US009098399B2

(12) **United States Patent**
Ellis et al.

(10) **Patent No.: US 9,098,399 B2**
(45) **Date of Patent: Aug. 4, 2015**

(54) **ELECTRONIC SYSTEM WITH STORAGE MANAGEMENT MECHANISM AND METHOD OF OPERATION THEREOF**

(75) Inventors: **Robert W. Ellis**, Phoenix, AZ (US); **James Fitzpatrick**, Sudbury, MA (US); **James Higgins**, Chandler, AZ (US)

(73) Assignee: **SMART STORAGE SYSTEMS, INC.**, Milpitas, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 30 days.

(21) Appl. No.: **13/590,826**

(22) Filed: **Aug. 21, 2012**

(65) **Prior Publication Data**

US 2013/0054881 A1 Feb. 28, 2013

Related U.S. Application Data

(60) Provisional application No. 61/529,913, filed on Aug. 31, 2011.

(51) **Int. Cl.**

G06F 12/00	(2006.01)
G06F 3/00	(2006.01)
G06F 12/02	(2006.01)
G06F 3/06	(2006.01)

(52) **U.S. Cl.**
CPC ***G06F 12/0246*** (2013.01); *G06F 3/0605* (2013.01); *G06F 3/067* (2013.01); *G06F 3/0647* (2013.01); *G06F 2212/7205* (2013.01)

(58) **Field of Classification Search**
USPC 711/165
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,048,481	A	9/1977	Bailey, Jr. et al.
4,839,587	A	6/1989	Flatley et al.
5,034,744	A	7/1991	Obinata
5,210,854	A	5/1993	Beaverton et al.
5,311,395	A	5/1994	McGaha et al.
5,450,354	A	9/1995	Sawada et al.
5,479,638	A	12/1995	Assar et al.
5,784,174	A	7/1998	Fujino et al.
5,790,828	A	8/1998	Jost
5,930,504	A	7/1999	Gabel
5,949,785	A	9/1999	Beasley
5,963,983	A	10/1999	Sakakura et al.
6,069,827	A	5/2000	Sinclair

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1 956 489	A2	8/2008
EP	1 990 921	A2	11/2008

(Continued)

OTHER PUBLICATIONS

Cooke, "Introduction to Flash Memory (T1A)," Flash Memory Summit, Aug. 22, 2008, Micron Technology, Inc., 102 pages.

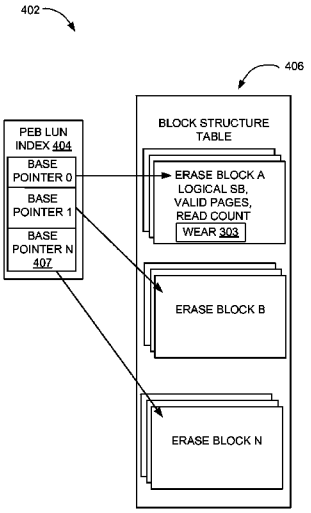
(Continued)

Primary Examiner — Matthew Bradley
Assistant Examiner — Craig Goldschmidt
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

A method of operation of an electronic system includes: forming a superblock by organizing an erase block according to a wear attribute; detecting a trigger count of the wear attribute of the superblock; updating a metadata table with the trigger count; and triggering a recycling event of the superblock based on the metadata table.

