
ORACLE®

Storage Technology Futures and Trends

Fujifilm Global IT Executive Summit 2015

Dr. Robert M. Raymond
Robert.raymond@oracle.com
Director, Archive Systems Development

Tom Wultich
Tom.wultich@oracle.com
Sr Director, Archive Product and Program Management

October 8, 2015

ORACLE

Helpful Links

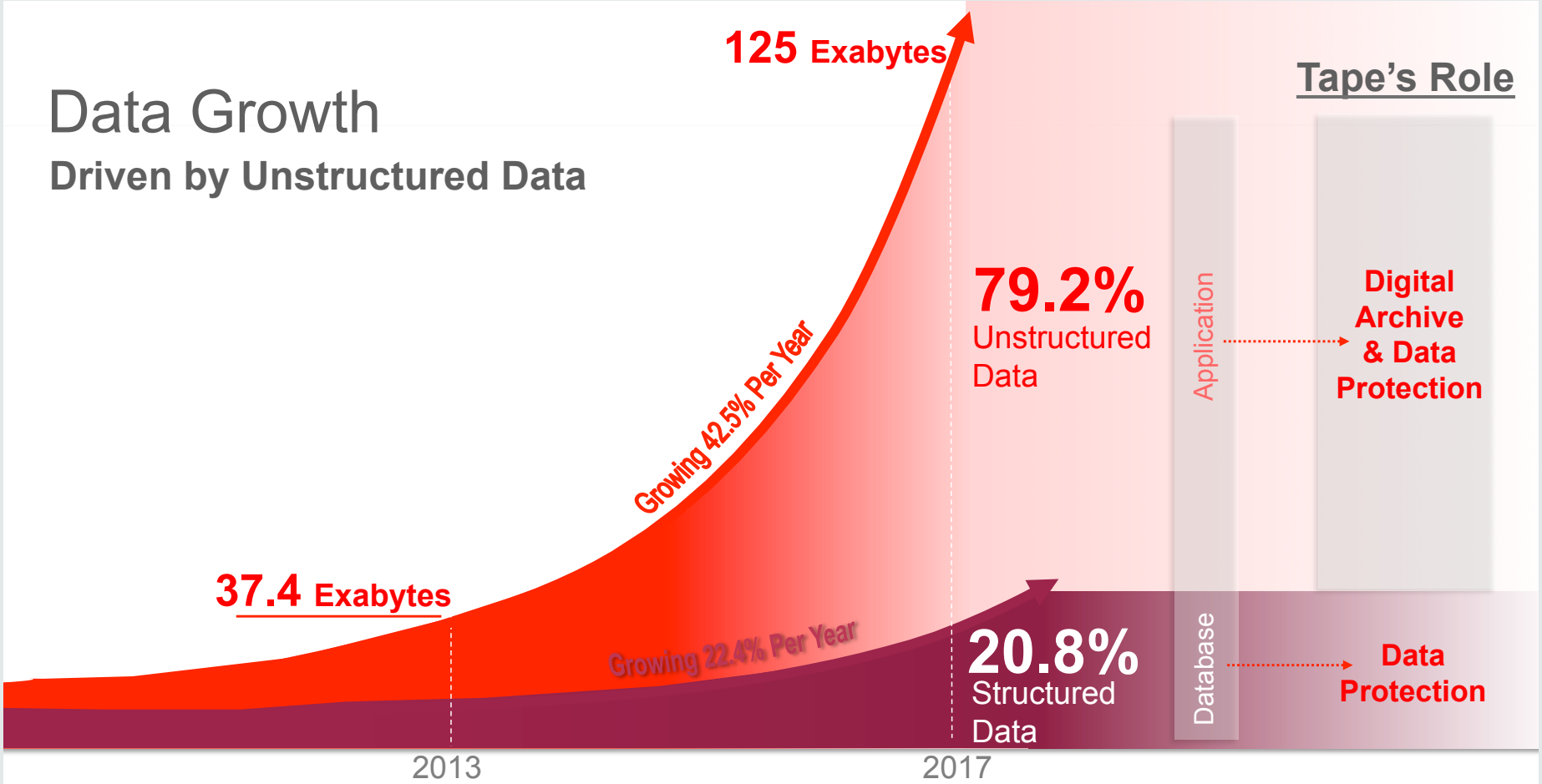
- Customer Perspective
  - Data @Scale Seattle- Aaron Ogus
  - https://www.youtube.com/watch?v=iNO_tIbqy50
- Tape Industry Perspective
  - Tape Storage Council
  - http://tapestorage.org/resources/
  - http://tapestorage.org/news-and-information/
- Oracle
  - Horison, ESG, Clipper Group Analysis
  - www.oracle.com

Program Agenda

1. Data storage trends
2. Storage device trends
3. Tape
4. Disk
5. Flash

Data Growth

Driven by Unstructured Data

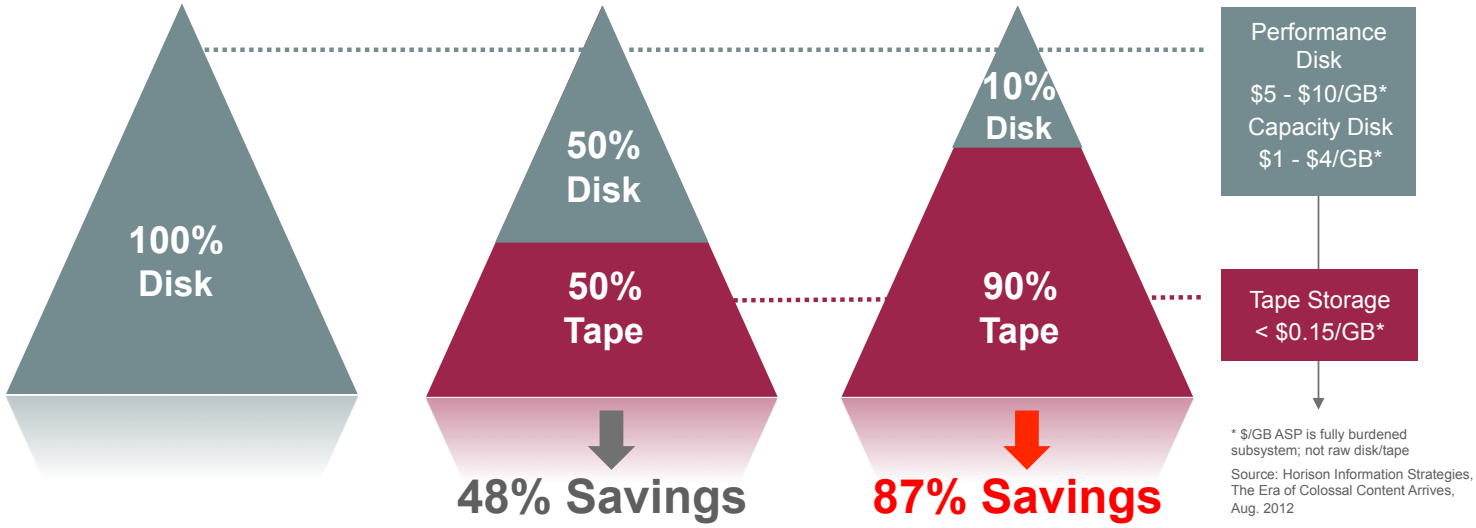


Source: IDC - 2014, Structured Data vs. Unstructured Data: The Balance of Power Continues to Shift

