Hard Disk Drives (HDD)

A technical development journey

Cyrill Gsell & Fabian Hauser

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What is a Hard Disk Drive?

- **Data storage**
- How does it work?
    1. Logical view
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What is a Hard Disk Drive: Von Neumann Scheme

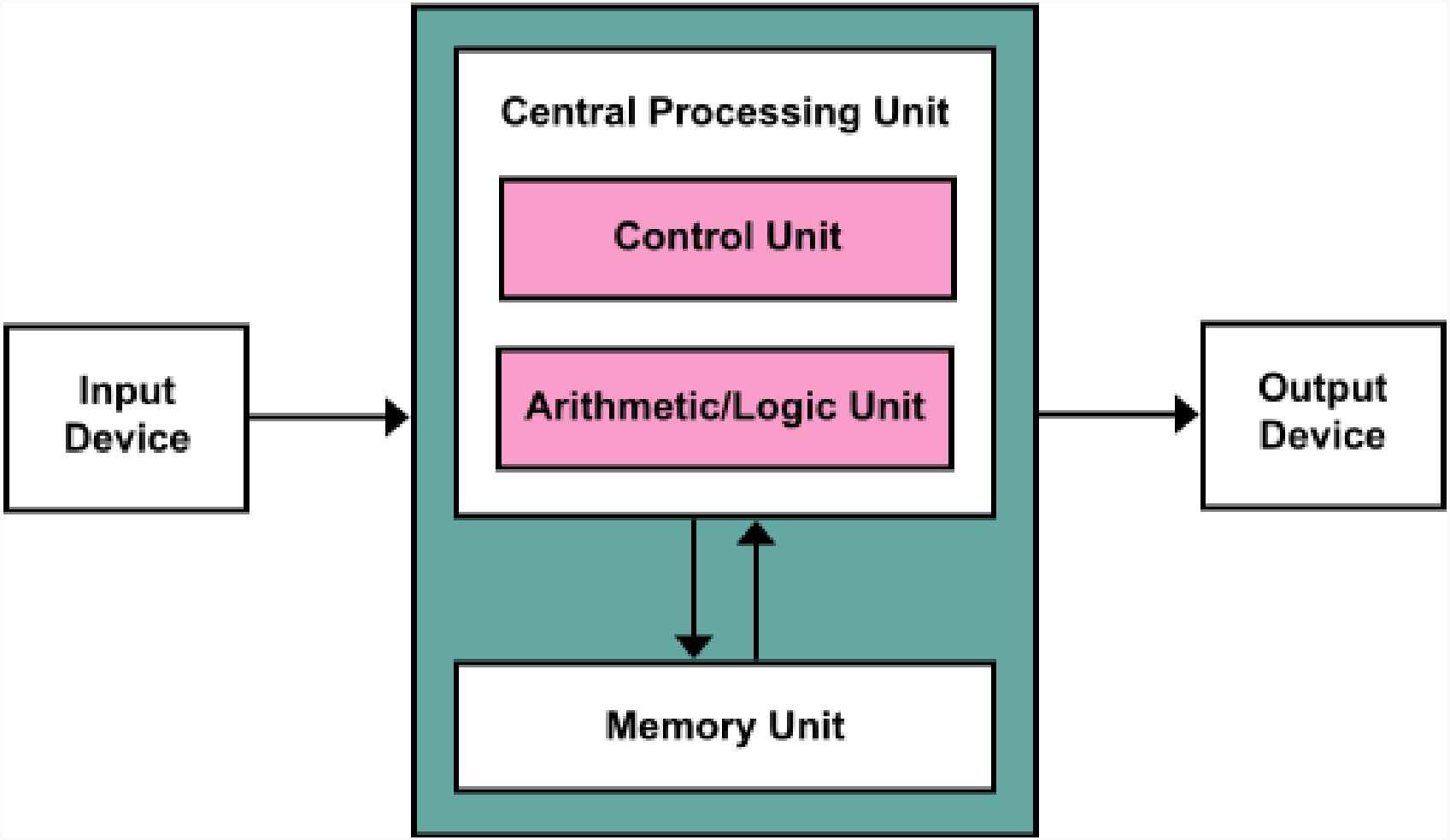
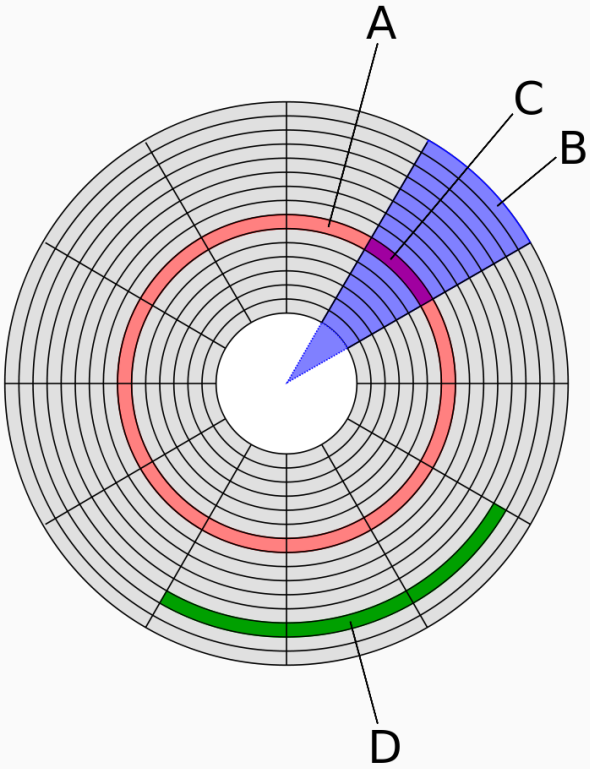