18 Claims, 5 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

6,091,652 A 7/2000 Haehn et al.
6,275,436 B1 8/2001 Tobita et al.
6,345,367 B1 2/2002 Sinclair
6,356,447 B2 3/2002 Scafidi
6,381,670 B1 4/2002 Lee et al.
6,412,080 B1 6/2002 Fleming et al.
6,529,997 B1 3/2003 Debiez et al.
6,552,581 B1 4/2003 Gabara
6,587,915 B1 7/2003 Kim
6,618,249 B2 9/2003 Fairchild
6,661,503 B1 12/2003 Yamaguchi et al.
6,728,913 B1 4/2004 Parker
6,763,424 B2 7/2004 Conley
6,775,792 B2 8/2004 Ulrich et al.
6,778,387 B2 8/2004 Fairchild
6,850,443 B2 2/2005 Lofgren et al.
6,854,070 B2 2/2005 Johnson et al.
6,871,304 B2 3/2005 Hadjihassan et al.
6,903,972 B2 6/2005 Lasser et al.
6,906,961 B2 6/2005 Eggleston et al.
6,975,028 B1 12/2005 Wayburn et al.
7,082,495 B2 7/2006 DeWhitt et al.
7,107,389 B2 9/2006 Inagaki et al.
7,139,864 B2 11/2006 Bennett et al.
7,233,497 B2 6/2007 Simon et al.
7,243,186 B2 7/2007 Liang et al.
7,298,888 B2 11/2007 Hamar
7,330,927 B1 2/2008 Reeve et al.
7,333,364 B2 2/2008 Yu et al.
7,350,101 B1 3/2008 Nguyen et al.
7,355,896 B2 4/2008 Li et al.
7,434,122 B2 10/2008 Jo
7,441,067 B2 10/2008 Gorobets et al.
7,516,267 B2 4/2009 Coulson et al.
7,613,871 B2 11/2009 Tanaka et al.
7,620,710 B2 11/2009 Kottomtharayil et al.
7,620,769 B2 11/2009 Lee et al.
7,639,532 B2 12/2009 Roohparvar et al.
7,661,054 B2 2/2010 Huffman et al.
7,679,948 B2 3/2010 Park et al.
7,693,422 B2 4/2010 Alicherry et al.
7,738,502 B2 6/2010 Chang et al.
7,743,216 B2 6/2010 Lubbers et al.
7,818,525 B1 10/2010 Frost et al.
7,827,348 B2 11/2010 Lee et al.
7,830,164 B2 11/2010 Earle et al.
7,979,614 B1 7/2011 Yang
8,001,135 B2 8/2011 Perlmutter et al.
8,010,738 B1 8/2011 Chilton et al.
8,028,123 B2 9/2011 Kilzer et al.
8,046,645 B2 10/2011 Hsu et al.
8,051,241 B2 11/2011 Feldman et al.
8,072,805 B2 12/2011 Chou et al.
8,095,724 B2 1/2012 Ji et al.
8,095,765 B2 1/2012 Asnaashari et al.
8,117,396 B1 2/2012 Fair et al.
8,127,202 B2 2/2012 Cornwell et al.
8,145,984 B2 3/2012 Sommer et al.
8,154,921 B2 4/2012 Mokhlesi et al.
8,169,825 B1 5/2012 Shalvi et al.
8,209,677 B2 6/2012 Shintani et al.
8,219,724 B1 7/2012 Caruso et al.
8,219,776 B2 7/2012 Forhan et al.
8,228,701 B2 7/2012 Sokolov et al.
8,245,101 B2 8/2012 Olbrich et al.
8,250,621 B2 8/2012 Cha
8,254,172 B1 * 8/2012 Kan 365/185.12
8,259,506 B1 9/2012 Sommer et al.
8,289,801 B2 10/2012 Smith et al.
8,296,534 B1 10/2012 Gupta et al.
8,332,578 B2 12/2012 Frickey, III et al.
8,363,413 B2 1/2013 Paquette et al.
8,369,141 B2 2/2013 Sommer et al.
8,386,700 B2 2/2013 Olbrich et al.
8,386,860 B2 2/2013 Tseng et al.
8,407,409 B2 3/2013 Kawaguchi
8,464,106 B2 6/2013 Filor et al.
8,503,238 B1 8/2013 Wu et al.
8,601,203 B2 12/2013 Holbrook et al.
8,612,804 B1 * 12/2013 Kang et al. 714/42
8,661,184 B2 2/2014 Wood et al.
8,832,506 B2 9/2014 Griffin et al.
2002/0056025 A1 5/2002 Qiu et al.
2002/0159285 A1 10/2002 Morley et al.
2003/0033308 A1 2/2003 Patel et al.
2003/0046603 A1 3/2003 Harari et al.
2003/0074592 A1 4/2003 Hasegawa
2003/0163633 A1 8/2003 Aasheim et al.
2004/0080985 A1 4/2004 Chang et al.
2004/0088511 A1 5/2004 Bacon et al.
2004/0252670 A1 12/2004 Rong et al.
2005/0021904 A1 1/2005 Iaculo et al.
2005/0038792 A1 2/2005 Johnson
2005/0073884 A1 4/2005 Gonzalez et al.
2005/0076102 A1 4/2005 Chen et al.
2005/0144516 A1 6/2005 Gonzalez et al.
2006/0015683 A1 1/2006 Ashmore et al.
2006/0020745 A1 1/2006 Conley et al.
2006/0022054 A1 2/2006 Elhamias et al.
2006/0136682 A1 6/2006 Haridas et al.
2006/0143365 A1 6/2006 Kikuchi
2006/0143475 A1 6/2006 Herbert et al.
2006/0253641 A1 11/2006 Gatzemeier et al.
2006/0256624 A1 11/2006 Eggleston et al.
2006/0282644 A1 12/2006 Wong
2006/0294574 A1 12/2006 Cha
2007/0050536 A1 3/2007 Kolokowsky
2007/0061511 A1 * 3/2007 Faber 711/113
2007/0067598 A1 3/2007 Fujimoto
2007/0083779 A1 4/2007 Misaka et al.
2007/0226592 A1 9/2007 Radke
2007/0234004 A1 10/2007 Oshima et al.
2007/0260811 A1 11/2007 Merry, Jr. et al.
2007/0263444 A1 11/2007 Gorobets et al.
2007/0276973 A1 11/2007 Tan et al.
2008/0046630 A1 2/2008 Lasser
2008/0052446 A1 2/2008 Lasser et al.
2008/0082736 A1 4/2008 Chow et al.
2008/0126720 A1 5/2008 Danilak
2008/0183918 A1 7/2008 Dhokia et al.
2008/0189588 A1 8/2008 Tanaka et al.
2008/0313505 A1 12/2008 Lee et al.
2009/0006900 A1 1/2009 Lastras-Montano et al.
2009/0019321 A1 1/2009 Radke
2009/0070651 A1 3/2009 Diggs et al.
2009/0083587 A1 3/2009 Ng et al.
2009/0089485 A1 4/2009 Yeh
2009/0091990 A1 4/2009 Park et al.
2009/0109786 A1 4/2009 Ye et al.
2009/0125670 A1 5/2009 Keays
2009/0138654 A1 5/2009 Sutardja
2009/0146721 A1 6/2009 Kurooka et al.
2009/0157948 A1 6/2009 Trichina et al.
2009/0164702 A1 6/2009 Kern
2009/0164710 A1 6/2009 Choi et al.
2009/0172262 A1 7/2009 Olbrich et al.
2009/0179707 A1 7/2009 Higashino
2009/0228634 A1 9/2009 Nakamura et al.
2009/0228761 A1 9/2009 Perlmutter et al.
2009/0259819 A1 10/2009 Chen et al.
2009/0259896 A1 10/2009 Hsu et al.
2009/0271562 A1 10/2009 Sinclair
2009/0287975 A1 11/2009 Kim et al.
2009/0300238 A1 12/2009 Panabaker et al.
2009/0323419 A1 * 12/2009 Lee et al. 365/185.11
2009/0327581 A1 12/2009 Coulson
2009/0327591 A1 12/2009 Moshayedi
2010/0017650 A1 1/2010 Chin et al.
2010/0023674 A1 1/2010 Aviles
2010/0050053 A1 2/2010 Wilson et al.
2010/0122019 A1 5/2010 Flynn et al.
2010/0128537 A1 5/2010 Suhail et al.
2010/0138592 A1 6/2010 Cheon
2010/0165689 A1 7/2010 Rotbard et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0169541	A1	7/2010	Freikorn	
2010/0172179	A1	7/2010	Gorobets et al.	
2010/0174845	A1	7/2010	Gorobets et al.	
2010/0217898	A1	8/2010	Priborsky et al.	
2010/0217915	A1	8/2010	O'Connor et al.	
2010/0228928	A1	9/2010	Asnaashari et al.	
2010/0262792	A1	10/2010	Hetzler et al.	
2010/0262795	A1	10/2010	Hetzler et al.	
2010/0262875	A1	10/2010	Hetzler et al.	
2010/0287328	A1*	11/2010	Feldman et al.	711/103
2010/0293367	A1	11/2010	Berke et al.	
2010/0312954	A1	12/2010	Jeon et al.	
2010/0318719	A1	12/2010	Keays et al.	
2010/0332726	A1	12/2010	Wang	
2011/0002224	A1	1/2011	Tamura	
2011/0016239	A1	1/2011	Stenfort	
2011/0055468	A1	3/2011	Gonzalez et al.	
2011/0066788	A1	3/2011	Eleftheriou et al.	
2011/0072423	A1	3/2011	Fukata	
2011/0078393	A1	3/2011	Lin	
2011/0099342	A1	4/2011	Ozdemir	
2011/0131365	A1	6/2011	Zhang et al.	
2011/0131447	A1	6/2011	Prakash et al.	
2011/0132000	A1	6/2011	Deane et al.	
2011/0145473	A1	6/2011	Maheshwari	
2011/0161775	A1	6/2011	Weingarten	
2011/0190963	A1	8/2011	Glassl et al.	
2011/0191522	A1	8/2011	Condict et al.	
2011/0191649	A1	8/2011	Lim et al.	
2011/0209032	A1	8/2011	Choi et al.	
2011/0238892	A1	9/2011	Tsai et al.	
2011/0239088	A1	9/2011	Post	
2011/0258496	A1	10/2011	Tseng et al.	
2011/0314219	A1	12/2011	Ulrich et al.	
2011/0320687	A1	12/2011	Belluomini et al.	
2012/0008401	A1	1/2012	Katz et al.	
2012/0011336	A1	1/2012	Saika	
2012/0047318	A1	2/2012	Yoon et al.	
2012/0047320	A1	2/2012	Yoo et al.	
2012/0047409	A1	2/2012	Post et al.	
2012/0066450	A1	3/2012	Yochai et al.	
2012/0124046	A1	5/2012	Provenzano	
2012/0124273	A1	5/2012	Goss et al.	
2012/0151260	A1	6/2012	Zimmermann et al.	
2012/0170365	A1	7/2012	Kang et al.	
2012/0213004	A1	8/2012	Yun et al.	
2012/0216085	A1	8/2012	Weingarten et al.	
2012/0236656	A1	9/2012	Cometti	
2012/0239858	A1	9/2012	Melik-Martirosian	
2012/0254686	A1	10/2012	Esumi et al.	
2012/0266048	A1	10/2012	Chung et al.	
2012/0278530	A1	11/2012	Ebsen	
2012/0284587	A1	11/2012	Yu et al.	
2012/0297113	A1	11/2012	Belluomini et al.	
2012/0311402	A1	12/2012	Tseng et al.	
2012/0324191	A1	12/2012	Strange et al.	
2012/0331207	A1	12/2012	Lassa et al.	
2013/0007380	A1	1/2013	Seekins et al.	
2013/0007543	A1	1/2013	Goss et al.	
2013/0054881	A1	2/2013	Ellis et al.	
2013/0060994	A1	3/2013	Higgins et al.	
2013/0073788	A1	3/2013	Post et al.	
2013/0080691	A1	3/2013	Weingarten et al.	
2013/0094289	A1	4/2013	Sridharan et al.	
2013/0100600	A1	4/2013	Yin et al.	
2013/0124792	A1	5/2013	Melik-Martirosian et al.	
2013/0151753	A1	6/2013	Jeon et al.	
2013/0198436	A1	8/2013	Bandic et al.	
2013/0238833	A1	9/2013	Vogan et al.	
2013/0265825	A1	10/2013	Lassa	
2013/0332791	A1	12/2013	Chu	
2014/0108891	A1	4/2014	Strasser et al.	
2014/0129874	A1	5/2014	Zaltsman et al.	
2014/0208174	A1	7/2014	Ellis et al.	

FOREIGN PATENT DOCUMENTS

EP	2 498 259	A2	9/2012
JP	2012129859	A	7/2012
WO	WO 2009/042298	A1	4/2009
WO	WO 2011/156466		12/2011

OTHER PUBLICATIONS

Gal et al., "Algorithms and Data Structures for Flash Memories," ACM Computing Surveys, Jun. 2005, vol. 37, No. 2, 30 pages.

IBM Corporation, "Systems Management, Work Management," Version 5, Release 4, 9th Edition, Feb. 2006 pp. 1-21.

O'Brien, "SMART Storage Systems Optimus SAS Enterprise SSD Review," SMART Storage Systems, Oct. 9, 2012, 44 pages.

Spanjer, "Flash Management—Why and How?" Smart Modular Technologies, Nov. 2009, http://www.scantec.de/fileadmin/pdf/Smart_Modular/Flash-Management.pdf, 14 pages.

Texas Instruments, "Power Management IC for Digital Set Top Boxes," SLVSA10A, Sep. 2009, pp. 1-22.

International Search Report and Written Opinion dated Dec. 20, 2013, received in PCT/US2013/045282, which corresponds to U.S. Appl. No. 13/493,949, 7 pages (Ellis).

International Search Report and Written Opinion dated Aug. 22, 2014, received in International Patent Application No. PCT/US2014/032978, which corresponds to U.S. Appl. No. 14/081,992, 10 pages (Ellis).

International Search Report and Written Opimon dated Nov. 7, 2014, received in International Patent Application No. PCT/US2014/049732, which corresponds to U.S. Appl. No. 14/334,350, 13 pages (Fitzpatrick).