ORACLE

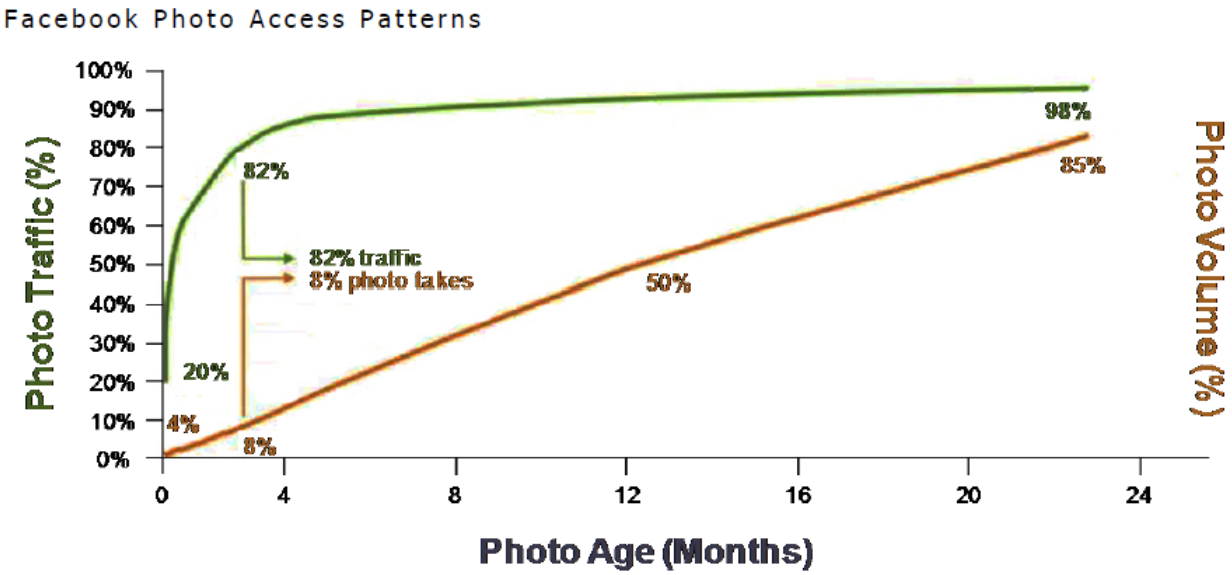
The Efficiency of Tiered Storage

Analyst Study: 1 PB Growing at 45% for 9 Years



Source: The Clipper Group, Revisiting the Search for Long-Term Storage — A TCO Analysis of Tape and Disk, May 13, 2013

Example: ~90% of an Organization's Data is Passive

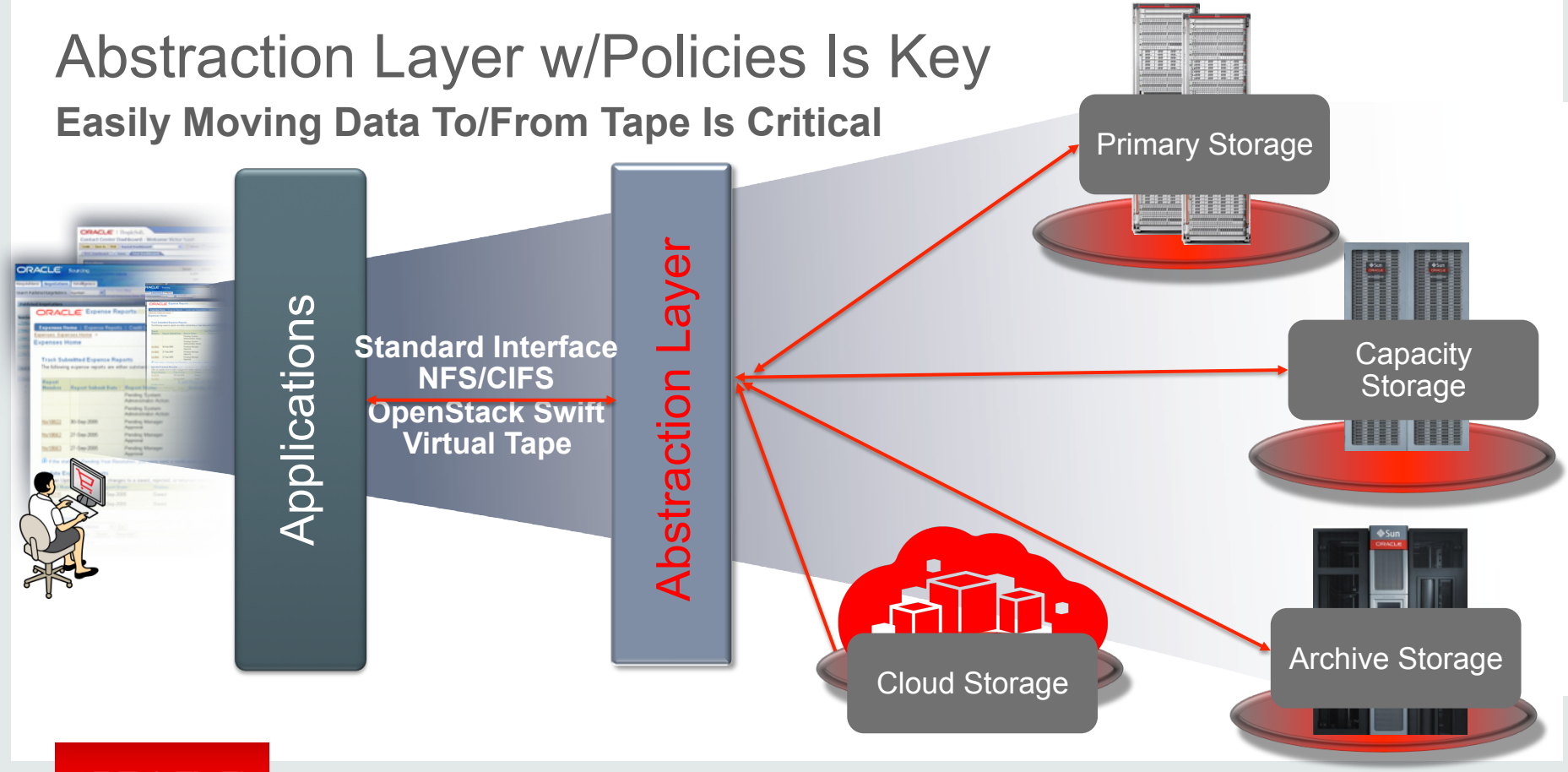


Note: Data is from the Open Compute Summit IV, January 2013, Santa Clara, California.

