



# Open Source Backup Conference

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## IBM Future of Tape Contemporary and cost- efficient backups to to tape

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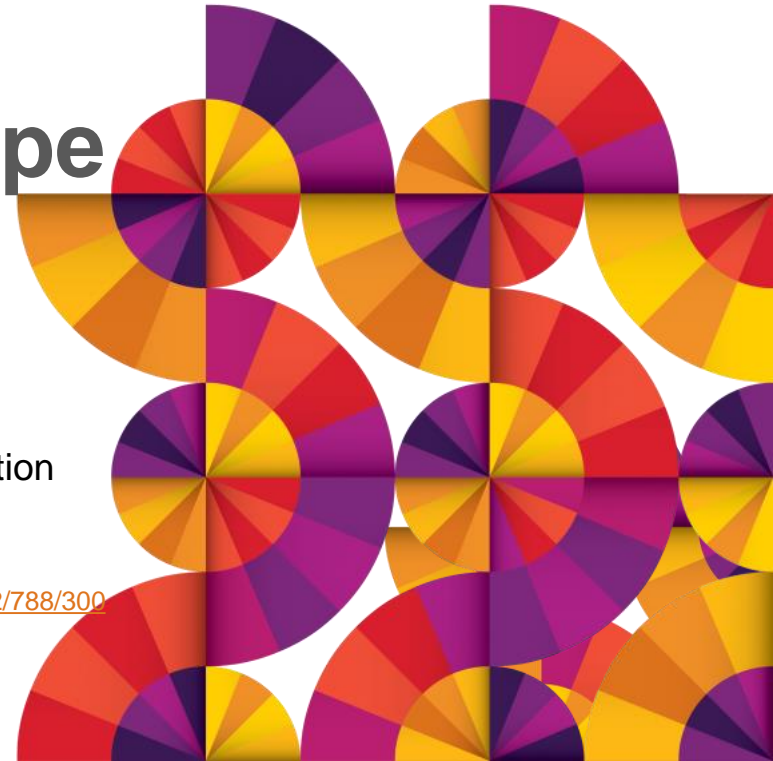
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<https://www.xing.com/net/ibmdataprotection>

<http://www.linkedin.com/pub/josef-weingand/2/788/300>

<http://de.slideshare.net/JosefWeingand>



## ■ Abstract:

Recently IBM demonstrated a 220 TB Tape Cartridge. I will show the future of Tape Technology and the enhancement made in Tape Storage. Also I give an outlook in Hard-Disk and in Flash Technology. The roadmap in areal density and capacity growth in those different technology will force us to rethink our backup storage architecture in the future. I will discuss and compare those different storage technologies areal density, roadmap, bit error rate, cost and power consumption. I will calculate some example related to backup environment where not only huge data are stored but also many data processed daily.

## ■ Agenda:

### ■ Storage Technology

### ■ Why Tape – Advantages of Tape

- Roadmap
- Reliability
- Performance
- Cost

### ■ Backup Storage – different Solutions/Architectures



## Physical Bit Cells (2015): NAND, HDD and TAPE

Bit cells shown at scale

NAND struggles with bit stability below 19nm for MLC/TLC  
Trend is to transition to larger cells with vertical (3d) stacking

HDD struggles with difficulty writing small magnetic grains needed to enable future areal density growth → shingling for now, HAMR for the future

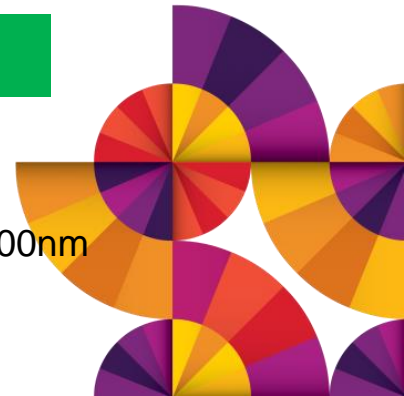
Tape's large bit cell suggests there is room to grow

■ **NAND - TLC**  
1500 Gbit/in<sup>2</sup>  
19nm x 19nm

■ **NAND - MLC**  
1024 Gbit/in<sup>2</sup>  
23nm x 23nm

■ **HDD**  
840 Gbit/in<sup>2</sup>  
60nm x 11nm

**TAPE**  
7 Gbit/in<sup>2</sup>  
2000nm x 100nm



## Tape Technology Demonstration IBM Rüschlikon

**Areal recording density :  
123 Gb/in<sup>2</sup>**

**88x LTO6 areal density**

**→ 220 TB cartridge capacity (\*)**



**This demonstration shows that tape  
technology has the potential for  
significant capacity increase for years to  
come!**

HDD Technology:

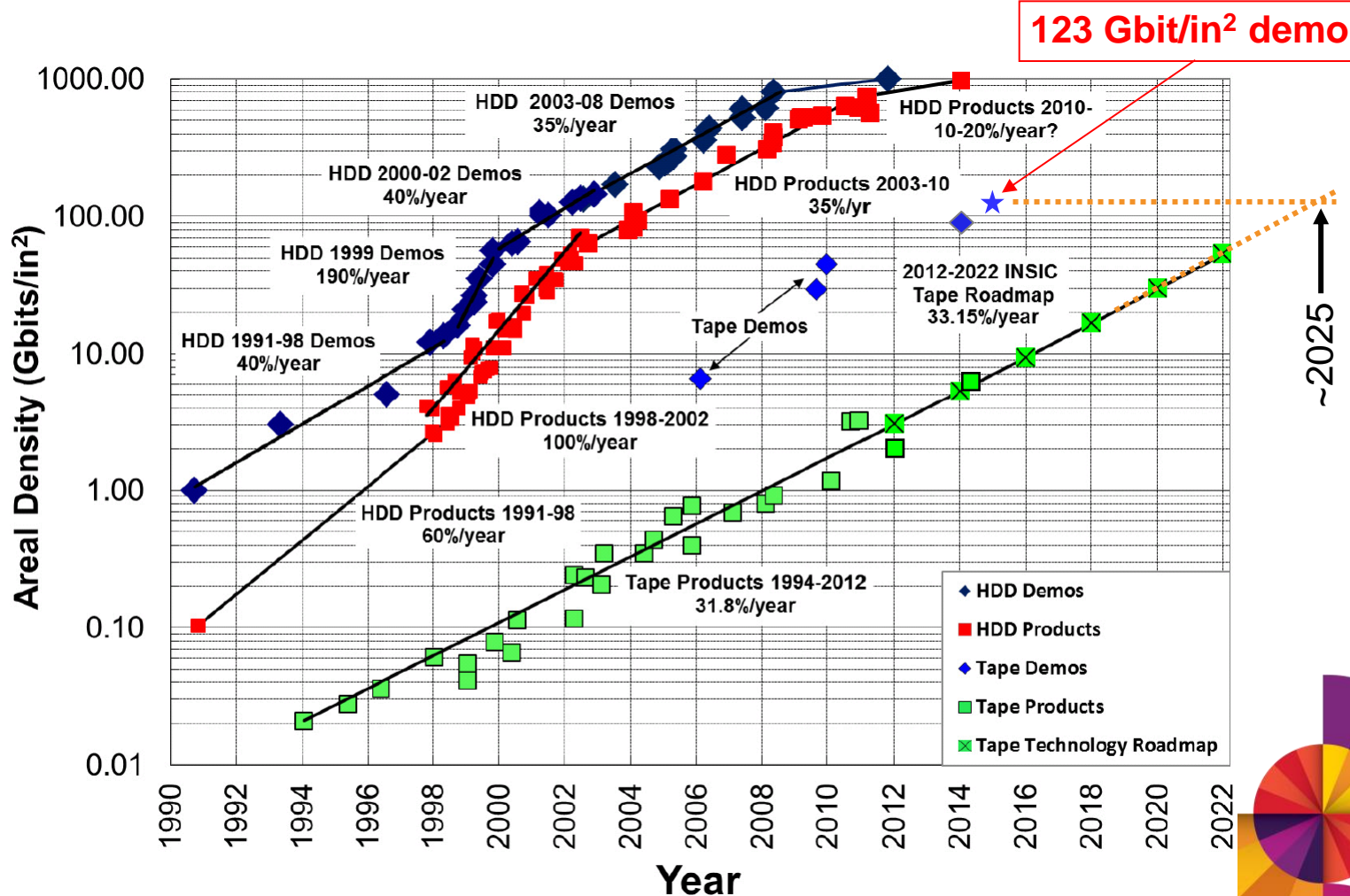
- No room to continue adding platters
- HDD capacity will be driven by areal density scaling (10-20% /a)

**Cost advantage of tape will continue to grow!**

(\*) 220 TB cartridge capacity, assuming LTO6 format overheads and taking into account the 48% increase in tape length enabled by the thinner Aramid tape substrate used

## IBM-FujiFilm demonstration of 123 Gb/in<sup>2</sup> on BaFe tape

Goal: Demonstrate the feasibility of tape roadmap for the next 10+ years



(Source: INSIC 2012-2022 International Magnetic Tape Storage Roadmap)



## Future of NAND, Disk and Tape

Presently, HDD growth is focused on introduction of more platters and SMR. Revolutionary technology like HAMR faces extendibility (Moore's Law) challenges and is not yet proven in manufacturing.