International Search Report and Written Opinion dated Oct. 17, 2014, received in International Patent Application No. PCT/US2014/049734, which corresponds to U.S. Appl. No. 14/332,259, 8 pages (Higgins).

International Search Report and Written Opinion dated Oct. 23, 2014, received in International Patent Application No. PCT/US2014/049736, which corresponds to U.S. Appl. No. 14/446,249 8 pages (Fitzpatrick).

International Search Report and Written Opinion dated Nov. 5, 2014, received in International Patent Application No. PCT/US2014/049282, which corresponds to U.S. Appl. No. 13/957,407, 12 pages (Fitzpatrick).

Tseng et al., "Understanding the Impact of Power Loss on Flash Memory," DAC'11, Jun. 5-10, 2011, San Diego, California, 6 pages.

Ulinktech, "ATA Command Table (in Alphabetic Order)," Feb. 6, 2011, https://web.archive.org/web/20110206060820/http://www.ulinktech.com/downloads/AT, 6 pages.

International Search Report and Written Opinion dated May 14, 2014, received in International Patent Application No. PCT/US2014/017168, which corresponds to U.S. Appl. No. 14/076,115, 6 pages (Fitzpatrick).

International Search Report and Written Opinion dated May 14, 2014, received in International Patent Application No. PCT/US2014/017169, which corresponds to U.S. Appl. No. 14/076,148, 6 pages (Fitzpatrick).

International Search Report dated Mar. 25, 2014, received in International Patent Application No. PCT/US2013/072400, which corresponds to U.S. Appl. No. 13/690,337, 3 pages (Ellis).

International Search Report and Written Opinion dated Jun. 12, 2014, received in International Patent Application No. PCT/US2014/018972, which corresponds to U.S. Appl. No. 13/779,352, 12 pages (Schmier).

Invitation to Pay Additional Fees dated Jul. 25, 2014, received in International Patent Application No. PCT/US2014/021290, which corresponds to U.S. Appl. No. 13/791,797, 8 pages (Dean).

International Search Report and Written Opinion dated Jul. 31, 2014, received in International Patent Application No. PCT/US2014/031465, which corresponds to U.S. Appl. No. 13/851,928, 13 pages (Ellis).

International Search Report and Written Opinion dated Jul. 31, 2014, received in International Patent Application No. PCT/US2014/033876, which corresponds to U.S. Appl. No. 13/861,326, 9 pages (Fitzpatrick).

(56) **References Cited**

OTHER PUBLICATIONS

Narayanan et al., "Migrating Server Storage to SSDs: Analysis of Tradeoffs," Computer Systems, Apr. 2009, 12 pages.
Shiraz et al., "Block Aging Prevention Technique (BAP) for Flash Based Solid State Disks," 7th International Conference on Emerging Technologies (ICET), Sep. 5, 2011, 6 pages.
Tai et al., "Prolongation of Lifetime and the Evaluation Method of Dependable SSD" 25 International Symposium on Defect and Fault Tolerance in VLSI Systems, 2010, NJ, USA, 8 pages.
Yimo et al., "WeLe-RAID: A SSD-Based RAID for System Endurance and Performance," Jan. 2011, Network and Parallel Computing, Springer, 14 pages.
International Search Report and Written Opinion dated Jun. 9, 2015, received in International Patent Application No. PCT/US2014/049731, which corresponds to U.S. Appl. No. 14/334,324, 9 pages (Fitzpatrick).
International Search Report and Written Opinion dated Feb. 18, 2015, received in International Patent Application No. PCT/US2014/065401, which corresponds to U.S. Appl. No. 14/082,031, 9 pages (Higgins).
International Search Report dated Apr. 15, 2014, received in International Patent Application No. PCT/US2013/078340, which corresponds to U.S. Appl. No. 13/746,542, 11 pages (Ellis).

* cited by examiner

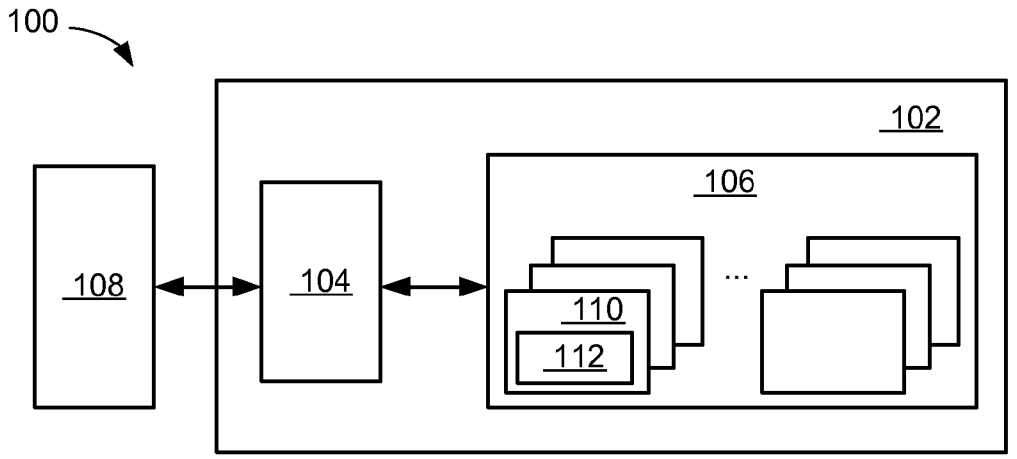

100
102
106
108
104
110
112
...