Source: Facebook, 2013

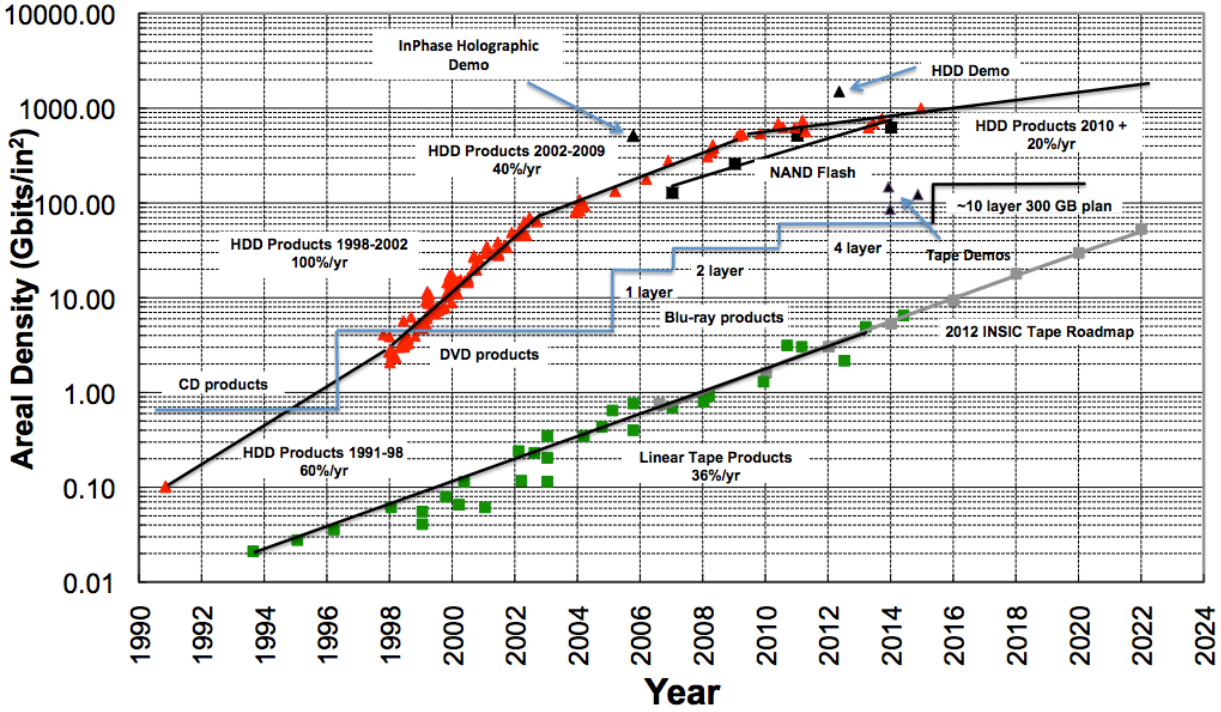
Abstraction Layer w/Policies Is Key

Easily Moving Data To/From Tape Is Critical



Storage Trends

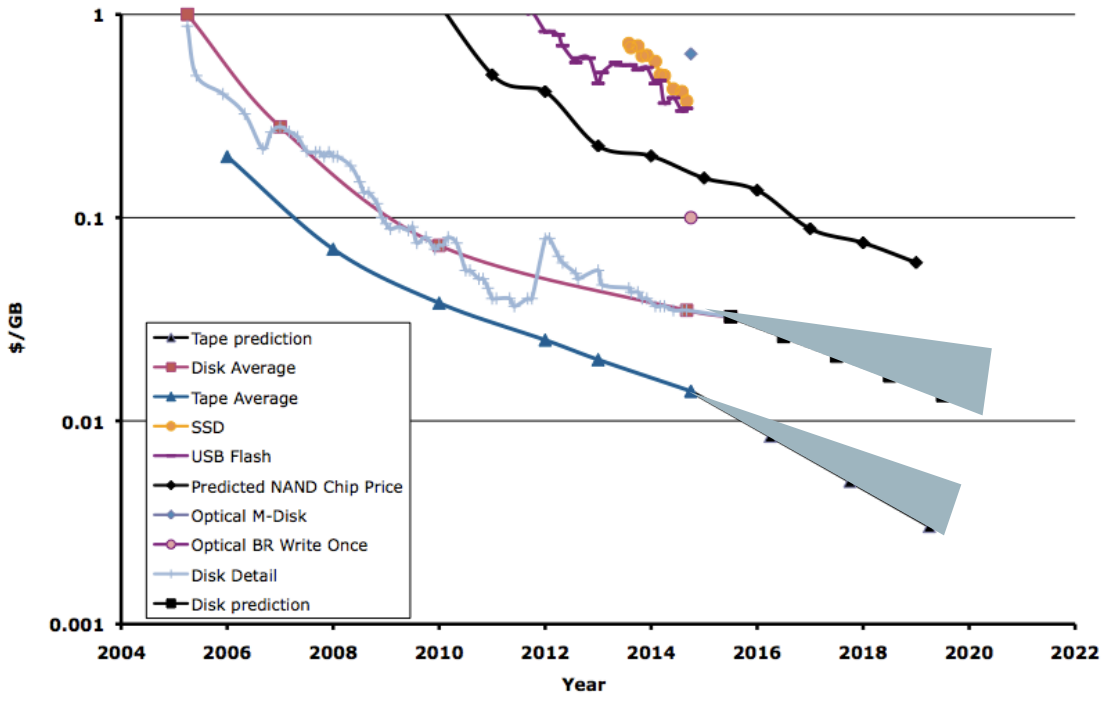
Storage Technologies Areal Density Trends



Tape gets its capacity by having 1000X the recording surface area comparing a 1/2 inch cartridge to a 3 1/2 inch disk.

Tape and disk data courtesy of INSIC

Storage Device Price Trends and Predictions

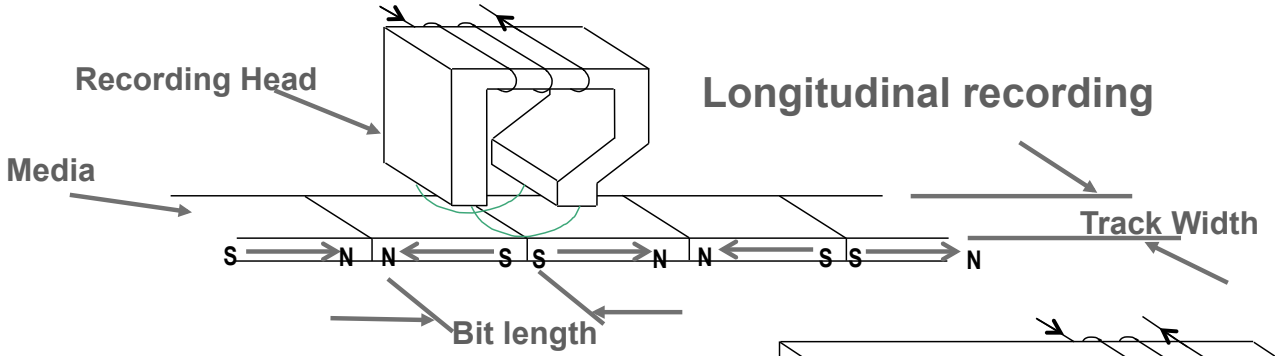


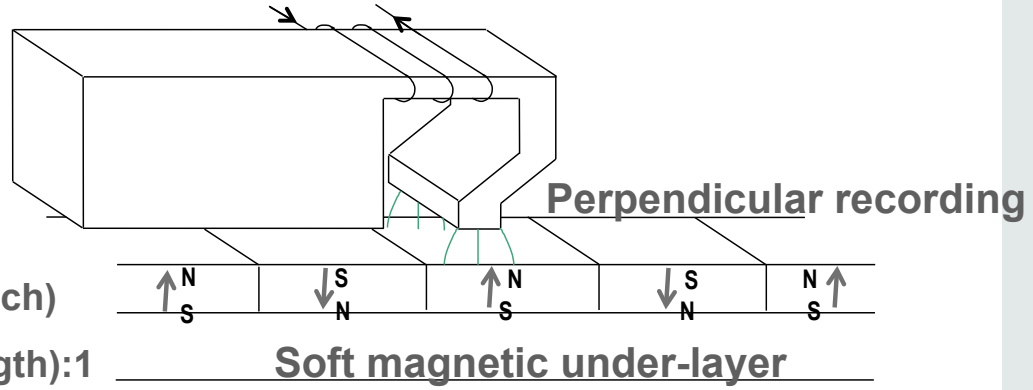
Disk price data detail:
http://www.jcmit.com/diskprice.htm

