The Decline of Magnetic Disk Storage Cost Over the Next 25 Years

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or

When Will the Cost of Magnetic Disk Storage Be Inconsequential for Your Document Management Application?

Introduction

The cost of magnetic disk storage space has dropped by about forty percent per year since 1989. Each year, the managers of more and more document management projects find that the cost of required magnetic disk space has become inconsequential in planning for their system.

Magnetic Disk Storage Required for Documents

Using the industry standard estimate of 50 thousand bytes of storage required for each scanned letter size page, and 10 thousand pages contained in each four drawer file cabinet, a GigaByte (about one thousand MegaBytes) is required to store the scanned contents of two file cabinets. Using an estimate of 50 dollars per GigaByte, based on current storage costs, the contents of two file cabinets can be stored digitally for 50 dollars.

Putting the Cost of Storage in Perspective

If two people discuss the cost of storage for one hour, and each person's time costs 25 dollars per hour, then the cost of discussing the storage equals the 50 dollar cost of storing the scanned images of two file cabinets full of documents. Because document management planning involves many people at many levels in an organization, and because many meetings are held at each level, the cost of discussion frequently exceeds the cost of the magnetic disk storage required to store the documents being discussed.

Projecting the Cost of Magnetic Disk Storage Over the Next 20 Years

The following table shows the cost per GigaByte and the cost per TeraByte (about one thousand GigaBytes) in each year from 1994 through the year 2024. As shown in the table, one GigaByte is sufficient storage for two file cabinets of scanned documents and one TeraByte is sufficient storage for two thousand file cabinets of scanned documents. The table is generated using an assumption of a price reduction of 37.5 percent each year.

The Basis for the Assumptions in the Table

This assumption of an annual price decrease of 37.5 percent is based on an increase in disk storage density of 60 percent per year. With this increase, for a given price, one can purchase 1.6 times as much storage capacity next year as one can purchase this year. The corresponding annual decrease in price per unit of storage is therefore 37.5 percent.

Projected Magnetic Disk Prices

Year	Cost for 1 GigaByte = 1,000 MBytes (Storage for 2 Scanned File Cabinets)	Cost for 1 TeraByte = 1,000 GBytes (Storage for 2,000 Scanned File Cabinets)
1992	1,000.00	1,000,000.00
1993	625.00	625,000.00
1994	390.63	390,625.00
1995	244.14	244,140.63
1996	152.59	152,587.89
1997	95.37	95,367.43
1998	59.60	59,604.64
1999	37.25	37,252.90
2000	23.28	23,283.06
2001	14.55	14,551.92
2002	9.09	9,094.95
2003	5.68	5,684.34
2004	3.55	3,552.71
2005	2.22	2,220.45
2006	1.39	1,387.78
2007	0.87	867.36
2008	0.54	542.10
2009	0.34	338.81
2010	0.21	211.76
2011	0.13	132.35
2012	0.08	82.72
2013	0.05	51.70
2014	0.03	32.31
2015	0.02	20.19
2016	0.01	12.62
2017	0.01	7.89
2018	0.00	4.93
2019	0.00	3.08
2020	0.00	1.93
2021	0.00	1.20
2022	0.00	0.75
2023	0.00	0.47
2024	0.00	0.29

The estimated increase is disk storage density is based on IBM's predictions for its magnetoresistive (MR) head technology. IBM invented the MR technology, and MR is currently the technological basis for advancements in the magnetic disk industry. IBM has been increasing the areal bit density of magnetic disks at a rate of 60 percent per year since 1989. IBM projects that the 60 percent rate of increase will continue for the foreseeable future. (Source: The Era of Magnetoresistive Heads, Ed Grochowski, IBM Research Division, Almaden Research Center, San Jose, CA., 1994).