FIG. 1

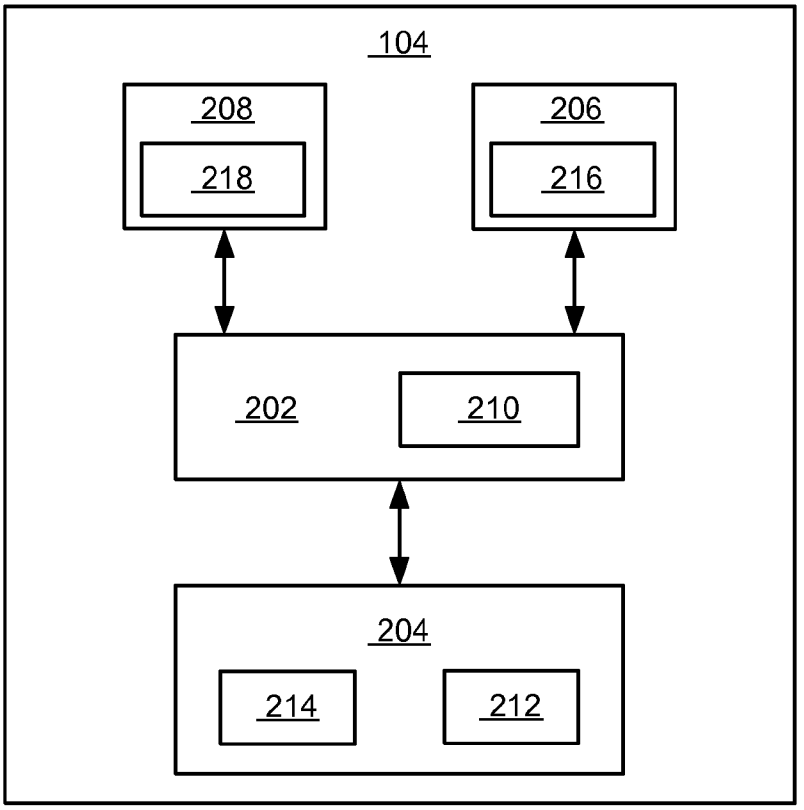

104
208
218
206
216
202
210
204
214
212

FIG. 2

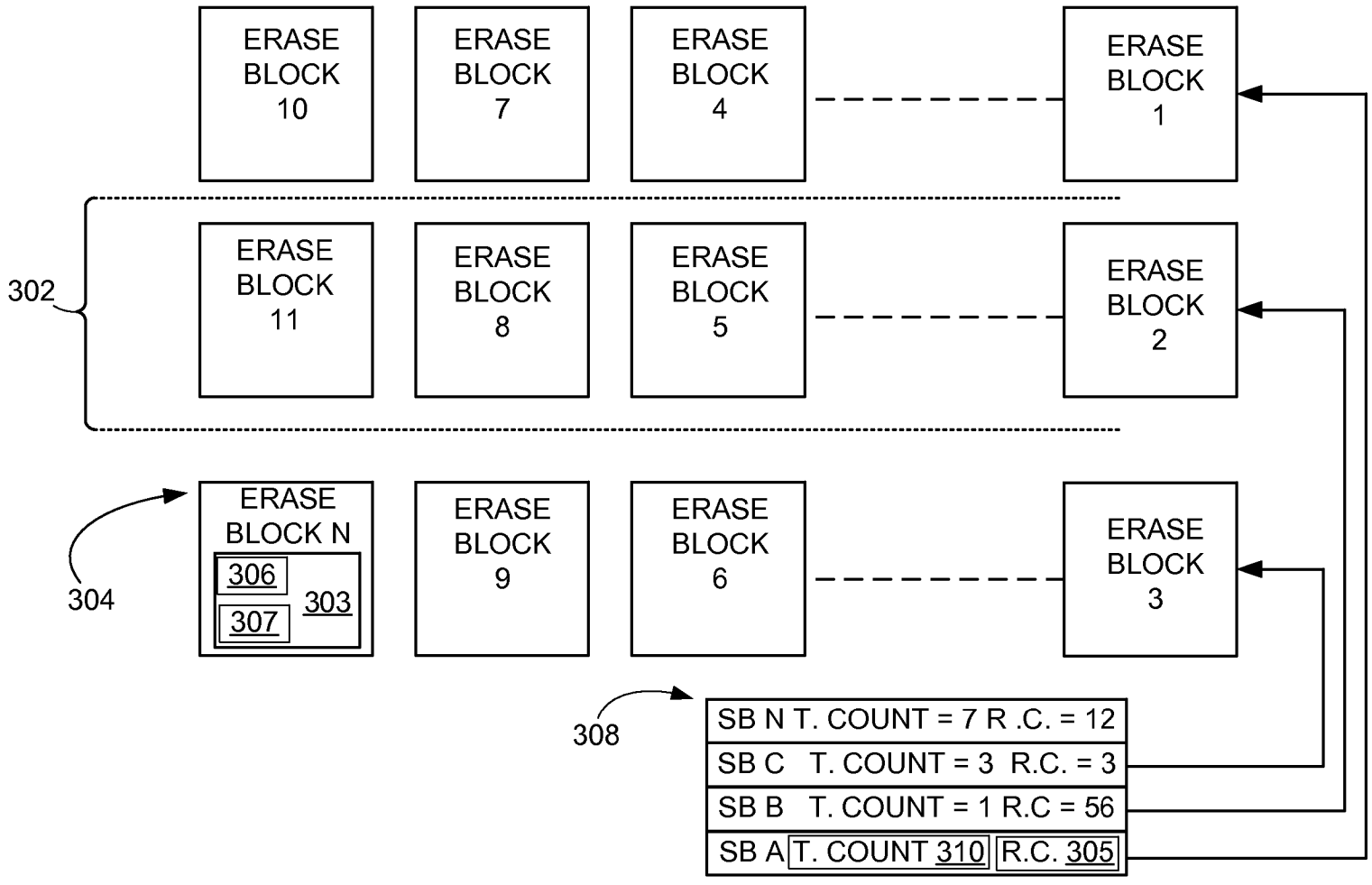

ERASE BLOCK 10
ERASE BLOCK 7
ERASE BLOCK 4
ERASE BLOCK 1
302
ERASE BLOCK 11
ERASE BLOCK 8
ERASE BLOCK 5
ERASE BLOCK 2
304
ERASE BLOCK N
306
307
303
ERASE BLOCK 9
ERASE BLOCK 6
ERASE BLOCK 3
308
SB N T. COUNT = 7 R .C. = 12
SB C T. COUNT = 3 R.C. = 3
SB B T. COUNT = 1 R.C = 56
SB A T. COUNT 310 R.C. 305

FIG. 3

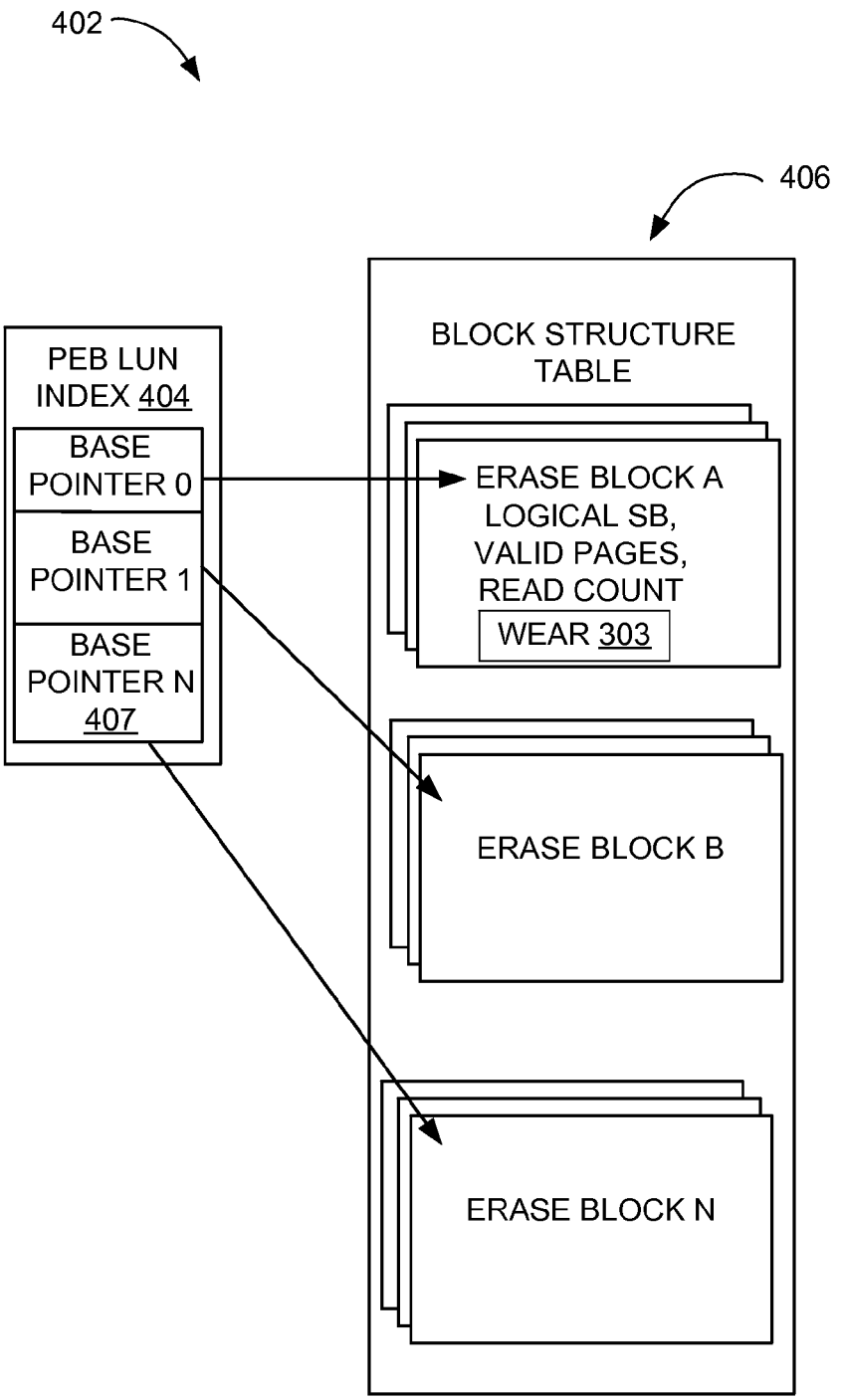

402
406
PEB LUN INDEX 404
BASE POINTER 0
BASE POINTER 1
BASE POINTER N 407
BLOCK STRUCTURE TABLE
ERASE BLOCK A LOGICAL SB, VALID PAGES, READ COUNT
WEAR 303
ERASE BLOCK B
ERASE BLOCK N