Figure 1: CC-BY-SA by Kapooht, Wikipedia

What is a Hard Disk Drive: Logical View



A Track

B Sector

C Sector of track

D Cluster of sectors

Figure 2: CC0, Wikipedia

What is a Hard Disk Drive: Physical View

Figure 3: CC0,Wikipedia

- Rotating disk: usually 7200 rpm
- Writing and reading head
- Magnet
- Electronics

What is a Hard Disk Drive: Physical View

Bit encoding / Magnetic structure

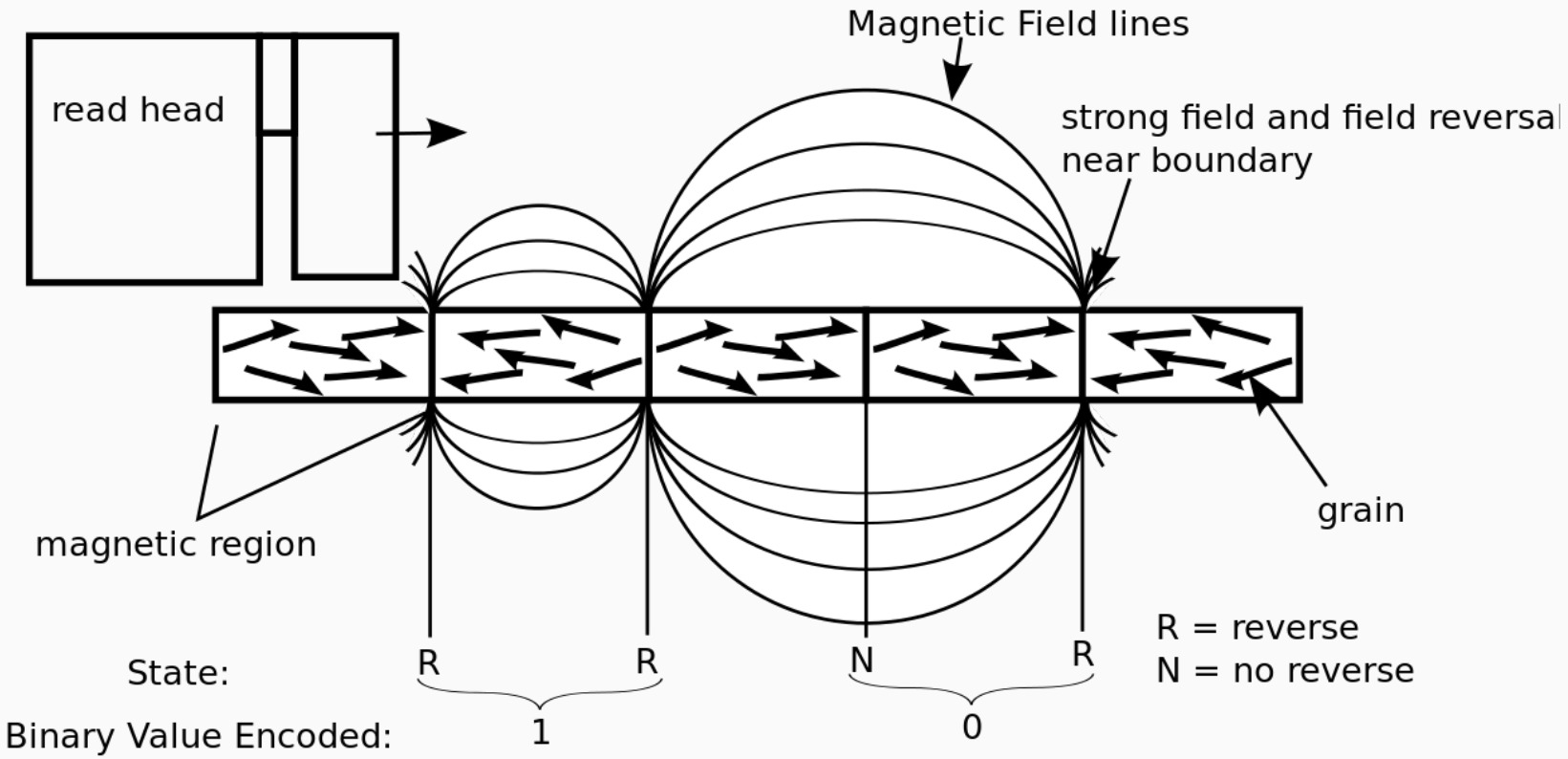


Figure 4: CC-BY-SA Allan Haldane, Wikipedia

What is a Hard Disk Drive: Physical View

Magnetic structure: close up

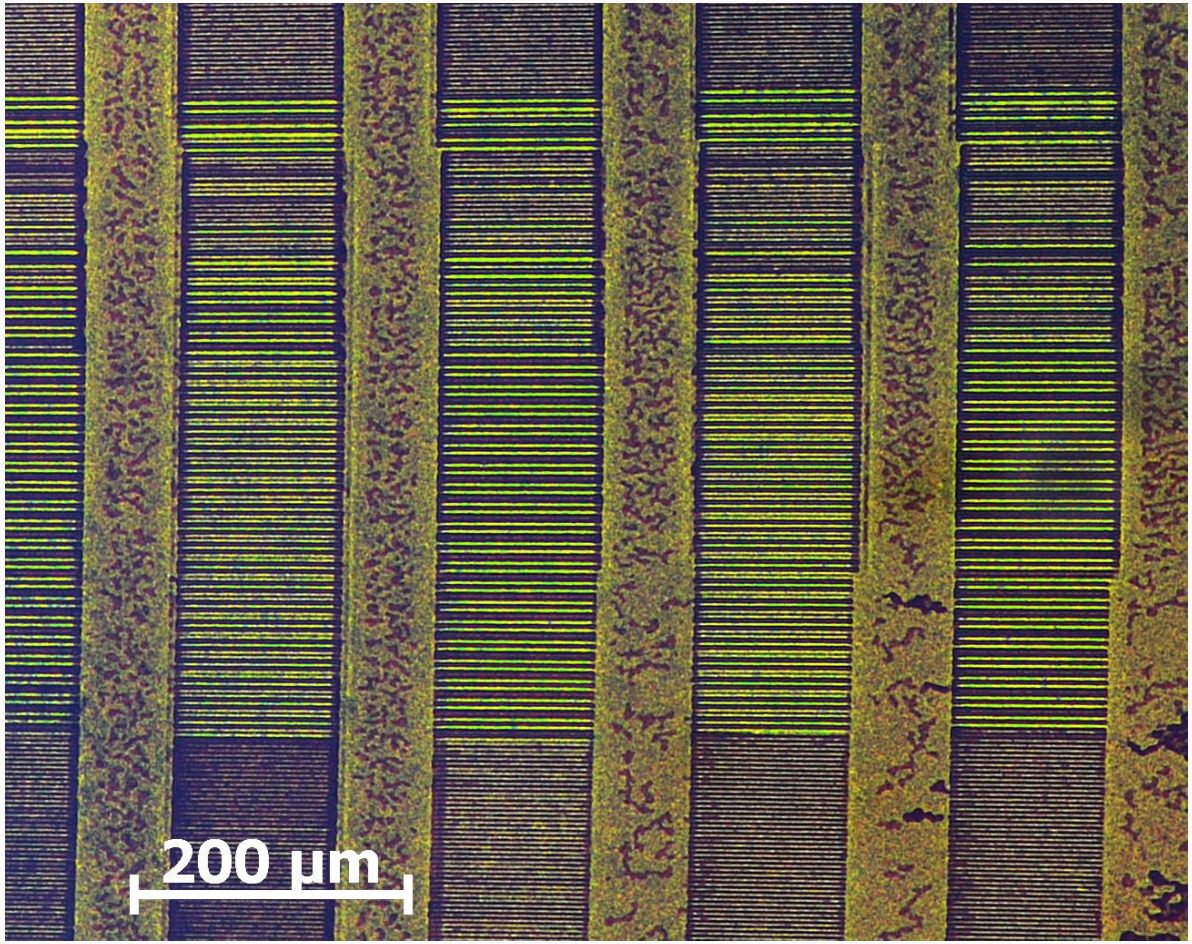


Figure 5: CC-BY-SA Matesy GmbH, Wikipedia

...but why can't we keep floppy disks?

