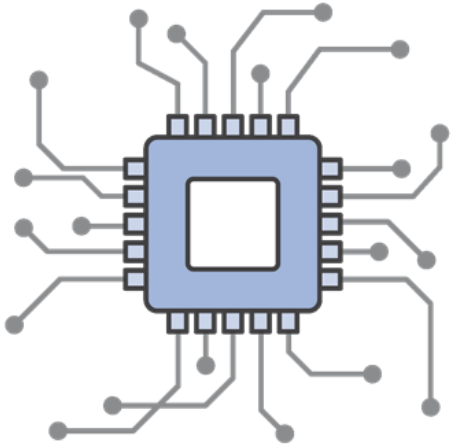
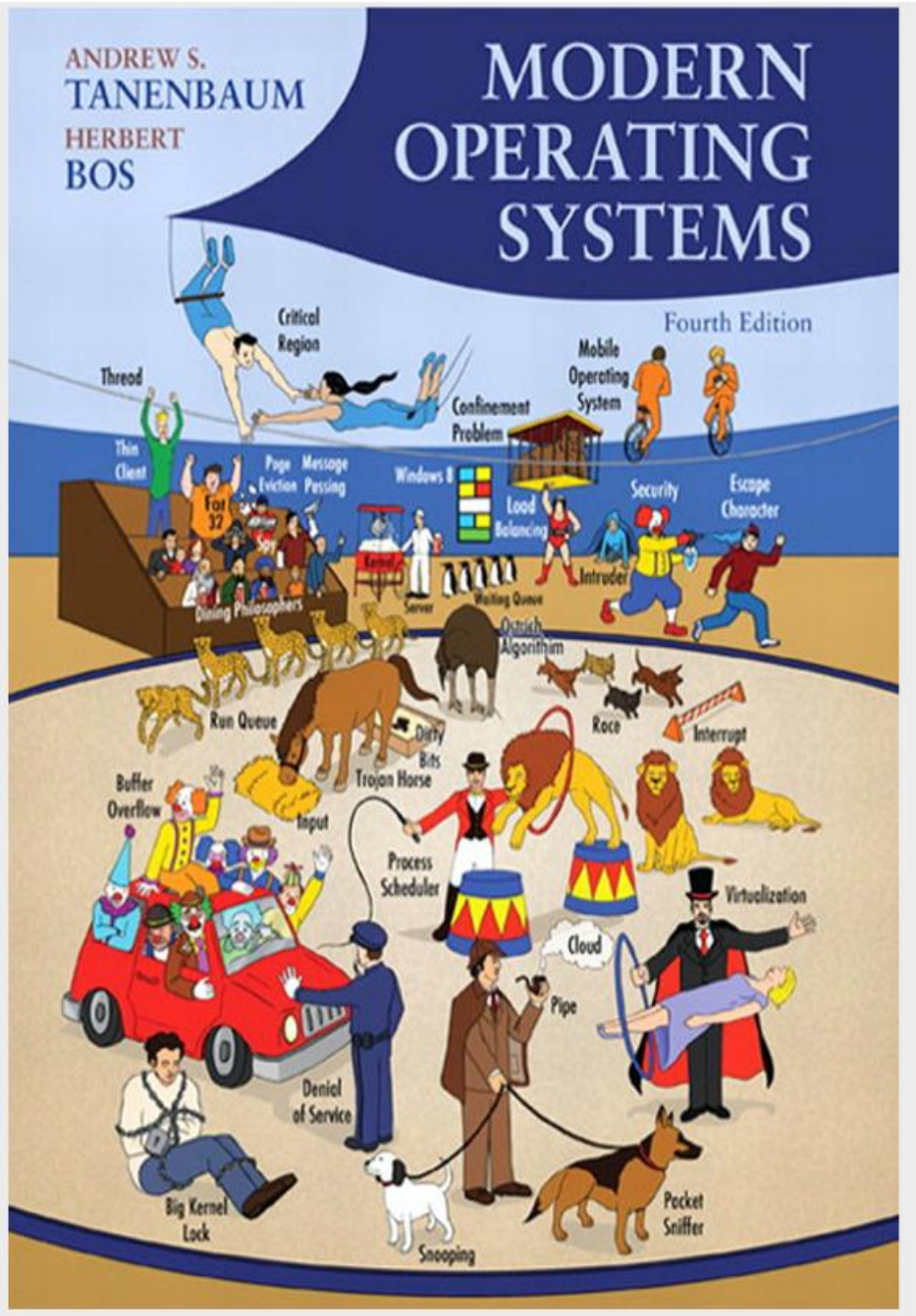


Large HDD
How long does it take to read a 1 TB ?

Question ?

- How long does it take to read a 1 TB ?
- How many bytes is a Terra Byte ?

