

Tom Coughlin Data Storage Consultant

PRESENTATION OVERVIEW

- **STORAGE APPLICATION DRIVERS**
- AREAL DENSITY GROWTH DRIVES APPLICATIONS
- NEW STORAGE APPLICATIONS
- INDUSTRY FORECASTS FOR NEW APPLICATIONS 2000-2004
- MAKING DRIVES PROFITABLE AGAIN

A little perspective...

- Our memories define our past and enable the accumulation of capability that drives our technological civilization.
- The major business of our age is to pass accumulated experiences, beliefs, and observations to future generations. Data storage is how we will pass on this legacy.
- That means lots of storage, and for all levels of users!

Drivers for Storage Applications

Data Storage Costs:

"...storage has more price elasticity than bandwidth and silicon chips. What this means is that for any 1 percent reduction in cost, there's a 4 percent increase in usage. Bandwidth only gets a 2.5 percent increase in usage for each 1- percent reduction in price. And the silicon chips that supply computers with the brains to process data only get a 1.5 percent demand increase for every percent in price a CPU drops."

– Lee Bruno in <u>Disk Driven Technology</u> (Red Herring, March 2000):

Data Storage Performance:

- capacity increases by >100% AGR.
- Iower storage cost means more applications for digital storage
- decreasing cost per GB makes smaller form factors drives with useful capacities.
- In a free society information must be available to all!



Trend Doubling Periods

18 months (Moore's Law) Semiconductor performance Computer performance/dollar 21 months (Roberts Law) Communications- bits/dollar < 1995 79 months Communications- bits/dollar w/DWDM 12 months Max. Internet Trunk Speed in service 22 months Internet Traffic Growth 1969-1982 21 months 9 months Internet Traffic Growth 1983-1997 Internet Traffic Growth 1997-2008 6 months 22 months Internet Router/Switch Max Speed <1997 Internet Router/Switch Max Speed > 1997 6 months



Computer Networks Drive Storage Demand

•In 2000 EMC estimated that within a year, some dot-coms will need an exabyte of storage capacity

•A UC Berkeley study at the end of 2000 predicted that while it took 300k years to accumulate the first 12 EB of data it will only take 2.5 years to double this.

•New wireless technologies will connect a billion cell phones, laptops and personal organizers to the Internet within three years (The Yankee Group)

Ubiquitous Computers = more storage!



Source: When Things Start to Think, Neil Gershenfeld

Decreasing cost of computers makes them available for more applications, and where there's computers there's storage!

•Storage must to tailored to the cost/requirements of the application

Advanced Applications Driving Storage Development:

- •genome mapping
- •protein modeling
- •digital movies
- •bomb modeling
- •weather and seismic modeling
- •backing up the web...a never ending job





Hans Moravec, When will computer hardware match the human brain?, Journal of Transhumanism. 1998. Vol. 1

As we hook up communication to the web... Current platform Platform convergence internet Television internet TV Cache Other sites



[3] Desktop PCs, notebook computers, and other established platforms frostangular boxes] are merging to create new kinds of electronic sectors lovald. While each

fature platform mixes different current. devices, the Web is common to all.

Next, the wireless internet!

New Devices will even bring smell files to the web

Cadhr

High Resolution Images-A BIG Driver

•High End Customer are initial drivers

> •medical file transfer

•movie distribution

•interactive collaborations

•physical simulation





Storage Requirements (GB/hr)



The Future is Storage-Centric Stored Data is the heart of a modern network.



•By 2004, companies will have to manage 10 times as much data as they do today (Meta Group)

•System vendors see storage eclipsing server sales in the near future

World Wide Storage Capacity of Disk Memory

(In PetaBytes, Source: Disk/Trend plus projection to 2004)



