http://arnaud-nauwynck.github.io

Big Data

History, Hardware-Software evolution

To

Distributed Computing

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Big Data ...

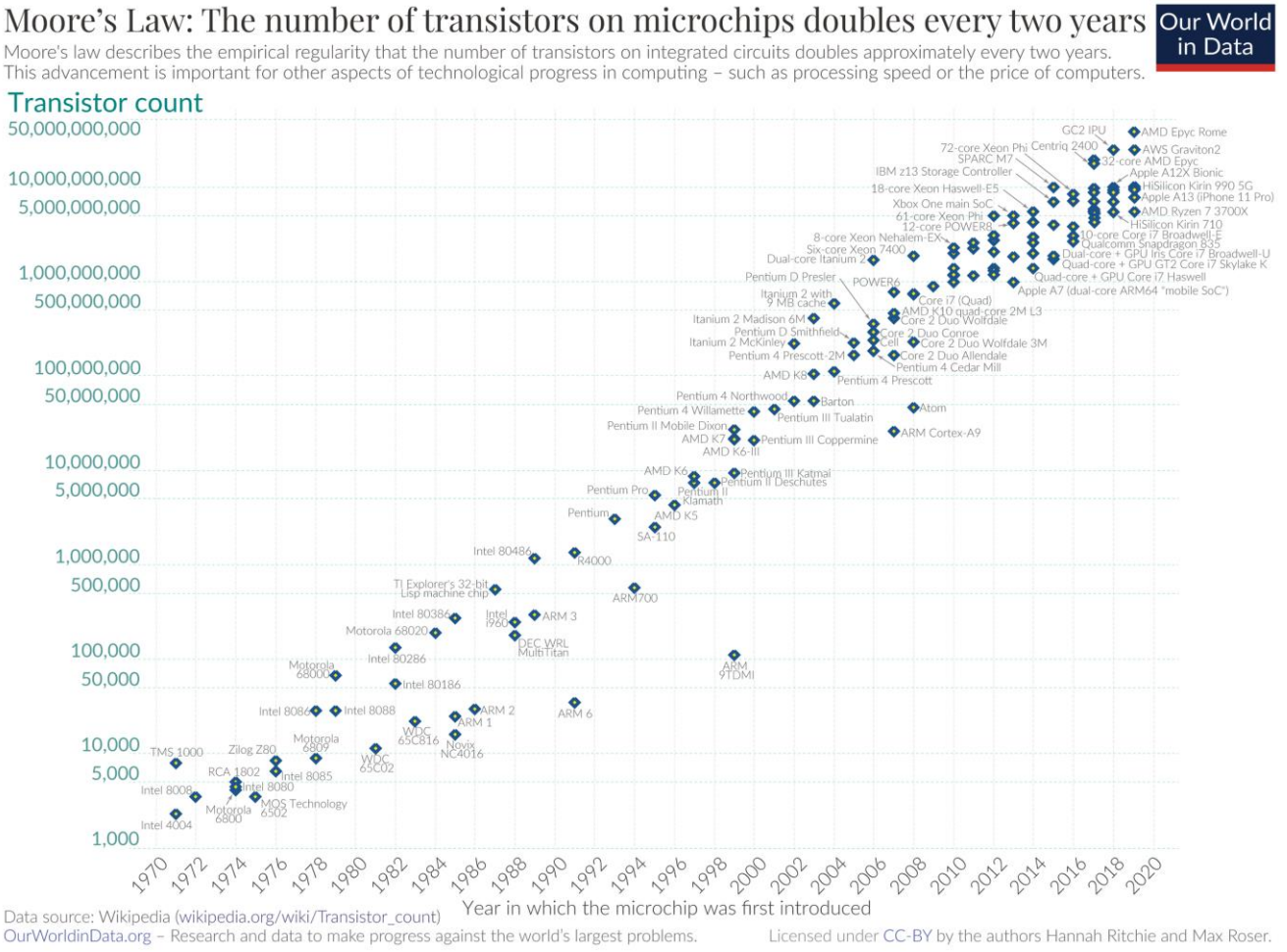
Big? is Time-relative

cell phone (in 2021) >= 1000x "more"

than Appolo moon
guidance computer (1968)

Moore’s Laws

Gordon Moore in 1965



MOSFET scaling (process nodes)

10 µm – 1971
6 µm – 1974
3 µm – 1977
1.5 µm – 1981
1 µm – 1984
800 nm – 1987
600 nm – 1990
350 nm – 1993
250 nm – 1996
180 nm – 1999
130 nm – 2001
90 nm – 2003
65 nm – 2005
45 nm – 2007
32 nm – 2009
22 nm – 2012
14 nm – 2014
10 nm – 2016
7 nm – 2018
5 nm – 2020

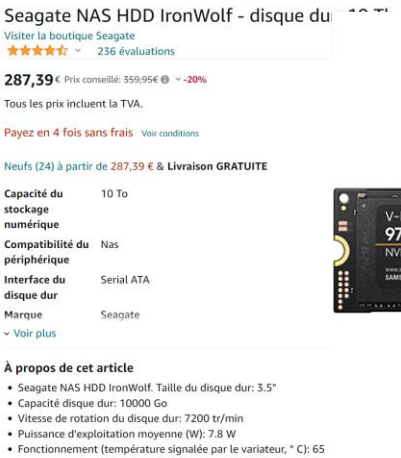
Future

3 nm ~ 2022

Kryder’s « Law »

density & capability of hard drive storage **~ *2 every 13 months**

HDD: 2To in 2011



HDD: 10To in 2021 (~300 euros)