NAND has a near term horizon of increasing density by 2 to 3x and a long term horizon of 6x. NAND areal density increases rely on transition to 3d geometry and requires new processing strategies. However, this is a core expertise of the semiconductor industry.

Tape areal density has been growing at approximately 30-40% per year using evolutionary technologies and is backed up with a consistent record of demonstrations.



## NAND Area Density

NAND has three strategies for increasing bits per unit area in a silicon chip

1 Lithographic scaling of the bit cell (x, y) dimensions by reducing  $F^*$

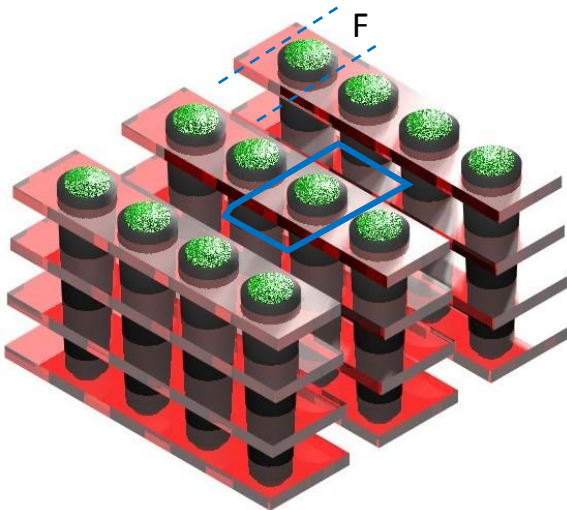
- 20nm to 16nm → 1.56X more density
- 16nm to 13nm → 1.51X more density

2 Increasing the number of bits per cell

- 1 bit per cell to MLC (2 bits per cell) → 2.00x increase
- MLC to TLC (3 bits per cell) → 1.50x increase

3 3D stacking (larger bit cell but multiple layers of cells)

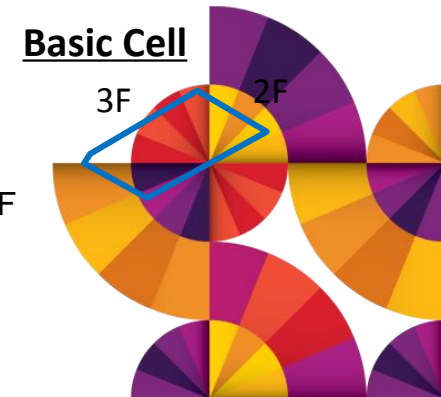
Example: 16 nm goes to 48 nm and cell design goes from  $4F^2$  to  $6F^2$  so cell area increases 13.5x  
But by using 27 layers the effective density on the surface of the wafer increases by 2.00x (27/13.5)



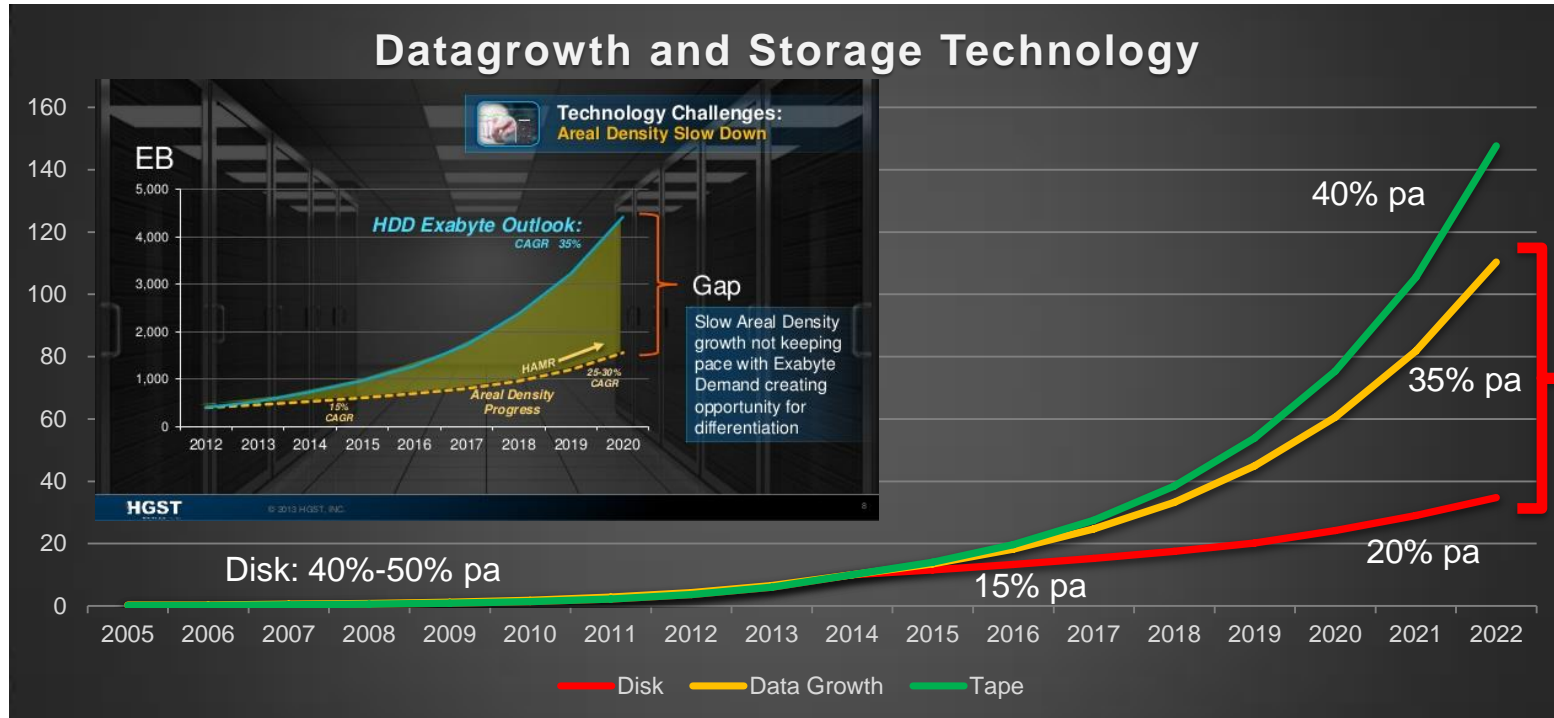
### 3D Design Example

- Basic Cell  $2F \times 3F$  (F is minimum feature)
- 12 cells per layer
- 4 layers
- 2 bits or 3 bits per cell

\*The basic NAND cell has an area of  $4F^2$ , where F is the minimum patterned feature forming the cell



## Data Growth and the GAP with HDD Technology



- Within 3 years you need 2,5x HDDs = 2,5x Cost
  - Example: Today 600TB ~ 300 HDDs/7,5 KW
    - in 3 years 1,8 PB ~ 750 HDDs/18,7KW

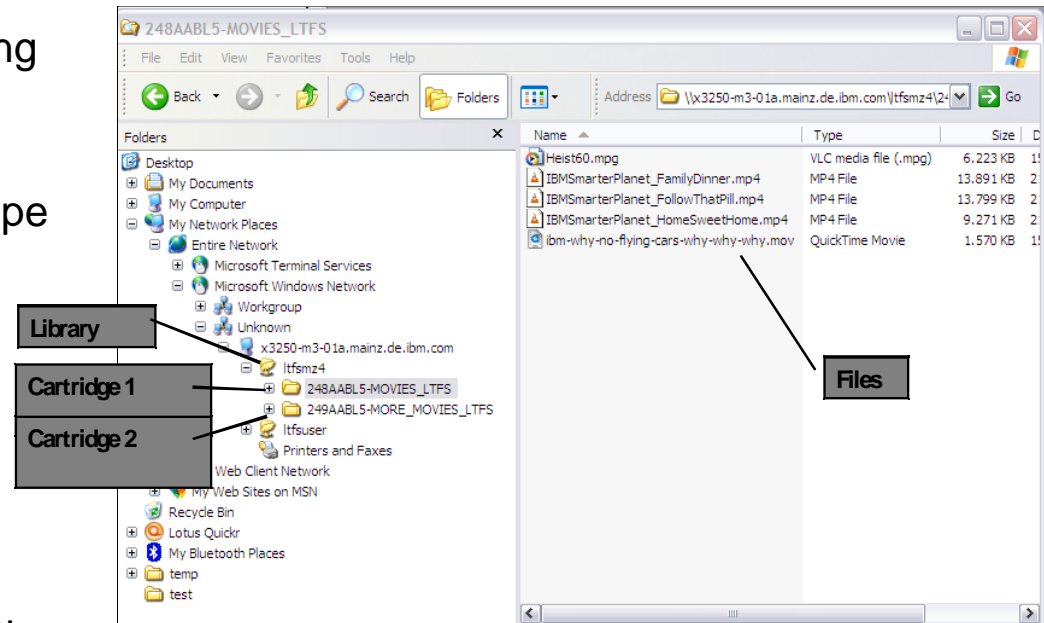
**Stop the discussion „Tape is dead“!**





## IBM Linear Tape File System (LTFS)

- Tape like USB-Stick
- Self-describing tape format for archiving data to tape
- Improves efficiency, simplifies direct access and management of files on tape
- Four offerings:
  - Standalone Drive Edition (SDE)
  - Library Edition (LE)
  - Storage Manager (SM)
  - Spectrum Archive / Enterprise Edition (EE)
- Supports LTO 5/6 and TS1140/TS1150 tape drives



## Press:

".... combination of flash and tape is better than tape alone or disk and tape for storing archival data. The argument is based on tape being not only cheaper than disk, but actually faster than disk for streaming large files."