NEW APPLICATIONS / STORAGE

- AUTOMOBILE MAPPING SYSTEMS
- GPS NAVAGATION SYSTEMS
- DIGITAL CAMERA SYSTEMS
- DIGITAL VIDEO SYSTEMS
- T.V.SET TOP BOXES (U.S. AND JAPAN)
- MULTIFUNCTIONAL COPY MACHINES
- AIRLINE ENTERATINMENT SYSTEMS
- INTERACTIVE HOME ENTERTAINMENT (WEB-TV/TiVo)
- MODELING AND ANIMATION MASTERING
- MOVIE AND IMAGE DISTRIBUTION
- MUSIC STORAGE AND DISTRIBUTION
- E-MAIL INTERNET STORAGE
- STORAGE SERVICE PROVIDERS
- GAMING MACHINES, SLOT, POKER
- APPLIANCES- SEWING MACHINES

Increased Areal Density makes VERY BIG Desktop and Mobile Drives

Disk Drive Data Capacity Growth (Double-Sided)



Increased Areal Density makes Smaller Form Factors USEFUL

27-mm Disk Drive Capacity Growth



Increased capacity creates useful small form factor data storage.

MIT Wearable Computer Group

Compaq PDA with Compact Flash Slot





Samsung Watchphone



The watchphone has no keypad. Instead, proprietary, speaker-independent, continuous-speech technology from Conversa is embedded so users can make and receive phone calls simply by speaking in their natural voice. Users can program frequently called numbers by voice. The watchphone will also include a function that will read out e-mail messages.



	The Personal Appliance Mobile Market				
Device	Description				
Computer Handheld	Equipped with keyboard, internet access, organizer and operating system i.e., windows CE with information services and web browser.				
Computer Handheld Wireless	The same features as the Handheld, but it has the additional ability to perform e-mails and web services by wireless radio links. Features personal organizer, interactive services, it can be worn like a pager and with mini-QWERT keyboard can provide instant wireless e-mail connectivity.				
hteractive Pagers					
Smart Phones	Phones that feature personal organizer, voice mail and digital voice recording.				
Screen Phones	Phones with high quality LCD displays that emulate the same functions and web connectivity as the wireless handheld computer.				
Digital Cameras	Cameras that record and store images digitally offering a substantial challenge to film. Recently, affordable digital cameras have progressed from typically 1.3 mega pixels in 1998 to 2.1+ mega pixels in 1999, competing with ASA 400 and 200 film quality. Amaiority of the digital camera providers now offers storage in the CompactFlash standard.				
Global Positioning Systems	GPS systems are available as handheld portable or Automobile in-dash devices. They are used for navigation as well as tracking. Introduce in 1998 as optional equipment in some automobiles, the popularity of these devices will continue to penetrate the automobile markets. A substantial potential exists for the handheld GPS device in military applications.				
Digital \olice Recorders	Attificial Intelligence Voice recording has been successfully introduced in the personal computer marketplace. Low cost memory-will enable its application to paint cost and handheids that can usurp the mini-keyboards.				
Digital Sound (MP3)	MP3 technically is MPEG 1 layer 3. It has become a popular de facto standard for quality through high bit resolution sound. With the new MP3 players, one can record and compress music digitally by copying CD's, DVD's, or downloading music form the internet. It does not take a trained music alcionado to discern the improvement this format offers.				
Warehouse Inventory	Hand held RF devices, usually enabled with barcode.				
Wearable Computers	Wearable computers are used for on-site maintenance with auto manufactures and aircraft industries leading the early Adapters. Some apply wearable single-eve displays that allow the individual to coordinate mechanisms with schematics and pictorial assemblies.				
Portable Games	Downloadable games that for use with the handheld and laptop computers and CE based handhelds.				

MP3

Digital Camera

RF Pager

HandHeld

Wearable



Storage for Wearable/Handheld Computers

Application	Min. MB	Avg. MB (2005)	
Mapping/Directions	5	1,000	
Face Recognition	500	2,000	
Camera	100	1000	
Phone Book, Dialer	2	10	
Calendar	1	1	
Email	1	500	
Fax	1	200	
To Do List	1	5	
Memo	1	1	
Speech Recognition/Output	200	500	
News	1	10	
Market Quotes	1	1	
Entertainment: Games/Video/Spoken Books	2	5,000	
TOTALS	816	10,528	

Projected Capacity Range for \$150 with Compact Flash and Microdrive



Microdrive Market Penetration



Networked Storage



SAN/NAS - Applications

Horizontal

Vertical

- Backup
- Archiving
- Data Replication
- Disaster Protection
- Data Sharing
- Data Warehousing

- OLTP
- ERP Business
- E-Commerce
- Broadcasting
- Pre-Press
- Geophysics



Source: Peripheral Concepts, Inc



NAS AND SAN - REVENUE FORECAST



Peripheral Concepts, Inc.