SSD: 2To in 2021 (~250 euros)

Density…

48 * HDD disks in 2U blade

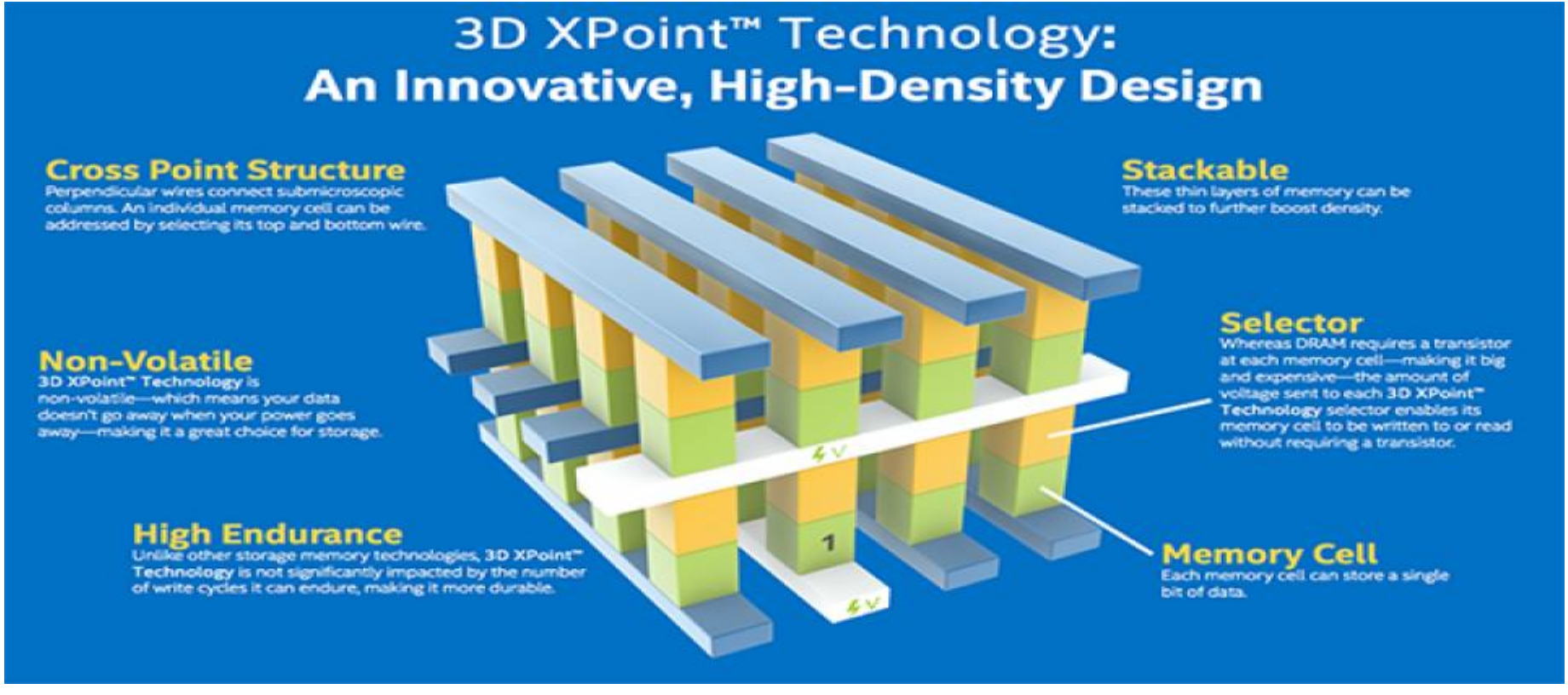
32 * SSD (E.1 EDSFF) in 1U blade

… 500 Tera / 1 Peta !! … 200 000 euros

SCM: Storage Class Memory

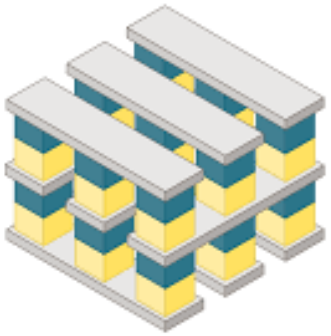
persistent + fast

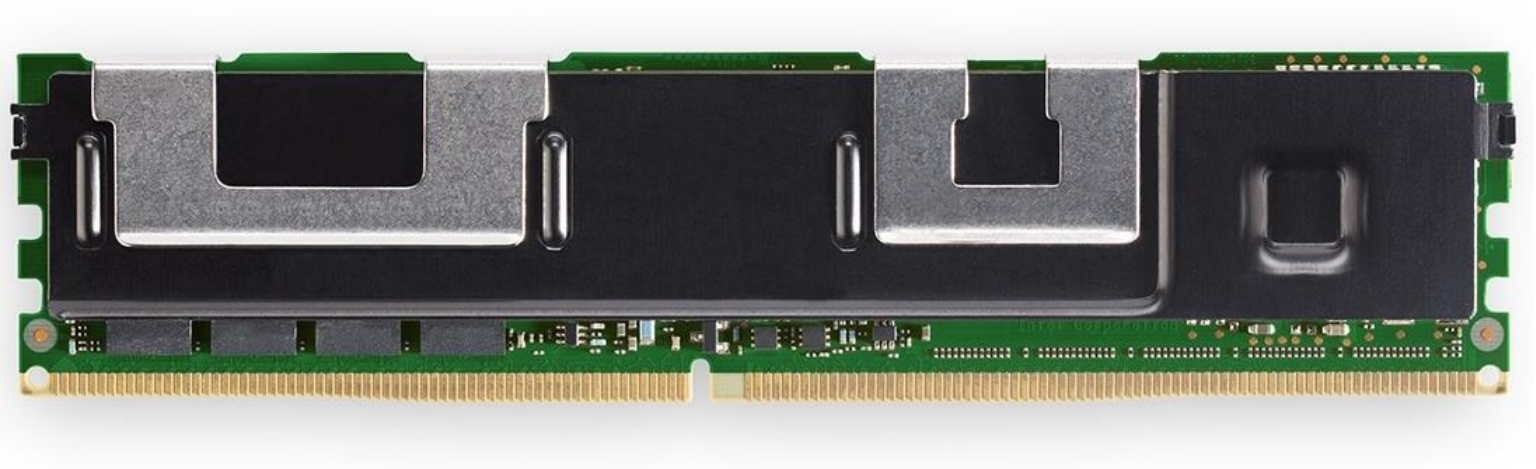
Compromise NDRAM <-> SSD



3D - Intel Optane

No transistors … changed of state (resistance)
in 3D stacks



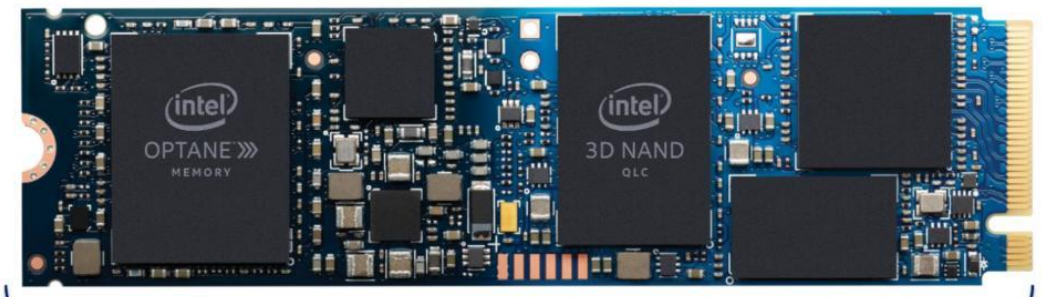


10x faster (*more expensive) than SSD
Slower (cheaper) than DDR4 RAM

⇒ For server up to 3To fast & persistent memory…
⇒ ~ 12 000 $ / 1 To

NAND (SSD) + Optane as Cache

INTEL® OPTANE™ MEMORY H10 WITH SOLID STATE STORAGE



Single device fits in small spaces with its versatile M.2 form factor designed for mobile device and desktops

INTEL® OPTANE™ TECHNOLOGY

- Accelerate your PC with breakthrough responsiveness so you can search and find files faster, and launch applications quicker
- Conquer storage-demanding applications with smart software that automatically learns your computing behaviors to accelerate frequent tasks

INTEL® QLC 3D NAND TECHNOLOGY

- Get up to 1TB of storage capacity with an Intel® QLC 3D NAND SSD into a smaller footprint
- Transfer data at PCIe* speeds, unleashing the full power of QLC, and getting from data to productivity faster

Memory & Disk Technologies Disruptions

RAM

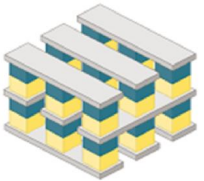
HDD

Tape

~2015
Switch HDD / SSD

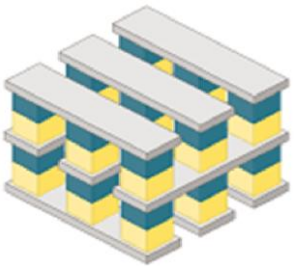
SSD (since 1991)