Flash price data detail
http://www.jcmit.com/flashprice.htm

Magnetic Recording

Magnetic Recording Definitions





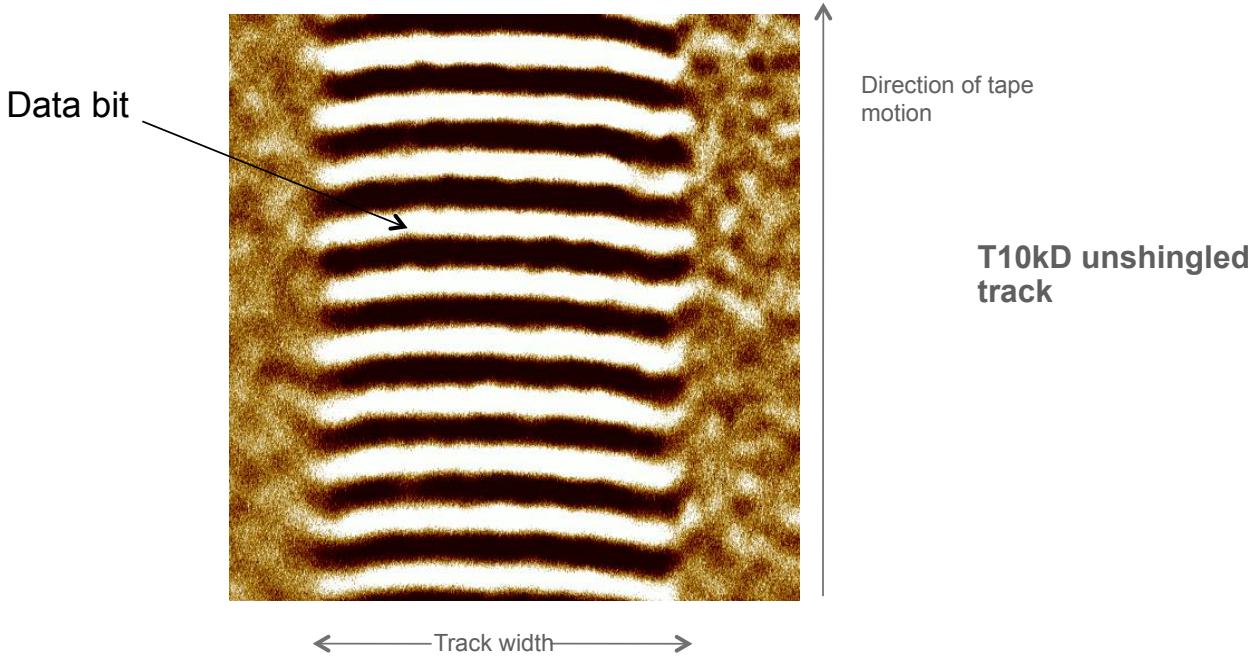
Tracks per inch (tpi) = $(\text{Track Pitch})^{-1}$

Bits per inch (bpi) = $(\text{Bit Length})^{-1}$

Areal density = (Tracks per inch) X (Bits per inch)

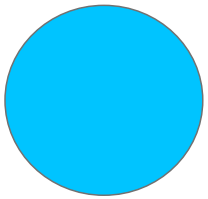
Bit aspect ratio (BAR) = (Track width) /(Bit length):1

Magnetic Force Microscope (MFM) Track Images



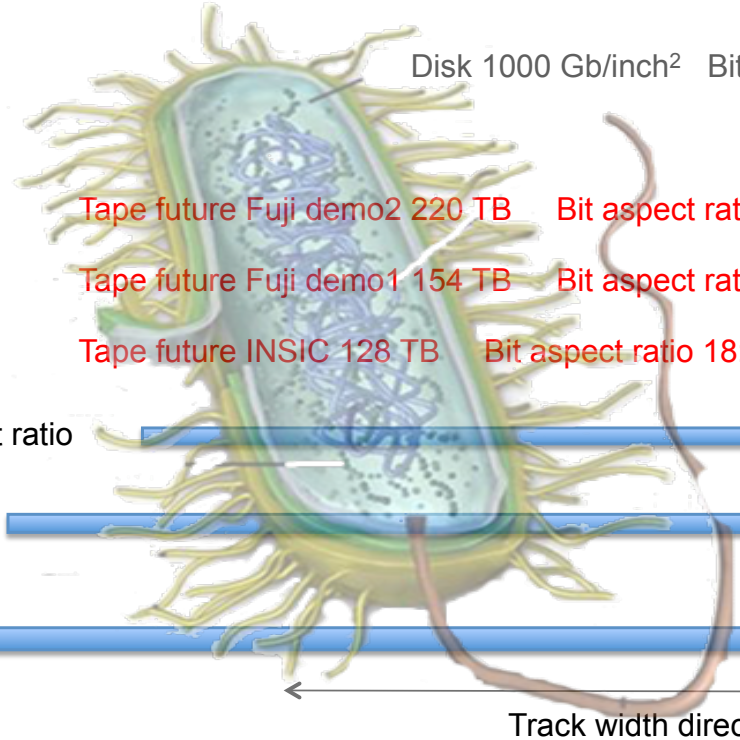
T10kD unshingled track

Data Bit Size Comparison



Bacterium
(2 um)

Blu-ray 405nm laser wavelength



Disk 1000 Gb/inch^2 Bit aspect ratio 3:1

Tape future Fuji demo2 220 TB Bit aspect ratio 4:1[4]

Tape future Fuji demo1 154 TB Bit aspect ratio 4:1[2]

Tape future INSIC 128 TB Bit aspect ratio 18:1[3]

TS1150 10 TB Bit aspect ratio 40:1

T10KD 8.5 TB Bit aspect ratio 41:1

T10KC 5.5 TB
Bit aspect ratio 43:1

Bit length direction

Track width direction

1. From Other demo 2014
2. From Fuji demo1 2014
3. From 2012 INSIC roadmap
4. From Fuji demo2 2015

ORACLE

Tape Storage Trends

Oracle StorageTek Tape – A Look Back

10 PB in 1998

x10

~ 6,000,000 carts
~ 8 acres
~ 4,100 tons

10 PB in 2014

1,177 carts
StorageTek SL3000 with T10000D
37 sq. feet
~1.5 tons

Tape Storage Projections - Recent Technology Demos

Demos show we've got solid technology to achieve roadmap goals

- INSIC tape roadmap shows technology path to 128 TB on a cartridge
- Fujifilm advanced BaFe demo1 (5/14)
  - Areal density of 85.9 GB/in^2
  - '154 TB' cartridge
  - http://www.fujifilmusa.com/press/news/display_news?newsID=880613
- Fujifilm advanced BaFe demo2 (4/15)
  - Areal density of 123 GB/in^2
  - '220 TB' cartridge
  - http://www.research.ibm.com/labs/zurich/sto/tape/arealdensity.html