...but why can't we keep floppy disks?

Figure 6: GFDL, JP, Wikipedia

HDDs are better considering:

- Capacity
- Durability
- Price
- Efficiency / Speed

(CD-ROM and USB-Sticks for portable applications.)

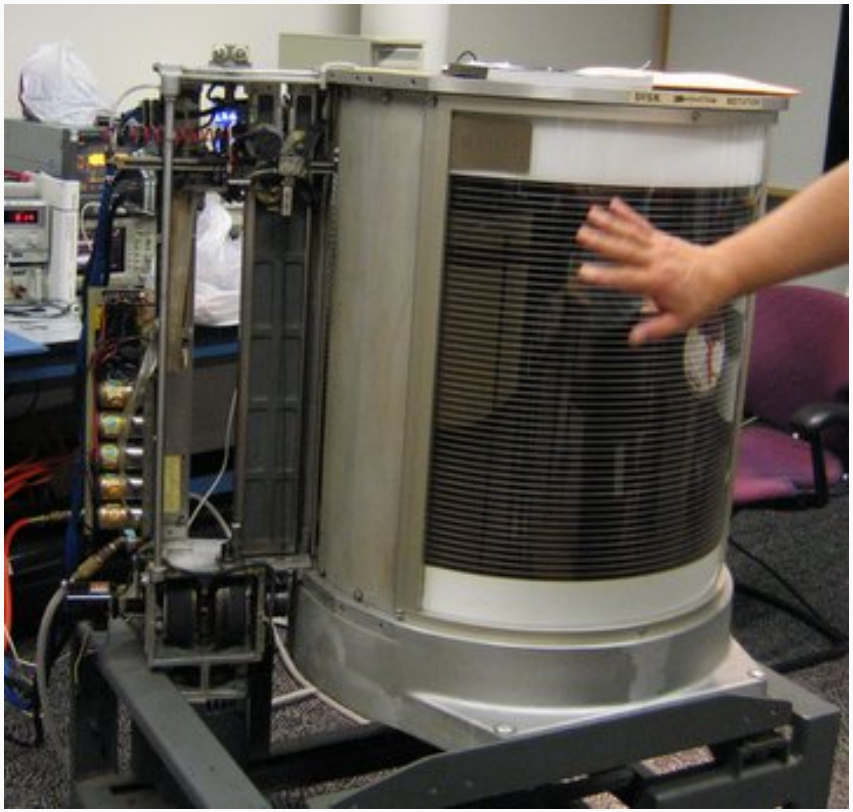
Evolution

Evolution: First attempts

Considering technologies at IBM research center, such as:

- wire matrices
- rod arrays
- drums / drum arrays

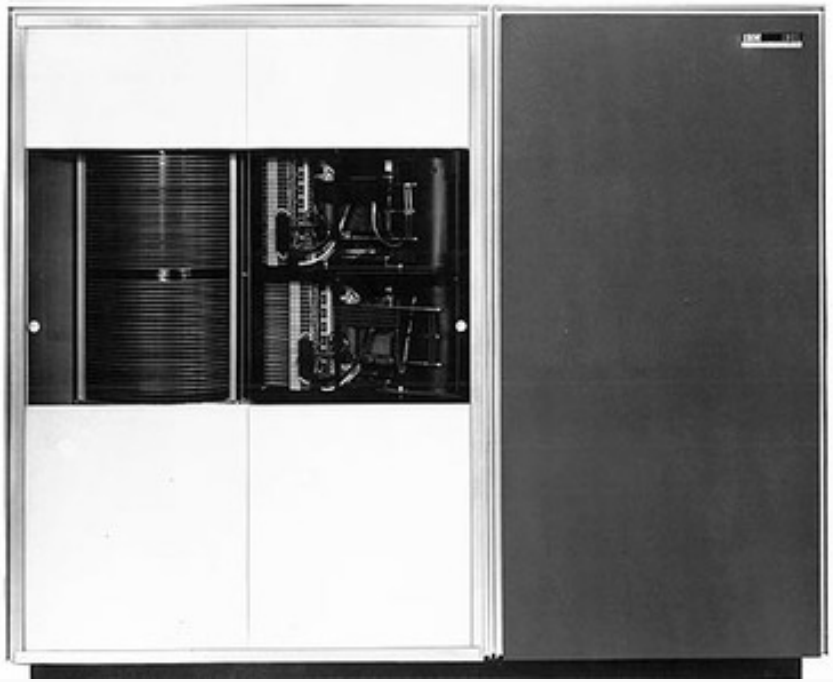
Evolution: IBM 350



1956 IBM 350 Disk File

Figure 7: CC BY-SA, Wikipedia

Evolution: IBM 1301



1961 IBM 1301 Disk Storage Unit

Figure 8: ibm.com

Evolution: IBM 1311

Figure 9: CC BY-SA, Eugen Nosko, Wikipedia

1962 IBM 1311 first disk drive using removable media

Evolution: IBM 3340 Winchester

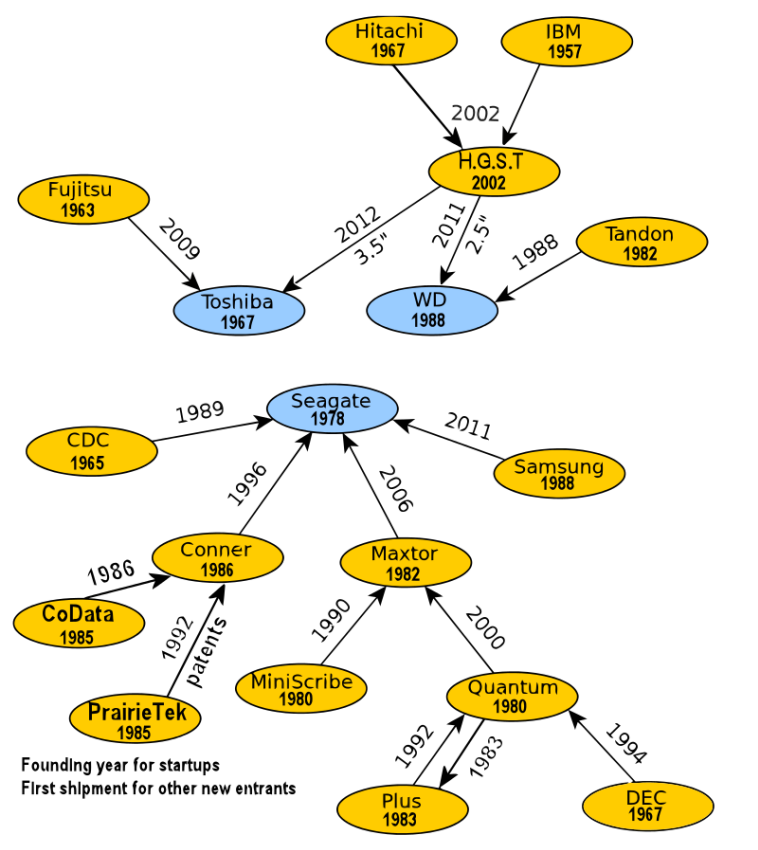
1973 IBM 3340 "Winchester"

Figure 10: ibm.com

Evolution: PC Era

early 1980	rare and very expensive optional feature for PCs
late 1980	standard on PC
1983-1988	HDDs continued getting smaller
1989	reaching 22 million units and $23 billion in revenue

Evolution: Industry Development



1985 75 active manufacturers

1999 Industry participants declined to 15

2009 6 remaining

2012 3 remaining

Figure 11: CC BY-SA, Juventas, Wikipedia

Evolution: State of the Art

- More capacity and speed
- Lower price
- Reached some physical boundaries
- First 10TB HDD in 2015