In a press release issued on December 29, 1997, IBM stated that the trend is continuing on track. On October 4, 1999 IBM issued a press release stating that the rate of increase in disk storage density had increased from 60 to 100 percent per year in each of the last two years. IBM also announced that it had demonstrated very stable bit densities in the lab. This could soon lead to the manufacture of 500 GigaByte 3 1/2 inch form factor magnetic disk drives (2 of the 500 GigaByte drives would store 1 TeraByte). IBM anticipated that the increase in density would continue. On October 15, 1999, IBM announced a 73 GigaByte, 3.5 inch, multi-platter, disk with a 2 Gigabit per second, serial, fiber channel, interface.

In technospeak: The latest milestone in data density was achieved by teams of scientists and engineers from IBM's Almaden Research Center and its Storage Systems Division, which develops, manufactures and sells data-storage products. As in IBM's previous record-density demonstrations of 1-, 3- and 5-gigabits per square inch (announced in December 1989, March 1995 and December 1996, respectively), manufacturable component technologies were used at realistic data rates, and product-level reading and writing accuracy was achieved. The scientists used an advanced version of the most sensitive sensor for reading data from disks, the giant magnetoresistive (GMR) head.

The areal density of 11.6 gigabits per square inch was reached at data rates of 14 million bytes per second. The on-track data was read essentially flawlessly, with an uncorrected rate of less than one error in a billion bits, which in products would be reduced by error-correcting codes to less than one in a trillion. The latter figure is equivalent to transcribing more than one thousand years of a daily newspaper before making a single error.

In addition to the advanced GMR read head, a narrow-track thin-film inductive write head, ultra-low-noise cobalt-alloy magnetic media and extended PRML (Partial-Response, Maximum Likelihood) channel electronics were used. Bits were packed at 315,000 per inch along the concentric tracks on the disk; tracks were written

at a density of 36,800 per radial inch. IBM said that additional technical details of this demonstration would be disclosed in future scientific papers and conference presentations.

A Longer Perspective for Retention Periods

IBM introduced the 5 MegaByte RAMAC disk drive in June 1957, at a monthly rental of $3,200.00 (in 1957 dollars). (Source: IBM's Early Computers, by Charles J. Bashe, MIT Press, Cambridge, MA, 1986.) In 1957 RAMAC magnetic disk storage cost 100 thousand dollars per MegaByte, or 100 million dollars per GigaByte, to purchase. (Adjusted to current dollars, and adjusted for IBM's historic desire to rent rather than sell). In 1998, magnetic disk storage cost 50 dollars per GigaByte. This represents a decline of two-million-to-one (from 100 million dollars to 50 dollars per MegaByte) in forty-one years or about a 29.8 percent decline per year.

The advances described here are based on magnetic disk technology. The study of the history of technology has shown that over long periods of time, as technologies are exhausted, new technologies replace them, and a steady rate of advancement is maintained. Holographic and nano-machine technologies have been under development for some time and promise several more orders of magnitude improvement in price and physical size reduction, as well as increases in speed, when advances in magnetic disk technology slow.

Cost Adjustment for Advanced Hardware and Support Technology

The cost per GigaByte for the most technically advanced magnetic disks, in the most advanced disk array configurations, in systems sold by vendors with the most extensive support, can cost up to five times as much as the cost per GigaByte for low tech magnetic disk drives in stand-alone generic PCs. The following interpretation adjusts for this difference.

The prices in the table change once per year. In actual practice, prices change continuously throughout the year. For generic systems, the listed cost per GigaByte is more applicable near the start of the year. For advanced systems, the listed cost per GigaByte is more applicable near the end of the year.

A Scanned Page Requires 50 Thousand Bytes of Storage Space When Compressed

All of the figures given for scanned images are for compressed file sizes. All imaging systems compress their image files for storage and transmission. Compressing removes the redundancy from the files, making the files smaller. These compressed page files have an average size of approximately 50 thousand bytes per page. Rarely is a given compressed page file exactly 50 thousand bytes.

