STORAGE DEVELOPER CONFERENCE
SDC 22
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BY Developers FOR Developers

A SNIA Event

DNA DATA STORAGE ALLIANCE
A SNIA Technology Affiliate

The Looming Need for Molecular Storage

How to store Yottabytes on a budget

Aaron Ogus
Distinguished Engineer – Microsoft Azure Storage

How to we store Exabytes of Data?

- Many kilometers of Storage Racks, in hundreds of Datacenters.
- Hundreds of MW of power.

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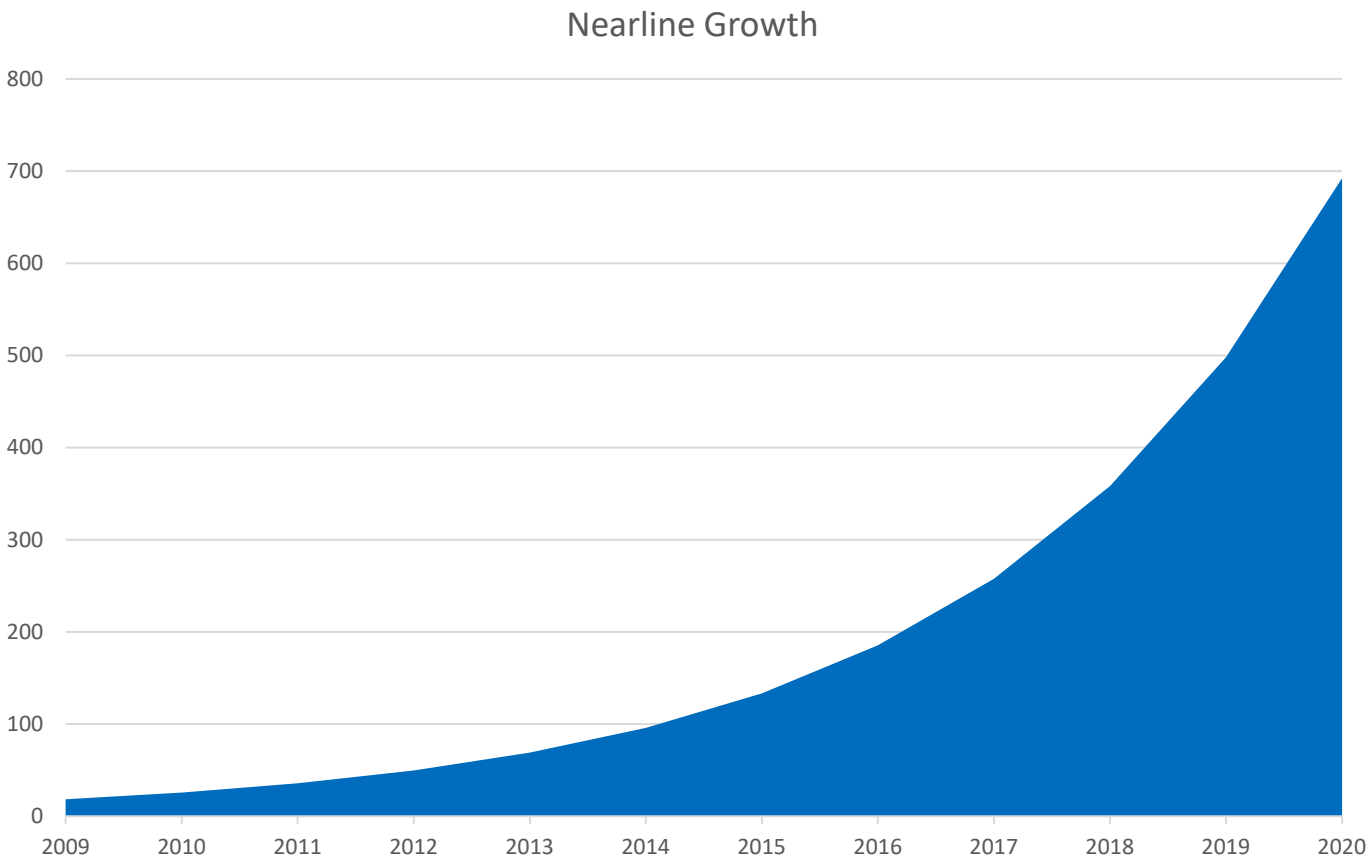
The vast majority of data is moving to the Cloud



- In 2010's HDD shifted from Consumer to DC. By 2030 almost all HDD will be nearline in the cloud.
- Underlying data growth signal is unwavering, and projects to over 7 ZB per year by 2030 <not shown>
- Data CAGR about 40%
- HDD Capacity CAGR < 20%