A Glance into the Future

A Glance into the Future

- In many areas superseded with SSDs / flash storage
- SSHD: SSD and HDD combined
  $\rightarrow$ good price & capacity
- Physical storage density limit: $\approx$ 75nm tracks.
  Work arounds:
  - Helium filling
  - Heat assistance (microwave)
  - Shingle Magnetic Recording *(SMR)*
  - Two-Dimensional Magnetic Recording *(TDMR)*

A Glance into the Future: SMR

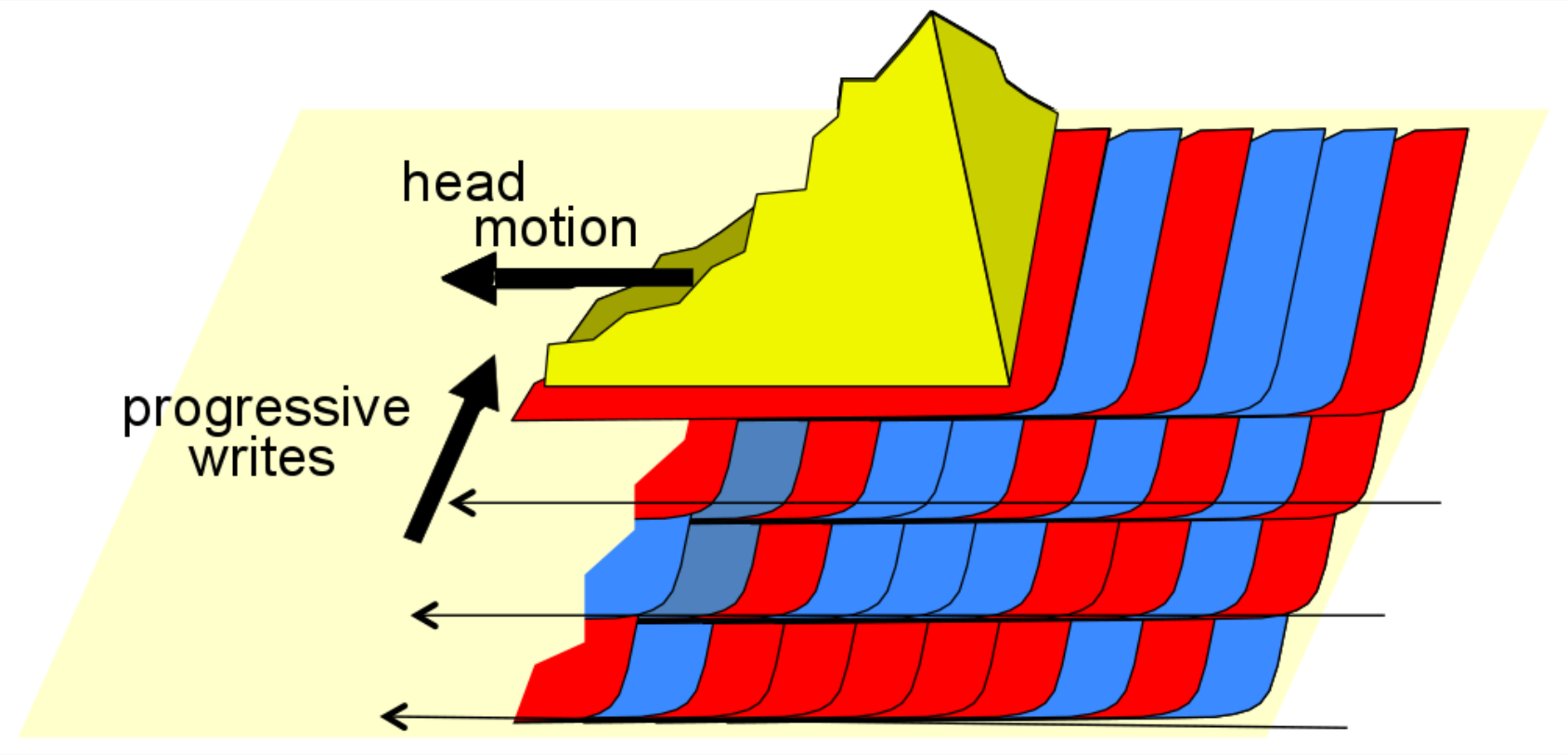


Figure 12: Wood, Williams et al., 2009

A Glance into the Future: TDMR

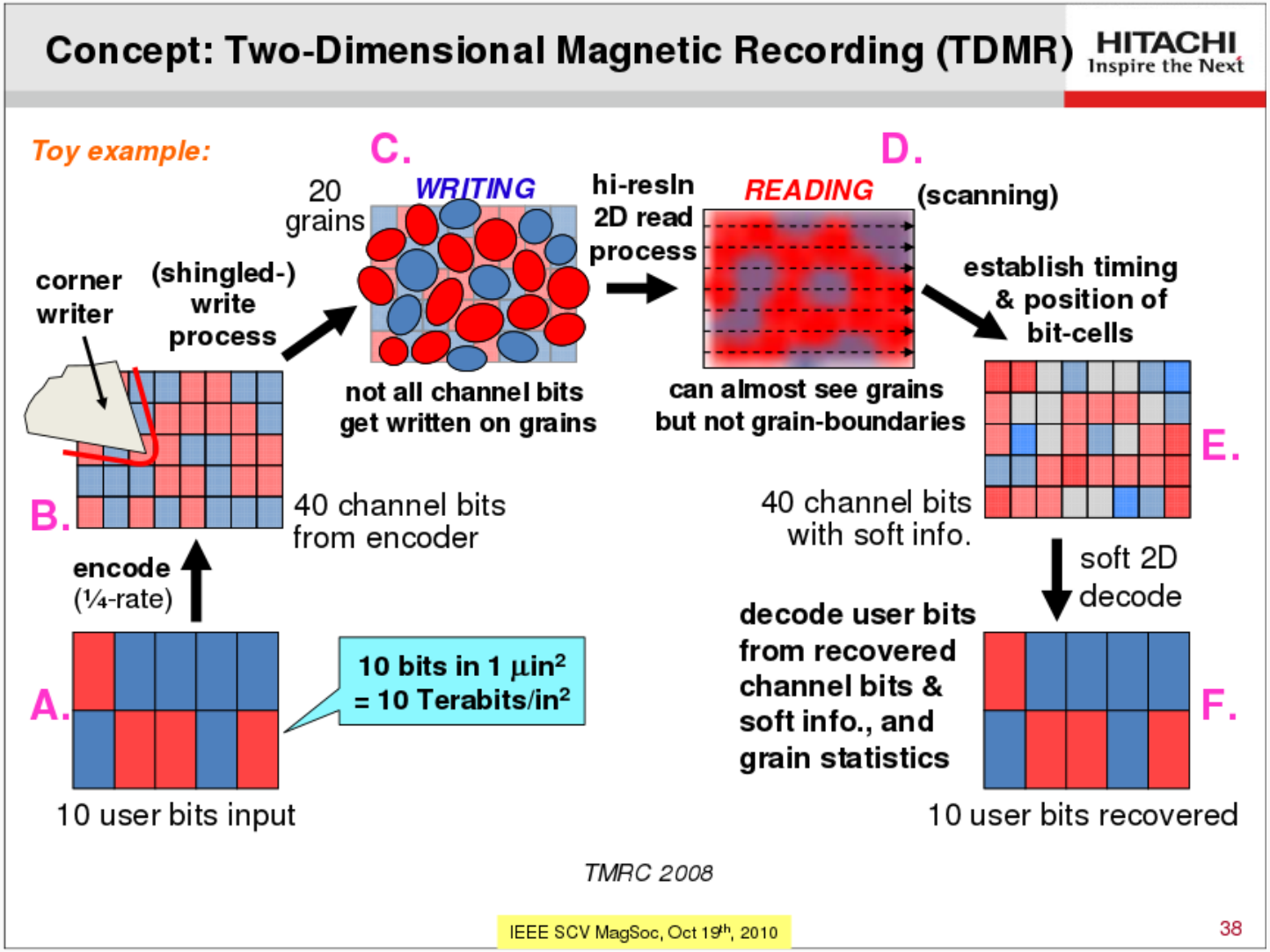


Figure 13: Hitatchi et al., 2010

Questions?

Thank you for your interest!

Ressources

- http://www.ewh.ieee.org/r6/scv/mag/MtgSum/Meeting2010_10_Presentation.pdf
- https://events.linuxfoundation.org/sites/events/files/slides/SMR-LinuxConUSA-2014.pdf