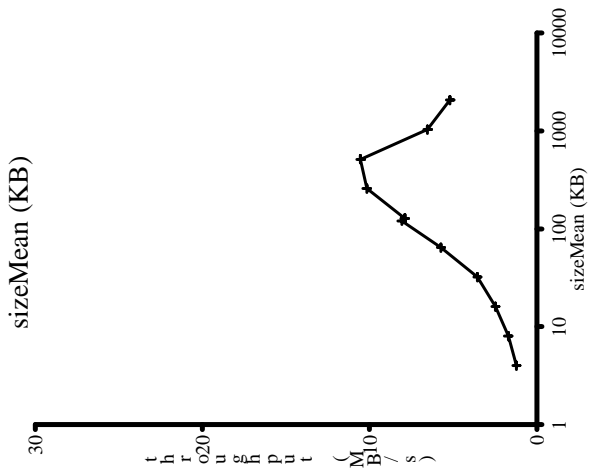
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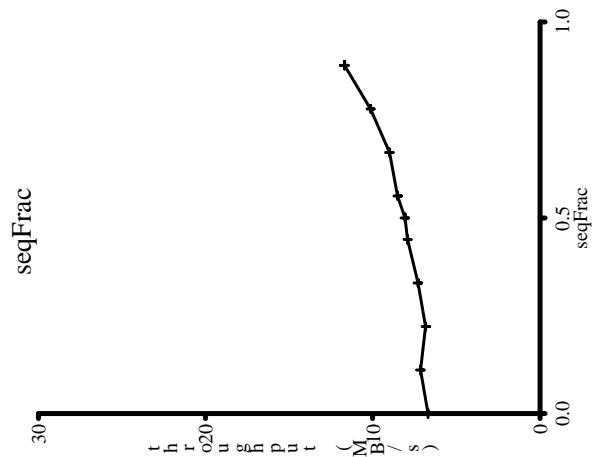
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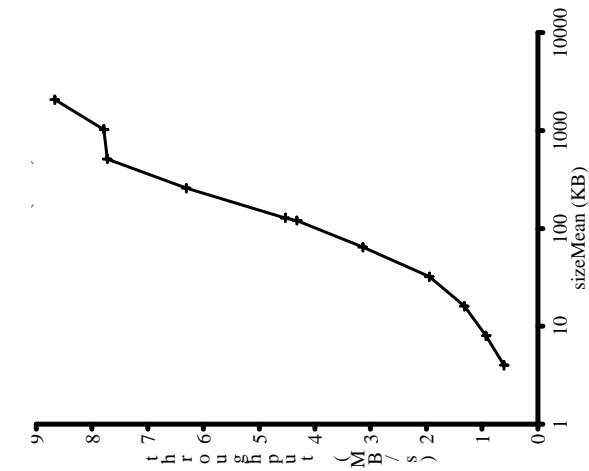


(a)

