



ChannelScience

Detecting the Future of Data Storage SM

IDE MA[®]

The Global Trade Association for the Disk Drive Industry for 20 Years



HDD:
The Next ~~50~~ Years

50,000

The Future Looks at Your Past:

Digital Archeology
and the
Hard Disk Drive

02006

Diskcon ~~2006~~

Celebrating the 50th Anniversary of the Hard Disk Drive
September 14, 2006

Chuck Sobey

csobey@channelscience.com

972-814-3441

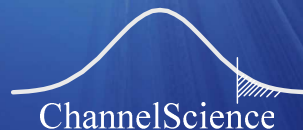
www.ChannelScience.com

What is Archeology?

- Anthropology: The Study of Humanity
 - Our physical characteristics as animals, and our unique non-biological characteristics we call culture.
 - Biological (physical) anthropology
 - Cultural (social) anthropology
 - Archaeology
- Archeology: The Study of Extinct Human Societies using the Material Remains of their Behavior

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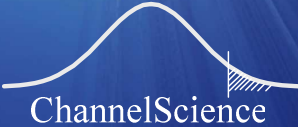
The Material Remains of Our Behavior



Most from: www.HitachiGST.com/techtimeline

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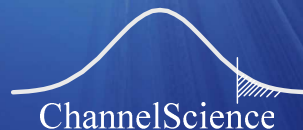
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Archeologists: Not Necessarily *Indiana Jones*

- Philosophers
- Grave Robbers
- Antiquarians
- Scientists (and Engineers)
 - Pseudo-archeologists (Remember *Chariots of the Gods?*)



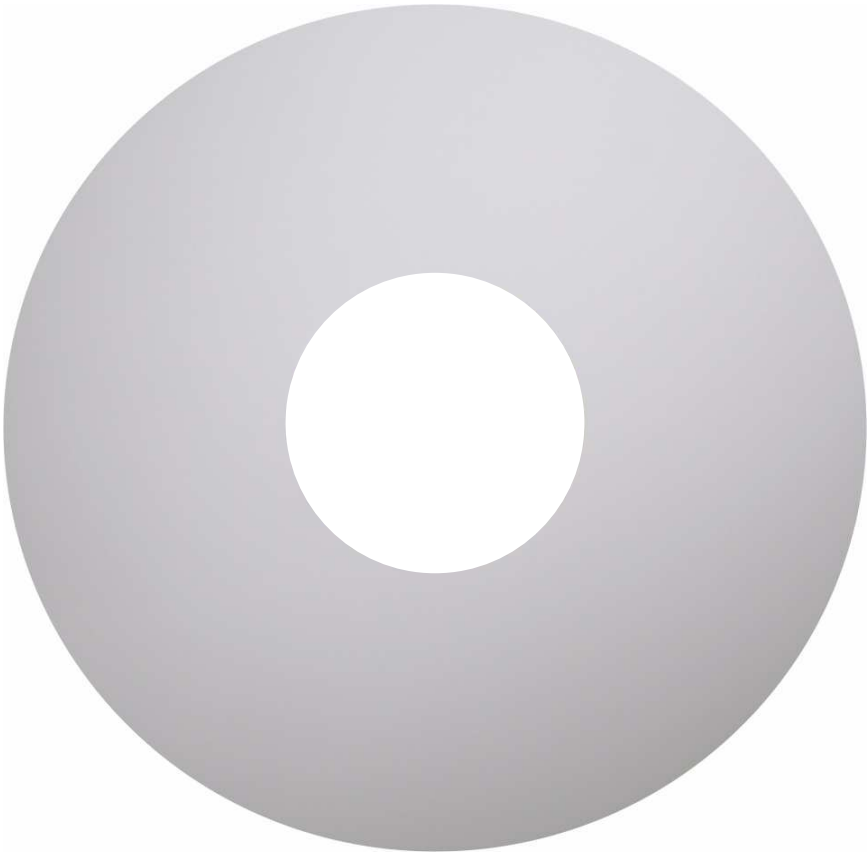
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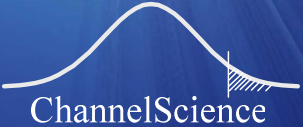
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Loiyangalani, Tanzania ~70,000 years ago