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Storage Efficiency Improvements 2008 to 2022

- 2006: 500GB HDD, 3 Replica, 4 HDD/Server
- 2008: 1 TB HDD, 3 Replica, 12 HDD/Server
- 2021: 20 TB HDD, <1.3 Replica, 80+ HDD/Server

- > 99.5% reduction in online storage cost over 15 years

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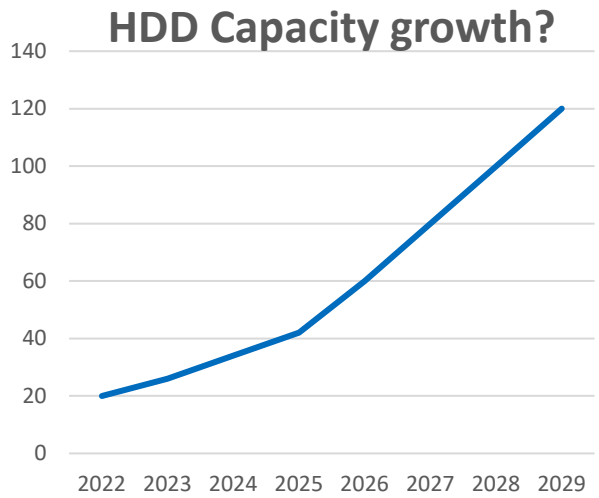
Efficiency Improvements for HDD continue… but.

- HDD Suppliers are shifting to MAMR and HAMR
- Only HAMR has legs to 60 TB+
- HAMR might run out of steam around 100TB
- Optimistically if we assume HDD growth to 230TB+, we will require 5% of current US Power capacity to be dedicated to spinning HDDs by 2042, and 60% by 2050



Something has to change:

- Data growth has to slow.
- Power Generating capacity needs to vastly increase.
- Data Storage Technology needs to change.

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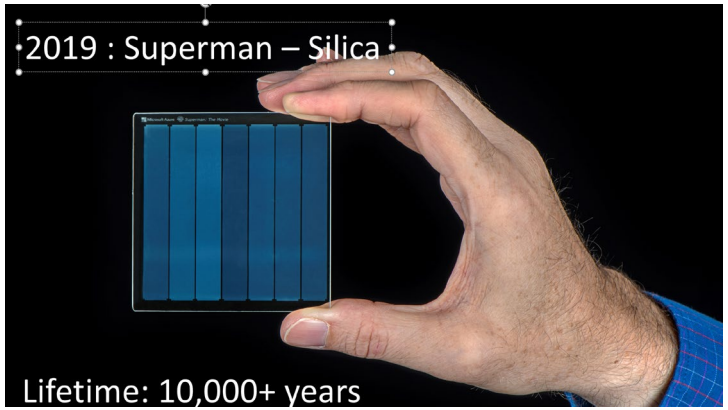
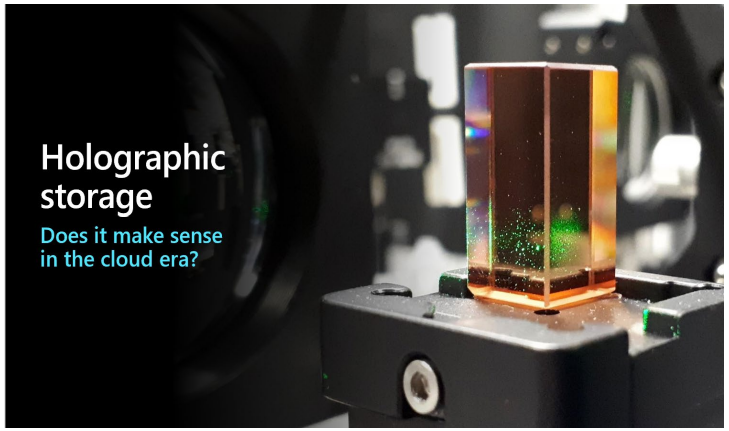
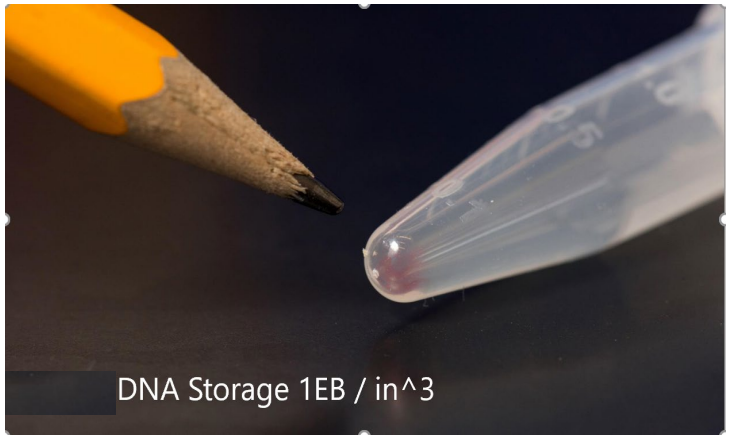
Azure Storage + MSR researching new media types