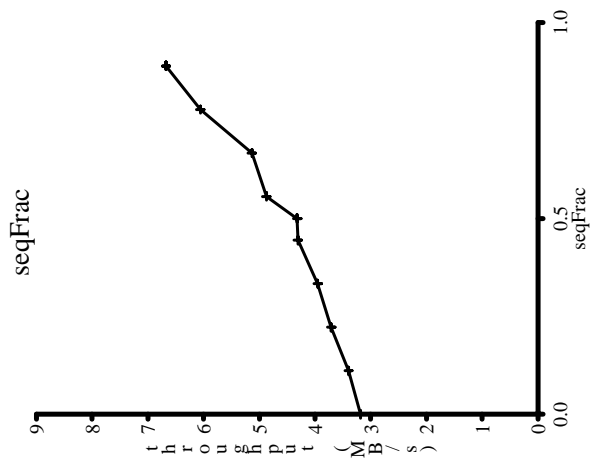


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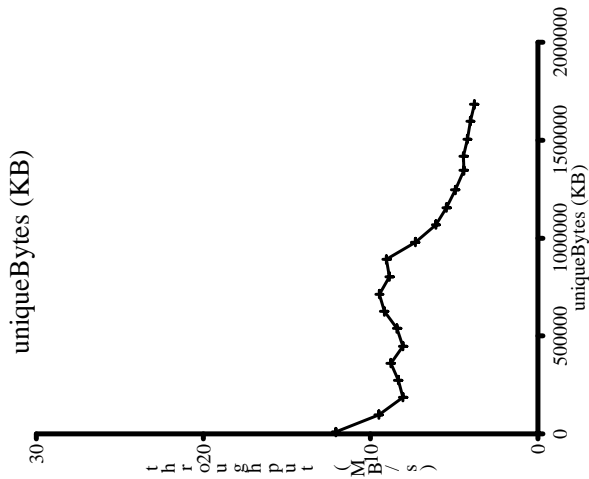
Plateau 2 [Convex C240]



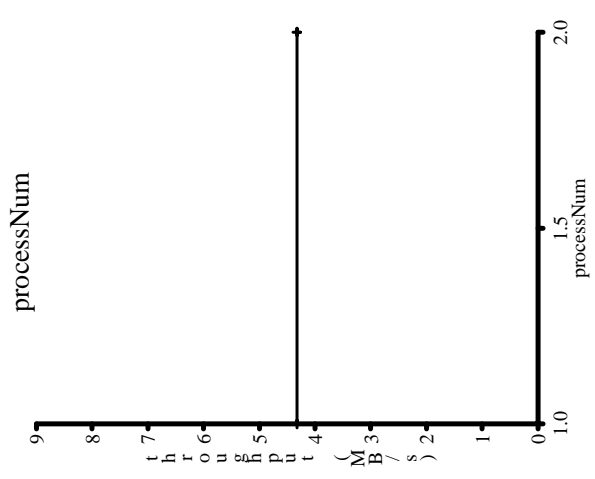
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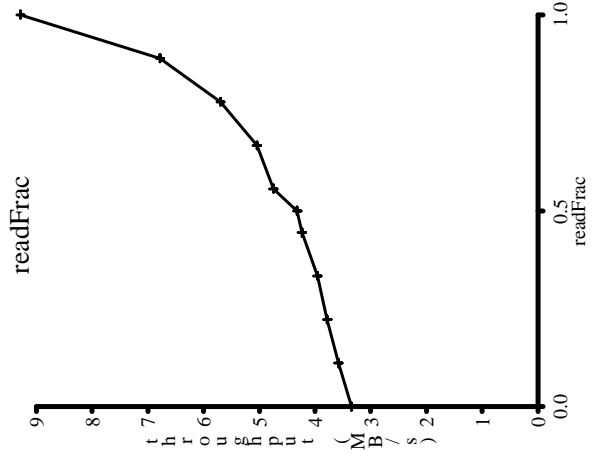
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(e)