"A core finding is that disk capacity prices are not decreasing as fast as those of flash or tape."

This tells us that the ability to get data off tape is getting faster, relatively, given the tape growth rates. And the areal density is growing at approximately 30 per cent versus disk, which is growing at only 9.6 per cent. Data can be extracted 4x faster from tape than it can from HDD.

.... tape can be faster than disk for large file

"..., tape is getting faster and is inexpensive and HDDs are not getting that much faster and,."

<http://www.theregister.co.uk/2014/07/16/flape/>

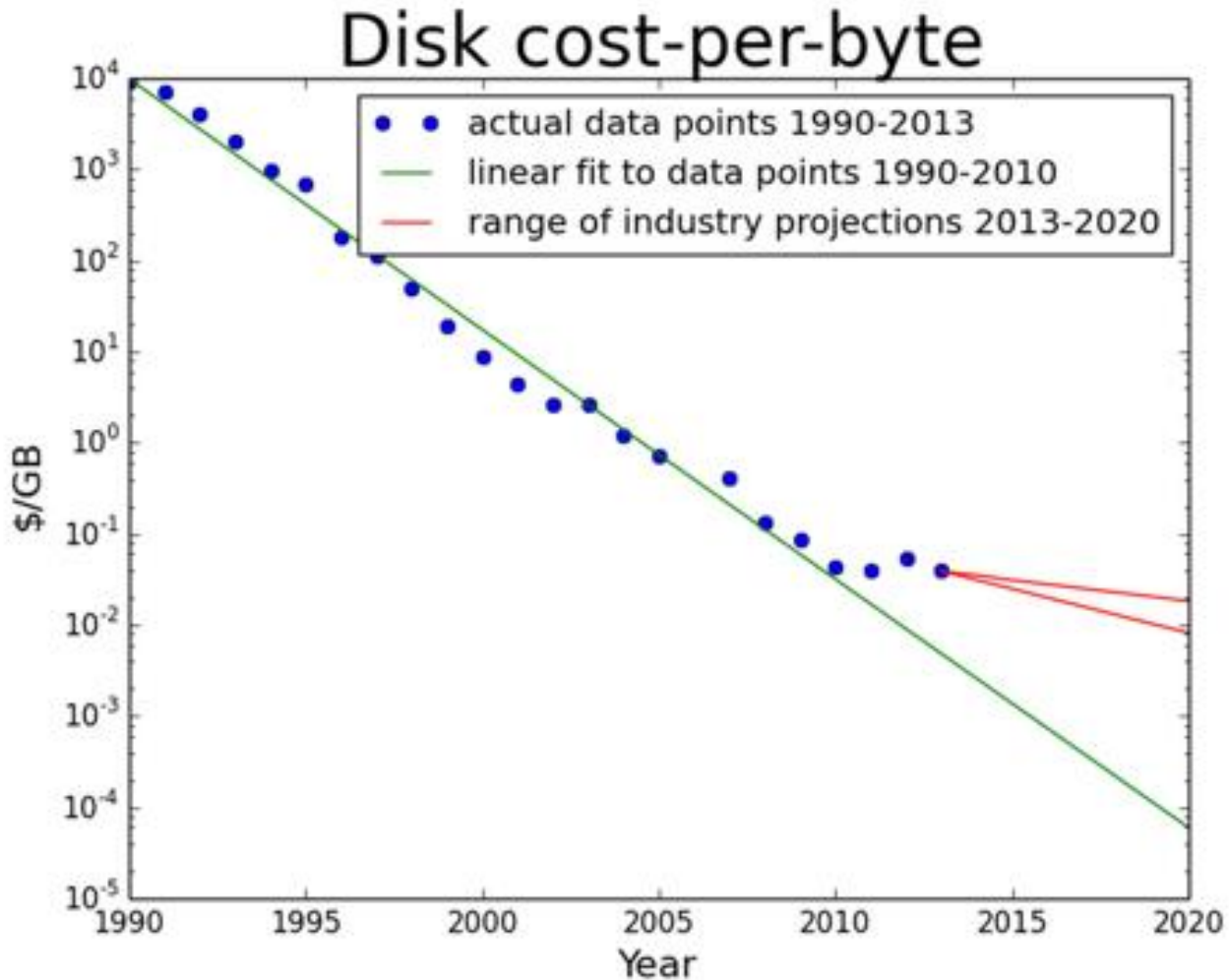


## Will the “Tape is Dead” Folks Please Sit Down?

....For them, tape's density and economies of scale remain an excellent backup and/or archival choice..... Tape is proving more reliable than disk, especially lower cost disk. The National Energy Research Scientific Computing Center (NERSC) reported that tape cartridges are up to four orders of magnitude more reliable than SATA.... After showing signs of bottoming out a few years ago, 2013 sales stopped declining and 2014 is seeing sales rise..... tape performance is generally superior with sequential access, which is why tape is particularly useful with backup, archive and big data sets.

<http://www.enterprisestorageforum.com/backup-recovery/will-the-tape-is-dead-folks-please-sit-down-1.html>





[http://www.theregister.co.uk/2014/11/10/kryders\\_law\\_of\\_ever\\_cheaper\\_storage\\_disproven/](http://www.theregister.co.uk/2014/11/10/kryders_law_of_ever_cheaper_storage_disproven/)

## Data Security

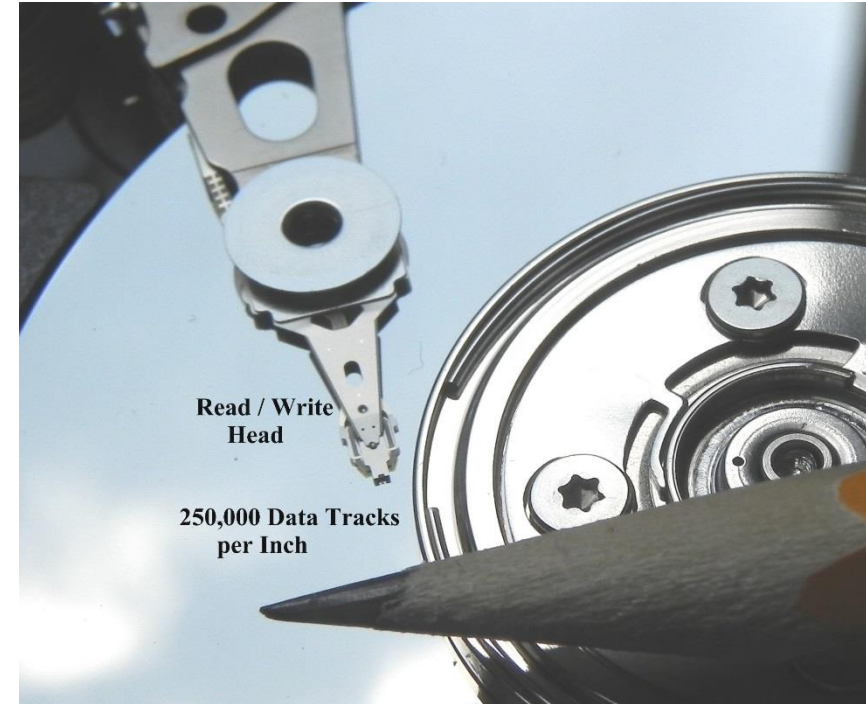
Device	Hard Error Rate in bits	Equivalent in Bytes	Equivalent in PB's
SATA Consumer	10E14	1.25E+13	0.01
SATA/SAS Nearline Enterprise	10E15	1.25E+14	0.11
Enterprise SAS/FC	10E16	1.25E+15	1.11
LTO and some Enterprise SAS SSD's	10E17	1.25E+16	11.10
Enterprise Tape	10E19	1.25E+18	1110.22

- SAS HDDs Bit Error Rate  $10^{16}$
- NL SAS  $10^{15}$ 
  - <http://www.enterprisestorageforum.com/storage-technology/sas-vs.-sata-1.html>
  - With NL SAS you will get a Data loss after **110 TB!!!!**
- Example: 50 TB/daily; 2,5 PB capacity
  - Raid5 with 8 TB (8+1) => 470 HDDs -> 0,12 TB per HDDs / daily -> Failure=Data Loss after ~**950 days**  
**= 2,5 years**
- With Tape: Data loss after 62 years!
  - Tape is doing a Read after Write Check!
  - IBM Jaguar Drives can recover a Media failure of about 11 mm
- Lifetime Warranty on IBM Tape Media
  - Returns > 0,02% (10 000 Cartridges -> 2 broken)
- **In addition Tape is a “offline” Media!**