- Data storage in DNA
- Data storage in Silica Glass
- Holographic Data storage in Sodium Niobate crystals

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Molecular Storage the Panacea for density

- Highest Storage Density of Any Technology
- DNA Storage Alliance is building standards around DNA storage.
  - First commercial products based on data storage in molecules.
- Problem: Read and Write Rates
- Electronic Molecular interface… based on medical research
- Can we build fast Molecular Storage?

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Where is most of Humanity's Data Stored?

- HDD industry shipped 1ZB for the first time in 2021
- 1,000,000,000,000,000,000,000 bytes 10^21
- Power if on 20TB HDDs @10W each would be:
  50Million HDDs and 500MW.

500 MW/ZB

- What about Human Brains?
- 8 Billion Humans
- 2.5PB per brain (estimated)
- Power @ 20W per brain: 160GW
- 2 Yottabytes in Brains (About 1000x data stored on HDD)

8 MW/ZB

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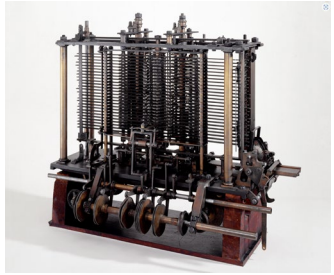
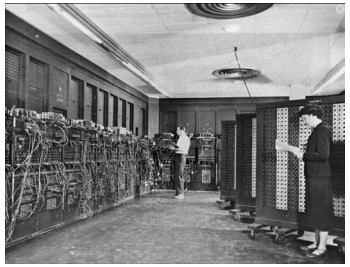
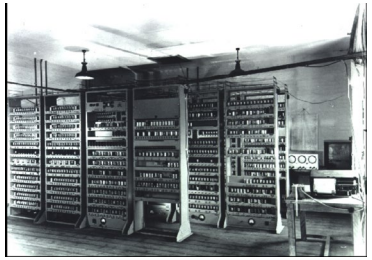
Compute Evolution



Analytic Engine
Designed 1820
Metal Gears
Mechanical

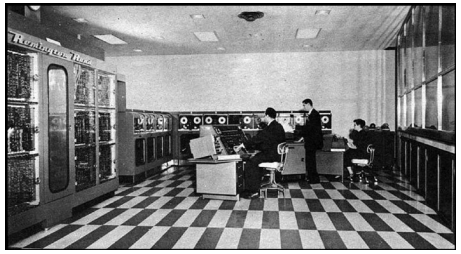


ENIAC
1945
Vacuum Tubes
Crystal Diodes

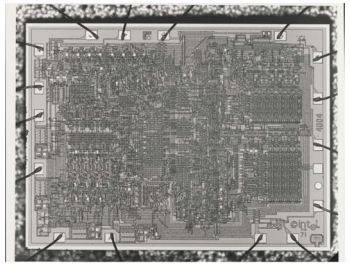


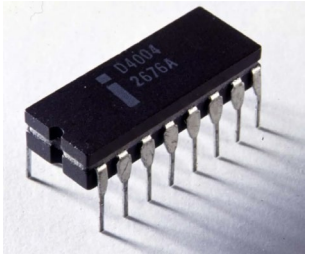
EDSAC
1949
Thermionic Valves

1955 Burroughs
Atlas
Transistors



1957
Univac
Transistors





Intel 4004: First computer on an IC
1971

Intel Xeon SPR
2021, 100,000,000x
improvement over 4004

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Storage needs a Platform shift for YottaScale (2042)

- Today's Storage Platforms:
  - Magnetic Charge (Tape/HDD/Core Memory)
  - Electric Charge (Flash, RAM)
  - Optical
  - Holographic (Lithium Niobate and Lasers)
  - Molecular (DNA)

- Future do we need fast Molecular Storage?
  - DNA based?
  - Can we build the toolchain for molecular machines?

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What's next?

- Research in Molecular Simulation is Ramping:
  - Alpha Fold - Google
  - AI4Science (announcement) - Microsoft
  - Medical Research
- Resolving the Molecular / Electronic interface is critical
- Possibility to leverage patterns from Biology? Molecular Machines?
- YottaScale 2042(ish), XanoScale 2063(ish)

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