Five Cents per Page for Scanning

Storage costs are very often less than ten percent of the cost of a document management system. When the cost of storage becomes inconsequential, the cost of scanning comes to the fore. Scanning cost can be reduced by engineering the production of paper out of business operations. Scanning costs can also be reduced by integrating scanning into the normal workflow by using digital copiers and by scanning documents rather than filing them.

Conclusion

Computer prices have a long history of substantial declines. Applications such as document management were at one time prohibitively expensive due to the cost of magnetic disk storage. Over the past few years the steady decline in storage prices has made document management first feasible, then an expected component of corporate management.

The cost of storage will continue to decline driven by technical advances, not the needs of document management. As this happens, the cost of storage will become inconsequential in document management planning, and other requirements, such as workplace reengineering, will come to the fore.

In addition, the continuing cost decline will bring many other document forms into records management. Examples are video, digital photographs, voice mail, and telemetry data from research, manufacturing equipment, and exploration.

Sidebar

Billions and Billions

Transistors are so inexpensive that nobody cares much about them any more. But, how many can you buy for a dollar? Every bit in RAM (Random Access Memory) requires a transistor to hold the value of one or zero in an associated capacitor. There are eight bits in a byte and about a million bytes in a MegaByte. The cost of a MegaByte of RAM is closing in on one dollar. At a dollar per MegaByte for RAM, you can buy eight million transistors for a dollar. Twenty-five years ago, RAM cost one dollar per byte, so the price reduction for RAM has been one-million-to-one over the past twenty-five years. As you can see from the table in this article, magnetic disk space will also drop by a factor of one-million-to-one over thirty years, so the cost of magnetic disk space is dropping in price at about the same rate at which RAM has dropped in price in the past.

For the nostalgia buffs, in the 1950's transistor radios were advertised based on the number of transistors they had. An eight transistor radio was said to be better than a six transistor radio. Then manufacturers started adding transistors for the sake of advertising rather than improving the radio, and the ten transistor radio was born. This eventually ran its course. But now, a 64 MegaByte PC has over one-half billion transistors. Soon school children will say: "My computer has a billion transistors.", "My computer is better, it has two billion transistors.", "My computer is the best, it has billions and billions of transistors!", ". . . or is that hamburgers . . .", ". . . or stars?"

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Note to Editors

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Dividing this Article into Parts for Serialization

If you decide to divide this article into parts please print at least the updates, comments, and acknowledgements sections in each of the parts along with:

'by SteveGilheany@ArchiveBuilders.com'.

Bio

Steve Gilheany, BA in Computer Science, MBA, MLS Specialization in Information Science, CDIA (Certified Document Imaging System Architect), AIIM Maser, and AIIM Laureate, of Information Technologies, CRM (Certified Records Manager, ARMA) has seventeen years experience in document imaging and is a Sr. Systems Engineer at Archive Builders.

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Steve Gilheany is a Sr. Systems Engineer at Archive Builders. He has worked in digital document management and document imaging for seventeen years.

His experience in the application of document management and document imaging in industry includes: aerospace, banking, manufacturing, natural resources, petroleum refining, transportation, energy, federal, state, and local government, civil engineering, utilities, entertainment, commercial records centers, archives, non-profit development, education, and administrative, engineering, production, legal, and medical records management. At the same time, he has worked in product management for hypertext, for windows based user interface systems, for computer displays, for engineering drawing, letter size, microform, and color scanning, and for xerographic, photographic, newspaper, engineering drawing, and color printing.

In addition, he has nine years of experience in data center operations and database and computer communications systems design, programming, testing, and software configuration management. He has an MLS Specialization in Information Science and an MBA with a concentration in Computer and Information Systems from UCLA, a California Adult Education teaching credential, and a BA in Computer Science from the University of Wisconsin at Madison. His industry certifications include: the CDIA (Certified Document Imaging System Architect) and the AIIM Master, and AIIM Laureate, of Information Technologies (from AIIM International, the Association of Information and Image Management, www.AIIM.org), and the CRM (Certified Records Manager) (from the ICRM, the Institute of Certified Records Managers, an affiliate of ARMA International, the Association of Records Managers and Administrators, www.ARMA.org).