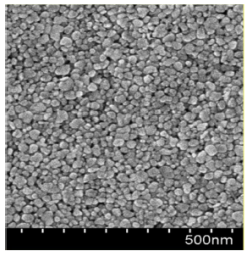
ORACLE

Next Generation BaFe

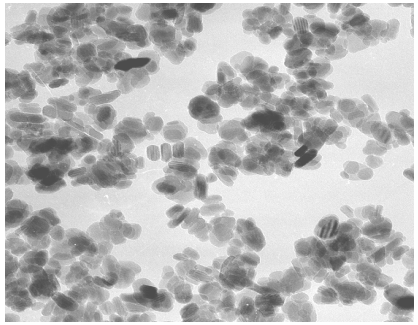
Fujifilm 85.9 GB/in^2/123 GB/in^2 Technology Demo1 and 2

- Smaller particle volume
- Tighter distribution of particle size and magnetic properties
- Perpendicular orientation (better alignment of particles)
- Smoother, more uniform surface through coating and dispersion improvements

BaFe



- Higher output
- Better signal to noise ratio
- Same reliability for archive
  - Chemically stable
  - Magnetically stable



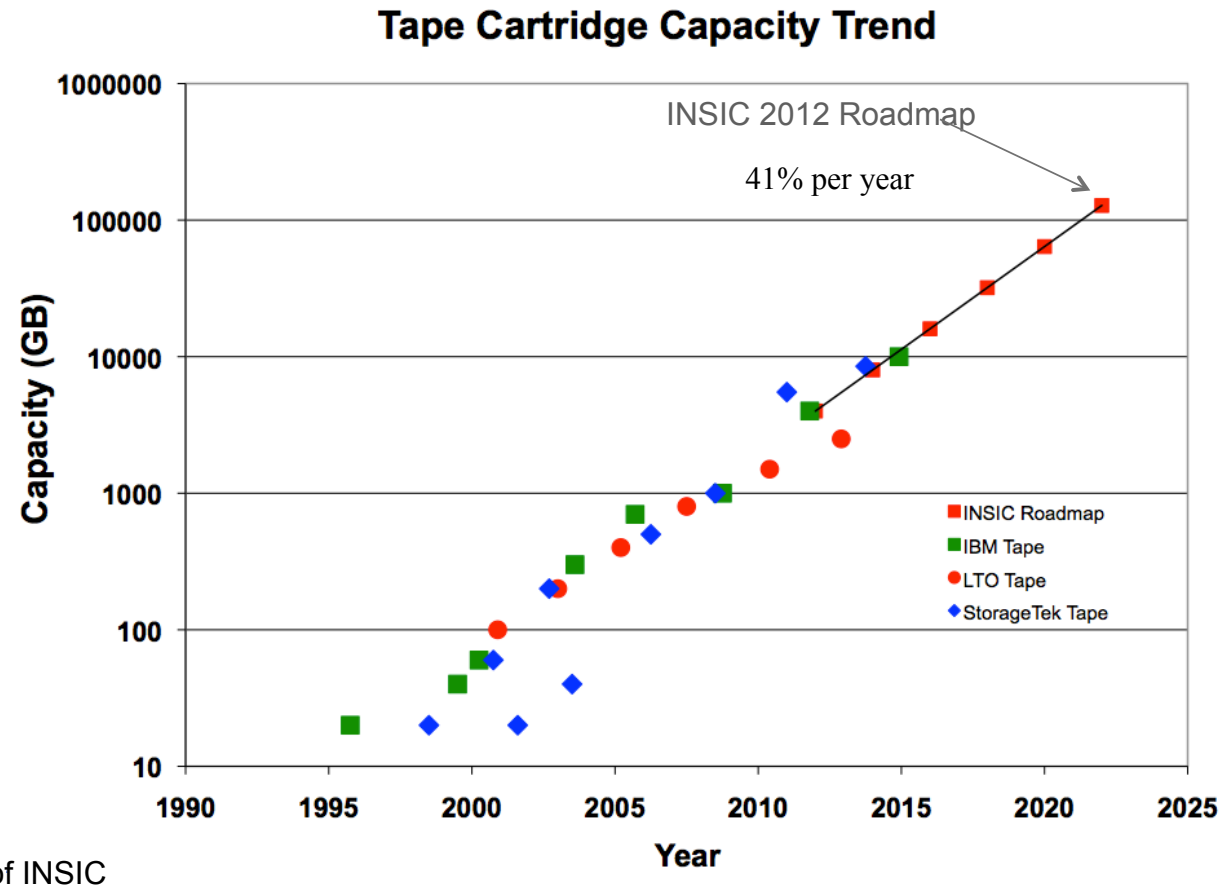
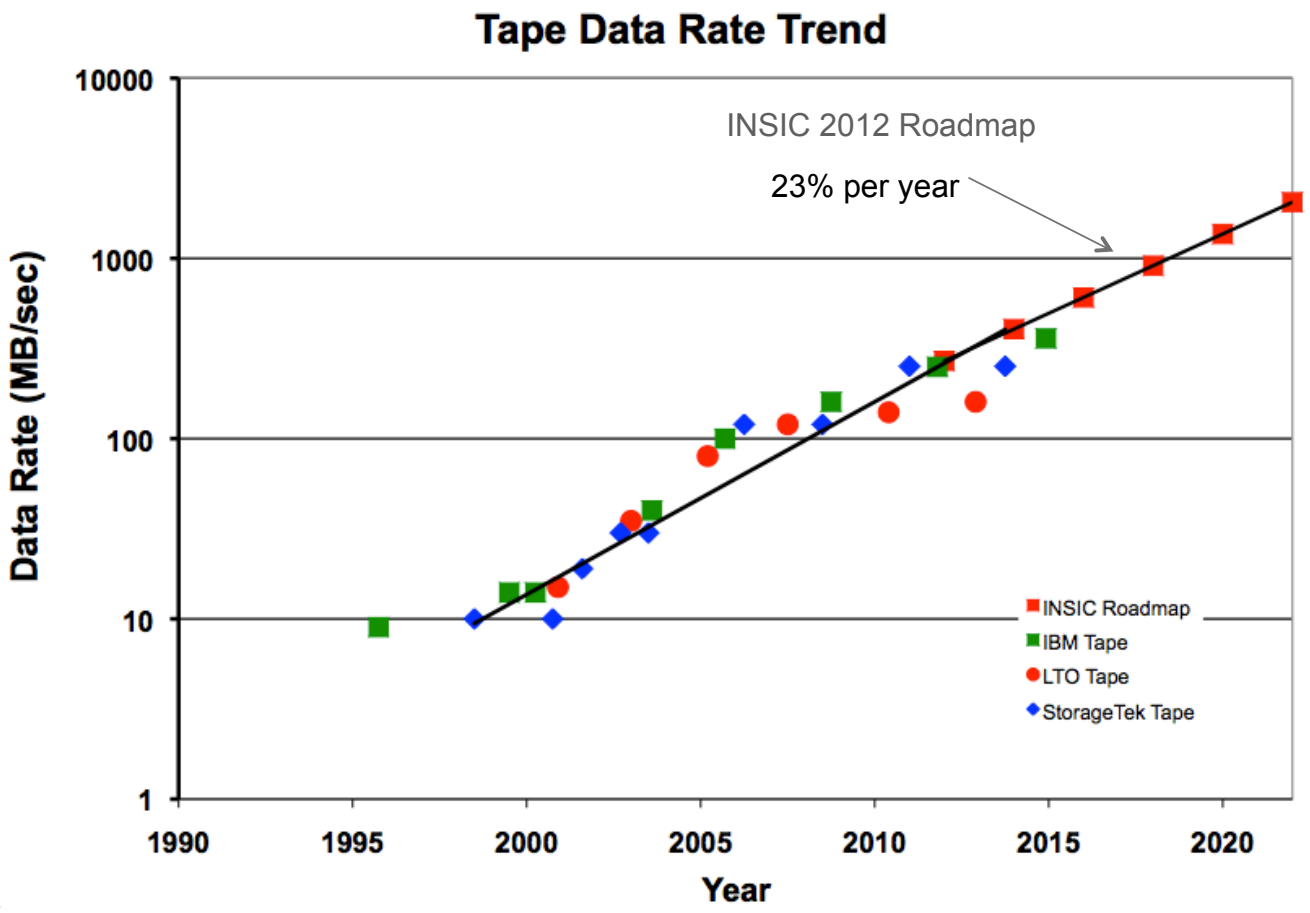