FIG. 4

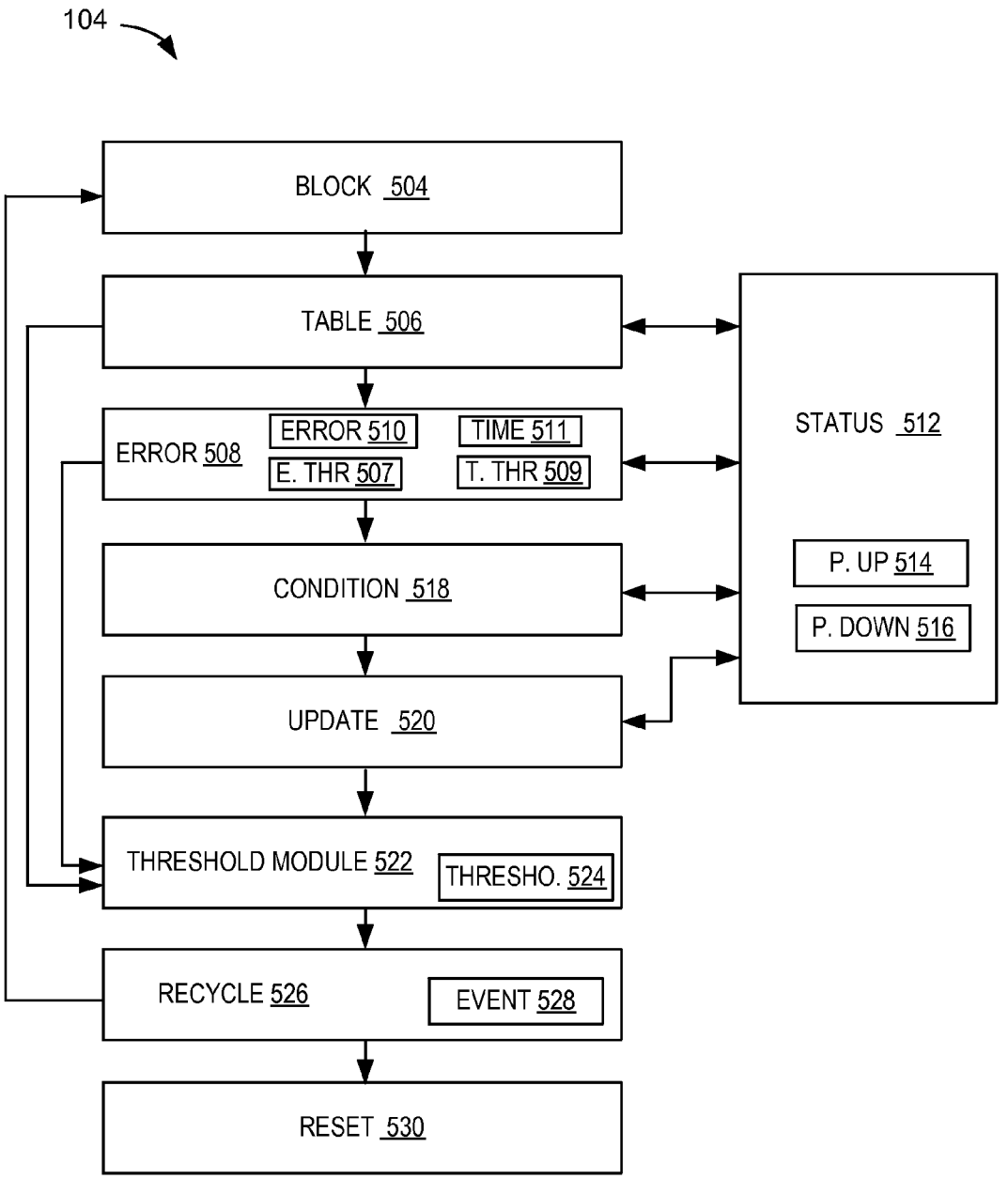

104
BLOCK 504
TABLE 506
ERROR 508
ERROR 510
TIME 511
E. THR 507
T. THR 509
STATUS 512
P. UP 514
P. DOWN 516
CONDITION 518
UPDATE 520
THRESHOLD MODULE 522
THRESHO. 524
RECYCLE 526
EVENT 528
RESET 530

FIG. 5

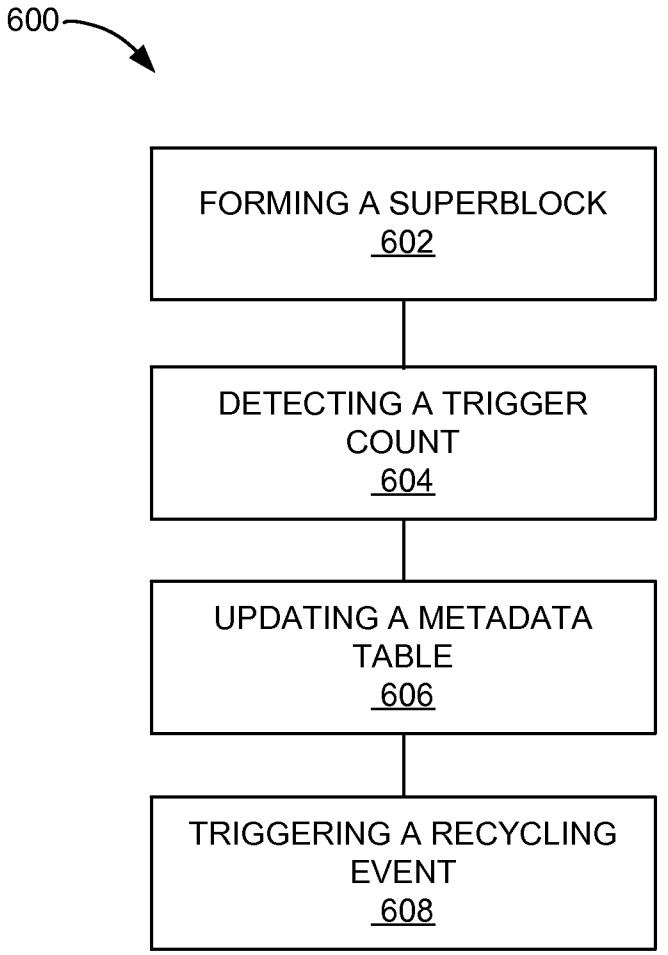

600
FORMING A SUPERBLOCK
602
DETECTING A TRIGGER COUNT
604
UPDATING A METADATA TABLE
606
TRIGGERING A RECYCLING EVENT
608

FIG. 6

ELECTRONIC SYSTEM WITH STORAGE MANAGEMENT MECHANISM AND METHOD OF OPERATION THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/529,913 filed Aug. 31, 2011, and the subject matter thereof is incorporated herein by reference thereto.

TECHNICAL FIELD

The present invention relates generally to an electronic system and more particularly to a system with storage management.

BACKGROUND ART

All electronic systems require some form of memory or storage. Data storage, often called storage or memory, refers to computer components and recording media that retain digital data. Data storage is a core function and fundamental component of consumer and industrial electronics, especially devices such as computers, televisions, cellular phones, mobile devices, and digital video cameras.

Recently, forms of long-term storage other than electromechanical hard disks have become feasible for use in computers. One of these is flash Electrically Erasable Programmable Read-Only Memory (EEPROM). Flash EEPROM memory includes a plurality of floating-gate field effect transistors arranged as memory cells. NAND flash is one form of non-volatile memory used in solid state storage devices. The memory cells are arranged in typical row and column fashion with circuitry for accessing individual cells. The memory transistors of those cells can store an analog value that can be interpreted to hold two logical states for Single Level Cell (SLC) or more than two logical states as for Multi Level Cells (MLC).

A flash memory cell, like a typical EEPROM cell but in contrast to Dynamic random-access memory (DRAM) memory, retains information when power is removed. Flash EEPROM memory has a number of characteristics, which adapt it to use as long-term memory. It is light in weight, occupies very little space, and consumes less power than electromechanical disk drives. Construction of a storage system with this type of memory allows for much higher bandwidth and higher input output operations per second than a typical electromechanical disk drive. More importantly, it is especially rugged and can operate at a much high temperature range. It will withstand, without adverse effects, repeated drops, each of which would destroy a typical electromechanical hard disk drive. A problem exhibited by flash memory is that it tends to have a limited life in use.

Thus, a need still remains for better storage management to prolong the performance and durability of electronic systems. In view of the increasing demand for storage management of electronic systems, it is increasingly critical that answers be found to these problems. In view of the ever-increasing commercial competitive pressures, along with growing consumer expectations and the diminishing opportunities for meaningful product differentiation in the marketplace, it is critical that answers be found for these problems. Additionally, the need to reduce costs, improve efficiencies and performance, and meet competitive pressures adds an even greater urgency to the critical necessity for finding answers to these problems.

Solutions to these problems have been long sought but prior developments have not taught or suggested any solutions and, thus, solutions to these problems have long eluded those skilled in the art.

DISCLOSURE OF THE INVENTION

The present invention provides a method of operation of an electronic system, including: forming a superblock by organizing an erase block according to a wear attribute; detecting a trigger count of the wear attribute of the superblock; updating a metadata table with the trigger count; and triggering a recycling event of the superblock based on the metadata table.

The present invention provides an electronic system, including: a block module for forming a superblock by organizing an erase block according to a wear attribute; a table module, coupled to the block module, for detecting a trigger count of the wear attribute of the superblock; an update module, coupled to the table module, for updating a metadata table with the trigger count; and a recycle module, coupled to the update module, for triggering a recycling event of the superblock based on the metadata table.

Certain embodiments of the invention have other steps or elements in addition to or in place of those mentioned above. The steps or elements will become apparent to those skilled in the art from a reading of the following detailed description when taken with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an electronic system with storage management mechanism in an embodiment of the present invention.

FIG. **2** is an exemplary hardware block diagram of the memory controller.

FIG. **3** is an example diagram of the storage management for the electronic system of FIG. **1**.

FIG. **4** is a block diagram of a metadata table of the electronic system of FIG. **1**.

FIG. **5** is a control flow of the memory controller of FIG. **2**.

FIG. **6** is a flow chart of a method of operation of the electronic system of FIG. **1** in a further embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

The following embodiments are described in sufficient detail to enable those skilled in the art to make and use the invention. It is to be understood that other embodiments would be evident based on the present disclosure, and that system, process, or mechanical changes may be made without departing from the scope of the present invention.