## Noise damage Disk Drives

- Inert gas discharge on live computer equipment has the possibility of damaging hard drives.
- <http://www.datacenterjournal.com/inert-gas-data-center-fire-protection-and-hard-disk-drive-damage/>
- [http://www.eurofeu.org/fileadmin/Dateien/pdf/Positionspapiere/Eurofeu\\_FEI-guide\\_Hard\\_drives\\_10\\_12\\_V1.pdf](http://www.eurofeu.org/fileadmin/Dateien/pdf/Positionspapiere/Eurofeu_FEI-guide_Hard_drives_10_12_V1.pdf)





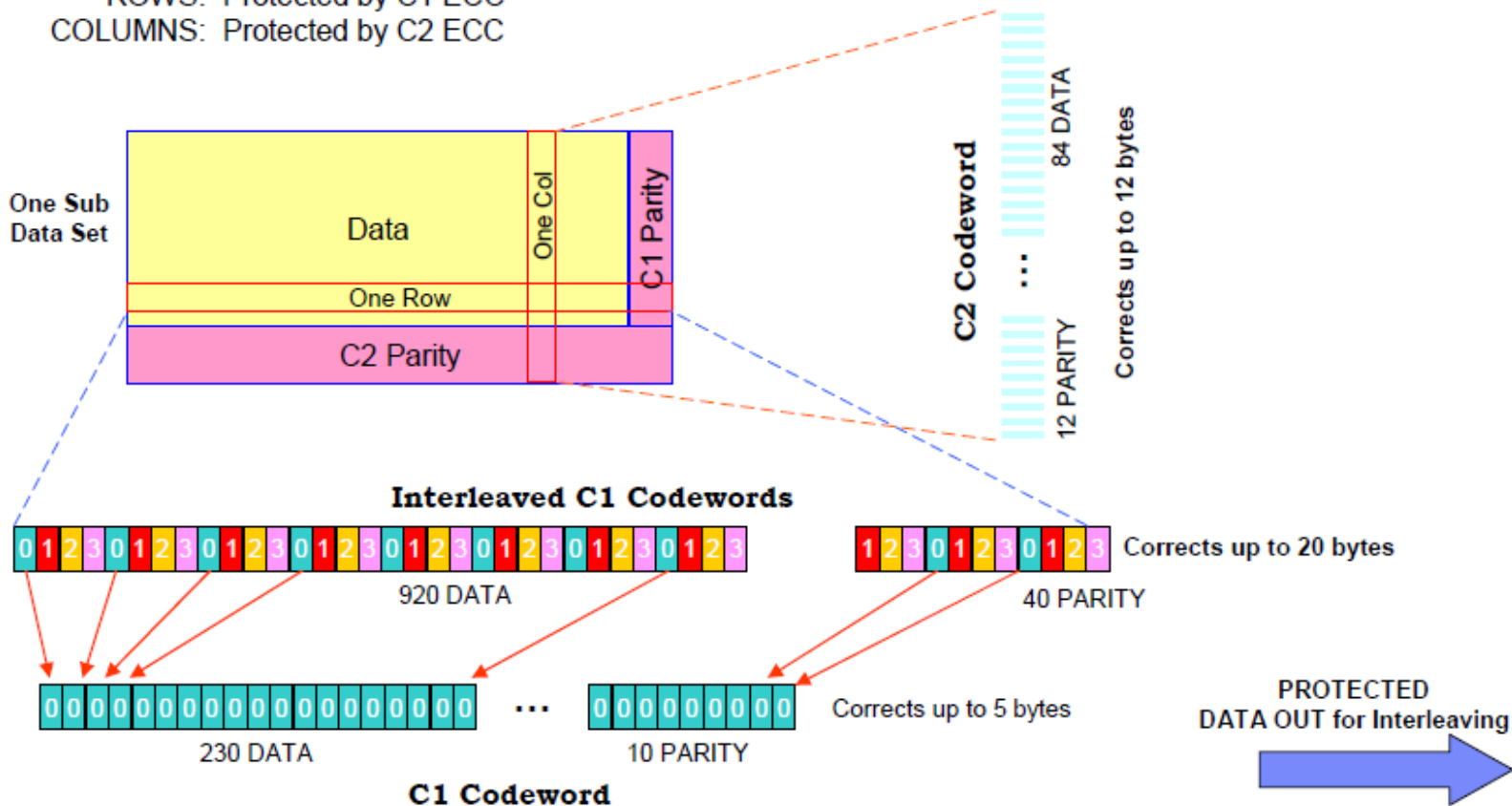
## Tape Data Format: 2-Level ECC – Very Strong Data Protection

- User data (optionally compressed/encrypted) is partitioned into fixed size Data Sets
- Data Set = 32 sub data sets
- Sub Data Set = 96 × 960-byte array

ROWS: Protected by C1 ECC  
COLUMNS: Protected by C2 ECC

### Failure Rate Comparison

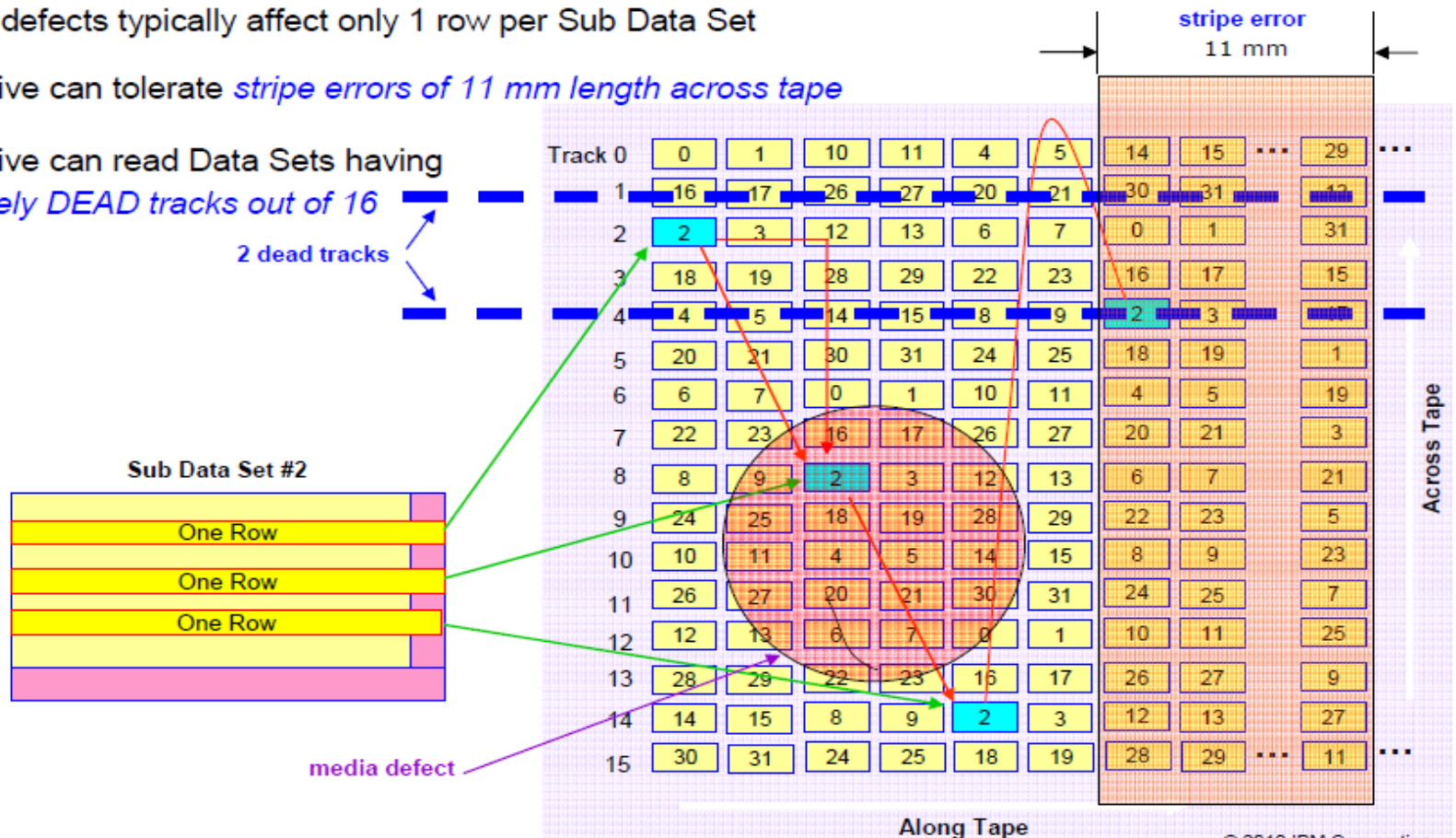
HDD (SATA):  $P_{\text{bit}} < 10^{-15}$  to  $10^{-14}$   
Tape:  $P_{\text{byte}} < 10^{-19}$



## Tape Data Format: Data Layout on Tape – Deep Interleaving

- Sub Data Set rows are written to the tape as 'packets'
- Sub Data Set packet interleaving on tape minimizes number of rows damaged by any one large error

- Media defects typically affect only 1 row per Sub Data Set
- The drive can tolerate *stripe errors of 11 mm length across tape*
- The drive can read Data Sets having *2 entirely DEAD tracks out of 16*



## Tape Saves the Day

- Ben Treynor, VP Engineering and Site Reliability Czar for Google Gmail, used the official Gmail blog to explain the situation and provided a powerful endorsement for off-line removable tape storage.
- “I know what some of you are thinking: **how could this happen if we have multiple copies of your data**, in multiple data centers...well, in some rare instances **software bugs can affect several copies of the data**. That's what happened here. Some copies of mail were deleted...**To protect your information from these unusual bugs, we also back it up to tape**. Since the **tapes are offline, they're protected** from such software bugs”.