Chart courtesy of INSIC



Disk Storage

Disk Magnetic Recording Tri-Lemma Review

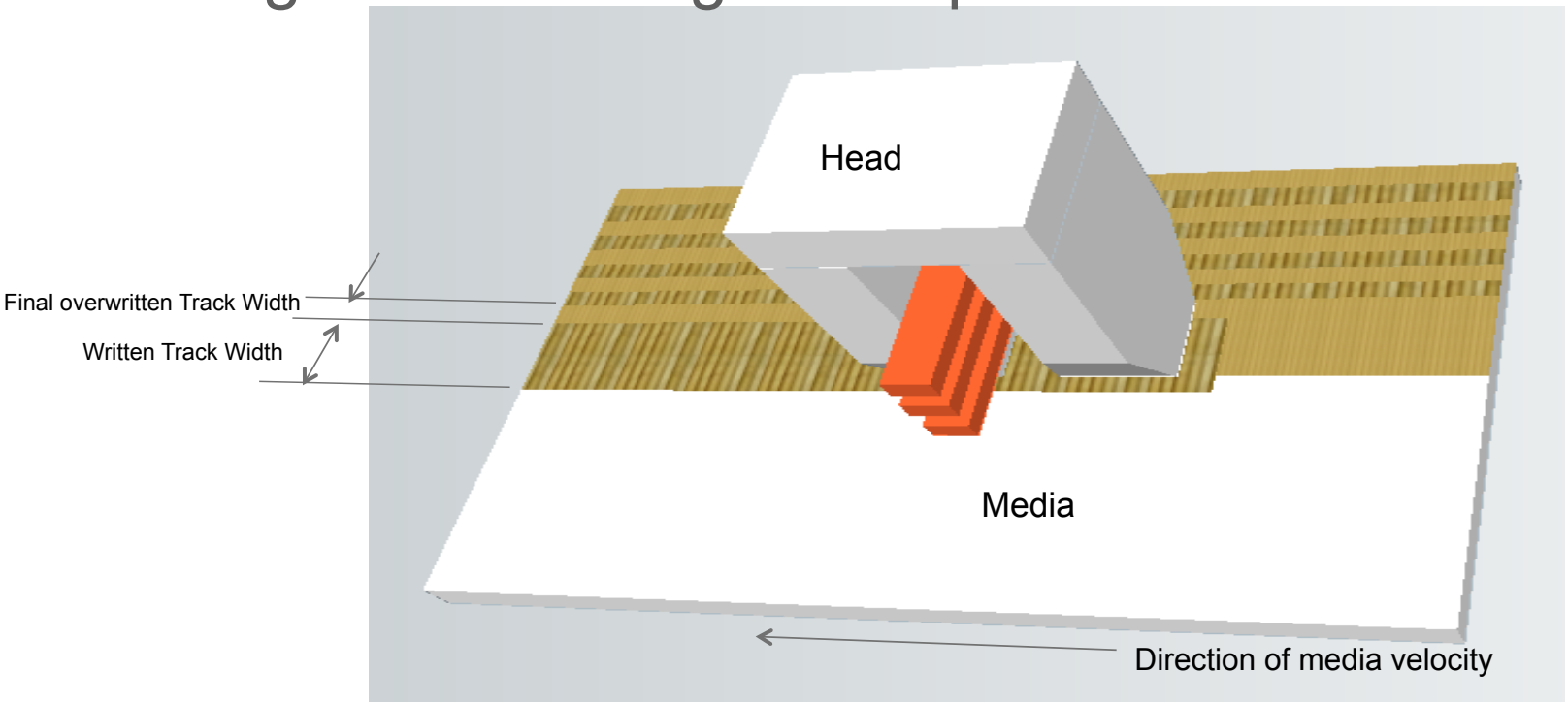
- Smaller bits => Smaller grains for required SNR
- Smaller grains => Higher Hc[1] for thermal stability
- Higher Hc => Can not write on the media

1. Hc is the media Coercivity, which is the strength of the magnetic field required to flip the magnetization in the media

New Disk Technologies Required

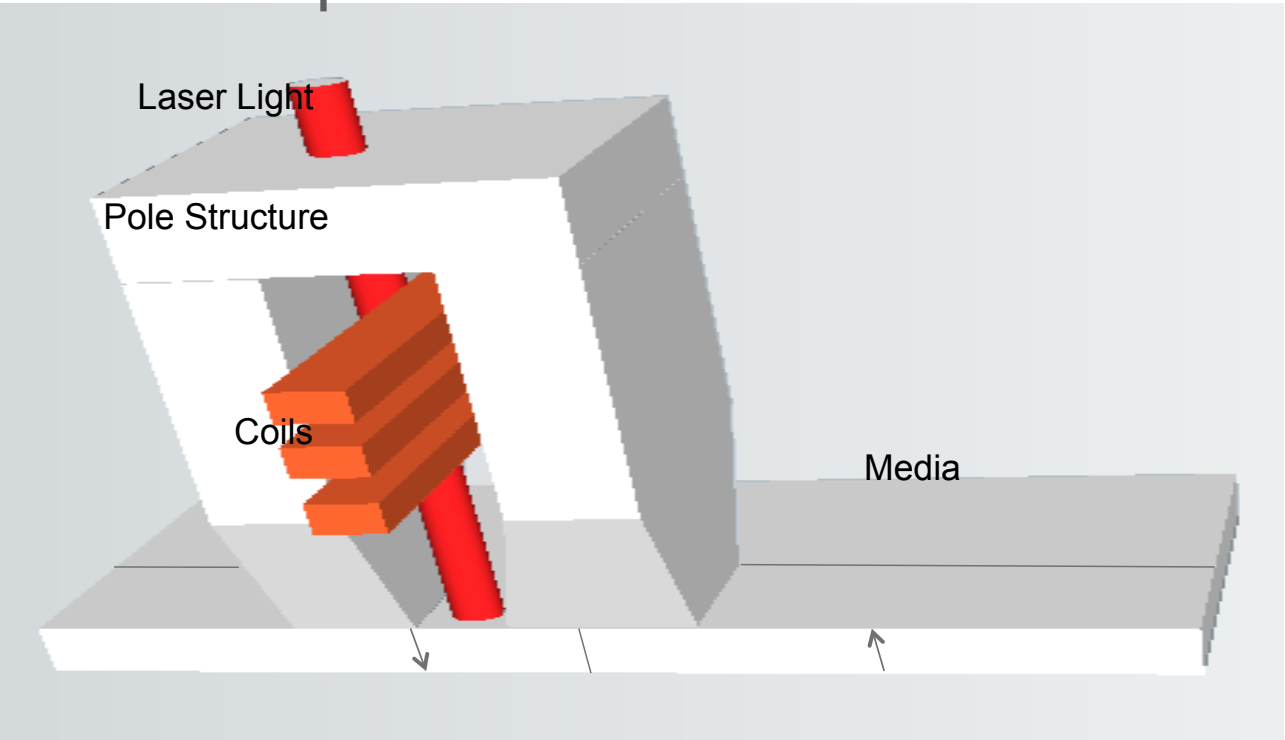
- Helium drives
- Shingled recording
- Energy assisted recording
- Bit pattern recording