In the following description, numerous specific details are given to provide a thorough understanding of the invention. However, it will be apparent that the invention may be practiced without these specific details. In order to avoid obscuring the present invention, some well-known circuits, system configurations, and process steps are not disclosed in detail.

The drawings showing embodiments of the system are semi-diagrammatic and not to scale and, particularly, some of the dimensions are for the clarity of presentation and are shown exaggerated in the drawing FIGs. Similarly, although the views in the drawings for ease of description generally show similar orientations, this depiction in the FIGs. is arbitrary for the most part. Generally, the invention can be operated in any orientation.

Where multiple embodiments are disclosed and described having some features in common, for clarity and ease of illustration, description, and comprehension thereof, similar and like features one to another will ordinarily be described with similar reference numerals. The embodiments have been numbered first embodiment, second embodiment, etc. as a matter of descriptive convenience and are not intended to have any other significance or provide limitations for the present invention.

The term "module" referred to herein can include hardware, software running on or coupled to hardware, or a combination thereof in the present invention in accordance with the context in which the term is used. For example, the software can be machine code, firmware, embedded code, and application software. Also for example, the hardware can be circuitry, processor, computer, integrated circuit, integrated circuit cores, a microelectromechanical system (MEMS), passive devices, environmental sensors including but not limited to temperature sensors, or a combination thereof.

Referring now to FIG. **1**, therein is shown an electronic system **100** with storage management mechanism in an embodiment of the present invention. The electronic system **100** includes a memory sub-system **102** having a memory controller **104** and a memory array **106**. The electronic system **100** includes a host system **108** communicating with the memory sub-system **102**.

The memory controller **104** provides data control and management of the memory array **106**. The memory controller **104** interfaces with the host system **108** and controls the memory array **106** to transfer data between the host system **108** and the memory array **106**.

The memory array **106** includes an array of memory devices **110** including flash memory devices or non-volatile memory devices. The memory array **106** can include pages of data or information. The host system **108** can request the memory controller **104** for reading, writing, and deleting data from or to the logical address space of the storage device that includes the memory array **106**.

The memory devices **110** can include chip selects **112**, which are defined as control inputs, for enabling the memory devices **110**. Each of the chip selects **112** can be used to control the operation of one of the memory devices **110**. When the chip selects **112** are enabled, the memory devices **110** are in active state for operation including reading, writing, or recycling. This is also true for sub addresses LUNs (logical units) within a device controlled by one chip select.

Referring now to FIG. **2**, therein is shown an exemplary hardware block diagram of the memory controller **104**. The memory controller **104** can include a control unit **202**, a storage unit **204**, a memory interface unit **206**, and a host interface unit **208**. The control unit **202** can include a control interface **210**. The control unit **202** can execute software **212** stored in the storage unit **204** to provide the intelligence of the memory controller **104**.

The control unit **202** can be implemented in a number of different manners. For example, the control unit **202** can be a processor, an embedded processor, a microprocessor, a hardware control logic, a hardware finite state machine (FSM), a digital signal processor (DSP), or a combination thereof.

The control interface **210** can be used for communication between the control unit **202** and other functional units in the memory controller **104**. The control interface **210** can also be used for communication that is external to the memory controller **104**.

The control interface **210** can receive information from the other functional units or from external sources, or can transmit information to the other functional units or to external destinations. The external sources and the external destinations refer to sources and destinations external to the memory controller **104**.

The control interface **210** can be implemented in different ways and can include different implementations depending on which functional units or external units are being interfaced with the control interface **210**. For example, the control interface **210** can be implemented with dedicated hardware such is an application-specific integrated circuit (ASIC), configurable hardware such as an FPGA (Field programmable Gate Array), discrete electronic hardware, or a combination thereof.

The storage unit **204** can include hardware, control firmware, and the software **212**. The storage unit **204** can contain a volatile memory, a non-volatile memory, an internal memory, an external memory, or a combination thereof. For example, the storage unit **204** can be a non-volatile storage such as non-volatile random access memory (NVRAM), Flash memory, disk storage, or a volatile storage such as static random access memory (SRAM).

The storage unit **204** can include a storage interface **214**. The storage interface **214** can also be used for communication that is external to the memory controller **104**. The storage interface **214** can receive information from the other functional units or from external sources, or can transmit information to the other functional units or to external destinations. The external sources and the external destinations refer to sources and destinations external to the memory controller **104**.

The storage interface **214** can include different implementations depending on which functional units or external units are being interfaced with the storage unit **204**. The storage interface **214** can be implemented with technologies and techniques similar to the implementation of the control interface **210**.

The memory interface unit **206** can enable external communication to and from the memory controller **104**. For example, the memory interface unit **206** can permit the memory controller **104** to communicate with the memory array **106** of FIG. **1**.

The memory interface unit **206** can include a memory interface **216**. The memory interface **216** can be used for communication between the memory interface unit **206** and other functional units in the memory controller **104**. The memory interface **216** can receive information from the other functional units or can transmit information to the other functional units.

The memory interface **216** can include different implementations depending on which functional units are being interfaced with the memory interface unit **206**. The memory interface **216** can be implemented with technologies and techniques similar to the implementation of the control interface **210**.

The host interface unit **208** allows the host system **108** of FIG. **1** to interface and interact with the memory controller **104**. The host interface unit **208** can include a host interface **218** to provide communication mechanism between the host interface unit **208** and the host system **108**.

The control unit **202** can operate the host interface unit **208** to send control or status information generated by the memory controller **104** to the host system **108**. The control unit **202** can also execute the software **212** for the other functions of the memory controller **104**. The control unit **202** can further execute the software **212** for interaction with the memory array **106** via the memory interface unit **206**.

The functional units in the memory controller **104** can work individually and independently of the other functional

units. For illustrative purposes, the memory controller **104** is described by operation of the memory controller **104** with the host system **108** and the memory array **106**. It is understood that the memory controller **104**, the host system **108**, and the memory array **106** can operate any of the modules and functions of the memory controller **104**.

Referring now to FIG. **3**, therein is shown an example diagram of the storage management for the electronic system **100** of FIG. **1**. The example includes erase blocks **304** of non-volatile memory in the memory array **106** of FIG. **1**. The portion of the erase blocks **304** are grouped into a superblock **302** and the example also includes multiple superblocks.

The superblock **302** is defined as a grouping of some of the erase blocks **304**. The superblock **302** can be a virtual or logical grouping of the erase blocks **304**. The memory controller **104** of FIG. **1** can manage data on a superblock level, instead of an individual erase block level to reduce the volume of information that needs to be tracked to manageable levels. The organization of the superblock **302** can be based on groupings of the erase blocks **304** based on a wear attribute **303**. The organization of the superblock **302** can be based on age characteristics, use models that support various types of retention strategy, or a combination thereof. The superblock **302** will be explained in further detail below.

The wear attribute **303** is defined as a characteristic of the erase blocks **304** that degrades the reliability of the erase blocks **304** to retain information. For example, the wear attribute **303** of the erase blocks **304** can include a read count **305**, a write age **306**, and a leakage **307**. The wear attribute **303** can also include an amount of bit errors of the erase blocks **304** as another characteristic that degrades the reliability of the erase blocks **304** to retain information.

The read count **305** is a value of a number of reads for one of the erase blocks **304**. The read count **305** indicates the relative age of one of the erase blocks **304**. The read count **305** can also be used to indicate the relative retention age or the relative read disturb age for one of the erase blacks **304**. The read count **305** can be reset if the erase blocks **304** in the superblock **302** are recycled by an erase/write verification cycle.

The write age **306** refers to the endurance of the erase blocks **304** and is the number of times the erase blocks **304** has been erased and rewritten. The write age **306** accumulates during the life span of the erase blocks **304**. The leakage **307** of the erase blocks **304** refers to the retention characteristics of the erase blocks **304** and is the loss of electric charge over time. The leakage **307** of the erase blocks **304** can be resent after recycling of the superblock **302**.

The electronic system **100** can include a condition table **308**. The condition table **308** is defined as a record for tracking information and metadata of the superblock **302** across power cycles. For example, the condition table **308** can be a record of the wear attribute **303**. The condition table **308** can be generated before the electronic system **100** is powered off and the condition table **308** can be stored in non-volatile memory. The condition table **308** can include a trigger count **310**. The condition table **308** will be explained in further detail below.

The trigger count **310** is defined as a value for one of the erase blocks **304** having the highest value for the wear attribute **303** in the superblock **302**. For example, the trigger count **310** can be the value of the read count **305** of one of the erase blocks **304** in the superblock **302** with the highest value. The trigger count **310** can also represent the value of the erase blocks **304** with the highest value for the write age **306** or the leakage **307**.

The trigger count **310** is a value that can trigger the recycling of the superblock **302**. The trigger count **310** can be associated with a value for the read count **305**, the write age **306**, and the leakage **307**. A single value for the trigger count **310** can represent all of the erase blocks **304** within the superblock **302** because recycling occurs on a superblock level. If the superblock **302** has undergone an erase/write verify cycle, the trigger count **310** for the read count **305** and the leakage **307** can be reset.