SCM - 3D Xpoint



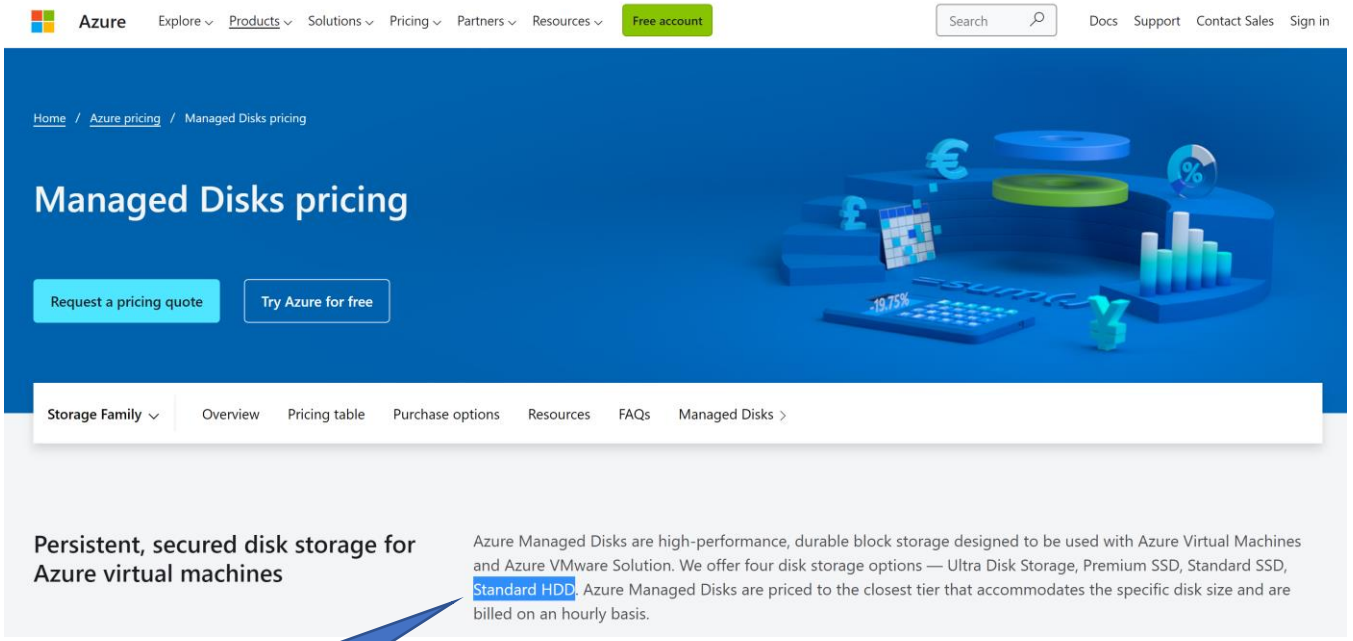
(since 2017)

future
switch??



Next switch ??
> 2022

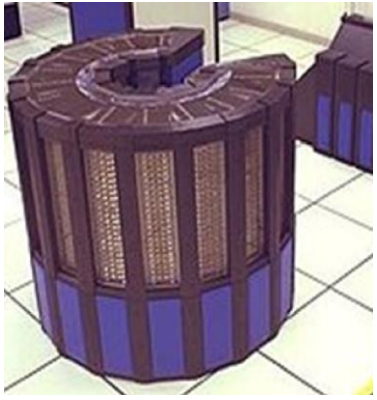
Example HDD -> SSD



???
No more HDD Hardwares in Azure DataCenters !!!!

HDD are emulated « throttled »
From SSD
For lower perf … lower billed

Vertical -> Horyzontal Scaling
Disruptions of DataCenters



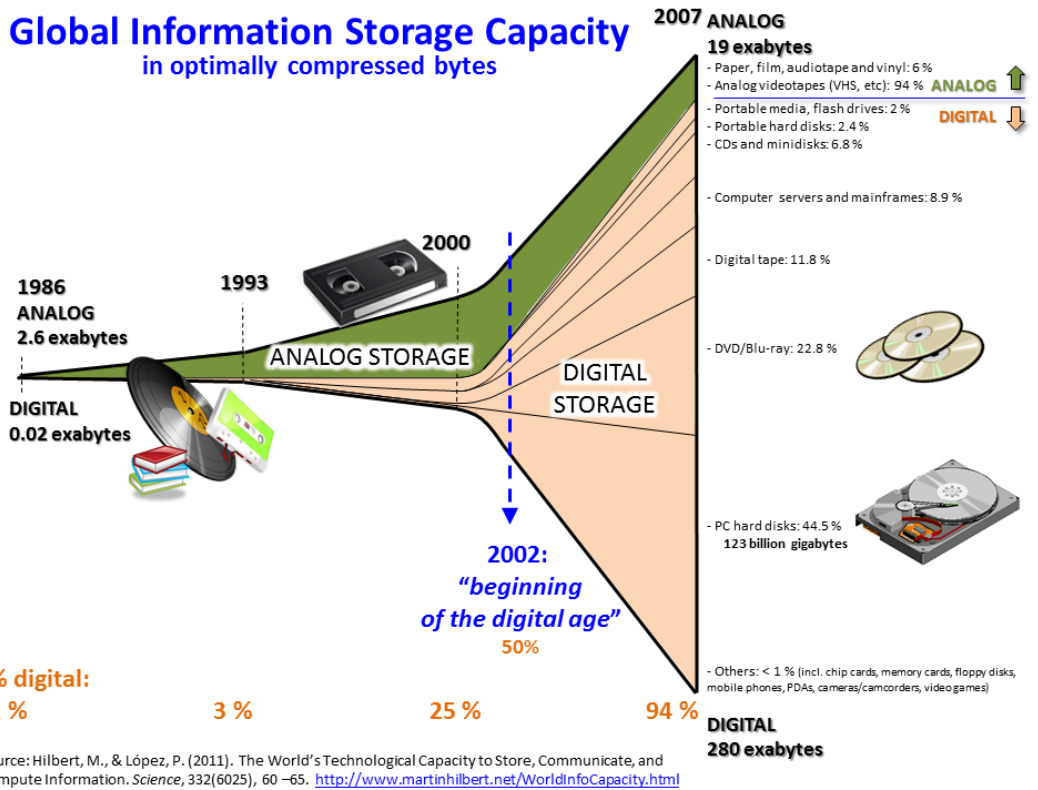
Hardwares:
Super-Computer
« Crays »

