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

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(54) **MIGRATING EXECUTION OF THREAD BETWEEN CORES OF DIFFERENT INSTRUCTION SET ARCHITECTURE IN MULTI-CORE PROCESSOR AND TRANSITIONING EACH CORE TO RESPECTIVE ON / OFF POWER STATE**

5,890,799	A *	4/1999	Yiu et al.	713/321
5,991,883	A	11/1999	Atkinson	
6,006,320	A	12/1999	Paraday	
6,021,484	A *	2/2000	Park	712/41
6,035,408	A	3/2000	Huang	
6,058,434	A	5/2000	Wilt et al.	
6,219,742	B1	4/2001	Stanley	
6,240,521	B1	5/2001	Barber et al.	
6,405,320	B1	6/2002	Lee et al.	
6,501,999	B1	12/2002	Cai	
6,513,057	B1	1/2003	McCrory	
6,513,124	B1	1/2003	Furuichi et al.	
6,567,839	B1	5/2003	Borkenhagen et al.	
6,631,474	B1	10/2003	Cai et al.	

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(Continued)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 538 days.

**FOREIGN PATENT DOCUMENTS**

GB	2382180	5/2003
WO	WO03100546	10/2003
WO	WO 03100546	10/2003
WO	2004/064119	7/2004

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**OTHER PUBLICATIONS**

(65) **Prior Publication Data**

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Seng et al. "Reducing Power with Dynamic Critical Path Information", Proc. of the 34th annual ACM/IEEE international symposium on Microarchitecture, ACM, Dec. 2001, pp. 114-123.

**Related U.S. Application Data**

(Continued)

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(51) **Int. Cl.**  
**G06F 1/32** (2006.01)

*Primary Examiner* — Kenneth Kim

(52) **U.S. Cl.**  
USPC ..... **713/100; 712/32; 713/323**

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(58) **Field of Classification Search**  
None  
See application file for complete search history.

(57) **ABSTRACT**

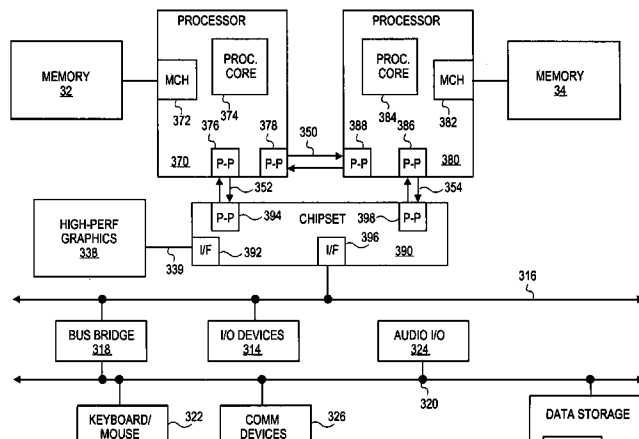
Techniques to control power and processing among a plurality of asymmetric cores. In one embodiment, one or more asymmetric cores are power managed to migrate processes or threads among a plurality of cores according to the performance and power needs of the system.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,763,242	A	8/1988	Lee et al.
5,293,500	A	3/1994	Ishida et al.

**20 Claims, 6 Drawing Sheets**



(56)

References Cited

U.S. PATENT DOCUMENTS

6,718,475 B2 4/2004 Cai  
 6,732,280 B1 5/2004 Cheok et al.  
 6,901,522 B2 5/2005 Buch  
 6,968,469 B1 11/2005 Fleischmann et al.  
 7,017,060 B2 3/2006 Therien et al.  
 7,069,463 B2 6/2006 Oh  
 7,093,147 B2 8/2006 Farkas et al.  
 7,171,546 B2 1/2007 Adams  
 7,269,752 B2 9/2007 John  
 7,334,142 B2 2/2008 Hack  
 7,461,275 B2\* 12/2008 Belmont et al. .... 713/300  
 7,492,368 B1 2/2009 Nordquist et al.  
 7,500,126 B2\* 3/2009 Terechko et al. .... 713/323  
 7,500,127 B2 3/2009 Fleck et al.  
 7,624,215 B2\* 11/2009 Axford et al. .... 710/260  
 7,743,232 B2\* 6/2010 Shen et al. .... 712/211  
 8,028,290 B2\* 9/2011 Rymarczyk et al. .... 718/104  
 8,060,727 B2\* 11/2011 Blixt ..... 712/32  
 8,214,808 B2\* 7/2012 Day et al. .... 717/140  
 2002/0095609 A1 7/2002 Tokunaga  
 2002/0129288 A1 9/2002 Loh et al.  
 2003/0065734 A1 4/2003 Ramakesavan  
 2003/0088800 A1 5/2003 Cai  
 2003/0100340 A1 5/2003 Cupps et al.  
 2003/0110012 A1 6/2003 Orenstein et al.  
 2003/0224768 A1 12/2003 Adjamah  
 2005/0066209 A1 3/2005 Kee et al.  
 2005/0132239 A1 6/2005 Athas et al.  
 2005/0182980 A1 8/2005 Sutardja  
 2006/0036878 A1 2/2006 Rothman et al.  
 2006/0095807 A1 5/2006 Grochowski et al.  
 2006/0294401 A1\* 12/2006 Munger ..... 713/300  
 2007/0038875 A1 2/2007 Cupps et al.