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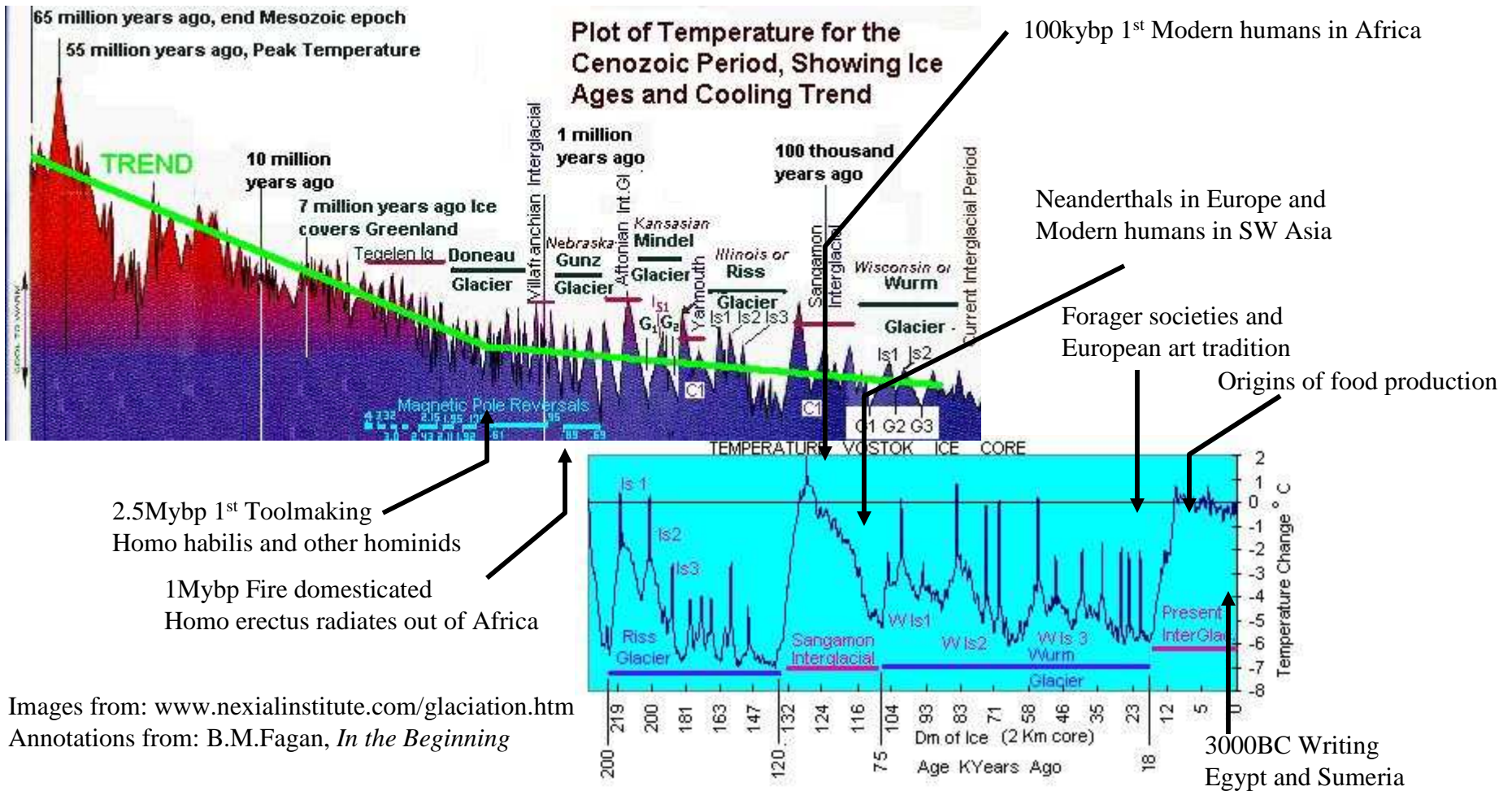
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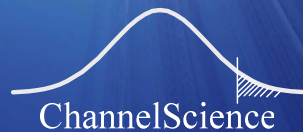
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Archeological Timeline and Interglacial Periods



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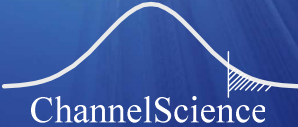
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The Next Ice Age is About 23,000 Years Out (unless human activity changes the climate)



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Today's Tools for Future Digital Archeologists

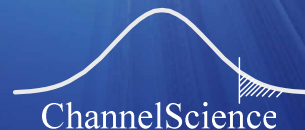
- Data Forensics
- Data Recovery
 - Getting usable data from a failed storage device

Maybe not that failed!



Courtesy Barry Bailey Photography

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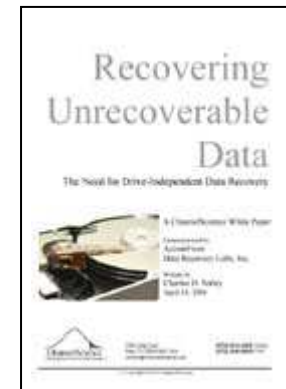


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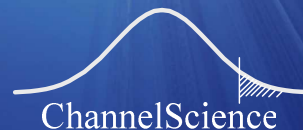
For More Information on Current Data Recovery Techniques

- Download *Recovering Unrecoverable Data: The Need for Drive-Independent Data Recovery*, Charles H. Sobey
- C.H. Sobey, L. Orto, and G. Sakaguchi, "Drive-Independent Data-Recovery: The Current State-of-the-Art," *IEEE Transactions on Magnetics*, February, 2006, pp. 188 - 193



www.ActionFront.com (Seagate)

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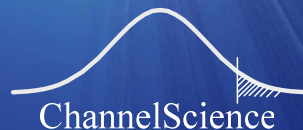
Unattributed Lament (from a well-known futurist)

“We are at the beginning of the Digital Dark Ages.
A generation’s worth of digital data is about to be
lost.”

“However, there will be plenty of paper evidence
left of who’s to blame.”

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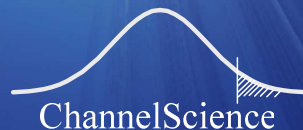
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How Long can Magnetic Bits Last?