1980 : PC

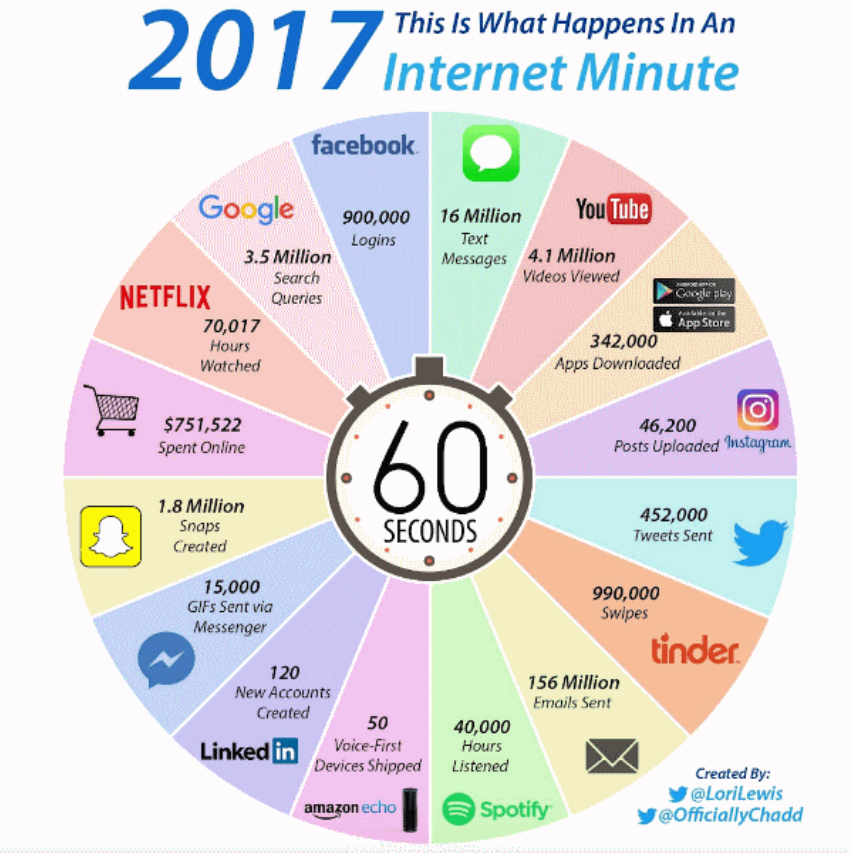
Hardwares:
Distributed (DataCenters)

« Blade » commodity hardwares

Data,Data,Data = DataCenters



Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html



how many petabytes of data does google have

All News Images Shopping Videos More Tools

About 971,000 results (0.49 seconds)

1,200 petabytes

Science Focus estimates that Google, Amazon, Microsoft and Facebook collectively store **at least 1,200 petabytes**. (That's not even including well-known storage sites like Dropbox.) A thousand gigabytes equals a terabyte - or 1 million megabytes. Jul 29, 2019

https://starry.com › blog › inside-the-internet › how-big-is...

How Big Is The Internet? Hint: Probably A Lot Bigger Than ...