From Google blog at <http://gmailblog.blogspot.com/2011/02/gmailback-soon-for-everyone.html>



**Online disk data is exposed to corruption**



**Use offline tape storage for outstanding protection**

# The Last Line of Defense!



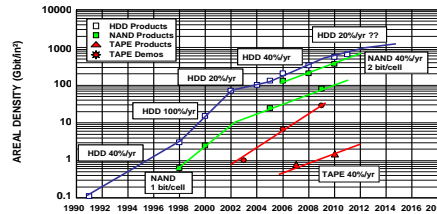
## Future for Tape

**Traditional Use for Tape:** *backup, disaster recovery, compliance, archive*



### Value

1/5<sup>th</sup> the cost of disk



### Capacity

Tape = 40% CAGR  
Disk = 15% CAGR



### Reliability

**275K time more reliable  
than disk\***



### Ease of Use

LTFS  
SNIA standard

**Today/Future:** *active file archive, low cost NAS storage for easy access to big data, cloud, HPC and other IT operations – and still for backup (Last line of defense)*



### Cloud

Tape solutions for cloud  
are a fraction of the cost


**Tape Advantages** *include lowest cost, superior reliability, high speed, ease of use and highly scalable capacity...*

\* Henry Newman, Instrumental Inc., April 19, 2014

\* Decad, Fontana, Hetzler – IBM Journal



## IBM Tape Drive Roadmaps



LTO Generations	LTO-3	LTO-4	LTO-5	LTO-6	LTO-7	LTO-8	LTO-9	LTO-10
Max Native Capacity	400 GB (L3)	800 GB (L4)	1.5 TB (L5)	2.5 TB (L6)	6 TB (L7)	Up to 12.8 TB (L8)	Up to 25 TB (L9)	Up to 48 TB (L10)
Other Native Capacities	200 GB L2 100 GB L1 R/O	400 GB L3 200 GB L2 R/O	800 GB L4 400 GB L3 R/O	1.5 TB L5 800 GB L4 R/O	2.5 TB L6 1.5 TB L5 R/O	6.4 TB L7 2.5 TB L6 R/O	12 TB L8 6.4 TB L7 R/O	25 TB L9 12.8 TB L8 R/O
Native Data Rate	80 MB/s	120 MB/s	140 MB/s	160 MB/s	300 MB/s	Up to 472 MB/s	Up to 708 MB/s	Up to 1100 MB/s

\* Data Compression engine enhancement from 2:1 to 2.5:1

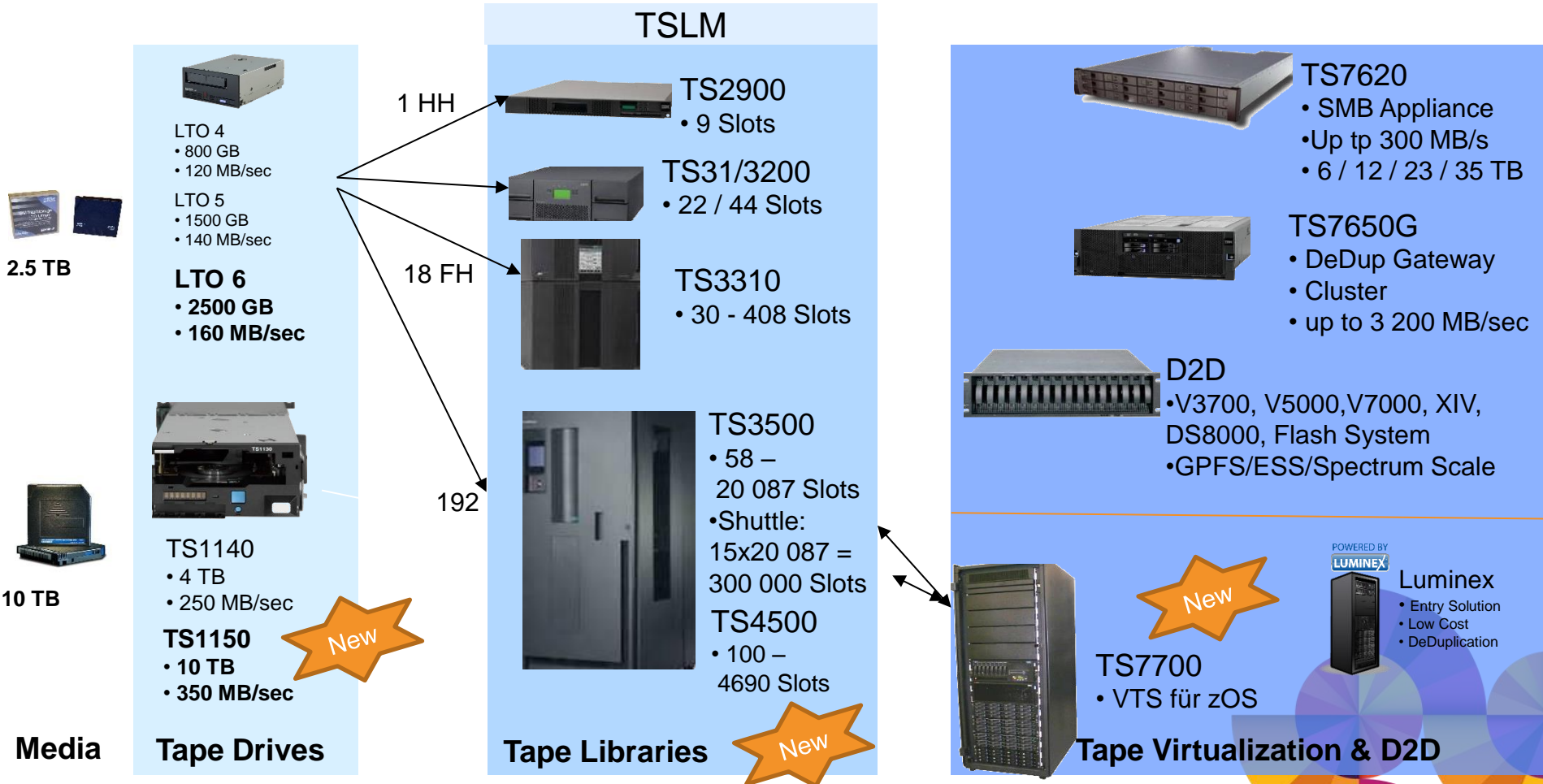
2005 2007 2009 2012

2003 2006 2008 2011 2014

TS1100 Generations	Gen-1 3592 J1A	Gen-2 TS1120	Gen-3 TS1130	Gen-4 TS1140	Gen-5 TS1150	Gen-6	Gen-7
Max Native Capacity	300 GB (JA)	700 GB (JB)	1.0 TB (JB)	4.0 TB (JC)	10 TB (JD)	15-20 TB (JD)	30-40 TB
Other Native Capacities with Media Reuse		500 GB JA	640 GB JA	1.6 TB JB 640 GB JA R/O	7 TB JC	8-10 TB JC 15-20 TB JD	8-10 TB JC 15-20 TB JD 30-40 TB JE
Native Data Rate	40 MB/s	100 MB/s	160 MB/s	250 MB/s	Up to 360 MB/s	Up to 540 MB/s	1000 MB/s







## TS1150 Tape Drive – 10 TB Capacity

- **5rd Generation of 3592 enterprise tape drive**
  - Barium Ferrite media (JD) with **10 TB native capacity**
  - **Media Re-Use with JC**
    - Read/Write JB: 4 TB -> **7 TB**
  - **360 MBps** native drive data rate
  - Dual 8Gb fiber channel interfaces with 700 MB/s max compressed data rate
- Improved Compression (+25%) 2,5 : 1 = **25 TB compressed capacity**
- Improved Performance
  - 2 GB Buffer
  - "Virtual Back Hitch,,
  - Speed Matching with 14 steps
- Fastest Data Access
  - High Resolution Tape Directory
  - Fastest locate Speed
  - **Read Ahead Feature**
- **LTFS Support: Single Drive, Library and with GPFS**
- MES upgrade for TS1140 available (Model Conversion)