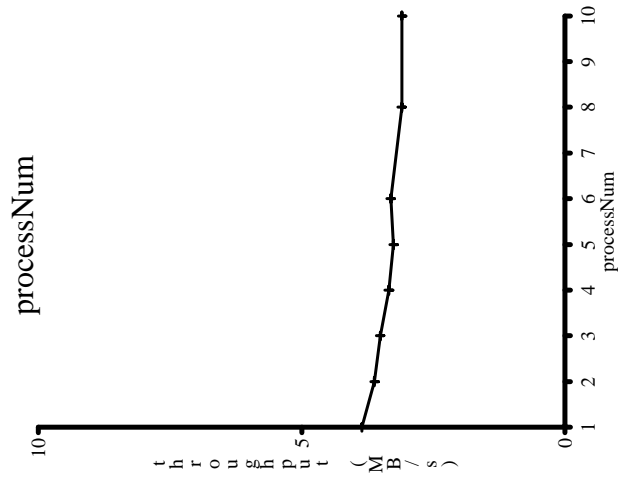


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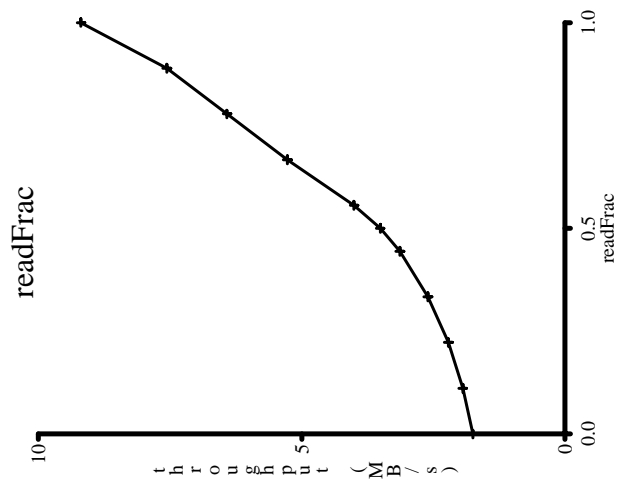


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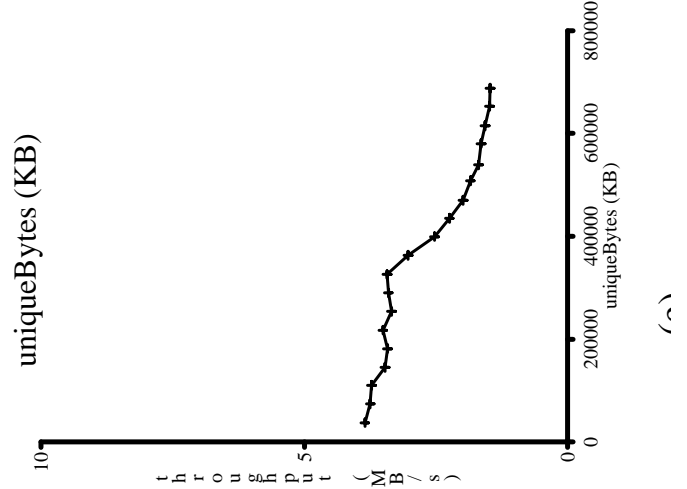
Plateau 1 [Solbourne]



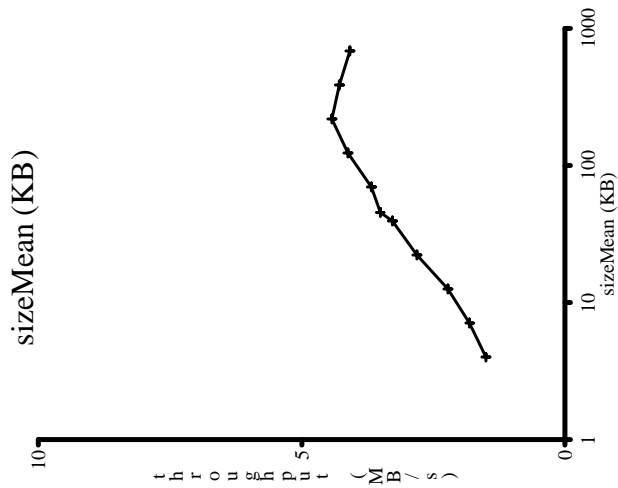
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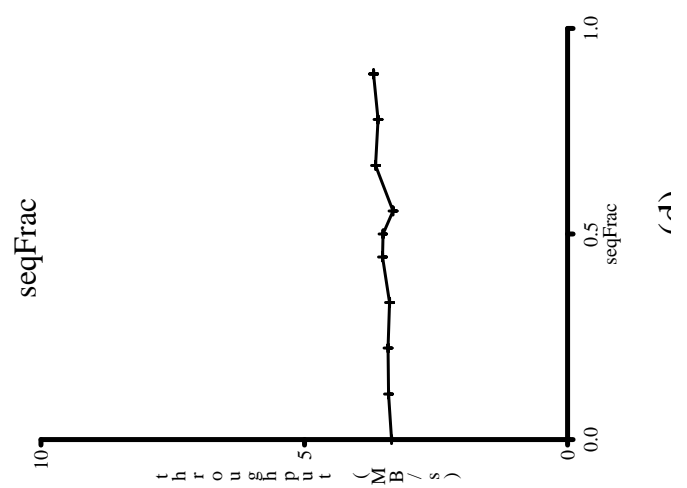
(b)