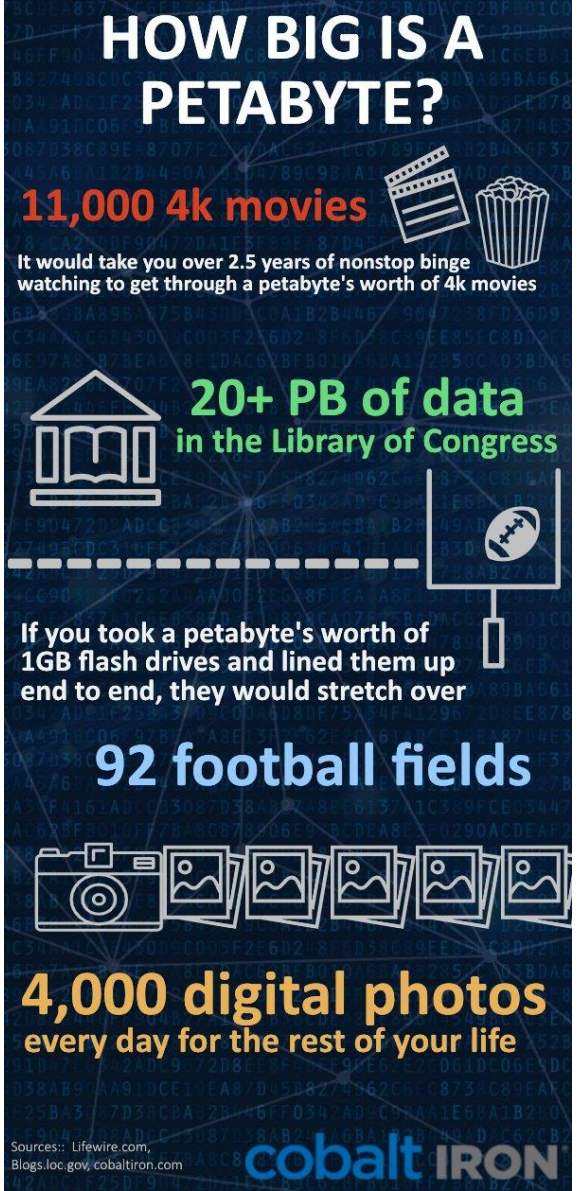
1 Peta = 1000 Teras

= 1,125,899,906,842,624 Bytes

Not Only for

Example at French Bank «SG » : 3 Petas in 2020
for storing Vars / Risks / market params / trades

« Small » Cluster : 6 racks
~ 90 servers * { 256 RAM + 42 cores + 8 disks }



Softwares for BigData ?

No more traditionnal
Oracle DB + single Jdbc client …

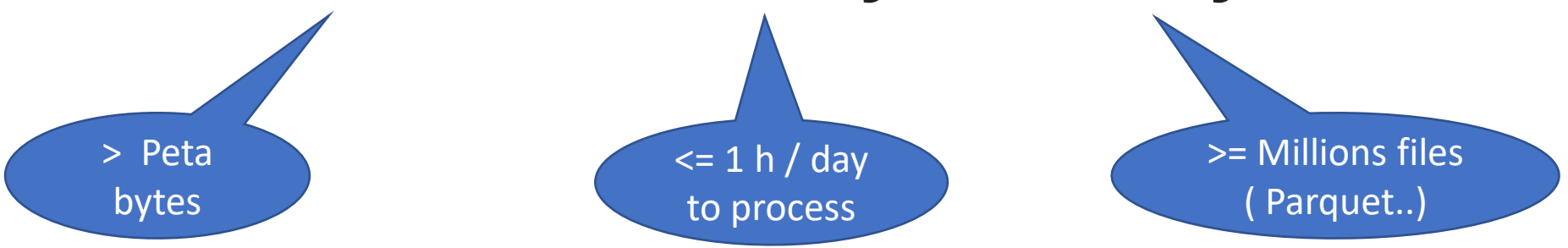
Definition of BigData

= NO FIT in a Single Server
(even 10Million$, Huge with SAN)

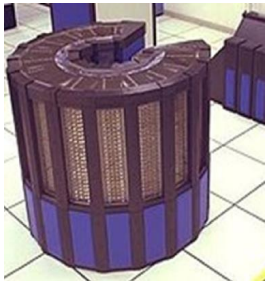
3 Vs
Volume, Velocity, Variety

(5vs : + veracity, value)

3 Vs
Volume, Velocity, Variety



Softwares Disruption
Distributed & Fault Tolerance



Software: **MPI**
Message
Passing
Interface
(1 OS, 1 process, N Threads)

1995

Software: **MapReduce**
Distributed computing
… Fault Tolerant

2004

MapReduce Google paper : 2004 (end of use ~2014)

MapReduce: Simplified Data Processing on Large Clusters

Jeffrey Dean and Sanjay Ghemawat

jeff@google.com, sanjay@google.com

Google, Inc.

Abstract

MapReduce is a programming model and an associated implementation for processing and generating large data sets. Users specify a *map* function that processes a key/value pair to generate a set of intermediate key/value pairs, and a *reduce* function that merges all intermediate values associated with the same intermediate key. Many real world tasks are expressible in this model, as shown in the paper.

Programs written in this functional style are automati-

given day, etc. Most such computations are conceptually straightforward. However, the input data is usually large and the computations have to be distributed across hundreds or thousands of machines in order to finish in a reasonable amount of time. The issues of how to parallelize the computation, distribute the data, and handle failures conspire to obscure the original simple computation with large amounts of complex code to deal with these issues.