- A rule-of-thumb for the industry
 - No more than 1% readback amplitude decay per “decade” on **average**
 - Of course a decade \neq 10 years
 - 1 second; 10 seconds; 100 seconds; 1000 seconds; ...
 - 31,536,000 seconds = 1 year
 - 1000 years = \sim 10.5 “decades”
 - 5,000 years = \sim 11.2 “decades”
 - 50,000 years = \sim 12.2 “decades”
- Currently, perpendicularly recorded bits are reported to decay at about 0.1% per decade
- **A lot of bits should still be present on a benignly neglected drive**

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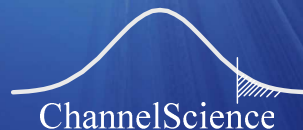
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This Isn't a Guarantee – But it is a Possibility!

- Here's the Guarantee
 - If magnetic patterns remain, they WILL contain lots of errors (on the most important bits)
- The Hope
 - Future humans and their technology will be more than capable of deciphering the bits that are there and reconstructing the missing ones – Math is math!
 - They will care enough about us to do it
- A Question
 - Do we care enough about them (and our legacy) to make it easier to do?

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Gordon Bell: www.MyLifeBits.com

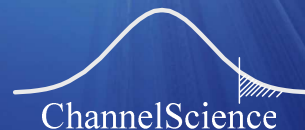
- Microsoft Researcher and key VAX developer
- Recording everything since 1998
- SenseCam camera
- New search capabilities being created



Photo by Mark Richards

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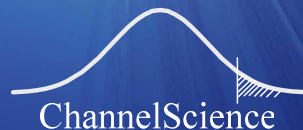
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The Short-term Future: The Digital Legacy on Grandma and Grandpa's Hard Disk Drives

- We look at old photos and documents now
- We need new search capabilities to find the relevant history and make it accessible (MyLifeBits – Microsoft Research)
- Synthetic Interview technology from Carnegie Mellon University
 - Albert Einstein and Benjamin Franklin
 - Can “it” learn?
 - Continue to offer advice to future generations
- Ian Pearson – Head of Futurology Unit of British Telecom
 - Could you tell it's not the real person over email?
 - Achieve **digital immortality**
 - By 2050 for the wealthy
 - 2080 for the rest of us

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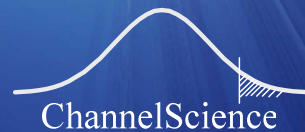
The Long-term Future An Archeologist Finds a Hard Disk Drive



Fossils and photography from the Steven Brittenham collection

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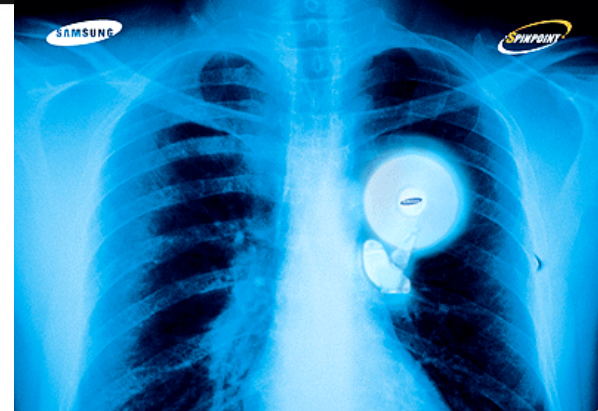
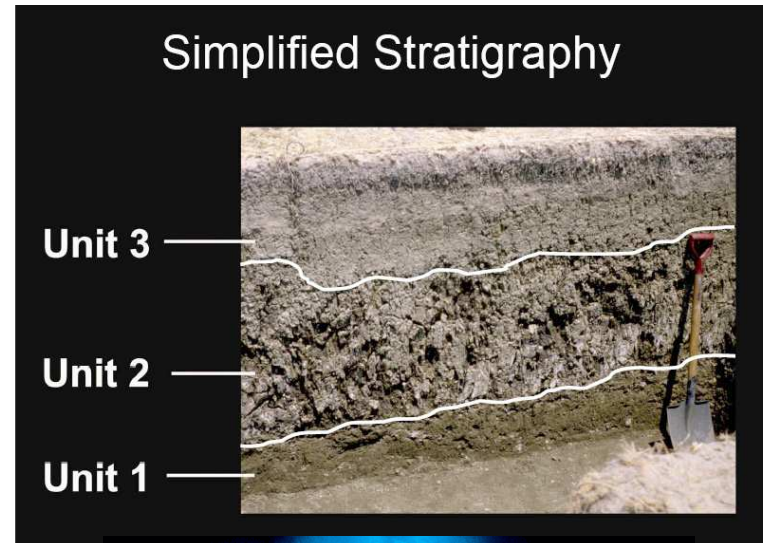


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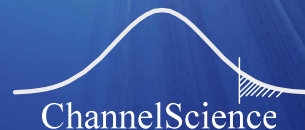
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An Archeologist Finds a Drive: Now What?

- Record the context of the find
- Are there “written” records identifying the artifact and its purpose?
- External physical exam
- Microscopic analysis (external)
- Internal imaging techniques
- Careful disassembly
 - Trying to get it to work first would probably be a disaster for the data
 - Will they even know it contains data?