2007/0083785 A1 4/2007 Sutardja  
 2007/0094444 A1\* 4/2007 Sutardja ..... 711/112  
 2007/0220246 A1 9/2007 Powell et al.  
 2007/0234077 A1\* 10/2007 Rothman et al. .... 713/300  
 2008/0028244 A1 1/2008 Capps et al.  
 2008/0028245 A1 1/2008 Ober et al.  
 2008/0307244 A1 12/2008 Bertelsen et al.  
 2009/0193243 A1\* 7/2009 Ely ..... 713/2  
 2009/0222654 A1 9/2009 Hum et al.  
 2010/0185833 A1\* 7/2010 Saito et al. .... 712/203  
 2010/0268916 A1\* 10/2010 Hu et al. .... 712/41

OTHER PUBLICATIONS

Irani et al., "Online Strategies for Dynamic Power Management in Systems with Multiple Power-Saving States," ACM Transactions on Embedded Computing Systems, vol. 2, No. 3, Aug. 2003, pp. 325-346.  
 Lefurgy et al., "Energy Management for Commercial Servers," Computer, IEEE, Dec. 2003, vol. 36, Issue 12, pp. 39-48.  
 Kumar et al., "Single-ISA Heterogeneous Multi-Core Architectures: The Potential for Processor Power Reduction," Proceedings of the 36th Annual IEEE/ACM International Symposium on Microarchitecture, 2003, pp. 81-92.  
 Benini et al., "A Survey of Design Techniques for System-Level Dynamic Power Management," IEEE Transactions on Very Large Scale Integration (VLSI) Systems, Jun. 2000, vol. 8, Issue 3, pp. 299-316.  
 Abramson et al., "Intel Virtualization Technology for Directed I/O," Intel Technology Journal, Aug. 10, 2006, vol. 10, Issue 3, pp. 179-192 (16 pages included).  
 International Search Report of PCT/2007/000010, Swedish Patent Office, Stockholm, Sweden, dated May 16, 2007, 4 pages.  
 International Search Report, PCT/2007/000010, dated May 16, 2007.