A.S.T


ANDREW S.
TANENBAUM
HERBERT
BOS
MODERN
OPERATING
SYSTEMS
Fourth Edition
Critical Region
Thread
Mobile Operating System
Confinement Problem
Thin Client
Page Eviction
Message Passing
Windows 8
Fax 32
Load Balancing
Security
Escape Character
Intruder
Dining Philosophers
Server
Waiting Queue
Ostrich Algorithm
Run Queue
Race
Interrupt
Dirty Bits
Trojan Horse
Buffer Overflow
Input
Process Scheduler
Virtualization
Cloud
Pipe
Denial of Service
Big Kernel Lock
Snooping
Pocket Sniffer

A.S.T Memory Cost Per Bit (CPB)

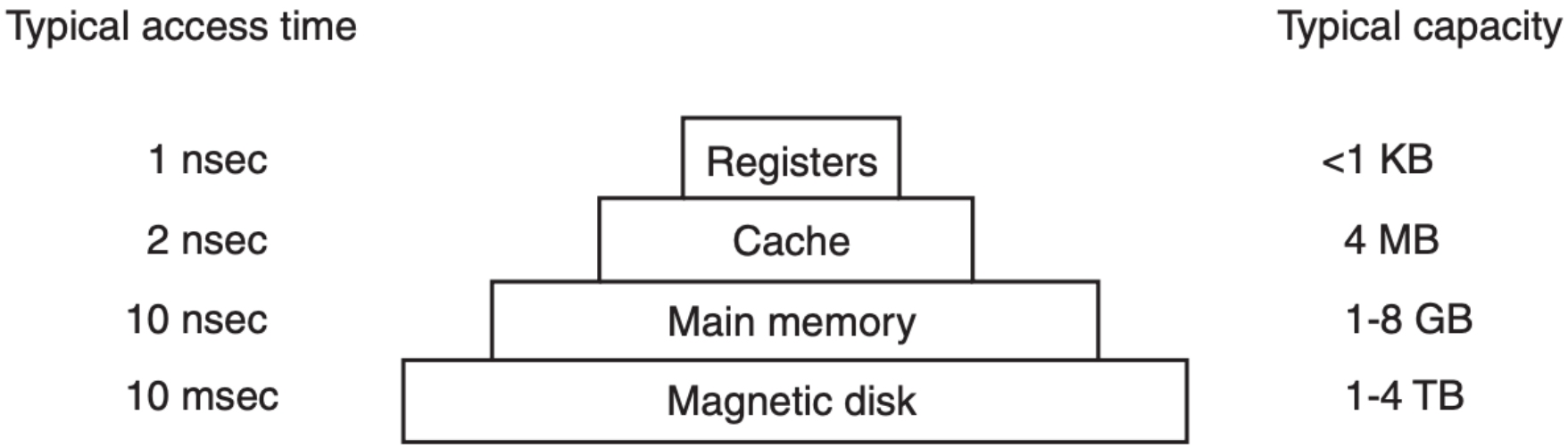


Figure 1-9. A typical memory hierarchy. The numbers are very rough approximations.

A.S.T Memory Cost Per Bit (CPB)

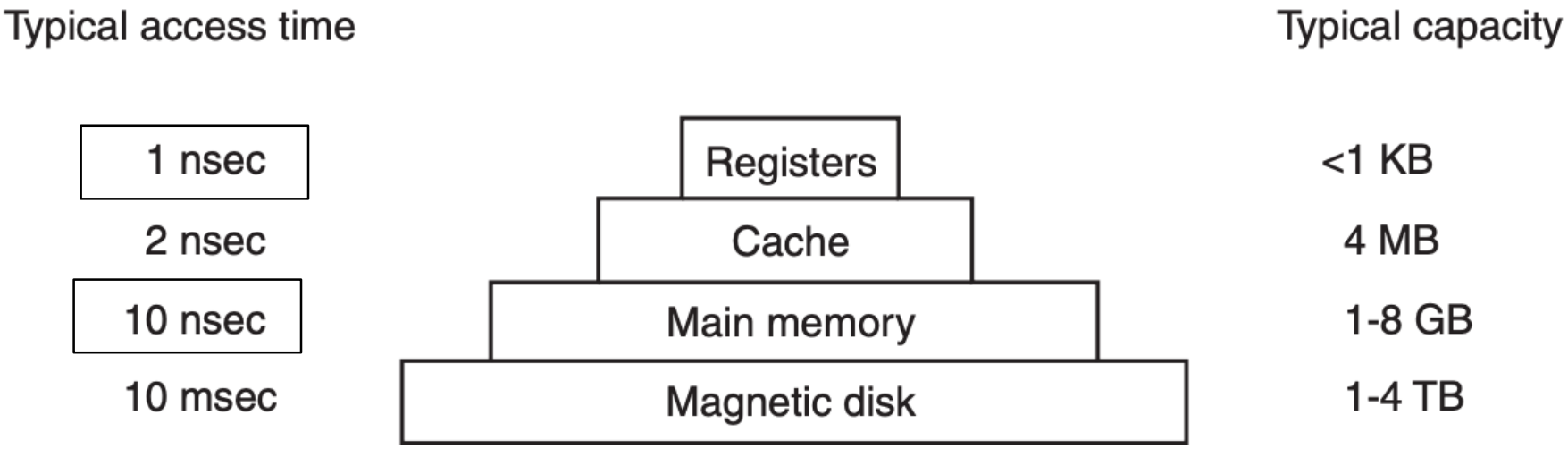


Figure 1-9. A typical memory hierarchy. The numbers are very rough approximations.