As a reaction to this complexity, we designed a new

MapReduce @Yahoo = Hadoop .. 2006

Constraint
=>
Architecture
Choice

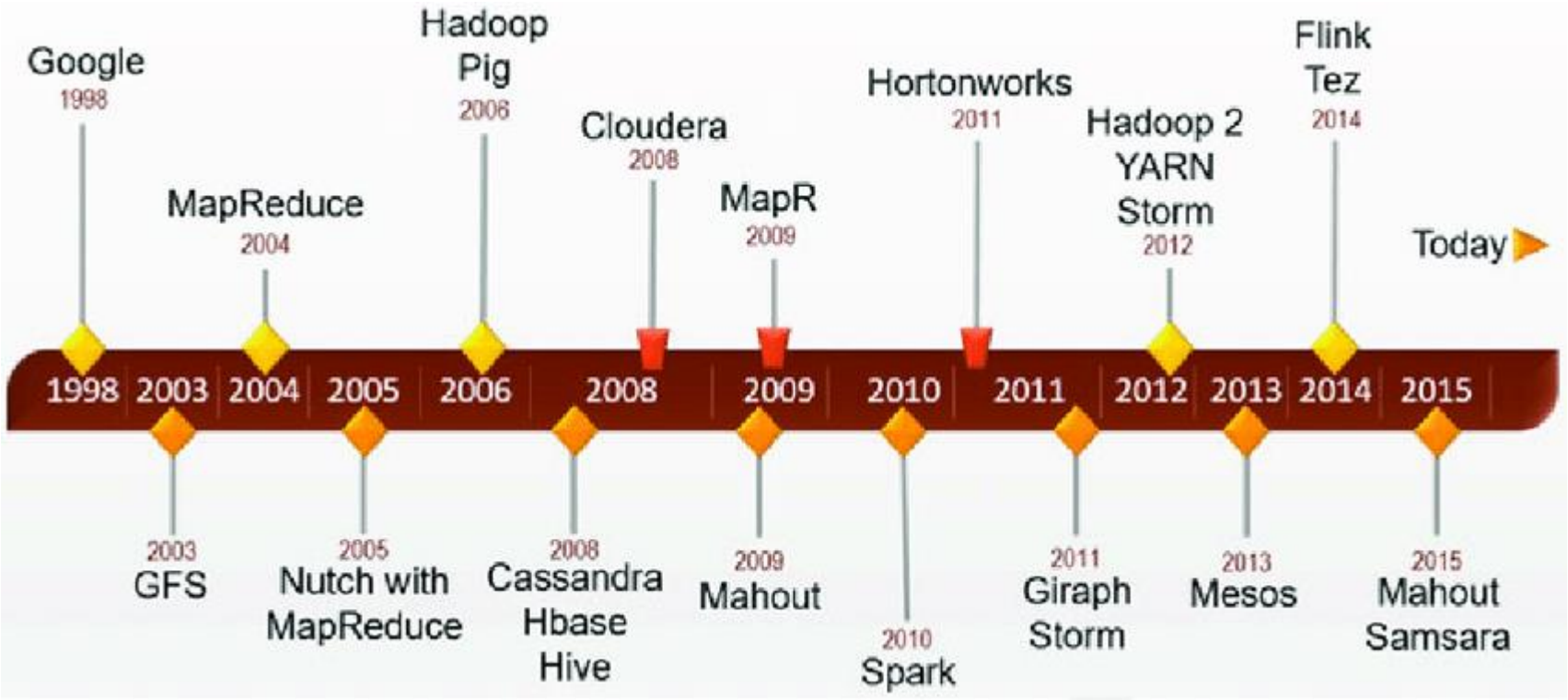
Commodity Hardwares (datacenters):
Only HDD + RAM
Data Locality : co-host Storage near Compute
use RAM to cache
avoid network

Think different?