\* cited by examiner

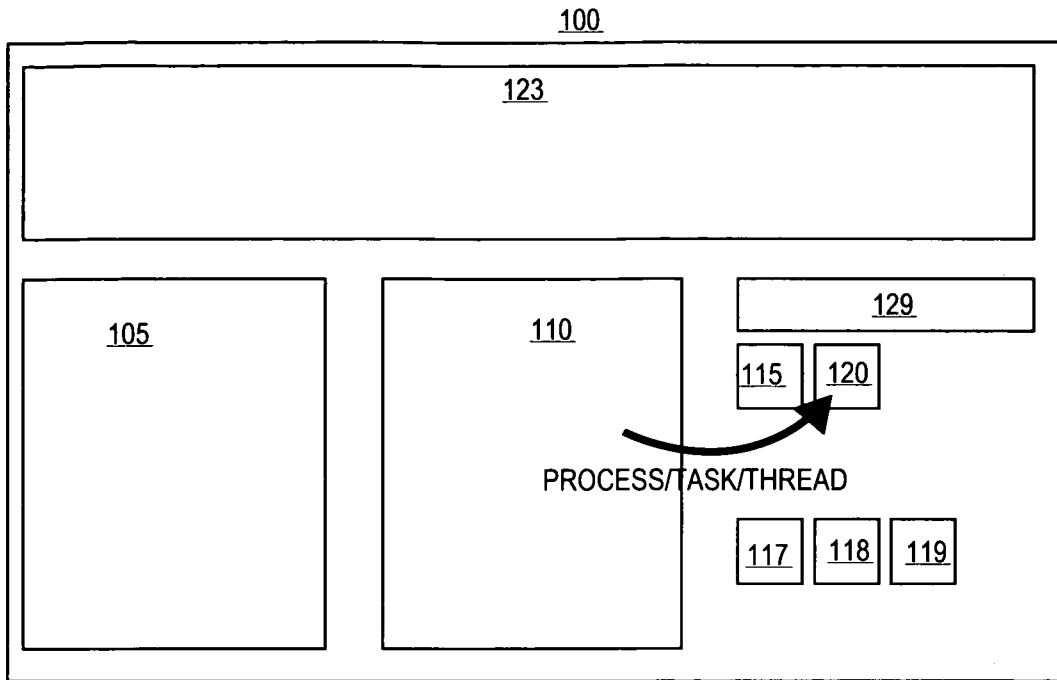


FIG. 1

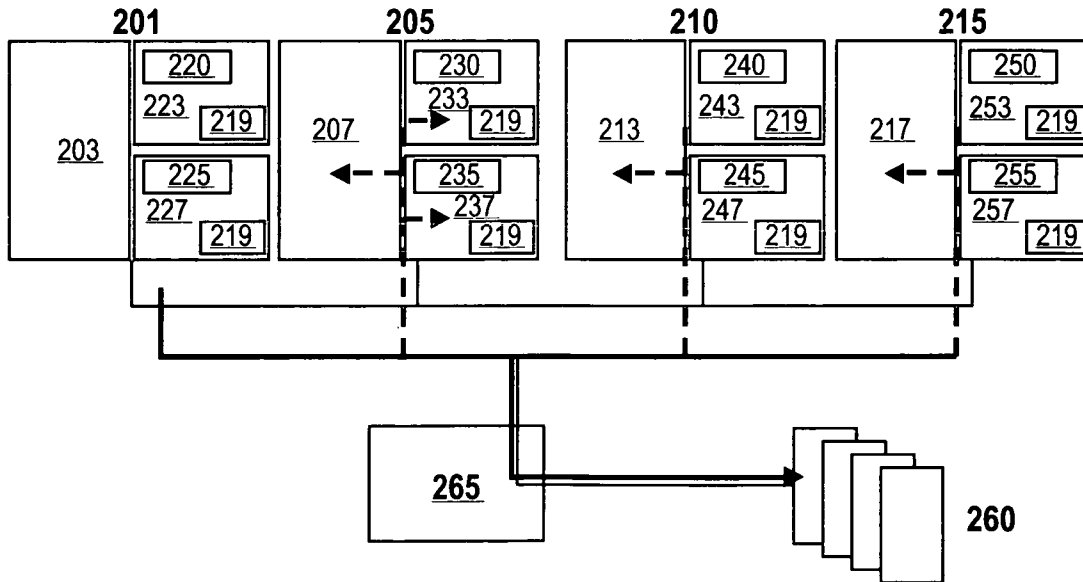


FIG. 2