Registers <=> Memory

CPU and memory

CPU

Address Register

ALU

Data Register

24 bits

Address Bus

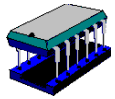
32 bits

Data Bus

Memory

0x00000001
0x00000002
0x00000003
0x00000004
0x00000005
0x00000006
0x00000007
0x00000008
0x00000009
0x0000000A
0x0000000B
0x0000000C
0x0000000D
0x0000000E
0x0000000F
0x00000010
0x00000011
0x00000012
0x00000013
0x00000014
0x00000015
0x00000016
0x00000017
0x00000018
0x00000019
0x0000001A
0x0000001B
0x0000001C
0x0000001D
0x0000001E
0x0000001F
0x00000020
0x00000021

1/10



A.S.T Memory Cost Per Bit (CPB)

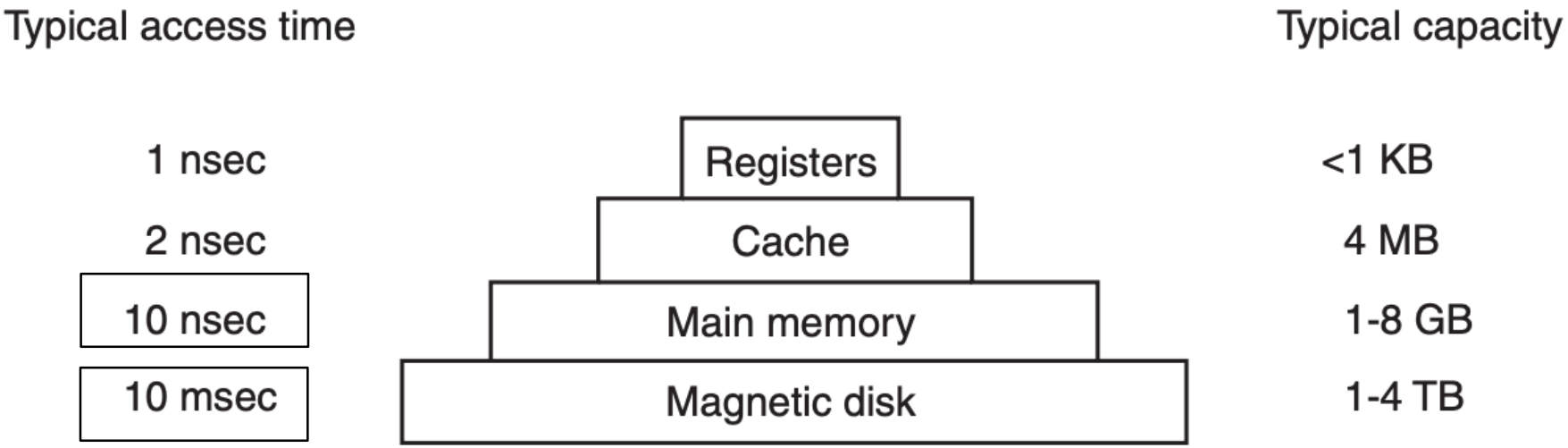
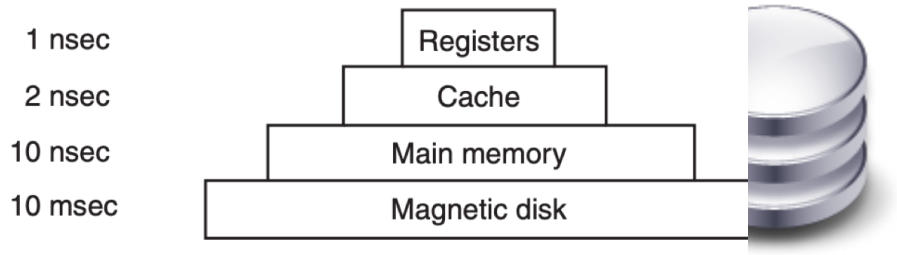


Figure 1-9. A typical memory hierarchy. The numbers are very rough approximations.

Memory <=> Magnetic Disk

A.S.T METRIC UNITS



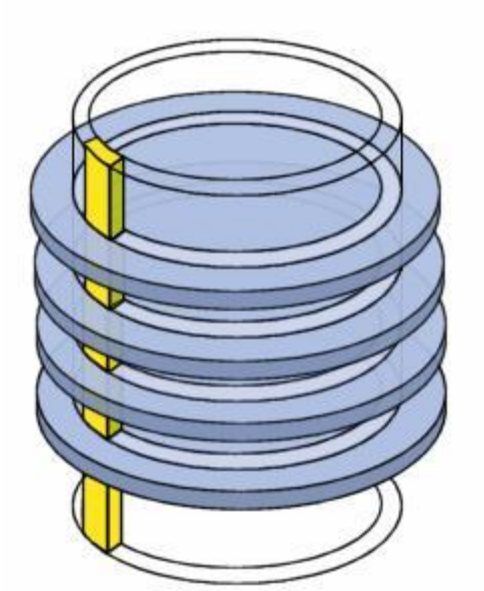
Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

Figure 1-31. The principal metric prefixes.