*Fastest Tape Drive with largest Capacity on earth!*



## TS2900, TS3100 und TS3200 Tape Libraries

- Drives LTO Full High and LTO Half High
  - TS2900: 1 x LTO HH Drives
  - TS3100: 1 x LTO FH or 2 x LTO HH Drives
  - TS3200: 2 x LTO FH oder 4 x LTO HH Drives
- Capacity (native/compressed – LTO7)
  - TS2900: 9 Slots – 22,5/56 TB – 54/135 TB
  - TS3100: 24 Slots – 60/150 TB – 144/360 TB
  - TS3200: 48 Slots – 120/300 TB – 288/720 TB
- Standard Features
  - Barcode Reader
  - Remote Management (Web Browser)
  - 2 / 4 Catridge Magazine
  - Partinoing
- Optional
  - Additional Power supply
  - Path Failover

TS2900



TS3200



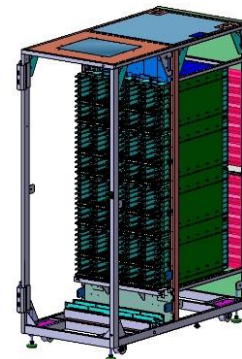
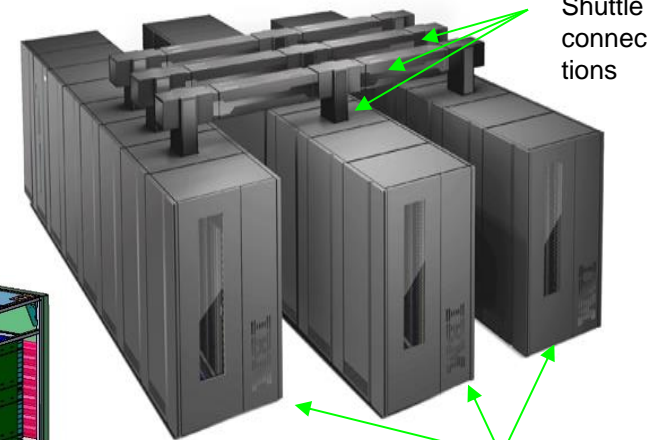
## TS3310 Tape Library

- 1-18 LTO Full High Tape Drives
- Capacity
  - 35 to 409 Slots
  - Up to 2,55 PB – 6,1 PB
- Rack-Modell and Stand-alone-Modell
- Standard Features
  - Barcode Reader
  - Remote Management (Web Browser)
  - Portioning
- Optional
  - Additional Power supply
  - Path Failover



## IBM TS3/4500 UltraScalable Tape Library

- 1-192 Tape Drives
  - LTO and/or TS1x00
- Capacity
  - More than 300 000 Slots
  - Up to 2,3 EB native / up to 5,7 EB compressed
  - 10 PB / 25 PB on 0,9 m<sup>2</sup>
- Standard Features
  - Barcode Reader
  - Remote Management
  - Partitioning
- Optional
  - HA

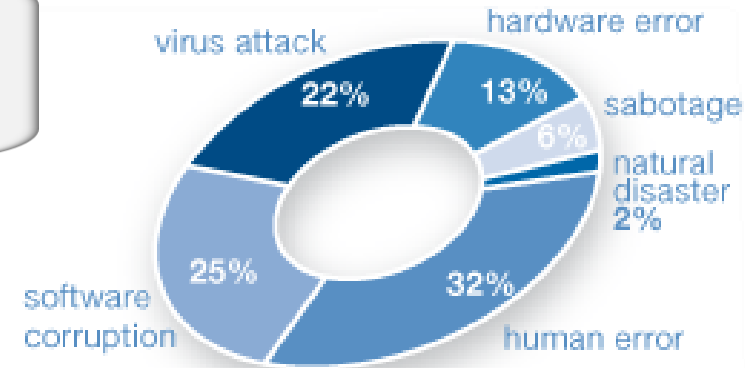




For many organizations, backup is either breaking or broken

**42% of small companies**  
have experienced data loss. **32%** lost files forever.

Source: "For Small Businesses, Bad Backup Can Lead to Data Loss",  
<http://www.businessnewsdaily.com/data-loss-backup-physical-online-1077/>



Source of data: The Cost of Data Loss by David M Smith

# 50%

*of organizations will augment with additional products or replace their current backup application by 2018, compared to what they deployed in 2014.\**

\* [Magic Quadrant for Enterprise Backup Software and Integrated Appliances](#), Gartner, June 2015. Gartner does not endorse any vendor, Solution or service depicted in its research publications, and does not advise technology users to select only those vendors with the highest ratings. Gartner research publications consist of the opinions of Gartner's research organization and should not be construed as statements of fact. Gartner disclaims all warranties, expressed or implied, with respect to this research, including any warranties of merchantability or fitness for a particular purpose.

## Data Protection Trends

### Data growth

Still the top concern of Data Protection buyers

### Cloud

Cloud is becoming a common backup destination. Cloud backup and DR services are thriving

### Snapshots

Continued adoption of snapshots for backup, and hardware-assisted snapshots for VMware

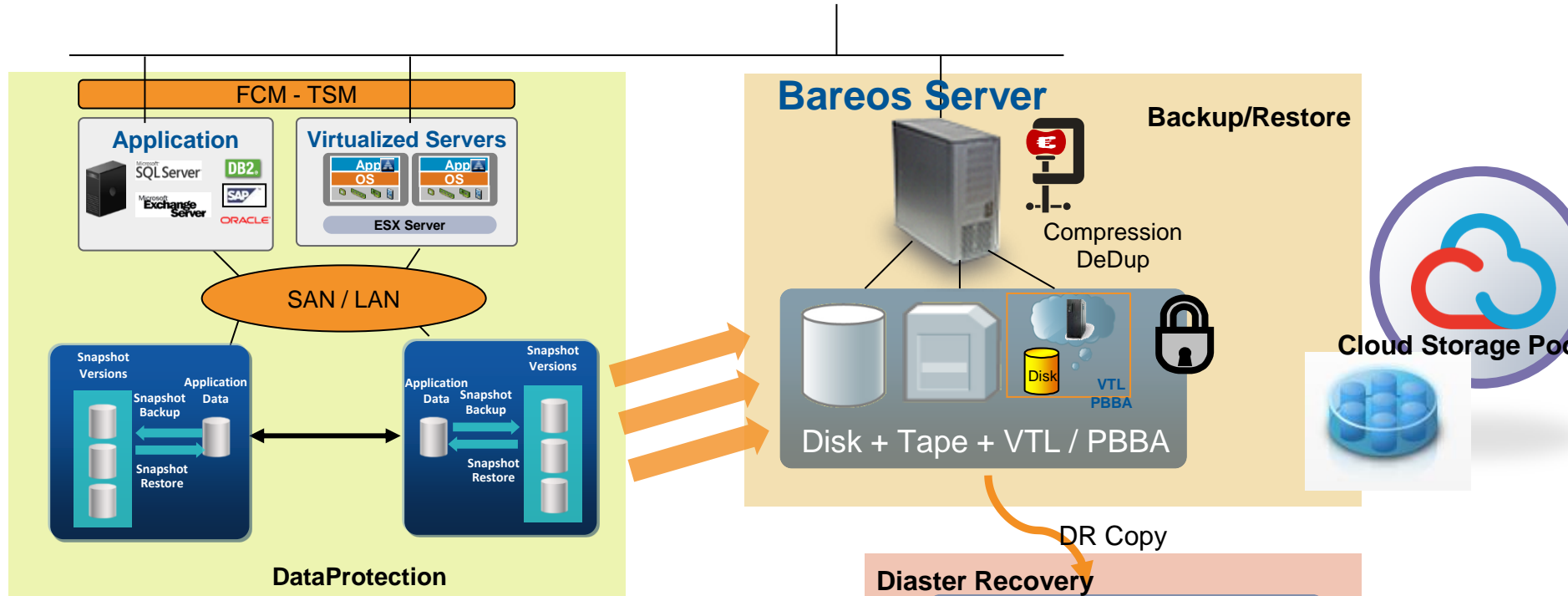
### Media matters: Disk backups and tape archives

Backups to disk are rapidly replacing solutions that backup only to tape.