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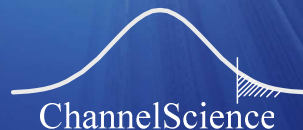
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What Data May be There? Another Guarantee

- Whatever we have carefully preserved for posterity will NOT be what interests the future most

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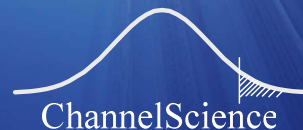
What if No Data Remain?

- Drives are very sturdy (paradoxically)
 - Compared with other parts of the PC
 - Beaker People → Hard Disk Drive People
- Who has drives and who doesn't?
- Where are the drives?
 - Geographically
 - In the home, office, school, etc.
- Trace trade routes
 - Development centers; sources of raw materials
 - Which components were made where, and when?
 - See book *From Silicon Valley to Singapore* by David G. McKendrick *et al*
- Manufacturing technology
 - HDD represents a large cross-section of technologies
- Provide chronology
- Archeological Fallback position
 - “It probably had **religious significance**”



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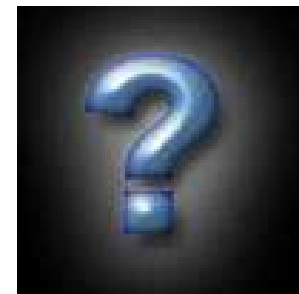
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Misinterpreting the Past



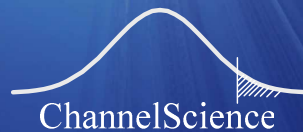
Fossils and photography from the Steven Brittenham collection

Religious
Significance



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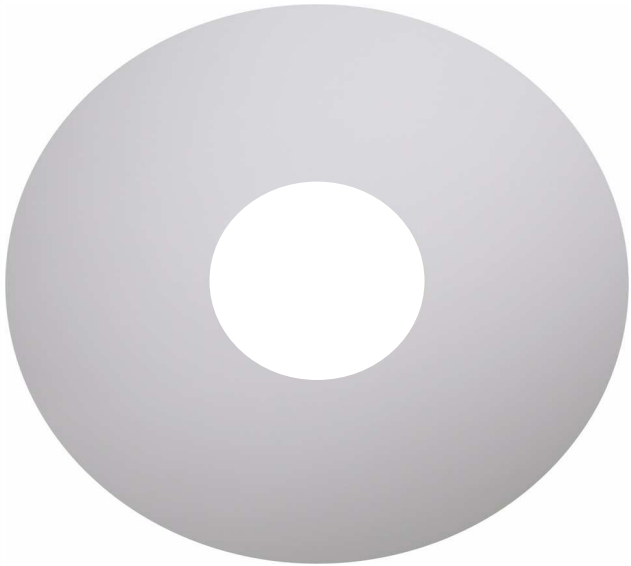
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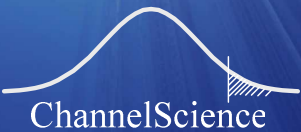
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Ostrich Egg Shell Bead, Phaistos Disc, Hard Disk



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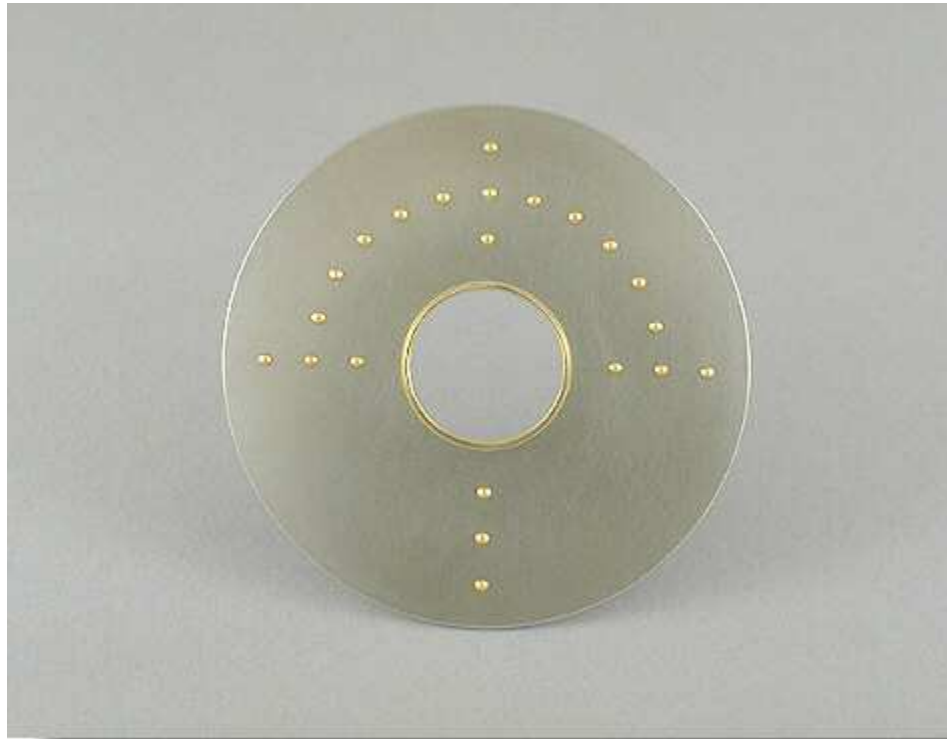
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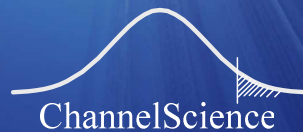
Perhaps it is Jewelry: A Brooch?



www.VelvetDivinci.com; Artist: Abrasha

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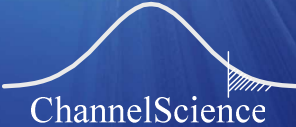
Or Belt Bling?



www.HGST.com

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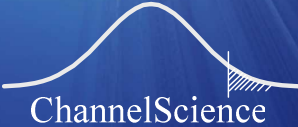
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Musical Instrument?