Memory Disk Access Time Ratio

Disk

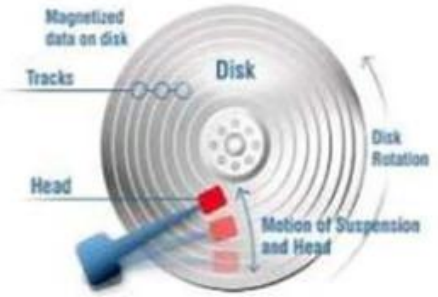
Memory



1 000 000

A.S.T : 100-150 MB/sec

SSD VS HDD



Comparison Chart	SSD	HDD
Mechanism	Solid NAND Flash	Magnetic rotating platters
Speed (SATA II)	80-250MB/sec	65-85MB/sec
Average Seek Time	0	< 10 ms
Noise	None	Noisy
Power consumption	2W>, Low power consumption	10W, Generates more heat
Weight	Lightweight	Heavier
Endurance	MTBF > 2,000,000 Hours	MTBF < 700,000 Hours
Temperature	-40 ~ 85	0 ~ 60
Reliability	Anti-shock	Non-shock resistant
Shock & Vibration	Excellent	Poor

Large number googol

- How many bytes is a Terra Byte ?

- BackRub became Google from « googol » 1 leading 100 zeros.

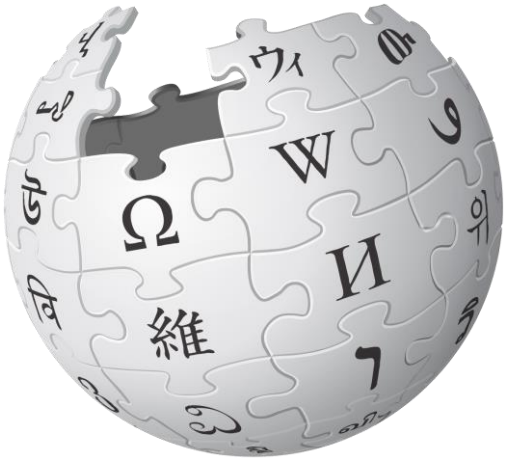
International System of Units Metric Prefix

- The International System of Units (SI, abbreviated from the French Système international (d'unités)) is the modern form of the metric system. It is the only system of measurement with an official status in nearly every country in the world.

- The SI prefixes are metric prefixes that were standardized for use in the International System of Units (SI) by the International Bureau of Weights and Measures (BIPM) in resolutions dating from 1960 to 1991.

Préfixes du Système international d'unités

- Les préfixes du Système international d'unités simplifient la manipulation des valeurs numériques de grandeurs physiques qui sont beaucoup plus petites ou beaucoup plus grandes que l'unité officielle.
- Ces préfixes désignent des multiples ou des fractions de 10 ou de 1 000.



International System of Units Metric Prefix

1000^m	10^n	Metric Prefix		Value in positional notation	Long Scale
		Prefix	Symbol		Name
1000^1	10^3	Kilo	k	1,000	Thousand
1000^2	10^6	Mega	M	1,000,000	Million
1000^3	10^9	Giga	G	1,000,000,000	Milliard
1000^4	10^{12}	Tera	T	1,000,000,000,000	Billion
1000^5	10^{15}	Peta	P	1,000,000,000,000,000	Billiard
1000^6	10^{18}	Exa	E	1,000,000,000,000,000,000	Trillion
1000^7	10^{21}	Zetta	Z	1,000,000,000,000,000,000,000	Trilliard
1000^8	10^{24}	Yotta	Y	1,000,000,000,000,000,000,000,000	Quadrillion

Long and short scales

Value in positional notation	Short Scale		Long Scale		
	Name	Logic	Name	Alternative Name	Logic
1,000	Thousand		Thousand		
1,000,000	Million	1,000 x 1,000 [1]	Million		1,000,000 [1]
1,000,000,000	Billion	1,000 x 1,000 [2]	Thousand Million	Milliard	1,000 x 1,000,000 [1]
1,000,000,000,000	Trillion	1,000 x 1,000 [3]	Billion		1,000,000 [2]
1,000,000,000,000,000	Quadrillion	1,000 x 1,000 [4]	Thousand Billion	Billiard	1,000 x 1,000,000 [2]
1,000,000,000,000,000,000	Quintillion	1,000 x 1,000 [5]	Trillion		1,000,000 [3]
1,000,000,000,000,000,000,000	Sextillion	1,000 x 1,000 [6]	Thousand Trillion	Trilliard	1,000 x 1,000,000 [3]
1,000,000,000,000,000,000,000,000	Septillion	1,000 x 1,000 [7]	Quadrillion		1,000 x 1,000,000 [4]

How long does it take to read a 1 TB ?
100 MB/s

				Quantity Read By Second
10^n	Metric Prefix		Value in positional notation	Time
				1 s
	Name	Symbol		1 s
10^3	kilobyte	kB	1 000	100 000 kB
10^6	megabyte	MB	1 000 000	100 MB
10^9	gigabyte	GB	1 000 000 000	0
10^{12}	terabyte	TB	1 000 000 000 000	0
10^{15}	petabyte	PB	1 000 000 000 000 000	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0