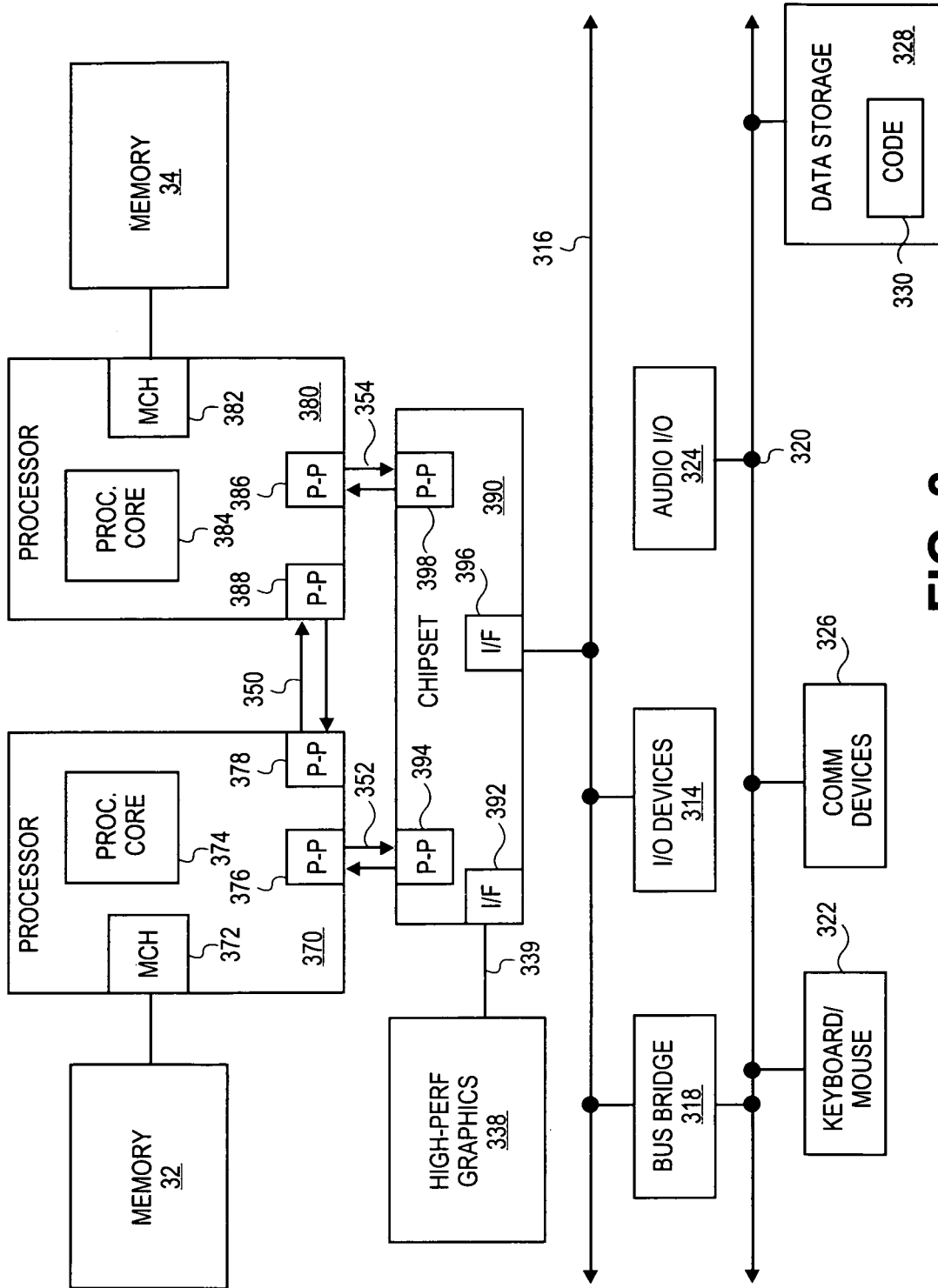


FIG. 3

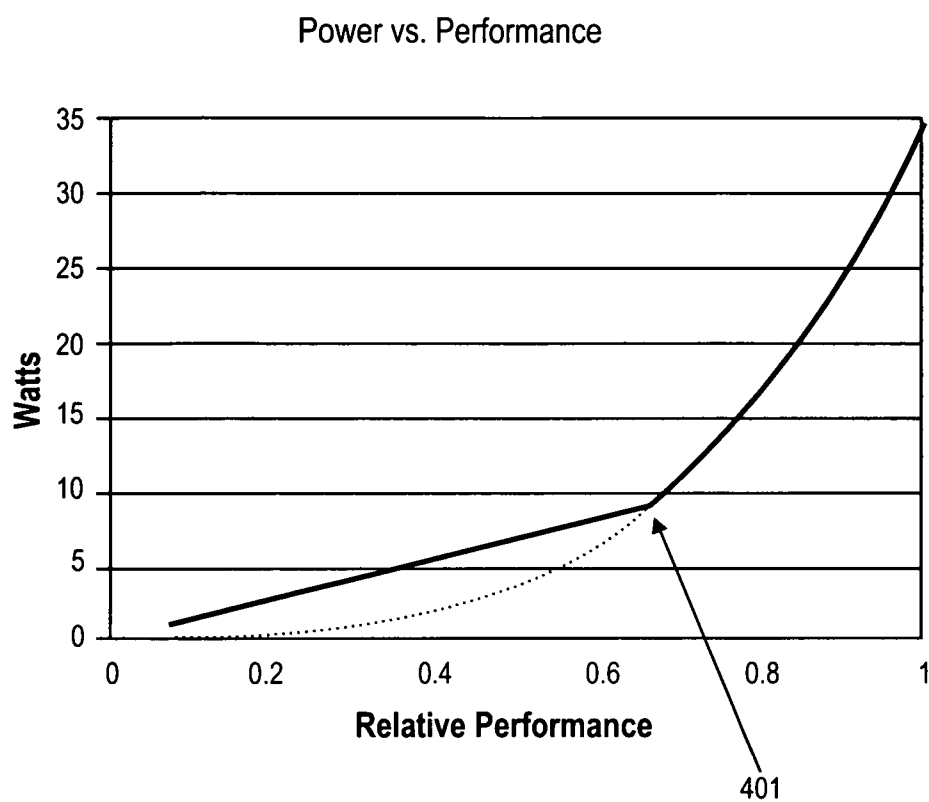


FIG. 4

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