Valentina Vuksic's "Harddisko"

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Speakers?

Tweeter →

Midrange →

Woofers →

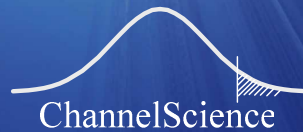
Cafeteria tray →



www.AfroTechMods.com

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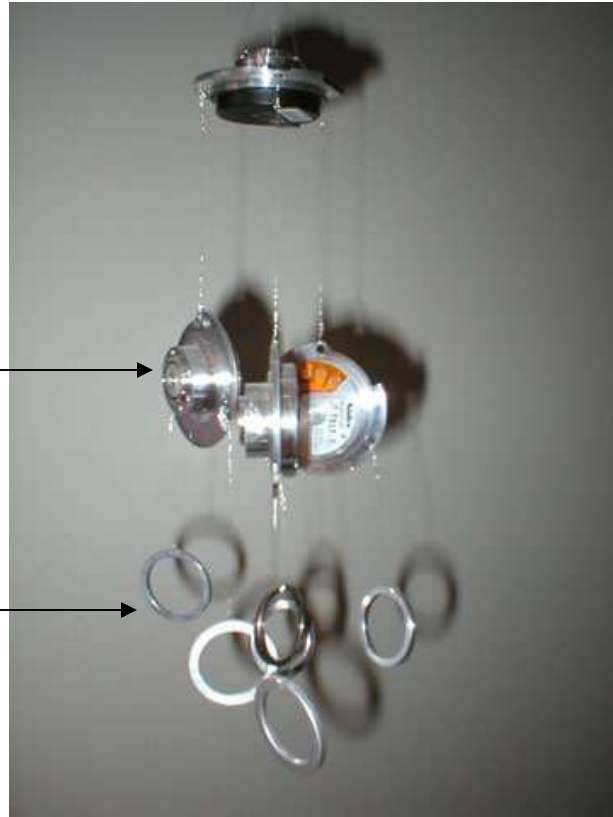
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Wind Chime?

Spindle motors

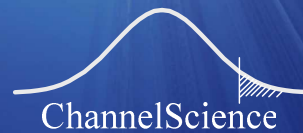
Spacers



<http://halogen.note.amherst.edu/~wing/wingie/tech/hdchime/hdchime.php>

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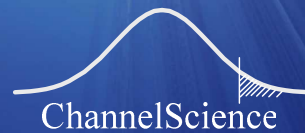
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Furniture?



Courtesy Prof. Cai Yang, CMU
www.contrib.andrew.cmu.edu/~ycai/

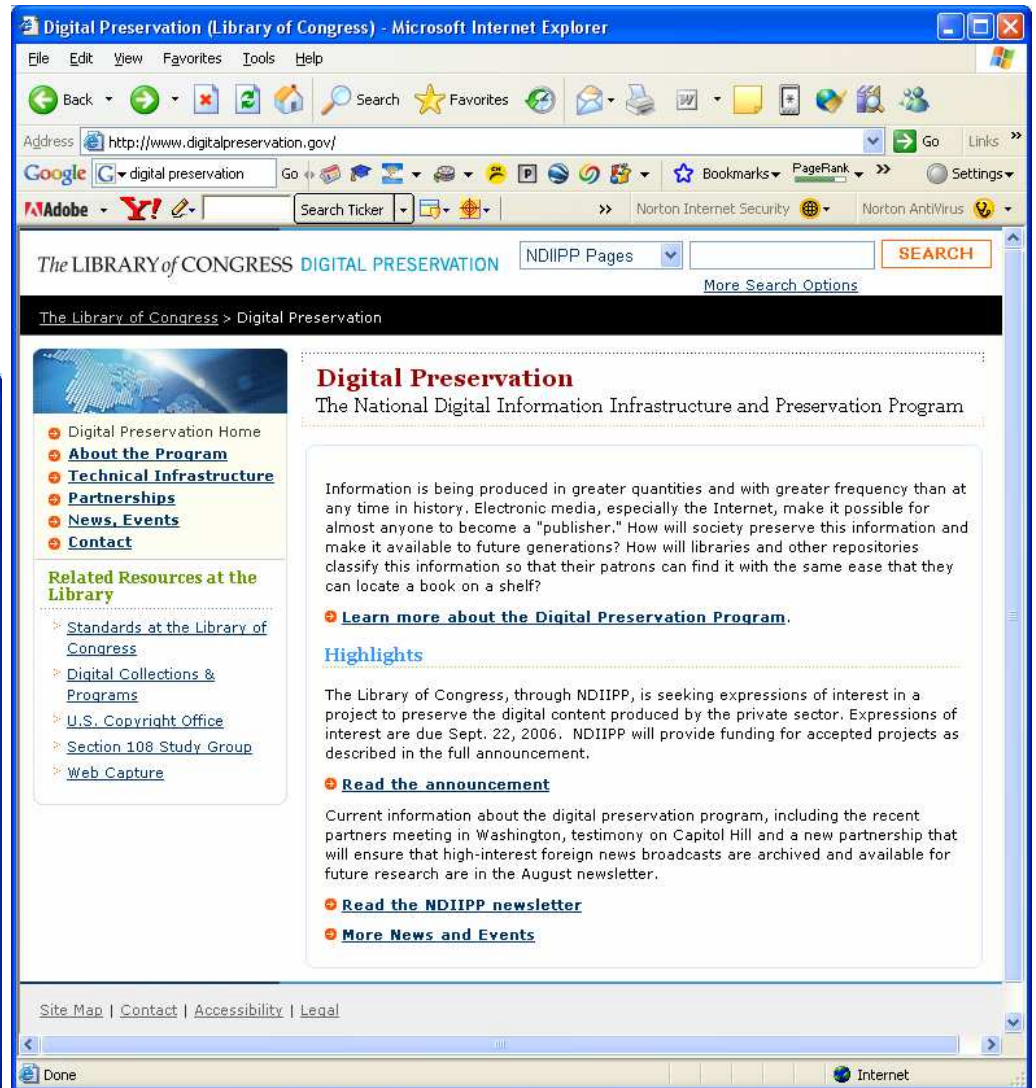
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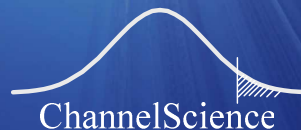
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Preserving Our Digital Heritage