How long does it take to read a 1 TB ? 100 MB/s

				Quantity Read By Second	
10^n	Metric Prefix		Value in positional notation	Time	
				1 s	10 s
	Name	Symbol		1 s	10 s
10^3	kilobyte	kB	1 000	100 000 kB	1 000 000 kB
10^6	megabyte	MB	1 000 000	100 MB	1 000 MB
10^9	gigabyte	GB	1 000 000 000	0	1 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0

How long does it take to read a 1 TB ?
100 MB/s

				Quantity Read By Second		
10^n	Metric Prefix		Value in positional notation	Time		
				1 s	10 s	1 h 00 mn
	Name	Symbol		1 s	10 s	3 600 s
10^3	kilobyte	kB	1 000	100 000 kB	1 000 000 kB	360 000 000 kB
10^6	megabyte	MB	1 000 000	100 MB	1 000 MB	360 000 MB
10^9	gigabyte	GB	1 000 000 000	0	1 GB	360 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0	,360 TB
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0	0

How long does it take to read a 1 TB ?
100 MB/s

				Quantity Read By Second			
10^n	Metric Prefix		Value in positional notation	Time			
				1 s	10 s	1 h 00 mn	2 h 00 mn
	Name	Symbol		1 s	10 s	3 600 s	7 200 s
10^3	kilobyte	kB	1 000	100 000 kB	1 000 000 kB	360 000 000 kB	720 000 000 kB
10^6	megabyte	MB	1 000 000	100 MB	1 000 MB	360 000 MB	720 000 MB
10^9	gigabyte	GB	1 000 000 000	0	1 GB	360 GB	720 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0	,360 TB	,720 TB
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0	0	0

How long does it take to read a 1 TB ? 100 MB/s

				Quantity Read By Second				
10^n	Metric Prefix		Value in positional notation	Time				
				1 s	10 s	1 h 00 mn	2 h 00 mn	2 h 30 mn
	Name	Symbol		1 s	10 s	3 600 s	7 200 s	9 000 s
10^3	kilobyte	kB	1 000	100 000 kB	1 000 000 kB	360 000 000 kB	720 000 000 kB	900 000 000 kB
10^6	megabyte	MB	1 000 000	100 MB	1 000 MB	360 000 MB	720 000 MB	900 000 MB
10^9	gigabyte	GB	1 000 000 000	0	1 GB	360 GB	720 GB	900 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0	,360 TB	,720 TB	,900 TB
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0	0	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0	0	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0	0	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0	0	0	0

How long does it take to read a 1 TB ? 100 MB/s

				Quantity Read By Second					
10^n	Metric Prefix		Value in positional notation	Time					
				1 s	10 s	1 h 00 mn	2 h 00 mn	2 h 30 mn	2 h 46 mn 40 s
	Name	Symbol		1 s	10 s	3 600 s	7 200 s	9 000 s	10 000 s
10^3	kilobyte	kB	1 000	100 000 kB	1 000 000 kB	360 000 000 kB	720 000 000 kB	900 000 000 kB	1 000 000 000 kB
10^6	megabyte	MB	1 000 000	100 MB	1 000 MB	360 000 MB	720 000 MB	900 000 MB	1 000 000 MB
10^9	gigabyte	GB	1 000 000 000	0	1 GB	360 GB	720 GB	900 GB	1 000 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0	,360 TB	,720 TB	,900 TB	1,000 TB
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0	0	0	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0	0	0	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0	0	0	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0	0	0	0	0

How long does it take to read a 1 TB ?
150 MB/s

				Quantity Read By Second					
10^n	Metric Prefix		Value in positional notation	Time					
				1 s	10 s	1 h 00 mn	1 h 30 mn	1 h 51 mn 07 s	2 h 00 mn
	Name	Symbol		1 s	10 s	3 600 s	5 400 s	6 667 s	7 200 s
10^3	kilobyte	kB	1 000	150 000 kB	1 500 000 kB	540 000 000 kB	810 000 000 kB	1 000 000 000 kB	1 080 000 000 kB
10^6	megabyte	MB	1 000 000	150 MB	1 500 MB	540 000 MB	810 000 MB	1 000 000 MB	1 080 000 MB
10^9	gigabyte	GB	1 000 000 000	0	2 GB	540 GB	810 GB	1 000 GB	1 080 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0	,540 TB	,810 TB	1,000 TB	1,080 TB
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0	0	0	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0	0	0	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0	0	0	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0	0	0	0	0

How long does it take to read a 1 TB ? 200 MB/s

				Quantity Read By Second				
10^n	Metric Prefix		Value in positional notation	Time				
				1 s	10 s	1 h 00 mn	1 h 23 mn 20 s	2 h 30 mn
	Name	Symbol		1 s	10 s	3 600 s	5 000 s	9 000 s
10^3	kilobyte	kB	1 000	200 000 kB	2 000 000 kB	720 000 000 kB	1 000 000 000 kB	1 800 000 000 kB
10^6	megabyte	MB	1 000 000	200 MB	2 000 MB	720 000 MB	1 000 000 MB	1 800 000 MB
10^9	gigabyte	GB	1 000 000 000	0	2 GB	720 GB	1 000 GB	1 800 GB
10^{12}	terabyte	TB	1 000 000 000 000	0	0	,720 TB	1,000 TB	1,800 TB
10^{15}	petabyte	PB	1 000 000 000 000 000	0	0	0	0	0
10^{18}	exabyte	EB	1 000 000 000 000 000 000	0	0	0	0	0
10^{21}	zettabyte	ZB	1 000 000 000 000 000 000 000	0	0	0	0	0
10^{24}	yottabyte	YB	1 000 000 000 000 000 000 000 000	0	0	0	0	0