Archiving to tape is increasing in both clouds and on-premises environments



## IBM DataProtection - Overview



- **Integration:** Application consistent Snap backup
- **Protection:** offline-Media, change of media and technology
- **Cost reduction:** Tiering, Compression, DeDup, Tape > 80%
- **Scalability:** based on requirements -> parallel & high performance backup of Snaps
- **Efficiency:** Unified GUI for Server / Infrastructure / Storage / Backup
- **Security:** Compliance, WORM and Encryption
- **IBM: Fit For Purpose**

## Data Intensive Solutions: Data Protection & Retention Economics

“Your Data Infrastructure Matters”



### Data

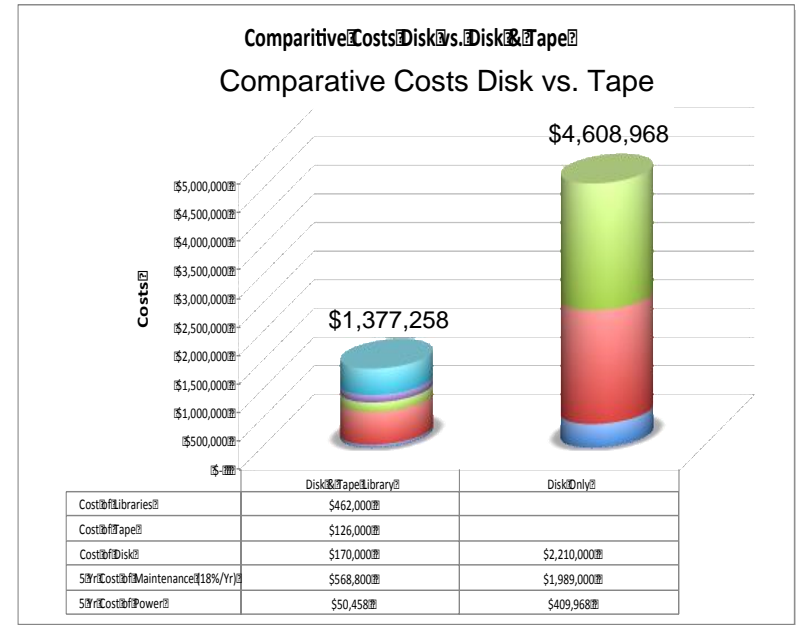
- small / large
- structured / unstructured
- Transactional / Persistent



**Leverage Disk,  
Disk technology (such  
as deduplication and  
compression), and Tape  
to tackle the most data  
intensive workloads.  
BACKUP!**

### ▪ DiskPool

- Open Systems
- Data Deduplication
- Fast Backup
- Cache for Tape
- Replicate for DR



Source: Wikibon

**Disk + Tape is ¼ the cost of  
Disk Only**

### Tape

- Low Cost
- Transportable
- Removable
- Fast
- Sharable
- Encryption
- Green
- Longer Life than Disk
- Protection



## Pros and cons of different Storage Tiers/Technologies

### ■ VTL

- +tape connection for LAN-free
- +Compression / DeDuplication
- +replication with reduced bandwidth requirements
- additional cost vs disk

=use it for

- Slow LAN-free backups...and some as above
- Replication

### ■ Tape

- +cheap
- +fast single stream, good scalability
- +high reliability (Bit error rate)
- bad access time

=use it for

- (LAN-free) backup for large databases / files





## Pros and cons of different Storage Tiers/Technologies

### ▪ Disk

- +Fast, random access
  - +parallel access
  - expensive, power, cooling, floor space
- =use it for
- Buffering, Small files, improve restore, new TSM function

### ▪ Flash

- Faster than disk
- =use it for
- TSM DB, high performance backup, better tape utilization
  - High Performance Backup and Migration to Tape

### ▪ Disk (VTL) with DeDup / Compression

- +saves capacity
- +may reduce capacity
- decreased performance/throughput

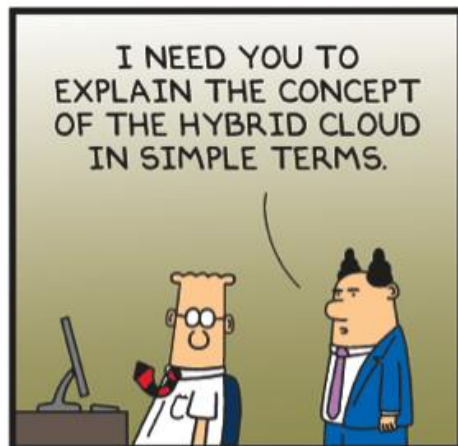
=use it for

- Data with high redundancy, data which needs to be stored for a longer time on disk



## Why Tape for Backup?

- Cost
  - Investment protection
- Performance (single Stream and scalability)
- **Security**
- Roadmap



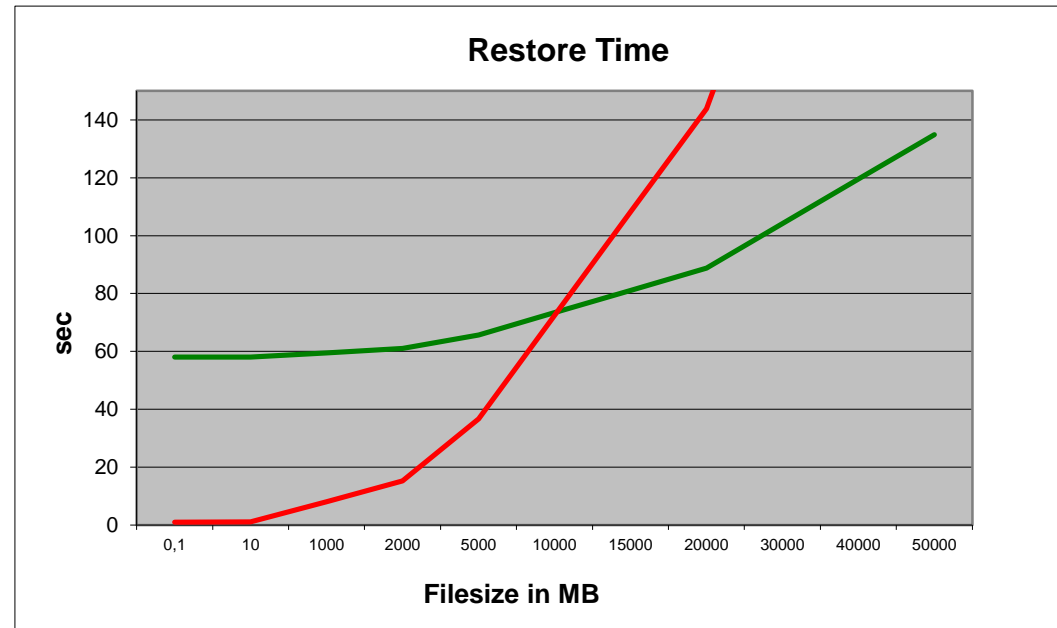
## Backup Storage Pool Solutions

- D2D2T –
  - New: with Flash = D/F2F2T
- D2T – Tape only
- D2D – Disk only
  - Options:
    - Spectrum Scale / GPFS
    - DeDup
- Combination



## D2T – Tape Backup

- For big Data
  - Database, DataWarehouse
    - Put Logs on Disk
- Good scalability
- High Single Stream Performance for Backup and Restore
- Using SAN = LAN-free



## D2T

- Example: 2,5 TB DB in 1 h
  - 720 MB/sec = 2 x TS1150 Tape Drive
    - 2 D\$
    - 1 T\$ ~ 6 D\$, 300 W
    - 200 TB
  - with V7000: ca 3 x Raid5 8+1
    - ~17 TB
    - 6,8 D\$, 470 W
  
- Example: 50 TB DB in 4 h
  - 3400 MB/sec = 10 x TS1150 Tape Drive
    - 10 D\$, 700 W
    - 200 TB
  - with V7000: ca 14 x Raid5 8+1
    - ~320 TB
    - 47 D\$, 2,6 kW
  - with Flash 900, 12 x 5,7 Module, 4000 MB/sec
    - 51 D\$, 625 W
    - 57 TB

Purchase cost are calculated on street level price

D\$ = price for one TS1150 Tape Drive



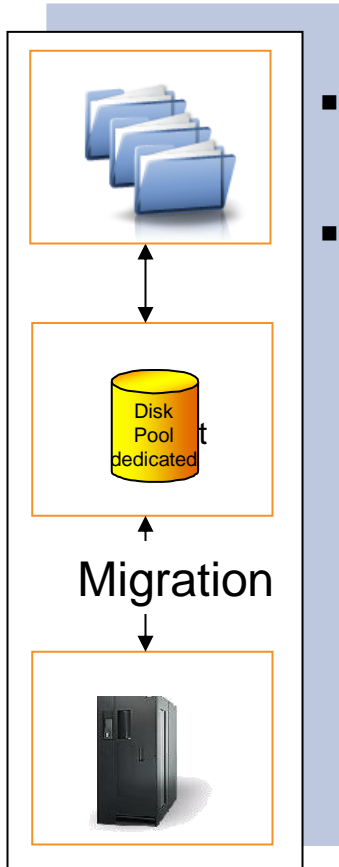


## TS3200 / TS3100 vs V3700

- TS3100 with 2 x LTO6 Drives
  - 60 / 150 TB
  - 100 W
  - ~0,3 Cent / Month
- TS3200 with 4 x LTO6 Drives
  - 120 / 300 TB
  - 200 W
  - ~0,3 Cent / Month
  - 1,7\$ x TS3100
- V3700 wit 12 x 8TB HDDs ~ 72 TB
  - 334 W
  - 1,6\$ x TS3100