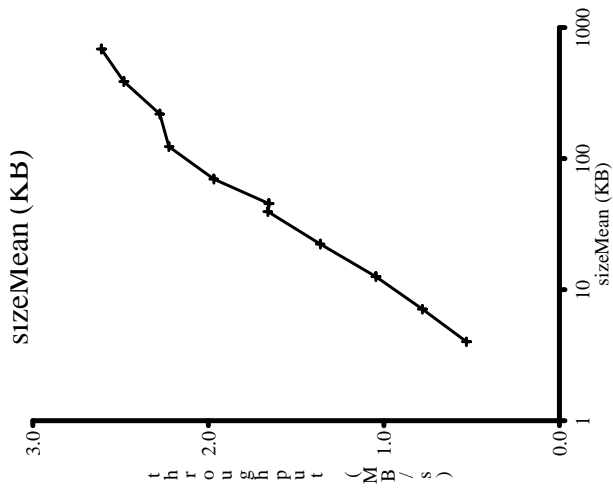
(a)



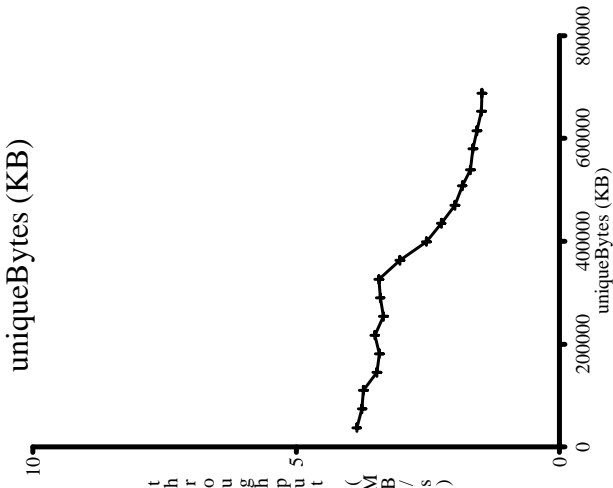
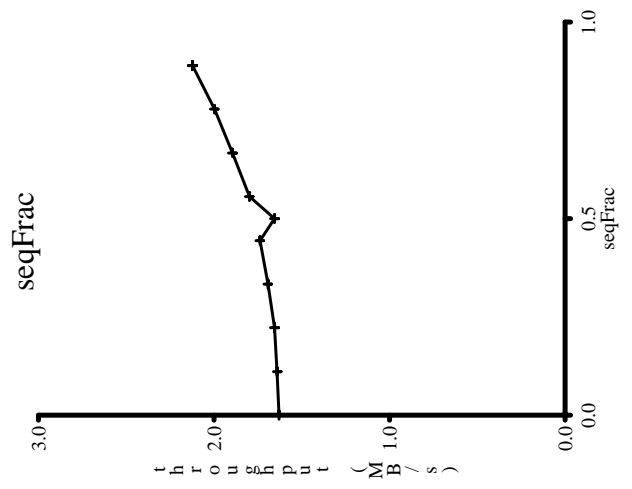
(b)



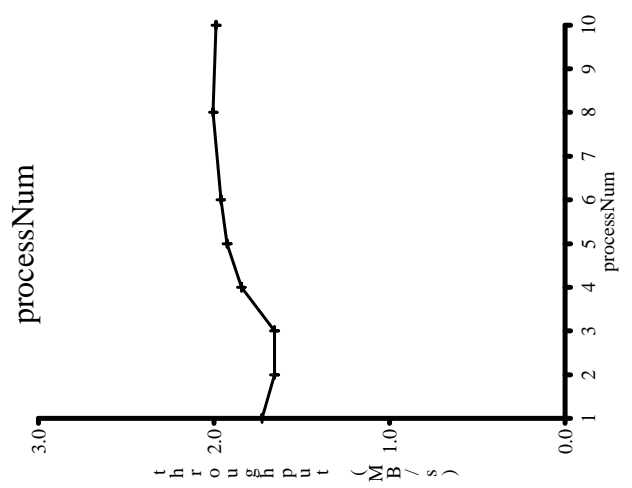
Plateau 2 [Solbourne]