Shingled Recording Concept



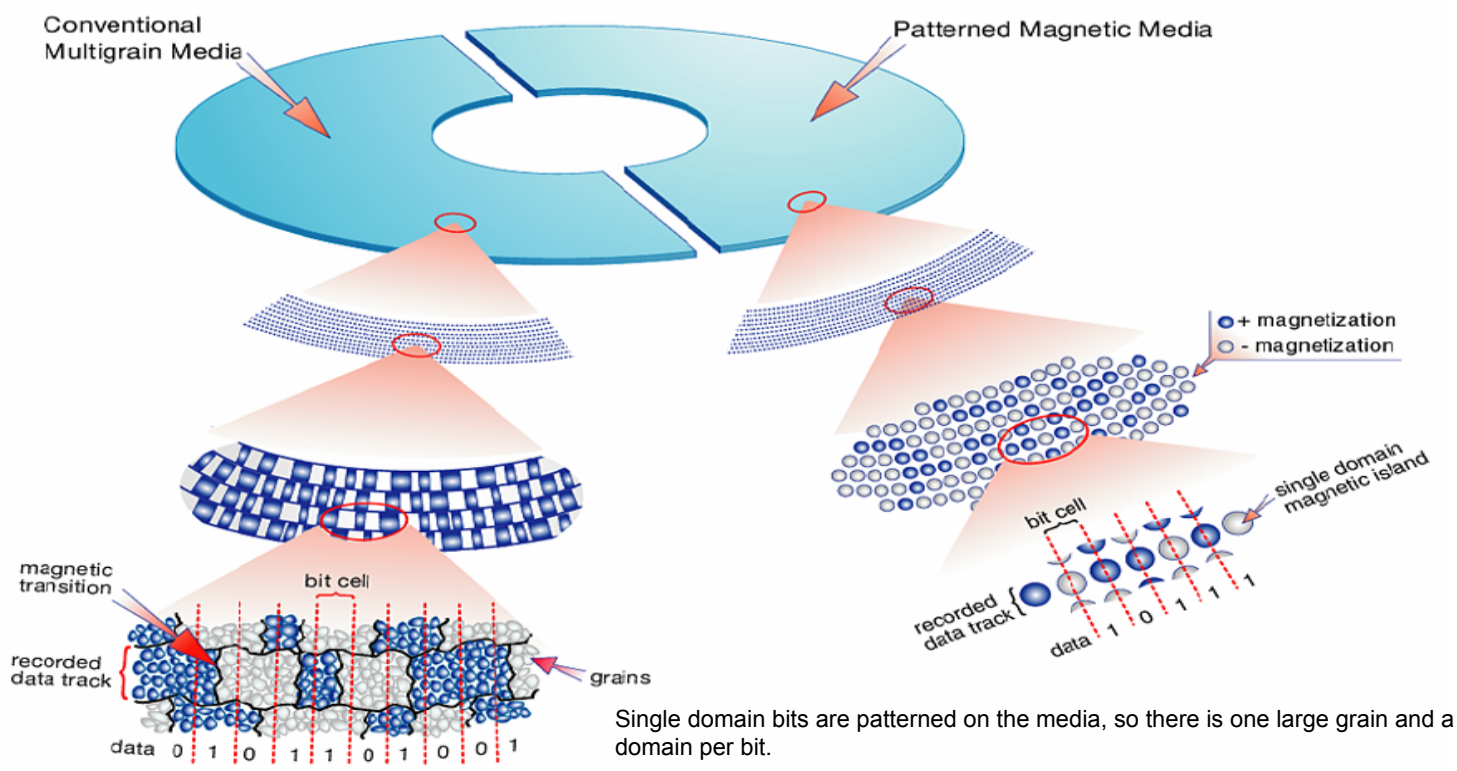
Wide tracks are partially overwritten to get narrower tracks

HAMR Concept



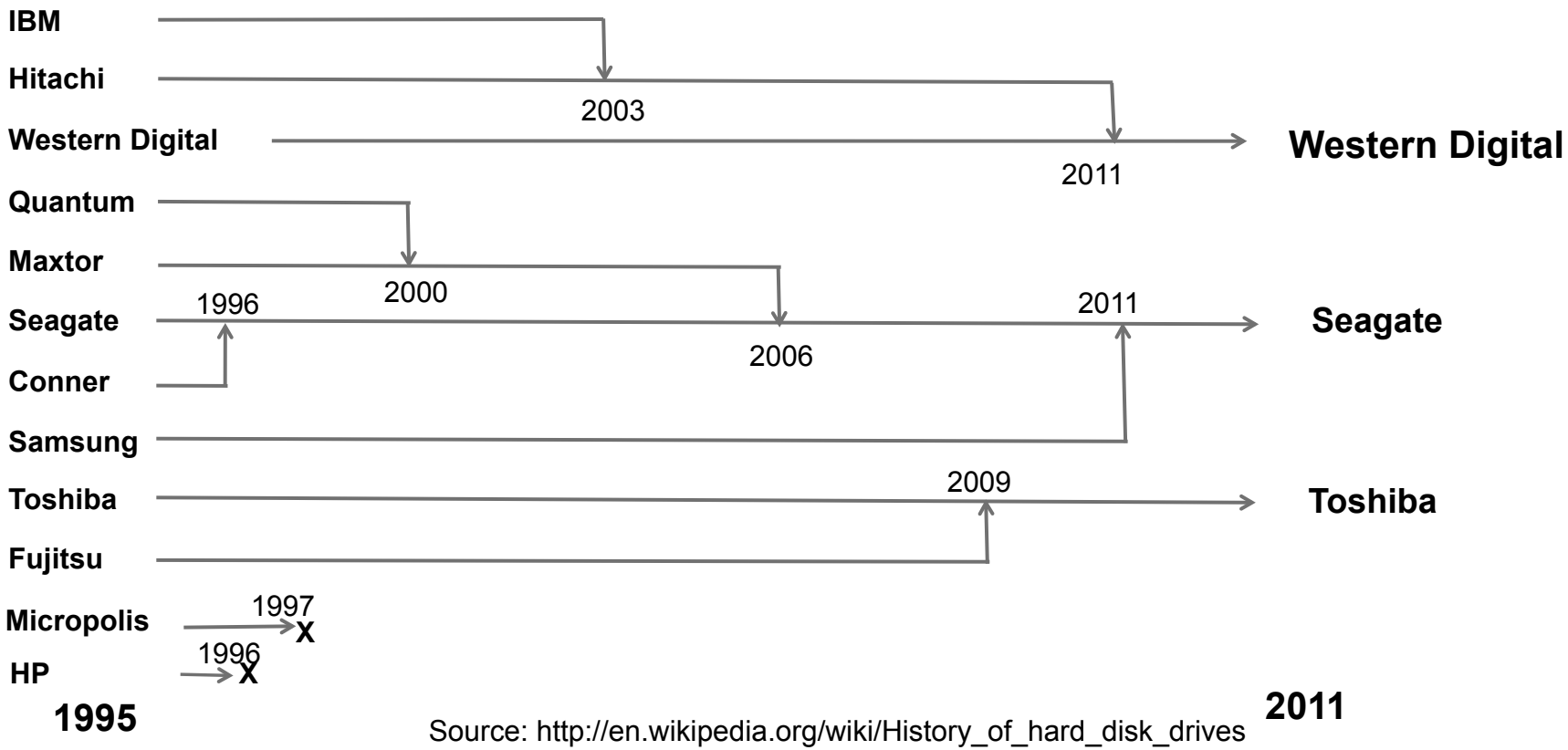
Laser heats media reducing media Hc so head magnetic field can write media