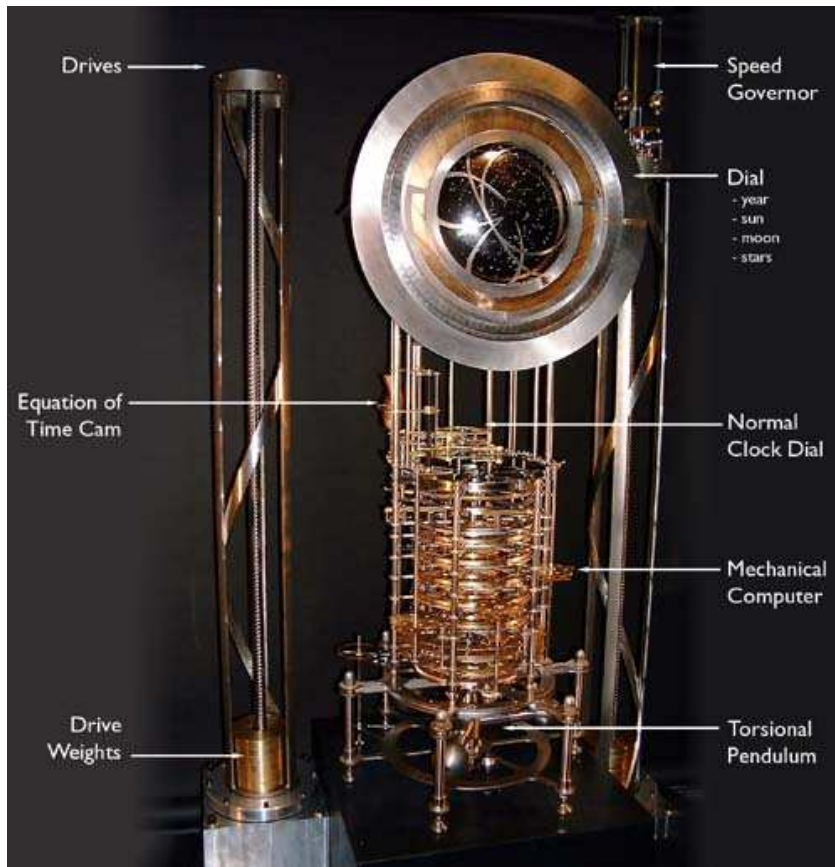
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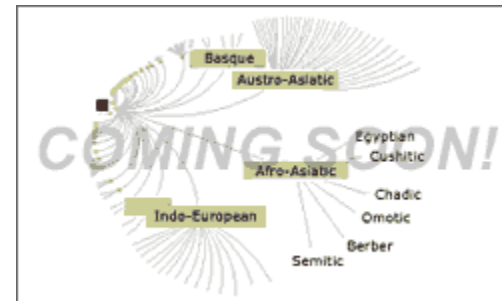
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Planning for the Future: www.LongNow.com