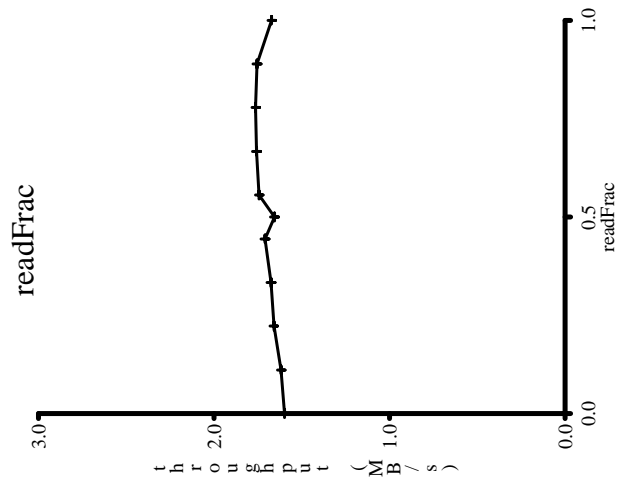
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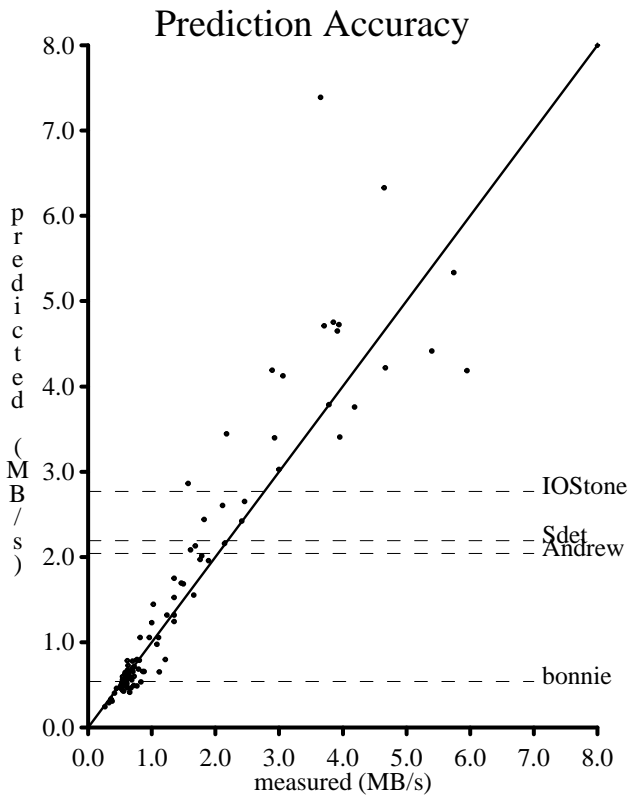
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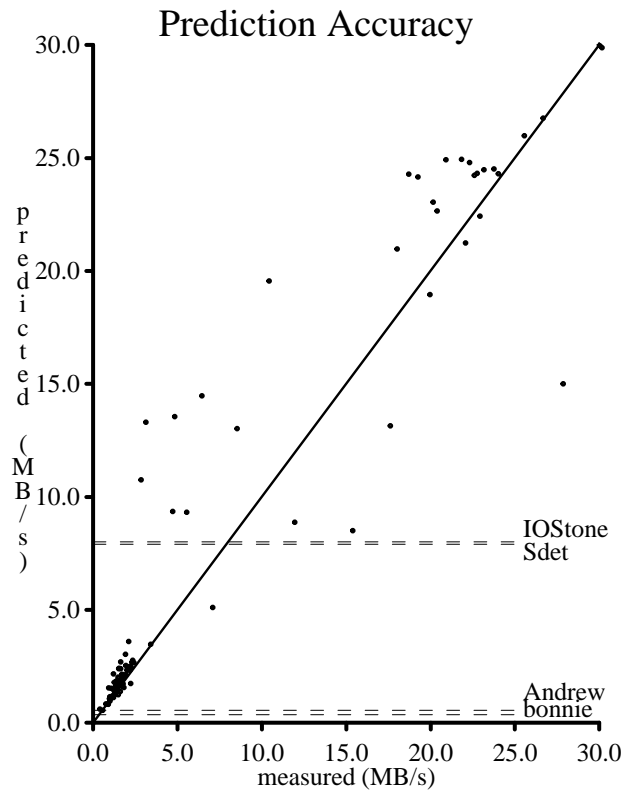
(u)