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Year	Cost For 1 GigaByte 1,000 MBytes (US Dollars) (Storage for 2 Scanned File Cabinets)	Cost For 1 TeraByte = 1,000 GigaBytes (US Dollars) (Storage for 2,000 Scanned File Cabinets)			
		EIDE PC Disk No Online Redundancy	EIDE or SCSI PC Disk Software RAID Redundancy	SCSI PC Disk Name Brand Fault Awareness Hardware RAID	Mainframe
		1X	2 X	5X	10X
1992	1,000.00	1,000,000.00	2,000,000.00	5,000,000.00	10,000,000.00
1993	625.00	625,000.00	1,250,000.00	3,125,000.00	6,250,000.00
1994	390.63	390,625.00	781,250.00	1,953,125.00	3,906,250.00
1995	244.14	244,140.63	488,281.25	1,220,703.13	2,441,406.25
1996	152.59	152,587.89	305,175.78	762,939.45	1,525,878.91
1997	95.37	95,367.43	190,734.86	476,837.16	953,674.32
1998	59.60	59,604.64	119,209.29	298,023.22	596,046.45
1999	37.25	37,252.90	74,505.81	186,264.51	372,529.03
2000	23.28	23,283.06	46,566.13	116,415.32	232,830.64
2001	14.55	14,551.92	29,103.83	72,759.58	145,519.15
2002	9.09	9,094.95	18,189.89	45,474.74	90,949.47
2003	5.68	5,684.34	11,368.68	28,421.71	56,843.42
2004	3.55	3,552.71	7,105.43	17,763.57	35,527.14
2005	2.22	2,220.45	4,440.89	11,102.23	22,204.46
2006	1.39	1,387.78	2,775.56	6,938.89	13,877.79
2007	0.87	867.36	1,734.72	4,336.81	8,673.62
2008	0.54	542.10	1,084.20	2,710.51	5,421.01
2009	0.34	338.81	677.63	1,694.07	3,388.13
2010	0.21	211.76	423.52	1,058.79	2,117.58
2011	0.13	132.35	264.70	661.74	1,323.49
2012	0.08	82.72	165.44	413.59	827.18
2013	0.05	51.70	103.40	258.49	516.99
2014	0.03	32.31	64.62	161.56	323.12
2015	0.02	20.19	40.39	100.97	201.95
2016	0.01	12.62	25.24	63.11	126.22
2017	0.01	7.89	15.78	39.44	78.89
2018	0.00	4.93	9.86	24.65	49.30
2019	0.00	3.08	6.16	15.41	30.81
2020	0.00	1.93	3.85	9.63	19.26
2021	0.00	1.20	2.41	6.02	12.04
2022	0.00	0.75	1.50	3.76	7.52
2023	0.00	0.47	0.94	2.35	4.70
2024	0.00	0.29	0.59	1.47	2.94
2025	0.00	0.18	0.37	0.92	1.84
2026	0.00	0.11	0.23	0.57	1.15
2027	0.00	0.07	0.14	0.36	0.72
2028	0.00	0.04	0.09	0.22	0.45
2029	0.00	0.03	0.06	0.14	0.28
2030	0.00	0.02	0.04	0.09	0.18
2031	0.00	0.01	0.02	0.05	0.11
2032	0.00	0.01	0.01	0.03	0.07
2033	0.00	0.00	0.01	0.02	0.04
2034	0.00	0.00	0.01	0.01	0.03
2035	0.00	0.00	0.00	0.01	0.02
2036	0.00	0.00	0.00	0.01	0.01
2037	0.00	0.00	0.00	0.00	0.01
2038	0.00	0.00	0.00	0.00	0.00