Bit Patterned Media Concept



Single domain bits are patterned on the media, so there is one large grain and a single magnetic domain per bit.

Disk Drive Manufacturers Family Tree



Source: http://en.wikipedia.org/wiki/History_of_hard_disk_drives

Flash Storage Trends

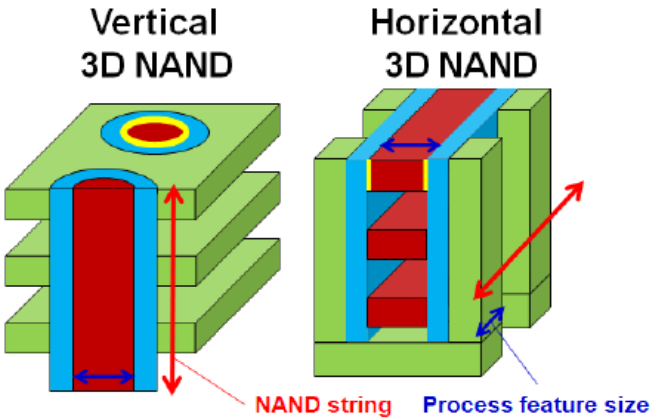
FLASH Challenges

- Reduction in cell size and more bits per cell results in degradation of retention time and endurance
  - 10 year retention dropping to 1year at end of endurance due to write cycles[1]
  - State detection level is determined by a small number of electrons
    - ~ 8 electrons per level for 16 nm TLC device
- As cell size shrink interference between cells increases[2]
- Basic performance has not improved (read, write and erase latencies) over the last decade[1]

1 International Technology Roadmap For Semiconductors, 2011 Edition Emerging Research Devices page 18
2 http://www.forbes.com/sites/michaelkanellos/2013/08/14/with-3d-chips-samsung-leaves-moores-law-behind/

3D NAND

- 3D stacking cells on top of each other enabling significant density increases
- Eliminate the need to reduce dimensions
  - no new lithographic technology needed, just a more layers to increase capacity
- Compared to latest 2-D NAND[1]
  - 2X the number of cells/inch[2]
  - ½ the power,
  - 2X as fast
  - 10X the endurance

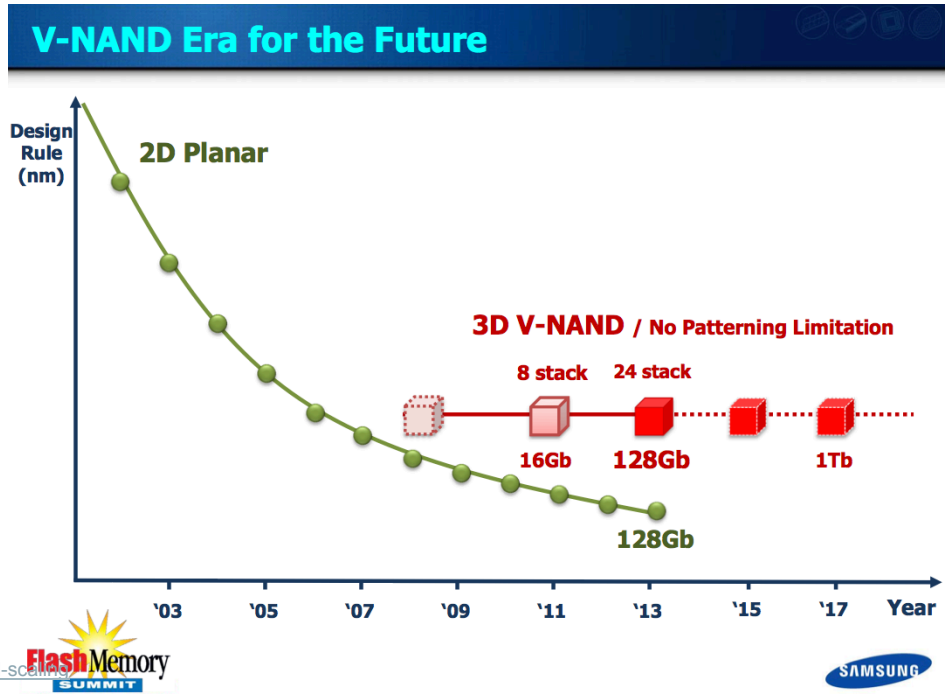


3D NAND architectures.

1. http://www.forbes.com/sites/michaelkanellos/2013/08/14/with-3d-chips-samsung-leaves-moores-law-behind/

3D NAND FLASH: Moving forward now with 5 manufacturers

- 1st to market: Samsung in 2013
  - 128 Gbit chip[1]
  - 24 layers of Flash cells
  - > 2.9 billion cells
  - 32 layer version released 5/14
- Intel and Micro announce 3D[2]
  - Could see 10TB in SSD drive format
- Toshiba and Sandisk announce 3D[3]



1. http://www.anandtech.com/show/7237/samsungs-vnand-hitting-the-reset-button-on-nand-scaling
2. http://www.digitaltrends.com/computing/need-space-ssd-intels-3d-nand-may-answer/
3. http://www.cbronline.com/news/tech/hardware/storage/toshiba-and-sandisk-partner-to-produce-high-capacity-3d-memory-chips-4268156

Summary

- Price/GB of Flash, Disk and Tape will remain differentiated
- Disk areal density growth is slowing and new technologies need to be introduced to overcome thermal instability issues.
- Flash moving to 3-D
- Tape area density growth can continue at current rate
  - New tape technology demos
  - Ideal archive technology
  - Ideal “Cold Storage” technology for the cloud

Hardware and Software
Engineered to Work Together


ORACLE®