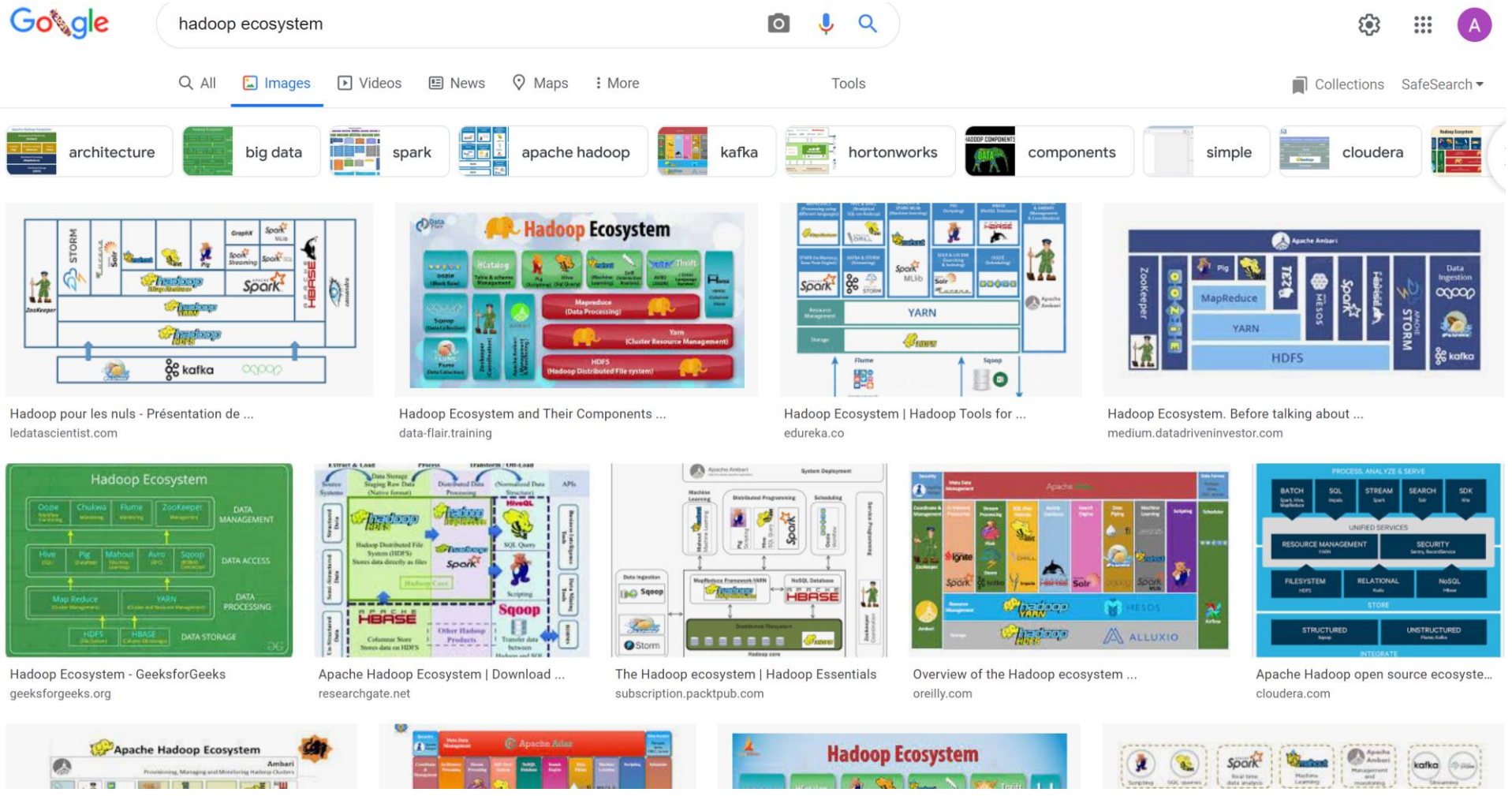
2006

2020

Hadoop + Community + Companies + Specific Tool 1 + Specific Tool 2+ …



Hadoop Ecosystem « Explosion »

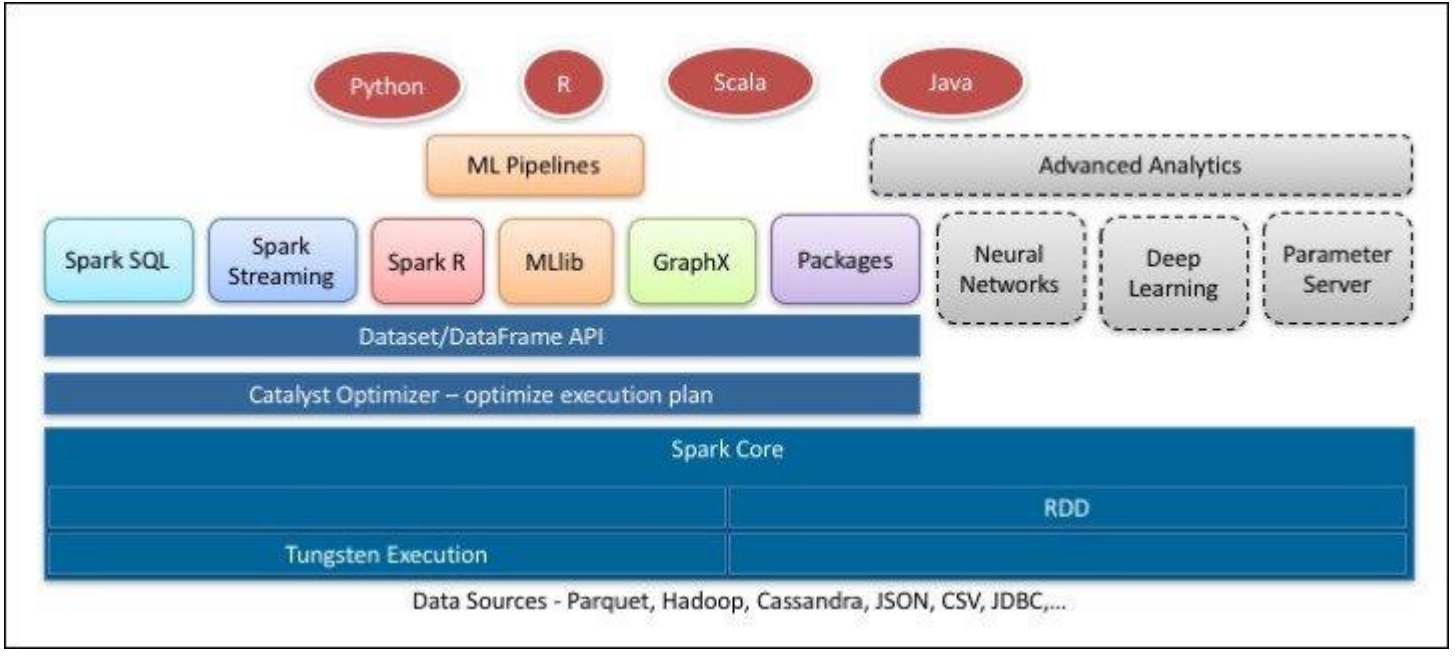


At The end, Only 1 will remain (French TV Game: Koh-Lanta)


APACHE
Spark
TM

Spark
Spark Sql / Mlib / ..
Spark Streaming

1 System
N library extensions
2 Modes (Batch / Streaming)


Python
R
Scala
Java
ML Pipelines
Advanced Analytics
Spark SQL
Spark Streaming
Spark R
MLlib
GraphX
Packages
Neural Networks
Deep Learning
Parameter Server
Dataset/DataFrame API
Catalyst Optimizer – optimize execution plan
Spark Core
RDD
Tungsten Execution
Data Sources - Parquet, Hadoop, Cassandra, JSON, CSV, JDBC,...