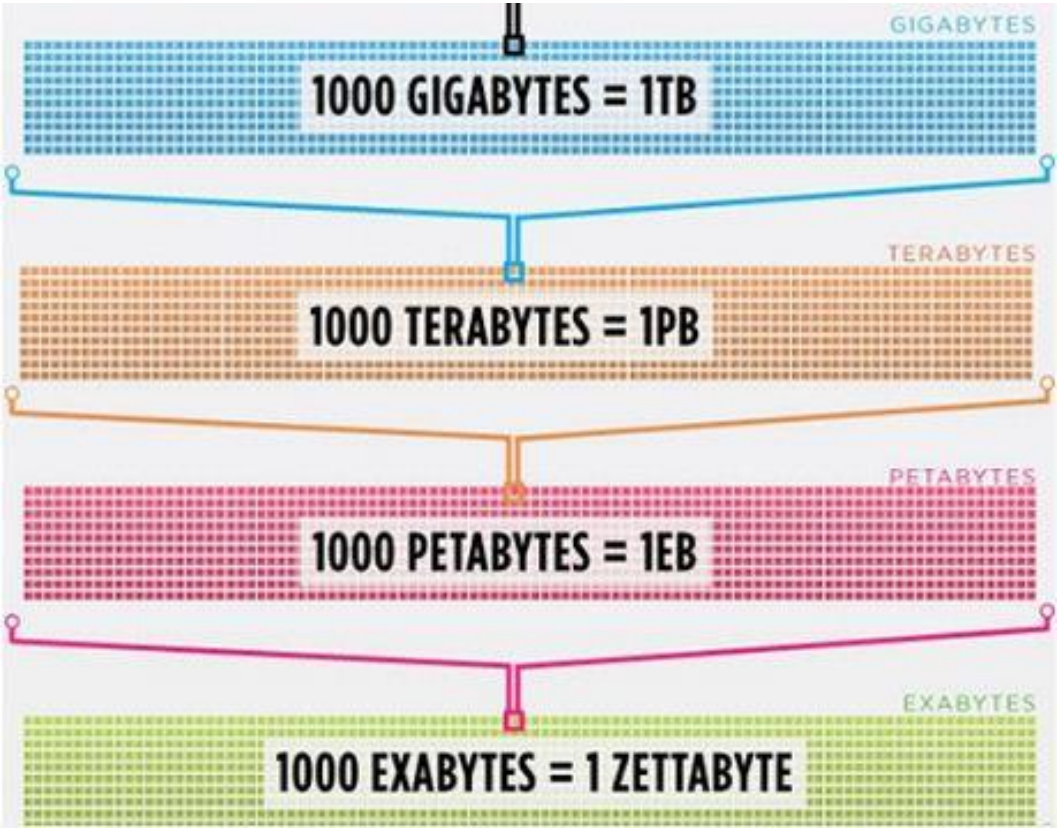
How long does it take to read a 1 TB ?

Data transfer rate	Time
100 MB/s	2 h 46 mn 40 s
150 MB/s	1 h 51 mn 07 s
200 MB/s	1 h 23 mn 20 s

Technology limit

- Today Reading 1 Terra = 3 hours.

- 100 Mbytes/Second



How to search item in a TB in less than 10 seconds ?

How to search item in a TB in less than 10 seconds ?

Data transfer rate	Time	Second	Searching Time	#HDD
100 MB/s	2 h 46 mn 40 s	10 000 s	10 s	1000
150 MB/s	1 h 51 mn 07 s	6 667 s	10 s	666,7
200 MB/s	1 h 23 mn 20 s	5 000 s	10 s	500

How to search item in a TB in less than 10 seconds ?

Data transfer rate	Time	Second	Searching Time	#HDD
100 MB/s	2 h 46 mn 40 s	10 000 s	10 s	1000
150 MB/s	1 h 51 mn 07 s	6 667 s	10 s	666,7
200 MB/s	1 h 23 mn 20 s	5 000 s	10 s	500