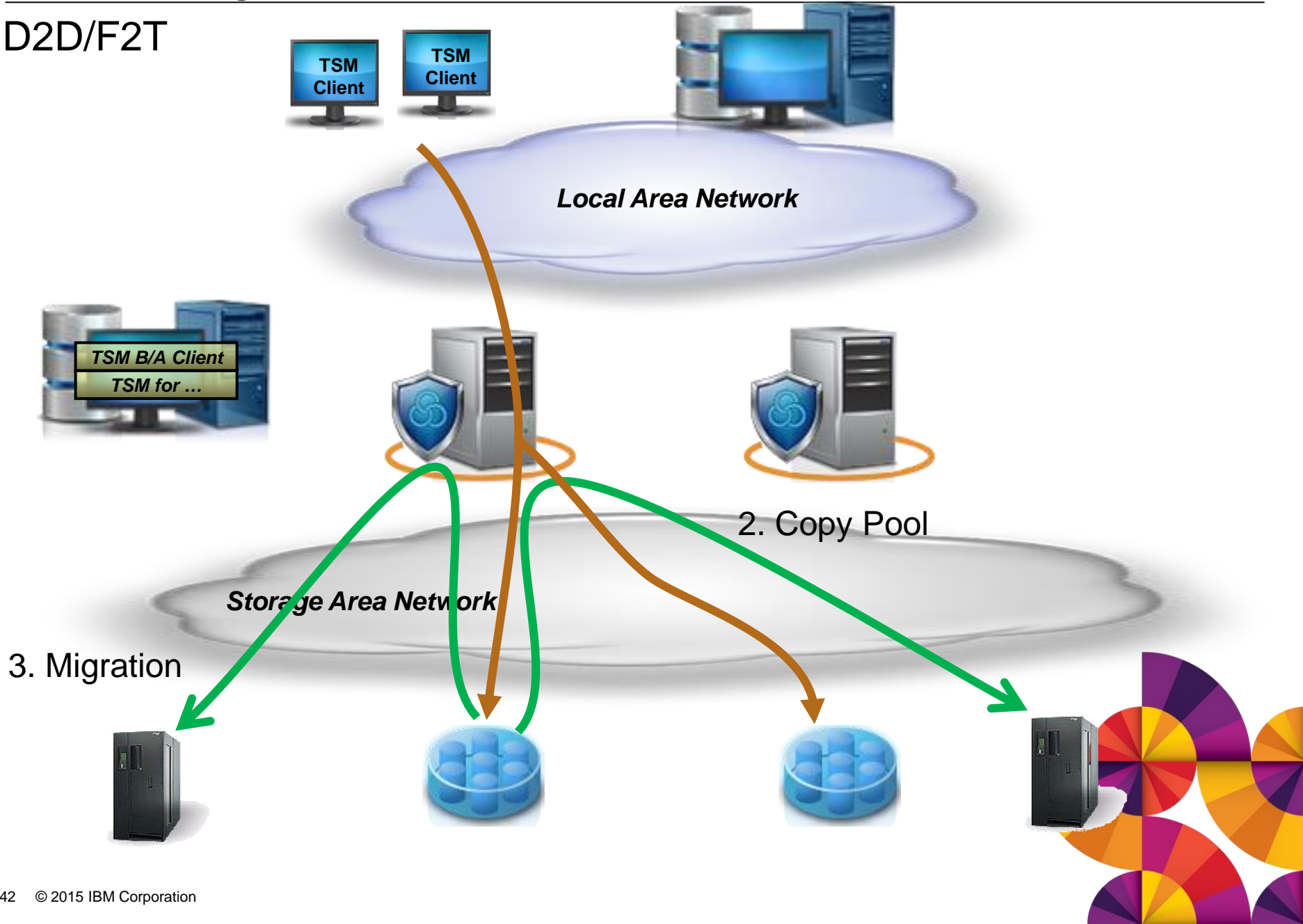
## General Data/ Universal using Disk Pool and Migration to Tape



- Use Disk Pool for “caching” the data
  - Some time later migrate data to Tape
- Size Disk Pool for at least 1-2 days of daily backup data
  - May increase the disk pool size to 5-7 days
- Take care about performance – most important single stream performance
  - Use dedicated disk system for Backup
    - Does not use disk system which is shared with productive data/workload
    - Performance and data protection issues
  - NL SAS/SATA may not full fill the performance requirements
  - CIFS/NFS may not fit the performance requirements
  - DeDuplication appliances will not full fill performance requirements
  - Recommendation: use SAS/FC Disk for primary disk pool with FC/SAN connection
  - Rule of Thumb“
    - SAS HDDs: Raid5 8+1                      -> ~260 MB/sec
    - NL SAS HDDs: Raid6 8+2                -> ~85 MB/sec



## D2D/F2T

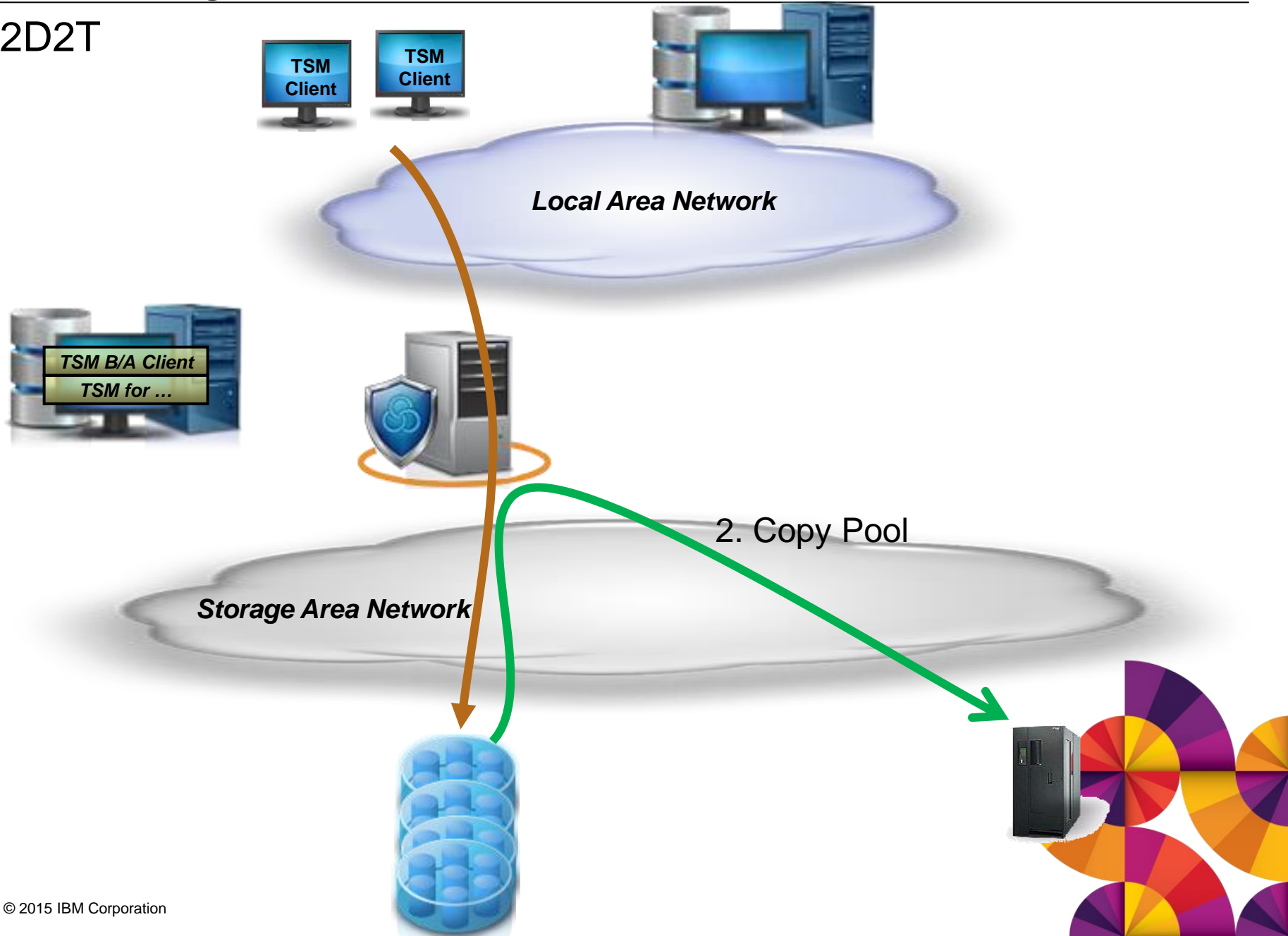


## Disk or Flash as „DiskPool“?

- Flash 900 10 000 MB/sec Read Performance
  - Can feed up to 27 Tape Drives for Migration
  - Ca 51 D\$, 57 TB, 650 W
  - V7000 with similar Performance
    - Ca 92 D\$, 5,1 kW
    - 650 TB



## D2D2T





## Disk Only

- V7000 with NL SAS 6 TB
  - Ca 980 TB
  - 53 D\$, 1,8 KW
  - 3,4 T\$ (with 12 x TS1150 = 0,8kW)
- with DeDup 2:1
  - V7000 with NL SAS = 1 960 TB
  - 3 T\$ (with 12 x TS1150 = 0,8kW)



# Questions?



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# Thank You!



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