MADALGO
CENTER FOR MASSIVE DATA ALGORITHMICS


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On Computational Models for Flash Memory Devices

Motivation

Flash memories

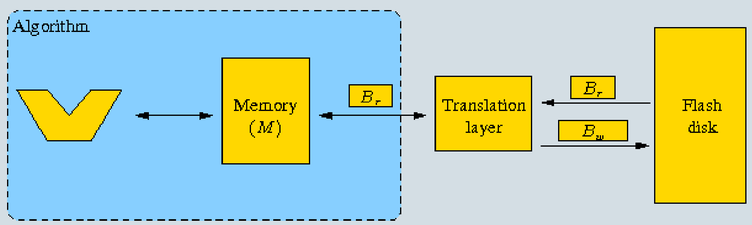
Between RAM memories and hard disks:

- are fast becoming the dominant storage on mobile computing
- have already replaced traditional hard disks on some devices

Characteristic	RAM	Flash	Hard disk
Volatile	Yes	No	No
Shock resistant	Yes	Yes	No
Physical size	Small	Small	Large
Storage capacity	Small	Large	Very large
Energy consumption	-	Medium	High
Price	Very high	Medium	Very cheap

Translation Layer (TL)

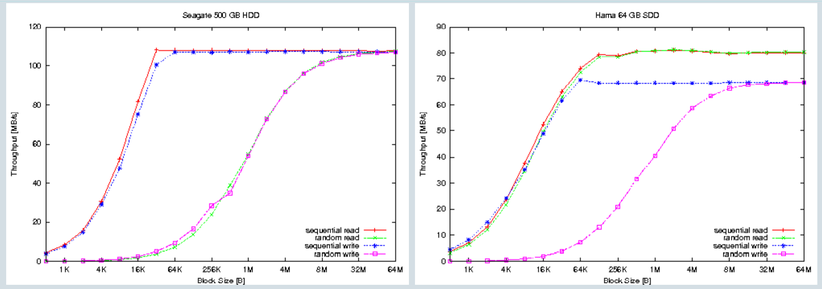
The algorithm uses the same block size (*Br*) for reads and writes, similar to the I/O-model



The translation layer:

- groups *Br*-sized blocks and writes *Bw*-sized blocks oblivious to algorithm
- accommodates the model (read block size *Br*, write block size *Bw*)

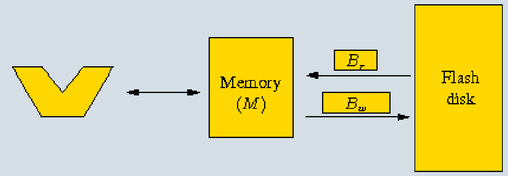
Hard Disks (HDD) vs Flash Disks (SSD)



Read/write blocks of data of size *B* randomly and sequentially

- HDDs, throughput provided by reads and writes is the same
- SSDs, results show that reads and writes are also done in blocks, but block size for reading is smaller than the block size for writing

Unit-cost Model



Memory of size *M* , infinite flash disk, block transfers of consecutive data

Reads in blocks of size *Br*, writes in blocks of size *Bw*

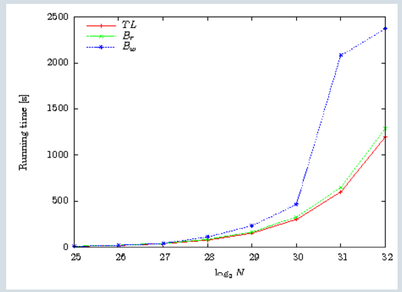
Cost of an algorithm: #items transferred. For *r* reads and *w* writes,

$$\text{cost} = r \cdot B_r + w \cdot B_w$$

Many existent algorithms in the I/O-model are easy to adapt in this model

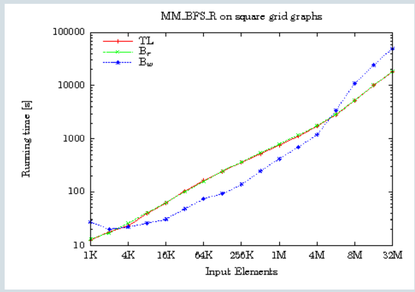
Experimental Results on Solid-State Disks

External Memory Sorting



Only sequential I/Os

External memory BFS



Mixed sequential and random I/Os

Naïve DFS (textbook algorithm)

#vertices	TL	*Br*	*Bw*
262,144	0.218039	0.219124	1.10229
1,048,576	0.925051	0.958422	1.73248
4,194,304	3879.14	4641.21	>20000
16,777,216	54465.7	>1 day	>1 day

Mostly random I/Os

Discussion

- Smallest running times are achieved in all cases when using the translation layer!
- As predicted by the unit-cost model, buffering *Br*-sized read blocks into *Bw*-sized write blocks improves the performance

Conclusion

- The unit-cost model is validated by experimental results

References

Deepak Ajwani, Andreas Beckmann, Riko Jacob, Ulrich Meyer and Gabriel Moruz. *On Computation Models for Flash Memory Devices*. 2009