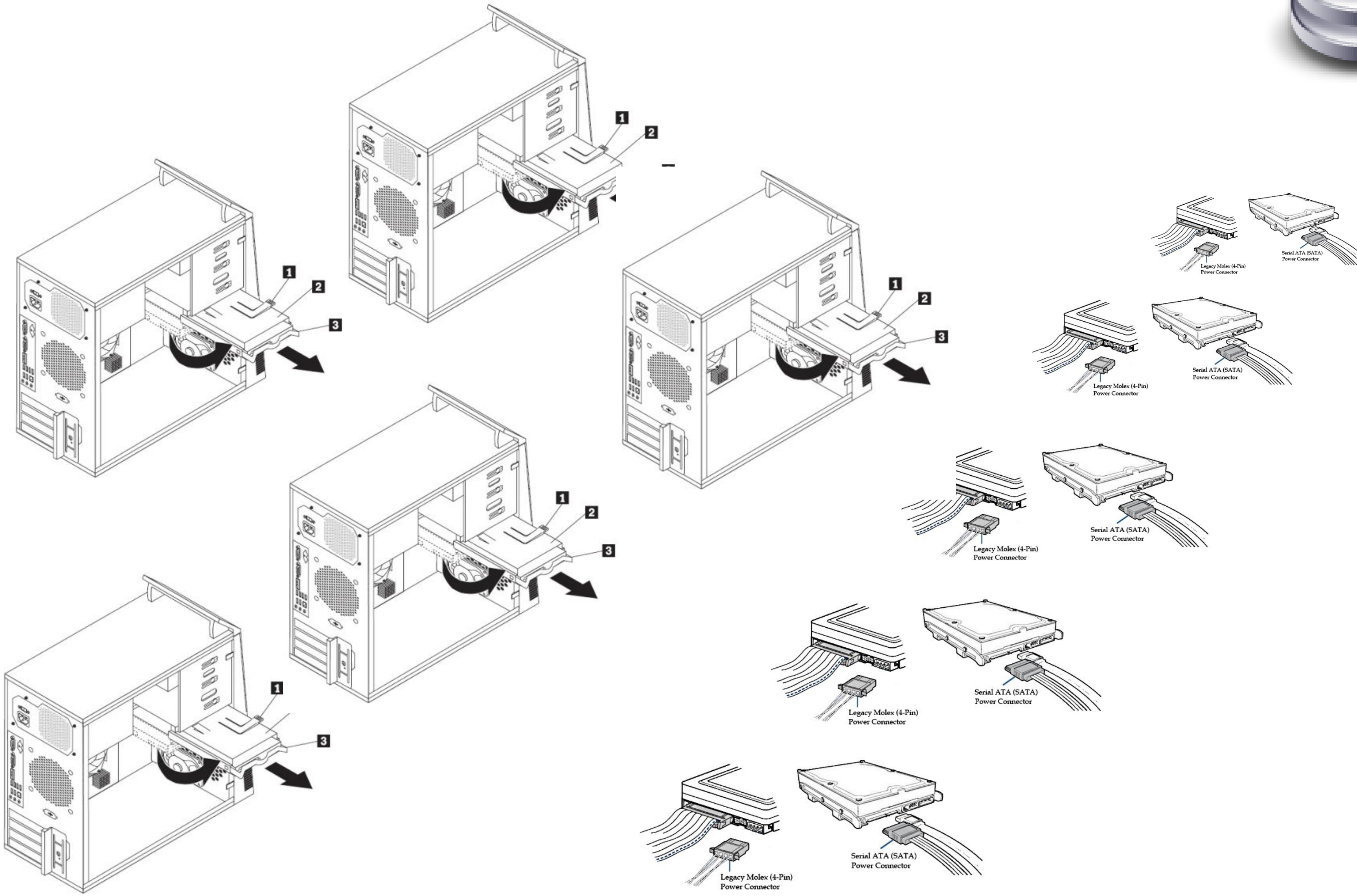
1 000 000 000 000	1 TB
1 000 000 000	1 GB