Referring now to FIG. **4**, therein is shown a block diagram of a metadata table **402** of the electronic system **100** of FIG. **1**. The metadata table **402** is defined as a record including data structures, tables, and indexes of the memory array **106** of FIG. **1**. The metadata table **402** stores information associated with the physical and logical attributes of the memory array **106**. For example, the metadata table **402** can include a record of the wear attribute **303**.

The metadata table **402** includes tabling infrastructure and linkages of metadata of the superblock **302** of FIG. **3**. During operation of the electronic system **100**, the metadata table **402** can be updated by changes made to the superblock **302** including changes to the wear attribute **303** of the erase blocks **304** of FIG. **3**. The metadata table **402** can include a program erase block index **404** and a block table **406**.

The program erase block index **404** is defined as an index for mapping the logical unit number of blocks to the physical address within the non-volatile memory structure. The program erase block index **404** can be stored on the storage unit **204** of FIG. **2** and can be modified by the memory controller **104** of FIG. **1**.

The program erase block index **404** can include a base pointer **407** associated with each of the erase blocks **304** of the non-volatile memory. For example, "base pointer **0**" can provide an index for linking a logical unit number to the physical address of the first of the erase blocks **304** in the superblock **302**. During recycling, if another one of the erase blocks **304** is assigned to the superblock **302**, the program erase block index **404** can be updated with the new physical address of the new spare block. The program erase block index **404** can include an N number of the base pointer **407** to index the erase blocks **304**.

The block table **406** records information regarding the metadata of the erase blocks **304** of the superblock **302**. The block table **406** can also include the wear attribute **303** of the erase blocks **304** within the superblock **302**. The block table **406** can also include a valid page count and a logical number for the superblock **302**.

The metadata table **402** can be stored on the storage unit **204** and can be modified by the memory controller **104**. During operation of the electronic system **100**, the metadata table **402** can be copied and modified in volatile memory, such as random access memory (RAM).

Referring now to FIG. **5**, therein is shown a control flow of the memory controller **104** of FIG. **2**. The memory controller **104** can include a block module **504**, a table module **506**, an error module **508**, a status module **512**, a condition module **518**, an update module **520**, a threshold module **522**, a recycle module **526**, and a reset module **530**.

In the control flow, as an example, each module is indicated by a number and successively higher module numbers follow one another. Control flow can pass from one module to the next higher numbered module unless explicitly otherwise indicated. The memory controller **104** can execute the block module **504**, the table module **506**, the error module **508**, the status module **512**, the condition module **518**, the update module **520**, the threshold module **522**, the recycle module **526**, and the reset module **530**.

The block module **504** forms the superblock **302** of FIG. **3** from the erase blocks **304** of FIG. **3**. For example, the superblock **302** can be modified and organized after a program/erase verification cycle of recycling. During recycling, the erase blocks **304** having errors caused by the wear attribute **303** of FIG. **3** can be replaced with a spare block from the erase blocks **304**.

The superblock **302** can be arranged with the erase blocks **304** having similar characteristics of the wear attribute **303**. For example, the erase blocks **304** in the superblock **302** can have a similar value for the write age **306** of FIG. **3**. Organizing the erase blocks **304** by the superblock **302** can maintain a grouping of the erase blocks **304** having similar relative age, endurances, and retention characteristics because the erase blocks **304** are written and erased together on a superblock level.

For example, one of the erase blocks **304** with the highest value for the read count **305** of FIG. **3** can be the trigger count **310** of FIG. **3** for the superblock **302**. The trigger count **310** can cause the recycling of the superblock **302** with all of the erase blocks **304** in the superblock **302** recycled together. Another example includes arranging the erase blocks **304** by minimal divergence in bit error rates per page for the superblock **302**. For example, the erase blocks **304** of the superblock **302** can be arranged by a bit error rate of increments of 25. The erase blocks **304** in the superblock **302** can include a bit error rate of 0-25, 26-50, and 125-150 as examples. The block module **504** can be coupled to the table module **506** for sharing information.

The table module **506** modifies the metadata table **402** of FIG. **4**. The table module **506** can modify the metadata table **402** for updating the tabling infrastructure and linkages of changes to the erase blocks **304** in the superblock **302**. The table module **506** can also identify the trigger count **310** of the superblock **302** from one of the erase blocks **304** with the highest value for the wear attribute **303**.

The trigger count **310** can include different values of the read count **305**, the write age **306**, and the leakage **307** of FIG. **3** from different examples of the erase blocks **304** of the superblock **302**. For example, the table module **506** can identify one of the erase blocks **304** having the highest value for the read count **305** and also identify one of the erase blocks **304** having the highest value for the leakage **307**.

The table module **506** can record the trigger count **310** of the superblock **302** for the read count **305**, the write age **306**, and the leakage **307** in the metadata table **402**. The table module **506** can be coupled to the update module **520** for updating the metadata table **402** with the trigger count **310**.

The metadata table **402** can be copied and modified in volatile memory such as RAM. The wear attribute **303** of each of the erase blocks **304** can also be tracked. The table module **506** can also track metadata on a superblock level to reduce the volume of information monitored to reduced and more manageable levels. For example, the erase blocks **304** are not recycled individually but recycled as the superblock **302**. The table module **506** can be coupled to the error module **508** and the threshold module **522** for sharing information.

The error module **508** detects a bit error count **510** in the erase blocks **304** in the superblock **302**. The bit error count **510** is defined as an amount of bit errors detected from one of the erase blocks **304**. For example, the error module **508** can detect bit errors in the superblock **302** of one or more of the erase blocks **304** as a numerical value for the bit error count **510**. The bit error count **510** can include a number associated with the bit error rate. If the bit error count **510** for the data stored on the erase blocks **304** exceeds a tolerable error threshold **507**, the error module **508** can request recycling of the superblock **302**. The wear attribute **303** can include the bit error count **510** as a characteristic of the erase blocks **304** that degrades reliability in retaining information.

The error module **508** can also detect a program time **511** of the erase blocks **304**. The program time **511** is defined as the amount of time needed to write information to one of the erase blocks **304**. If the program time **511** exceeds a tolerable time threshold **509**, the error module **508** can request recycling of the superblock **302**. The error module **508** can be coupled to the status module **512** and the threshold module **522**.

The status module **512** detects a power up **514** and a power down **516** of the electronic system **100** of FIG. **1**. For example, if the power down **516** of the electronic system **100** is detected, the memory controller **104** can save information and metadata to the condition table **308** of FIG. **3**. Further, if the power up **514** is detected, the memory controller **104** can access the condition table **308** from non-volatile memory. The status module **512** can be coupled to the table module **506**, the error module **508**, the condition module **518**, and the update module **520** for sharing information.

The condition module **518** generates the condition table **308**. The condition module **518** records the trigger count **310** of the wear attribute **303** to the condition table **308** for each of the superblock **302**. The condition module **518** can save the condition table **308** in non-volatile memory, such as in the storage unit **204** of FIG. **2**, an external non-volatile memory, or a combination thereof. The condition module **518** can be coupled to the update module **520** for sharing information.

The update module **520** updates the metadata table **402**. For example, during operation of the electronic system **100**, the update module **520** can update the metadata table **402** with the trigger count **310** of the superblock **302**.

The update module **520** can also update the metadata table **402** with information from the condition table **308**. The update module **520** can detect the power up **514** of the electronic system **100** and update the metadata table **402** with the condition table **308**. The condition table **308** including the trigger count **310** of the superblock **302** can be copied to the metadata table **402**. The metadata table **402** can be updated with the condition table **308** instead of detecting the trigger count **310** from each of the superblock **302** in the memory array **106** of FIG. **1**.

The update module **520** can also retrieve the condition table **308** from the non-volatile memory. The update module **520** can retrieve the condition table **308** from the non-volatile memory during the power up **514**. The update module **520** can be coupled to the threshold module **522** for sharing information.

The threshold module **522** compares the bit error count **510**, the program time **511**, or the trigger count **310** with a recycle threshold **524**. The recycle threshold **524** is defined as a minimum value that will trigger an erase/write verify cycle for recycling the superblock **302**. The recycle threshold **524** can be a different value for the bit error count **510**, the program time **511**, and the trigger count **310**.

The threshold module **522** can monitor the bit error count **510**, the program time **511**, and the trigger count **310** of the wear attribute **303**. If the bit error count **510**, the program time **511**, or the trigger count **310** meet or exceed the recycle threshold **524**, the threshold module **522** can request recycling of the superblock **302**.

For example, the threshold module **522** can detect that the trigger count **310** for the superblock **302** that has exceeded the recycle threshold **524**. The threshold module **522** can request the recycling of the superblock **302**. The threshold module **522** can be coupled to the recycle module **526** for performing recycling and wear leveling operations.