- •These are the back-bone of e-commerce and the internet
- •Driving the market for high end disk drives
- •Performance and reliability are key







Traditional model 0S0 model In an Object-based Storage Device (OSD) model, the file system storage component is moved from the operating system to the storage device.

Source: InfoStor, Sept. 2000

Storage Service Providers



Storage Service Provider Supplier Market Share (1999), Source: IDC •The visible and hidden costs of storage management represent about half of IT costs

•SSP = Storage as a utility, lease as much as you want, when you want it without having to maintain it

•Allows a company to focus on it's core competency

• •411 % CAGR expected to 2003 (Soloman Smith Barney)

•Enterprise Storage Group projects SSP sales of \$11.2B by 2004

•No clear winner(s) yet in this category

Worldwide Storage Device Forecast (Units Millions)



Source: Peripheral Research Corp.

Worldwide Storage Device Revenue Summary (\$Billions)

CATEGORY	1999	2000	2001	2002	2003	2004
RIGID DISK DRIVES	33.4	37.2	43.9	51.3	54.0	61.1
OPTICAL DRIVES	7.5	7.7	8.9	9.3	9.8	10.3
TAPE DRIVES	4.6	4.8	5.0	4.8	4.4	4.0
FLEXIBLE DRIVES	2.5	2.4	2.4	2.3	1.9	1.7
TOTALS	48.0	52.1	60.2	67.7	70.1	77.1

Source: Peripheral Research Corp.

Computer Disk Storage / Non-Computer Disk Storage Markets (Units Millions)



Source: Peripheral Research Corp.

Emerging Non-PC HDD Storage Markets (Units OOO)

SEGMENT	2000	2001	2002	2003	2004
LASER PRINTERS	1,380	1,905	2,787	3,159	3602
GPS SYSTEMS	300	700	940	1,300	1,400
SET TOP BOXES	8,000	12,100	18,700	26,400	29,870
DIGITAL CAMERA	16,420	27,590	42,860	68,600	79,800
GAMING INDUSTRY	2.4	3.7	4.8	5.6	6.0
AUDIO/APPLIANCE	1,420	3,570	5,965	7,414	8,215
OTHER	37	45	70	75	80
TOTALS	33,730	61,183	81,867	106,953	122,973

Source: Peripheral Research Corp.

Biggest Current Limitations to Storage are Economic, not Technical

- Continued price pressure has caused considerable consolidation in the industry.
- Remaining companies may be sustainable but only if their profitability improves.
- Drive and component companies must make better profits in order to finance capital improvements and retain technical talent needed to sustain the data areal density growth.
 - Current capital equipment for heads and media cannot go above 100 Gb/in²!
 - With higher TPI, how will photolithographic equipment become available on time to meet track-width needs?
 - Drive and component companies will run out of gas in 2-3 years without new investments!
- Growth of storage systems and the Internet itself is dependent on continued increases in storage capacity.

Some Comparisons of Storage **Company Categories**

Storage Food			
Chain		Average	Gross Margin
Drive		Annual Price (\$/GB)	(%)
Company	Drive Company	2.5	12
SAN/NAS Company	SAN/NAS Compay	60	>45
Storage System Provider	Storage System Provider	636 (\$53/GB/mo, mananged storage)	>60



Opportunities for Drive Companies

With various form factors and applications perhaps there is an opportunity for drive companies to segment the market

Move from data storage to information management.

Build new intelligence into the drive

Specialize, become the best-in-class for particular types of storage

Improve margins by differentiation and bringing greater functionality into drives

Share margins with storage system companies Use improved margins to reward investors & employees and provide capitalization for technical improvements e.g. areal density increases

Storage for the Next Generation