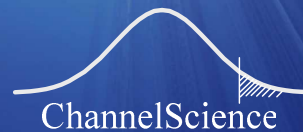
10,000 year clock



Rosetta Project
2300 languages

HDD:
The Next ~~50~~ Years

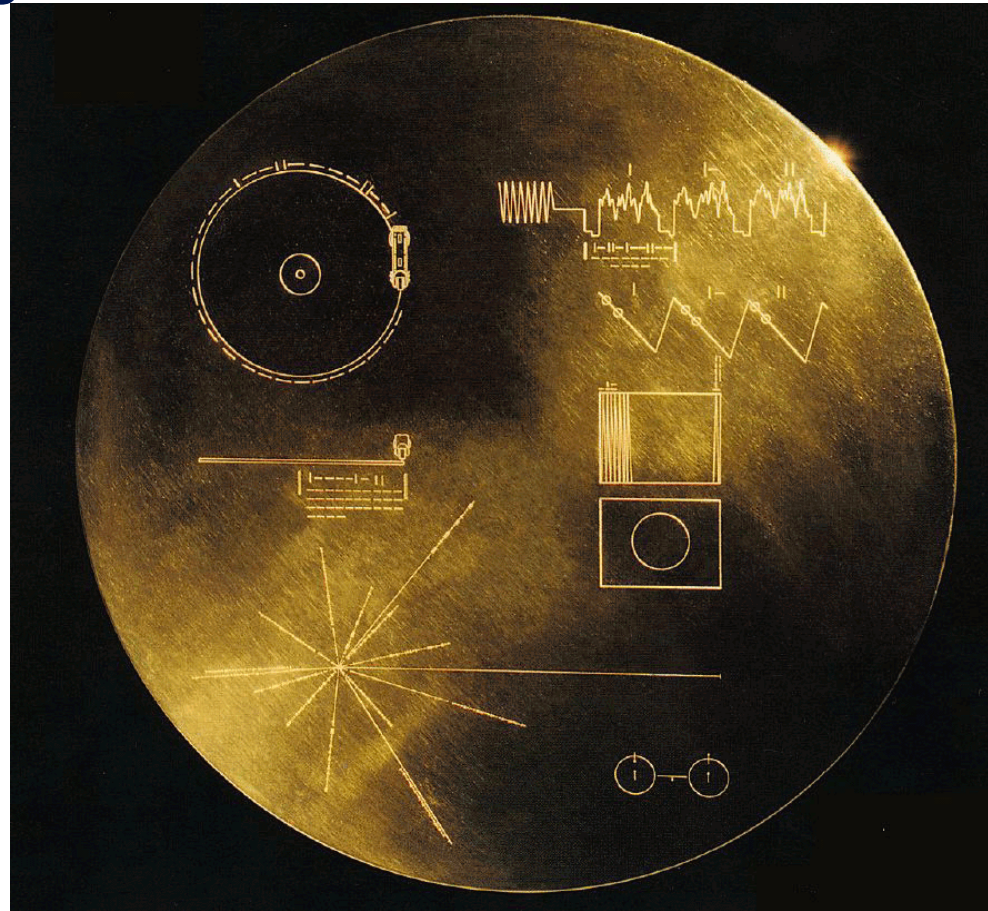
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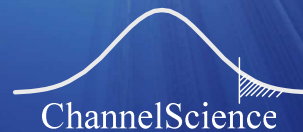
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Messages to the Future (> 40,000 years) The Voyager Golden Record



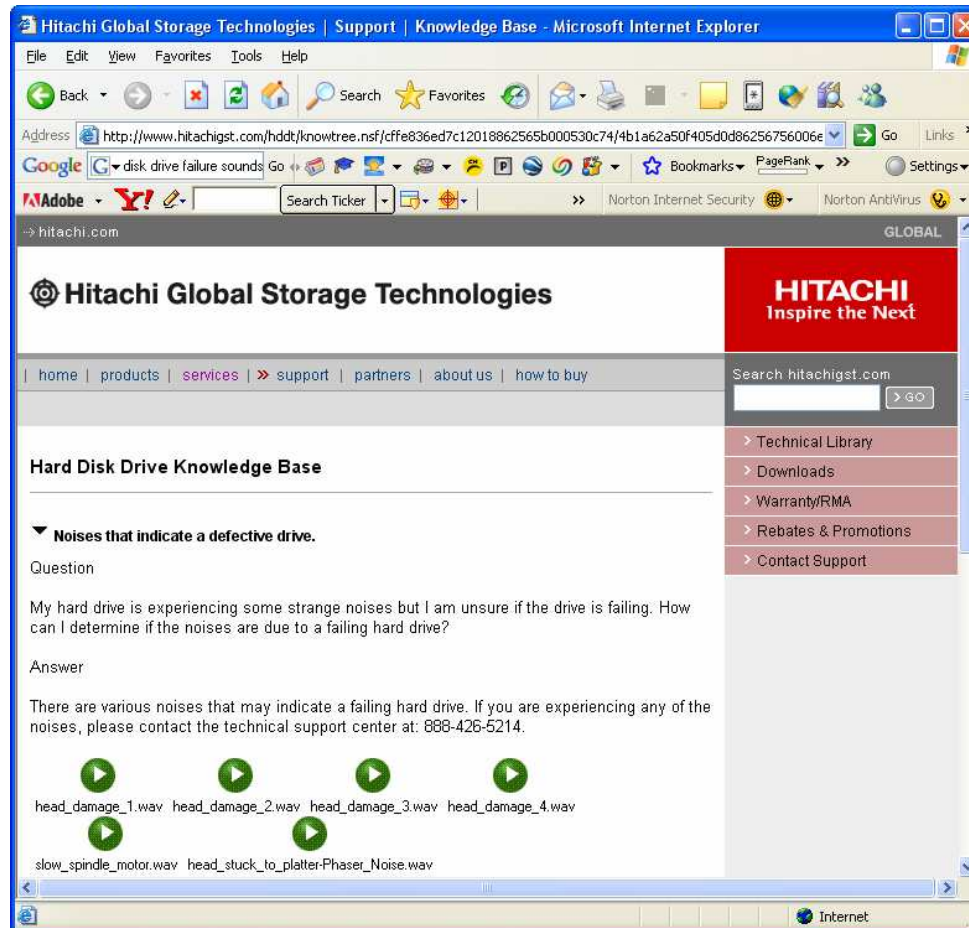
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Did the Background Music Sound Familiar?



