Pesky Physics
What Might It Mean for Mass Storage?

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Fundamental Physical Challenges

- Moore’s Law
  - The cost of lithography and tooling
  - The thickness of the FET gate insulator

- Superparamagnetic Limit
Semiconductor Lithography Scaling Reaching Physical Limits

Litho Tool Cost Growing Hyper-Exponentially ➔ Cost Growing Faster Than Performance Benefit

Tool costs over time

Year


Exposure tool price

$0 $10,000,000 $20,000,000 $30,000,000 $40,000,000 $50,000,000 $60,000,000

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Cost and the Future of Lithography
Discontinuity in Processor Design Due to Power Constraint

Designing processors for increased clock speed yields diminishing returns.

Power constrains benefits of frequency increases
Consequence is the switch to multi-core systems.
Superparamagnetic Effect Constrains Magnetic Storage
Areal Density Growth is Slowing

Physical Limits Are Constraining Technology Growth

- Feature Size for semiconductors
  - Severe power and thermal constraints
  - Slowing performance gains
  - Raising costs
  - Direction for progress unclear

- Superparamagnetic Effect
  - Slowing performance gains
  - Raising costs
  - Optical or other medium to bypass

- It appears that industry is maturing
Maturation of Commercial Aviation

Aircraft Speed (mph)

- Wright Brothers
- Curtiss Flying Boat
- Ford Trimotor
- Boeing 247
- Boeing Stratoliner
- DeHaviland Comet
- DC-3
- Boeing 707
- Concorde
- Boeing 747
- 767
- A-320
- 777
- MD-90

Speed of Sound in Air

1900 1920 1940 1960 1980 2000 2020
For Commercial Aviation it Changed the Engineering Focus

- Optimize value
  - Manufacture
  - Operational

Technology and Material development

Aircraft Speed (mph) vs. Time

1900 1920 1940 1960 1980 2000 2020

Wright Brothers
Ford Trimotor
Boeing 247
DC-3
Boeing Stratoliner
DeHaviland Comet
Concorde
Boeing 707
MD-90
A-320
777
747
767
DC-10

Aircraft Speed (mph)

1,000
100
10
1

Speed of Sound in Air
Mass Storage: Features vs Technology

Features

- Sys Admin
- Migration management
- Parallel Programming Model
- Data protection
- Power consumption
- Total cost of ownership

Technology & Performance

- Power and feature size
- Paramagnetic Limit
The Mass Storage Industry is maturing technically
  - Rate of semiconductor performance gains are slowing
  - Rate of aerial density increases is slowing

What are the storage drivers going forward?

What does this mean for us?
Personal Devices Are Driving Storage Growth – Big Time

What’s Driving Personal Content Capacity?

- Personal digital devices are driving storage demands
- This will impact business investments
- In turn this will impact the mass storage markets
Is There a Digital Family Shoebox in Our Future?

- Needs traditional mass storage stewardship features
  - Sys Admin (amateur easy) -- Data Security
  - Migration management -- Data Persistence
  - Low TCO
- Multi-media rich
- Indexed, organized, searchable, & retrievable
- Require new level of association between elements – for instance, genealogy with photos and videos
- Need open standards
  - Family shoebox information exchange
  - Data representation for physical media
- Compatibility with cloud computing???
Integration of Data Storage Islands

- Motivation prepare to support enhanced collaborations
- Mass Storage stewardship + services to integrate data storage islands
- Support for information interoperability – ontology or other semantic mechanism

Resulting consolidations
- Reduces number of copies ➔ virtual performance and cost improvement ➔ end-to-end system performance improvements
- Simplifies data management

Potential industries
- Retail marketing with RFID and POS data capture
- Electrical grid sensing to improve service delivery without capital expenditures
- Automotive – use the sensor data to improve products; perhaps usage pricing
- WalMart and CostCo photo capabilities: on-line album sharing
What Else????