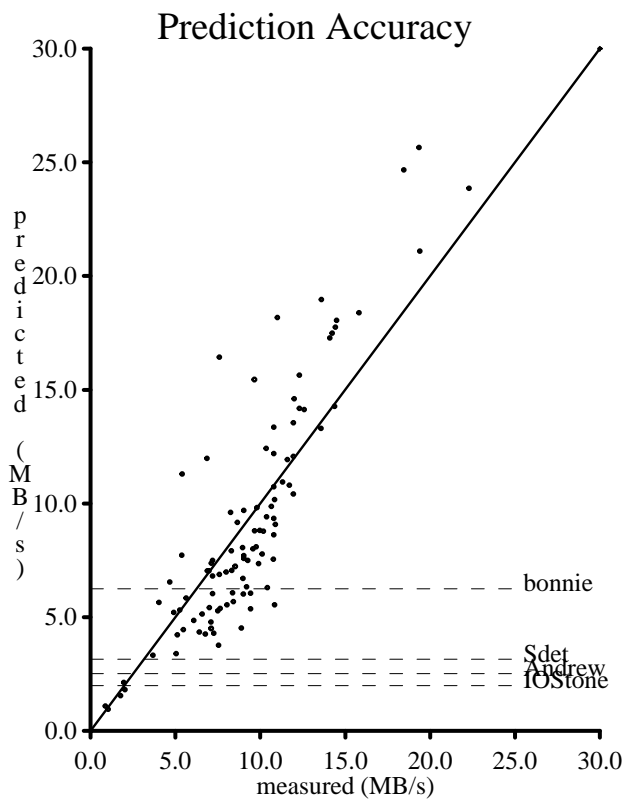
Prediction Accuracy



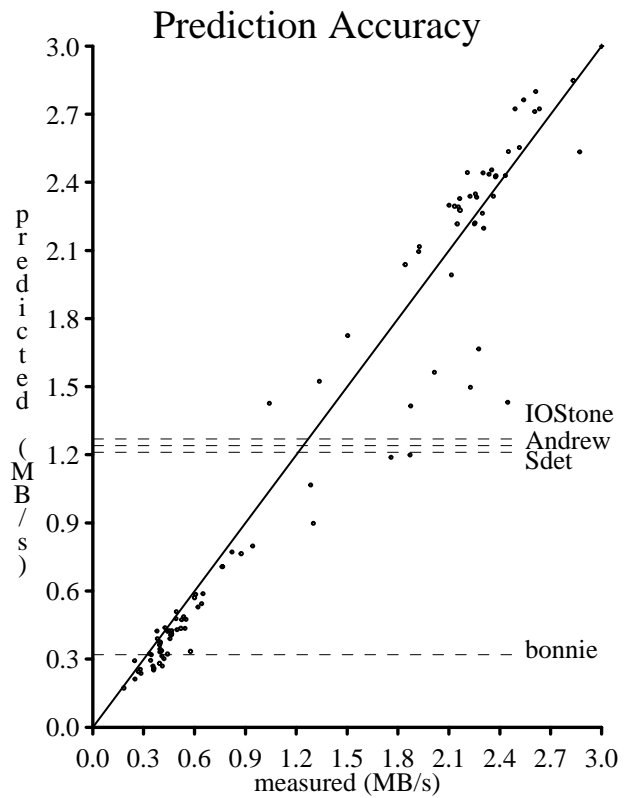
(a) DECstation 5000/200



(b) HP 730



(c) Convex C240



Sparc 1