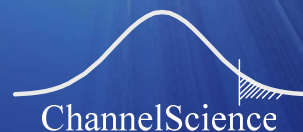
Gizmodo Hard Drive Dying
Dance Track Competition
Winner

James Postlethwaite
“Hitachi Hard Drive Project –
Noriko Version”

www.Gizmodo.com

You may also want to hear
“My Hard Drive Crizzash”
A runner-up

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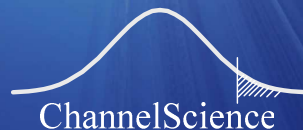
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Archeology Teaches that Humanity, Culture, and Science Have Endured

- In the past, data from dominant civilizations were saved by other cultures
- We have an increasingly global society
- When the world is one, there is no backup!

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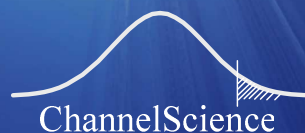
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LOCKSS (Stanford University)

- Selected the hard disk drive as the preservation **medium of choice!**
- “Lots of Copies Keep Stuff Safe”
- Open source, peer-to-peer, distributed content
- Copies regularly compared
- When users buy new storage devices, the archive is automatically migrated forward to the new technology

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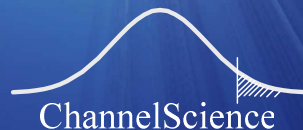
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Take-aways for an HDD-related Company

- It is OK to devote resources to the very long-term thinking
 - Microsoft Research – Digital Immortality
 - British Telecom – Futurology Unit
 - The very long view can spur new thinking, new connections, new products, and new services – Today!
- Projects with a long view: Break the tyranny of areal density
 - We're very practical!
 - Use as team building or “sabbatical” reward
 - Feed lessons-learned back into production
 - Design an HDD to last 50 years
 - Design a drive to be built by multiple generations
 - Simulate this by multiple, staggered teams
 - Create a Voyager “Golden Disk Drive” cover explanation
 - Design an “alternative energy” HDD
- The long-term future of data is uncertain
 - Where there is a need, there is a business opportunity!

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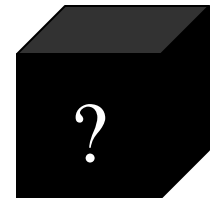
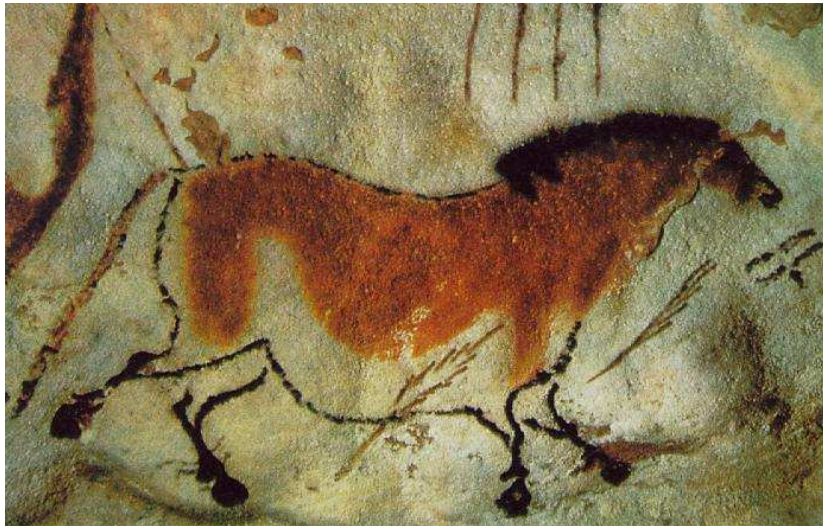
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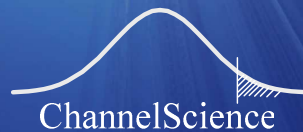
If We Don't Improve the Future of Data, Who Will?

Our industry is critical to the future (as well as the present)

- From time-to-time take the long view!
- Plan for our digital legacy
- Storing data is a noble profession



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Thank You

LSI Logic, Inc.

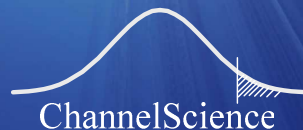
For sponsoring this talk!

Acknowledgement: Thank you all for your Help!

- Barry Bailey
- Gordon Bell
- Stewart Brand
- Steve Brittenham
- Brian Fagan
- Ed Grochowski
- Bill Higgins
- Al Hoagland
- Jay Hoinville – Euxine Technologies
- Robert Kemper
- Mike Mallery
- Reto Wettach
- Cai Yang
- And anyone I forgot!

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Detecting the Future of Data Storage SM