The recycle module **526** triggers a recycling event **528**. The recycling event **528** is defined as a data preservation operation for moving and erasing data on the erase blocks **304** of the superblock **302**. For example, the recycling event **528** can be used as a wear leveling operation that rearranges data across the superblock **302** and another of the superblock **302**. The recycling event **528** is for prolonging the life of the erase blocks **304** and for ensuring the integrity of data stored on the erase blocks **304**. Data contained in the superblock **302** is copied to another of the superblock **302**. The superblock **302** having the re-written data resets the read count **305** and the leakage **307** of the superblock **302**.

The trigger count **310** for relative age and retention characteristics is also reset because the read count **305** and the leakage **307** of the erase blocks **304** have been refreshed in another of the superblock **302**. During the recycling event **528**, the erase blocks **304** with reliability issues such as the bit error count **510** and the program time **511** can be replaced with the erase blocks **304** from spares. The block module **504** can replace the erase blocks **304** in the superblock **302** with reliability issues with other spares of the erase blocks **304**. The recycle module **526** can be coupled to the block module **504** and the reset module **530** for sharing information.

The reset module **530** resets the trigger count **310** for the superblock **302** in the metadata table **402**. The reset module **530** also updates the write age **306** of the superblock **302** after the recycling event **528**. After the recycling event **528**, the erase blocks **304** in the superblock **302** will the same value for the read count **305** and for the leakage **307**.

The control flow of the memory controller **104** describes the module functions or order as an example. The modules can be partitioned differently. For example, the block module **504**, the table module **506**, the error module **508**, the status module **512**, then the condition module **518**, the update module **520**, the threshold module **522**, the recycle module **526**, and the reset module **530** can be implemented as one module or with lesser number of modules. Each of the modules can operate individually and independently of the other modules.

The block module **504**, the table module **506**, the error module **508**, the status module **512**, the condition module **518**, the update module **520**, the threshold module **522**, the recycle module **526**, and the reset module **530** can be hardware implementations in the memory controller **104** or can be implemented as hardware within the electronic system **100** but outside the memory controller **104**. The modules of the memory controller **104** can be hardware, software running on or coupled to hardware, or a combination thereof.

It has been discovered that the organization of the superblock **302** by the wear attribute **303** reduces the volume of information tracked by the metadata table **402** and the condition table **308** to manageable levels. The erase blocks **304** organized in the superblock **302** can include blocks having similar relative age, endurance, and retention characteristics. Data management and recycling/wear leveling can occur on the superblock level instead of on the erase block level and the memory storage capacity of the non-volatile memory system can increase without increasing the volume of information that must be tracked.

It has also been discovered that the condition table **308** of the superblock **302** reduces the volume of information that needs to be tracked to manageable levels across power cycles. The condition table **308** can be used to store only the trigger count **310** for the superblock **302** because the trigger count **310** can control when the superblock **302** undergoes the recycling event **528**. During the power down **516**, one value for the wear attribute **303** can be stored for the superblock **302** instead of individual values for each of the erase blocks **304**.

It has further been discovered that the condition table **308** improves data reliability and improves the wear leveling of the non-volatile memory across power cycles. The trigger count **310** of the wear attribute **303** can be stored in the condition table **308** at the power down **516**. During the power up **514**, the metadata table **402** can be synchronized with the condition table **308** without disturbing the erase blocks **304** within the superblock **302**. Information from the condition table **308** can be compared with the recycle threshold **524** and the recycling event **528** can be triggered at initialization of the electronic system **100**.

Referring now to FIG. **6**, therein is shown a flow chart of a method **600** of operation of the electronic system **100** of FIG. **1** in a further embodiment of the present invention. The method **600** includes: forming a superblock by organizing an erase block according to a wear attribute in a block **602**; detecting a trigger count of the wear attribute of the superblock in a block **604**; updating a metadata table with the trigger count in a block **606**; and triggering a recycling event of the superblock based on the metadata table in a block **608**.

Thus, it has been discovered that the electronic system **100** of the present invention furnishes important and heretofore unknown and unavailable solutions, capabilities, and functional aspects for an electronic system with read disturb management mechanism. The resulting method, process, apparatus, device, product, and/or system is straightforward, cost-effective, uncomplicated, highly versatile, accurate, sensitive, and effective, and can be implemented by adapting known components for ready, efficient, and economical manufacturing, application, and utilization.

Another important aspect of the present invention is that it valuably supports and services the historical trend of reducing costs, simplifying systems, and increasing performance. These and other valuable aspects of the present invention consequently further the state of the technology to at least the next level.

While the invention has been described in conjunction with a specific best mode, it is to be understood that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the aforegoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations that fall within the scope of the included claims. All matters hithertofore set forth herein or shown in the accompanying drawings are to be interpreted in an illustrative and non-limiting sense.

What is claimed is:

1. A method of operation of an electronic system comprising:

forming a plurality of superblocks from a set of erase blocks by organizing the set of erase blocks according to a wear attribute of each of the erase blocks in the set of erase blocks, each superblock comprising a plurality of erase blocks from the set of erase blocks;

for a respective superblock of the plurality of superblocks:

detecting a trigger count of the wear attributes of the erase blocks of the respective superblock;

updating a metadata table with the trigger count; and

in accordance with the trigger count meeting or exceeding a recycle threshold, triggering a recycling event of the respective superblock.

2. The method as claimed in claim **1** wherein detecting the trigger count of the wear attributes of the erase blocks of the respective superblock includes identifying a read count, a write age, a leakage, or a combination thereof from an erase block of the respective superblock.

3. The method as claimed in claim 1 further comprising generating a condition table for storing the trigger count from the metadata table during a power down.

4. The method as claimed in claim 1, wherein the trigger count is a highest value of the wear attributes of the plurality of erase blocks comprising the respective superblock.

5. The method as claimed in claim 1 further comprising:

detecting the recycling event; and

resetting the trigger count for the respective superblock based on the recycling event.

6. The method as claimed in claim 1, wherein each erase block of the respective superblock has a wear attribute value, and the trigger count is a highest value of the wear attribute for the plurality of erase blocks comprising the respective superblock.

7. The method as claimed in claim 1, including:

detecting a bit error count of the respective superblock;

wherein triggering the recycling event includes triggering the recycling event of the respective superblock in accordance with the bit error count meeting or exceeding the recycle threshold.

8. The method as claimed in claim 1, including:

detecting a program time of the respective superblock;

wherein triggering the recycling event includes triggering the recycling event of the respective superblock in accordance with the program time meeting or exceeding the recycle threshold.

9. The method as claimed in claim 3 further comprising:

detecting a power up; and

updating the metadata table with the condition table during the power up.

10. An electronic system comprising:

a plurality of non-volatile memory devices including a set of erase blocks; and

a memory controller including one or more processors and memory storing software for execution by the one or more processors, the software including:

a block module for forming a plurality of superblocks from a set of erase blocks by organizing the set of erase blocks according to a wear attribute of each of the erase blocks in the set of erase blocks, each superblock comprising a plurality of erase blocks from the set of erase blocks;

a table module, coupled to the block module, for detecting a trigger count of the wear attributes of the erase blocks of a respective superblock of the plurality of superblocks;

an update module, coupled to the table module, for updating a metadata table with the trigger count;

a threshold module, coupled to the table module, for detecting the trigger count meeting or exceeding a recycle threshold; and

a recycle module, coupled to the update module, for triggering a recycling event of the respective superblock in accordance with the trigger count meeting or exceeding the recycle threshold.

11. The system as claimed in claim 10 wherein the table module is for identifying a read count, a write age, a leakage, or a combination thereof from an erase block of the respective superblock.

12. The system as claimed in claim 10 further comprising a condition module, coupled to the table module, for generating a condition table for storing the trigger count from the metadata table during a power down.

13. The system as claimed in claim 10, wherein the trigger count is a highest value of the wear attributes of the plurality of erase blocks comprising the respective superblock.

14. The system as claimed in claim 10 further comprising a reset module, coupled to the recycling module, for resetting the trigger count for the respective superblock based on the recycling event.

15. The system as claimed in claim 10, wherein each erase block of the respective superblock has a wear attribute value, and the trigger count is a highest value of the wear attribute for the plurality of erase blocks comprising the respective superblock.

16. The system as claimed in claim 10,

wherein the threshold module is for detecting a bit error count of the respective superblock; and

wherein the recycle module is for triggering the recycling event of the respective superblock in accordance with the bit error count meeting or exceeding the recycle threshold.

17. The system as claimed in claim 10,

wherein the threshold module is for detecting a program time of the respective superblock; and

wherein the recycle module is for triggering the recycling event of the respective superblock in accordance with the program time meeting or exceeding the recycle threshold.

18. The system as claimed in claim 10 further comprising:

a status module, coupled to the table module, for detecting a power up; and

wherein:

the update module is for updating the metadata table with the condition table during the power up.

* * * * *