1000 1 GB HDD

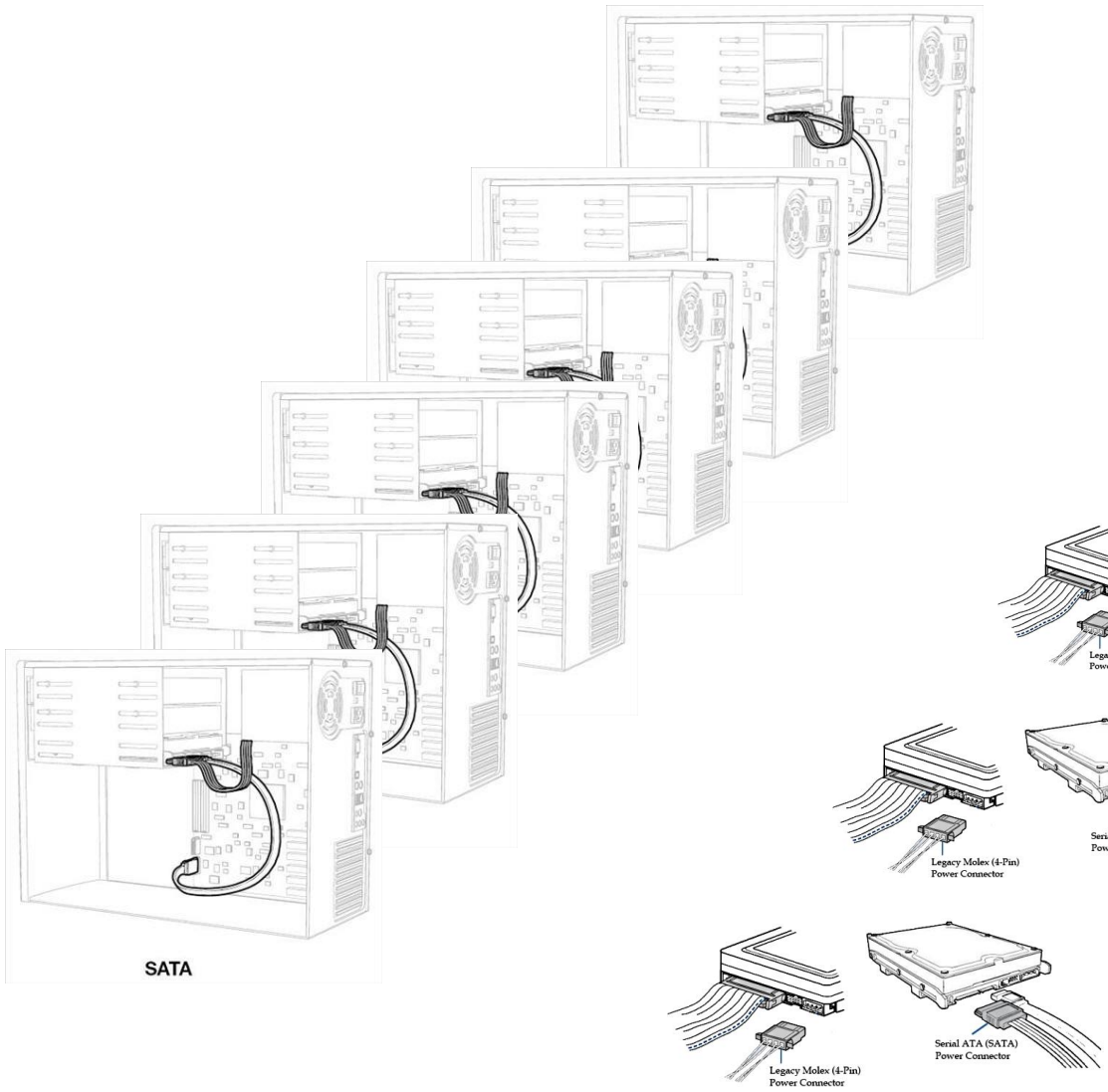

PULL


RELEASE

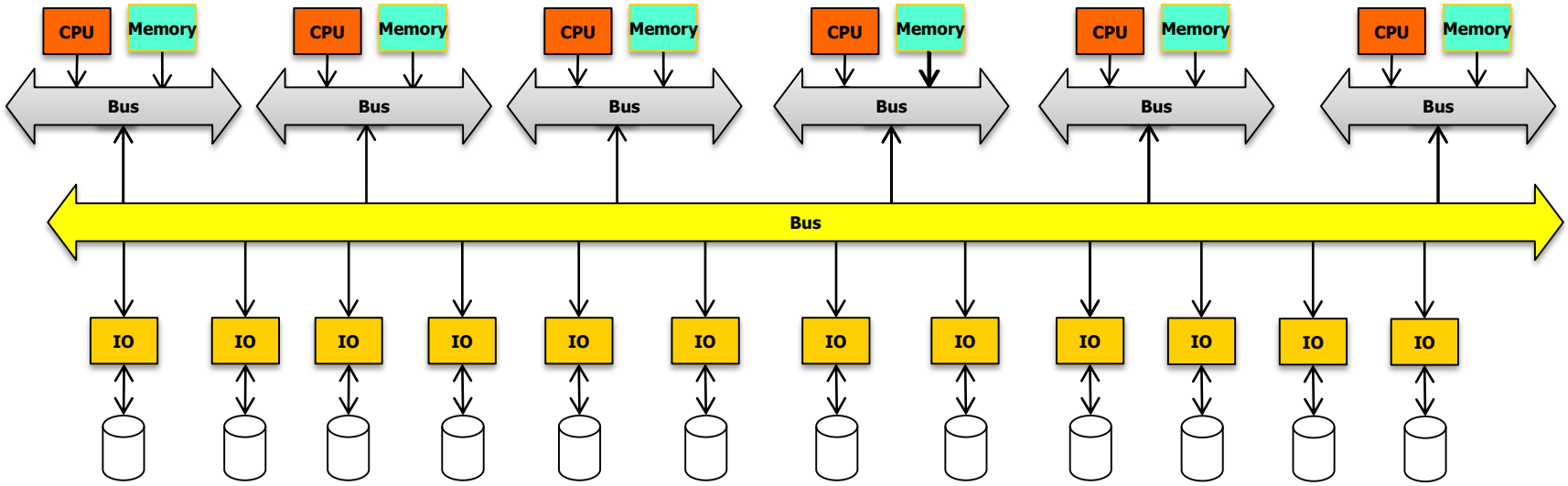
Commodity Computer



Commodity Computer



Horizontal Scalability : Shared Disk



Storage capacity

- Storage capacity has grown exponentially but read speed has not kept up.
- 1990:
  - Store 1,400 MB
  - Transfer speed of 4.5 MB/s
  - Read the entire drive in ~ 5 minutes
- 2010:
  - Store 1 TB
  - Transfer speed of 100 MB/s
  - Read the entire drive in ~ 3 hours

Storage capacity

- Split data on multiple disks

- 1000 drives working at 100 MB/s can read 1TB of data in 10 seconds